FEDERAL WATER POLLUTION CONTROL ACT

(33 U.S.C. 1251 et seq.)

AN ACT To provide for water pollution control activities in the Public Health Service of the Federal Security Agency and in the Federal Works Agency, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I—RESEARCH AND RELATED PROGRAMS

DECLARATION OF GOALS AND POLICY

SEC. 101. (a) The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act—

(1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;

(2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;

(3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;

(4) it is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works;

(5) it is the national policy that areawide treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each State;

(6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into the navigable waters, waters of the contiguous zone and the oceans; and

(7) it is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

(b) It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this Act. It is the policy of Congress that the States manage the construction grant program under this Act and implement the permit programs under sections 402 and 404 of

this Act. It is further the policy of the Congress to support and research relating to the prevention, reduction, and elimination of pollution, and to provide Federal technical services and financial aid to State and interstate agencies and municipalities in connection with the prevention, reduction, and elimination of pollution.

(c) It is further the policy of Congress that the President, acting through the Secretary of State and such national and international organizations as he determines appropriate, shall take such action as may be necessary to insure that to the fullest extent possible all foreign countries shall take meaningful action for the prevention, reduction, and elimination of pollution in their waters and in international waters and for the achievement of goals regarding the elimination of discharge of pollutants and the improvement of water quality to at least the same extent as the United States does under its laws.

(d) Except as otherwise expressly provided in this Act, the Administrator of the Environmental Protection Agency (hereinafter in this Act called "Administrator") shall administer this Act.

(e) Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under this Act shall be provided for, encouraged, and assisted by the Administrator and the States. The Administrator, in cooperation with the States, shall develop and publish regulations specifying minimum guidelines for public participation in such processes.

(f) It is the national policy that to the maximum extent possible the procedures utilized for implementing this Act shall encourage the drastic minimization of paperwork and interagency decision procedures, and the best use of available manpower and funds, so as to prevent needless duplication and unnecessary delays at all levels of government.

(g) It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. It is the further policy of Congress that nothing in this Act shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

(33 U.S.C. 1251)

COMPREHENSIVE PROGRAMS FOR WATER POLLUTION CONTROL

SEC. 102. (a) The Administrator shall, after careful investigation, and in cooperation with other Federal agencies, State water pollution control agencies, interstate agencies, and the municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for the protection and propagation of fish and aquatic life and wildlife, recreational purposes, and the withdrawal of such waters for public water supply, agricultural, industrial, and other purposes. For the purpose of this section, the Administrator is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial wastes, or substance which may adversely affect such waters.

(b)(1) In the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other Federal agency, consideration shall be given to inclusion of storage for regulation of streamflow, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source.

(2) The need for and the value of storage for regulation of streamflow (other than for water quality) including but not limited to navigation, salt water intrusion, recreation, esthetics, and fish and wildlife, shall be determined by the Corps of Engineers, Bureau of Reclamation, or other Federal agencies.

(3) The need for, the value of, and the impact of, storage for water quality control shall be determined by the Administrator, and his views on these matters shall be set forth in any report or presentation to Congress proposing authorization or construction of any reservoir including such storage.

(4) The value of such storage shall be taken into account in determining the economic value of the entire project of which it is a part, and costs shall be allocated to the purpose of regulation of streamflow in a manner which will insure that all project purposes, share equitable in the benefits of multiple-purpose construction.

(5) Costs of regulation of streamflow features incorporated in any Federal reservoir or other impoundment under the provisions of this Act shall be determined and the beneficiaries identified and if the benefits are widespread or national in scope, the costs of such features shall be nonreimbursable.

(6) No license granted by the Federal Power Commission for a hydroelectric power project shall include storage for regulation of streamflow for the purpose of water quality control unless the Administrator shall recommend its inclusion and such reservoir storage capacity shall not exceed such proportion of the total storage required for the water quality control plan as the drainage area of such reservoir bears to the drainage area of the river basin or basins involved in such water quality control plan.

(c)(1) The Administrator shall, at the request of the Governor of a State, or a majority of the Governors when more than one State is involved make a grant to pay not to exceed 50 per centum of the administrative expenses of a planning agency for a period not to exceed three years, which period shall begin after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, if such agency provides for adequate representation of appropriate State, interstate, local, or (when appropriate) international interests in the basin or portion thereof involved and is capable of developing an effective, comprehensive water quality control plan for a basin or portion thereof.

(2) Each planning agency receiving a grant under this subsection shall develop a comprehensive pollution control plan for the basin or portion thereof which—

(A) is consistent with any applicable water quality standards, effluent and other limitations, and thermal discharge regulations established pursuant to current law within the basin;

(B) recommends such treatment works as will provide the most effective and economical means of collection, storage, treatment, and elimination of pollutants and recommends means to encourage both municipal and industrial use of such works;

(C) recommends maintenance and improvement of water quality within the basin or portion thereof and recommends methods of adequately financing those facilities as may be necessary to implement the plan; and

(D) as appropriate, is developed in cooperation with, and is consistent with any comprehensive plan prepared by the Water Resources Council, any areawide waste management plans developed pursuant to section 208 of this Act, and any State plan developed pursuant to section 303(e) of this Act.

(3) For the purposes of this subsection the term "basin" includes, but is not limited to, rivers and their tributaries, streams, coastal waters, sounds, estuaries, bays, lakes, and portions thereof, as well as the lands drained thereby.

(d) [Repealed by section 2021(a) of Public Law 104–66 (109 Stat. 726).]

(33 U.S.C. 1252)

INTERSTATE COOPERATION AND UNIFORM LAWS

SEC. 103. (a) The Administrator shall encourage cooperative activities by the States for the prevention, reduction, and elimination of pollution, encourage the enactment of improved and, so far as practicable, uniform State laws relating to the prevention, reduction, and elimination of pollution; and encourage compacts between States for the prevention and control of pollution.

(b) The consent of the Congress is hereby given to two or more States to negotiate and enter into agreements or compacts, not in conflict with any law or treaty of the United States, for (1) cooperative effort and mutual assistance for the prevention and control of pollution and the enforcement of their respective laws relating thereto, and (2) the establishment of such agencies, joint or otherwise, as they may deem desirable for making effective such agreements and compacts. No such agreement or compact shall be binding or obligatory upon any State a party thereto unless and until it has been approved by the Congress.

(33 U.S.C. 1253)

RESEARCH, INVESTIGATIONS, TRAINING, AND INFORMATION

SEC. 104. (a) The Administrator shall establish national programs for the prevention, reduction, and elimination of pollution and as part of such programs shall—

(1) in cooperation with other Federal, State, and local agencies, conduct and promote the coordination and acceler-

tion of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of pollution;

(2) encourage, cooperate with, and render technical services to pollution control agencies and other appropriate public or private agencies, institutions, and organizations, and individuals, including the general public, in the conduct of activities referred to in paragraph (1) of this subsection;

(3) conduct, in cooperation with State water pollution control agencies and other interested agencies, organizations and persons, public investigations concerning the pollution of any navigable waters, and report on the results of such investigations;

(4) establish advisory committees composed of recognized experts in various aspects of pollution and representatives of the public to assist in the examination and evaluation of research progress and proposals and to avoid duplication of research;

(5) in cooperation with the States, and their political subdivisions, and other Federal agencies establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters and ground waters and the contiguous zone and the oceans and the Administrator shall, to the extent practicable, conduct such surveillance by utilizing the resources of the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the Geological Survey, and the Coast Guard, and shall report on such quality in the report required under subsection (a) of section 516; and

(6) initiate and promote the coordination and acceleration of research designed to develop the most effective practicable tools and techniques for measuring the social and economic costs and benefits of activities which are subject to regulations under this Act; and shall transmit a report on the results of such research to the Congress not later than January 1, 1974.

(b) In carrying out the provisions of subsection (a) of this section the Administrator is authorized to—

(1) collect and make available, through publications and other appropriate means, the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities referred to in paragraph (1) of subsection (a);

(2) cooperate with other Federal departments and agencies, State water pollution control agencies, interstate agencies, other public and private agencies, institutions, organizations, industries involved, and individuals, in the preparation and conduct of such research and other activities referred to in paragraph (1) of subsection (a);

(3) make grants to State water pollution control agencies, interstate agencies, other public or nonprofit private agencies, institutions, organizations, and individuals, for purposes stated in paragraph (1) of subsection (a) of this section;

(4) contract with public or private agencies, institutions, organizations, and individuals, without regard to sections 3648 and 3709 of the Revised Statutes (31 U.S.C. 529; 41 U.S.C. 5), referred to in paragraph (1) of subsection (a);

(5) establish and maintain research fellowships at public or nonprofit private educational institutions or research organizations;

(6) collect and disseminate, in cooperation with other Federal departments and agencies, and with other public or private agencies, institutions, and organizations having related responsibilities, basic data on chemical, physical, and biological effects of varying water quality and other information pertaining to pollution and the prevention, reduction, and elimination thereof; and

(7) develop effective and practical processes, methods, and prototype devices for the prevention, reduction, and elimination of pollution.

(c) In carrying out the provisions of subsection (a) of this section the Administrator shall conduct research on, and survey the results of other scientific studies on, the harmful effects on the health or welfare of persons caused by pollutants. In order to avoid duplication of effort, the Administrator shall, to the extent practicable, conduct such research in cooperation with and through the facilities of the Secretary of Health, Education, and Welfare.

(d) In carrying out the provisions of this section the Administrator shall develop and demonstrate under varied conditions (including conducting such basic and applied research, studies, and experiments as may be necessary):

(1) Practicable means of treating municipal sewage, and other waterborne wastes to implement the requirements of section 201 of this Act;

(2) Improved methods and procedures to identify and measure the effects of pollutants, including those pollutants created by new technological developments; and

(3) Methods and procedures for evaluating the effects on water quality of augmented streamflows to control pollution not susceptible to other means of prevention, reduction, or elimination.

(e) The Administrator shall establish, equip, and maintain field laboratory and research facilities, including, but not limited to, one to be located in the northeastern area of the United States, one in the Middle Atlantic area, one in the southeastern area, one in the midwestern area, one in the southwestern area, one in the Pacific Northwest, and one in the State of Alaska, for the conduct of research, investigations, experiments, field demonstrations and studies, and training relating to the prevention, reduction and elimination of pollution. Insofar as practicable, each such facility shall be located near institutions of higher learning in which graduate training in such research might be carried out. In conjunction with the development of criteria under section 403 of this Act, the Administrator shall construct the facilities authorized for the National Marine Water Quality Laboratory established under this subsection.

(f) The Administrator shall conduct research and technical development work, and make studies, with respect to the quality of the waters of the Great Lakes, including an analysis of the present and projected future water quality of the Great Lakes under varying conditions of waste treatment and disposal, an evaluation of the water quality needs of those to be served by such waters, an evaluation of municipal, industrial, and vessel waste treatment and disposal practices with respect to such waters, and a study of alternate means of solving pollution problems (including additional waste treatment measures) with respect to such waters.

(g)(1) For the purpose of providing an adequate supply of trained personnel to operate and maintain existing and future treatment works and related activities, and for the purpose of enhancing substantially the proficiency of those engaged in such activities, the Administrator shall finance pilot programs, in cooperation with State and interstate agencies, municipalities, educational institutions, and other organizations and individuals, of manpower development and training and retraining of persons in, on entering into, the field of operation and maintenance of treatment works and related activities. Such program and any funds expended for such a program shall supplement, not supplant, other manpower and training programs and funds available for the purposes of this paragraph. The Administrator is authorized, under such terms and conditions as he deems appropriate, to enter into agreements with one or more States, acting jointly or severally, or with other public or private agencies or institutions for the development and implementation of such a program.

(2) The Administrator is authorized to enter into agreements with public and private agencies and institutions, and individuals to develop and maintain an effective system for forecasting the supply of, and demand for, various professional and other occupational categories needed for the prevention, reduction, and elimination of pollution in each region, State, or area of the United States and, from time to time, to publish the results of such forecasts.

(3) In furtherance of the purposes of this Act, the Administrator is authorized to—

(A) make grants to public or private agencies and institutions and to individuals for training projects, and provide for the conduct of training by contract with public or private agencies and institutions and with individuals without regard to sections 3648 and 3709 of the Revised Statutes;

(B) establish and maintain research fellowships in the Environmental Protection Agency with such stipends and allowances, including traveling and subsistence expenses, as he may deem necessary to procure the assistance of the most promising research fellows; and

(C) provide, in addition to the program established under paragraph (1) of this subsection, training in technical matters relating to the causes, prevention, reduction, and elimination of pollution for personnel of public agencies and other persons with suitable qualifications.

(4) The Administrator shall submit, through the President, a report to the Congress not later than December 31, 1973, summarizing the actions taken under this subsection and the effectiveness of such actions, and setting forth the number of persons trained, the occupational categories for which training was provided, the effectiveness of other Federal, State, and local training programs in

this field, together with estimates of future needs, recommendations on improving training programs, and such other information and recommendations, including legislative recommendations, as he deems appropriate.

(h) The Administrator is authorized to enter into contracts, with, or make grants to, public or private agencies and organizations and individuals for (A) the purpose of developing and demonstrating new or improved methods for the prevention, removal, reduction, and elimination of pollution in lakes, including the undesirable effects of nutrients and vegetation, and (B) the construction of publicly owned research facilities for such purpose.

(i) The Administrator, in cooperation with the Secretary of the department in which the Coast Guard is operating, shall—

(1) engage in such research, studies, experiments, and demonstrations as he deems appropriate, relative to the removal of oil from any waters and to the prevention, control, and elimination of oil and hazardous substances pollution;

(2) publish from time to time the results of such activities; and

(3) from time to time, develop and publish in the Federal Register specifications and other technical information on the various chemical compounds used in the control of oil and hazardous substances spills.

In carrying out this subsection, the Administrator may enter into contracts with, or make grants to, public or private agencies and organizations and individuals.

(j) The Secretary of the department in which the Coast Guard is operating shall engage in such research, studies, experiments, and demonstrations as he deems appropriate relative to equipment which is to be installed on board a vessel and is designed to receive, retain, treat, or discharge human body wastes and the wastes from toilets and other receptacles intended to receive or retain body wastes with particular emphasis on equipment to be installed on small recreational vessels. The Secretary of the department in which the Coast Guard is operating shall report to Congress the results of such research, studies, experiments, and demonstrations prior to the effective date of any regulations established under section 312 of this Act. In carrying out this subsection the Secretary of the department in which the Coast Guard is operating may enter into contracts with, or make grants to, public or private organizations and individuals.

(k) In carrying out the provisions of this section relating to the conduct by the Administrator of demonstration projects and the development of field laboratories and reseach facilities, the Administrator may acquire land and interests therein by purchase, with appropriated or donated funds, by donation, or by exchange for acquired or public lands under his jurisdiction which he classifies as suitable for disposition. The values of the properties so exchanged either shall be approximately equal, or if they are not approximately equal, the values shall be equalized by the payment of cash to the grantor or to the Administrator as the circumstances require.

(l)(1) The Administrator shall, after consultation with appropriate local, State, and Federal agencies, public and private organizations, and interested individuals, as soon as practicable but not later than January 1, 1973, develop and issue to the States for the purpose of carrying out this Act the latest scientific knowledge available in indicating the kind and extent of effects on health and welfare which may be expected from the presence of pesticides in the water in varying quantities. He shall revise and add to such information whenever necessary to reflect developing scientific knowledge.

(2) The President shall, in consultation with appropriate local, State, and Federal agencies, public and private organizations, and interested individuals, conduct studies and investigations of methods to control the release of pesticides into the environment which study shall include examination of the persistency of pesticides in the water environment and alternative thereto. The President shall submit reports, from time to time, on such investigations to Congress together with his recommendations for any necessary legislation.

(m)(1) The Administrator shall, in an effort to prevent degradation of the environment from the disposal of waste oil, conduct a study of (A) the generation of used engine, machine, cooling, and similar waste oil, including quantities generated, the nature and quality of such oil, present collecting methods and disposal practices, and alternate uses of such oil; (B) the long-term, chronic biological effects of the disposal of such waste oil; and (C) the potential market for such oils, including the economic and legal factors relating to the sale of products made from such oils, the level of subsidy, if any, needed to encourage the purchase by public and private nonprofit agencies of products from such oil, and the practicability of Federal procurement, on a priority basis, of products made from such oil. In conducting such study, the Administrator shall consult with affected industries and other persons.

(2) The Administrator shall report the preliminary results of such study to Congress within six months after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, and shall submit a final report to Congress within 18 months after such date of enactment.

(n)(1) The Administrator shall, in cooperation with the Secretary of the Army, the Secretary of Agriculture, the Water Resources Council, and with other appropriate Federal, State, interstate, or local public bodies and private organizations, institutions, and individuals, conduct and promote, encourage contributions to, continuing comprehensive studies of the effects of pollution, including sedimentation, in the estuaries and estuarine zones of the United States on fish and wildlife, on sport and commercial fishing, on recreation, on water supply and water power, and on other beneficial purposes. Such studies shall also consider the effect of demographic trends, the exploitation of mineral resources and fossil fuels, land and industrial development, navigation, flood and erosion control, and other uses of estuaries and estuarine zones upon the pollution of the waters therein.

(2) In conducting such studies, the Administrator shall assemble, coordinate, and organize all existing pertinent information on the Nation's estuaries and estuarine zones; carry out a program of investigations and surveys to supplement existing information in

representative estuaries and estuarine zones; and identify the problems and areas where further research and study are required.

(3) The Administrator shall submit to Congress, from time to time, reports of the studies authorized by this subsection but at least one such report during any six-year period. Copies of each such report shall be made available to all interested parties, public and private.

(4) For the purpose of this subsection, the term "estuarine zones" means an environmental system consisting of an estuary and those transitional areas which are consistently influenced or affected by water from an estuary such as, but not limited to, salt marshes, coastal and intertidal areas, bays, harbors, lagoons, inshore waters, and channels, and the term "estuary" means all or part of the mouth of a river or stream or other body of water having unimpaired natural connection with open sea and within which the sea water is measurably diluted with fresh water derived from land drainage.

(o)(1) The Administrator shall conduct research and investigations on devices, systems, incentives, pricing policy, and other methods of reducing the total flow of sewage, including, but not limited to, unnecessary water consumption in order to reduce the requirements for, and the costs of, sewage and waste treatment services. Such research and investigations shall be directed to develop devices, systems, policies, and methods capable of achieving the maximum reduction of unnecessary water consumption.

(2) The Administrator shall report the preliminary results of such studies and investigations to the Congress within one year after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, and annually thereafter in the report required under subsection (a) of section 516. Such report shall include recommendations for any legislation that may be required to provide for the adoption and use of devices, systems, policies, or other methods of reducing water consumption and reducing the total flow of sewage. Such report shall include an estimate of the benefits to be derived from adoption and use of such devices, systems, policies, or other methods and also shall reflect estimates of any increase in private, public, or other cost that would be occasioned thereby.

(p) In carrying out the provisions of subsection (a) of this section the Administrator shall, in cooperation with the Secretary of Agriculture, other Federal agencies, and the States, carry out a comprehensive study and research program to determine new and improved methods and the better application of existing methods of preventing, reducing, and eliminating pollution from agriculture, including the legal, economic, and other implications of the use of such methods.

(q)(1) The Administrator shall conduct a comprehensive program of research and investigation and pilot project implementation into new and improved methods of preventing, reducing, storing, collecting, treating, or otherwise eliminating pollution from sewage in rural and other areas where collection of sewage in conventional, community-wide sewage collection systems is impractical, uneconomical, or otherwise infeasible, or where soil conditions or other factors preclude the use of septic tank and drainage field systems.

(2) The Administrator shall conduct a comprehensive program of research and investigation and pilot project implementation into new and improved methods for the collection and treatment of sewage and other liquid wastes combined with the treatment and disposal of solid wastes.

(3) The Administrator shall establish, either within the Environmental Protection Agency, or through contract with an appropriate public or private non-profit organization, a national clearinghouse which shall (A) receive reports and information resulting from research, demonstrations, and other projects funded under this Act related to paragraph (1) of this subsection and to subsection (e)(2) of section 105; (B) coordinate and disseminate such reports and information for use by Federal and State agencies, municipalities, institutions, and persons in developing new and improved methods pursuant to this subsection; and (C) provide for the collection and dissemination of reports and information relevant to this subsection from other Federal and State agencies, institutions, universities, and persons.

(4) SMALL FLOWS CLEARINGHOUSE.—Notwithstanding section 205(d) of this Act, from amounts that are set aside for a fiscal year under section 205(i) of this Act and are not obligated by the end of the 24-month period of availability for such amounts under section 205(d), the Administrator shall make available $1,000,000 or such unobligated amount, whichever is less, to support a national clearinghouse within the Environmental Protection Agency to collect and disseminate information on small flows of sewage and innovative or alternative wastewater treatment processes and techniques, consistent with paragraph (3). This paragraph shall apply with respect to amounts set aside under section 205(i) for which the 24-month period of availability referred to in the preceding sentence ends on or after September 30, 1986.

(r) The Administrator is authorized to make grants to colleges and universities to conduct basic research into the structure and function of fresh water aquatic ecosystems, and to improve understanding of the ecological characteristics necessary to the maintenance of the chemical, physical, and biological integrity of freshwater aquatic ecosystems.

(s) The Administrator is authorized to make grants to one or more institutions of higher education (regionally located and to be designated as "River Study Centers") for the purpose of conducting and reporting on interdisciplinary studies on the nature of river systems, including hydrology, biology, ecology, economics, the relationship between river uses and land uses, and the effects of development within river basins on river systems and on the value of water resources and water related activities. No such grant in any fiscal year shall exceed $1,000,000.

(t) The Administrator shall, in cooperation with State and Federal agencies and public and private organizations, conduct continuing comprehensive studies of the effects and methods of control of thermal discharges. In evaluating alternative methods of control the studies shall consider (1) such data as are available on the latest available technology, economic feasibility including cost-effectiveness analysis, and (2) the total impact on the environment, considering not only water quality but also air quality, land use, and effective utilization and conservation of fresh water and other natural resources. Such studies shall consider methods of minimizing adverse effects and maximizing beneficial effects of thermal discharges. The results of these studies shall be reported by the Administrator as soon as practicable, but not later than 270 days after enactment of this subsection, and shall be made available to the public and the States, and considered as they become available by the Administrator in carrying out section 316 of this Act and by the State in proposing thermal water quality standards.

(u) There is authorized to be appropriated (1) not to exceed $100,000,000 per fiscal year for the fiscal year ending June 30, 1973, the fiscal year ending June 30, 1974, and the fiscal year ending June 30, 1975, not to exceed $14,039,000 for the fiscal year ending September 30, 1980, not to exceed $20,697,000 for the fiscal year ending September 30, 1981, not to exceed $22,770,000 for the fiscal year ending September 30, 1982, such sums as may be necessary for fiscal years 1983 through 1985, and not to exceed $22,770,000 per fiscal year for each of the fiscal years 1986 through 1990, for carrying out the provisions of this section, other than subsections (g)(1) and (2), (p), (r), and (t), except that such authorizations are not for any research, development, or demonstration activity pursuant to such provisions; (2) not to exceed $7,500,000 for fiscal years 1973, 1974, and 1975, $2,000,000 for fiscal year 1977, $3,000,000 for fiscal year 1978, $3,000,000 for fiscal year 1979, $3,000,000 for fiscal year 1980, $3,000,000 for fiscal year 1981, $3,000,000 for fiscal year 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $3,000,000 per fiscal year for each of the fiscal years 1986 through 1990, for carrying out the provisions of subsection (g)(1); (3) not to exceed $2,500,000 for fiscal years 1973, 1974, and 1975, $1,000,000 for fiscal year 1977, $1,500,000 for fiscal year 1978, $1,500,000 for fiscal year 1979, $1,500,000 for fiscal year 1980, $1,500,000 for fiscal year 1981, $1,500,000 for fiscal year 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $1,500,000 per fiscal year for each of the fiscal years 1986 through 1990, for carrying out the provisions of subsection (g)(2); (4) not to exceed $10,000,000 for each of the fiscal years ending June 30, 1973, June 30, 1974, and June 30, 1975, for carrying out the provisions of subsection (p); (5) not to exceed $15,000,000 per fiscal year for the fiscal years ending June 30, 1973, June 30, 1974, and June 30, 1975, for carrying out the provisions of subsection (r); and (6) not to exceed $10,000,000 per fiscal year for the fiscal years ending June 30, 1973, June 30, 1974, and June 30, 1975, for carrying out the provisions of subsection (t).

(33 U.S.C. 1254)

GRANTS FOR RESEARCH AND DEVELOPMENT

SEC. 105. (a) The Administrator is authorized to conduct in the Environmental Protection Agency, and to make grants to any

State, municipality, or intermunicipal or interstate agency for the purpose of assisting in the development of—

(1) any project which will demonstrate a new or improved method of preventing, reducing, and eliminating the discharge into any waters of pollutants from sewers which carry storm water or both storm water and pollutants; or

(2) any project which will demonstrate advanced waste treatment and water purification methods (including the temporary use of new or improved chemical additives which provide substantial immediate improvement to existing treatment processes), or new or improved methods of joint treatment systems for municipal and industrial wastes;

and to include in such grants such amounts as are necessary for the purpose of reports, plans, and specifications in connection therewith.

(b) The Administrator is authorized to make grants to any State or States or interstate agency to demonstrate, in river basins or portions thereof, advanced treatment and environmental enhancement techniques to control pollution from all sources, within such basins or portions thereof, including nonpoint sources, together with in stream water quality improvement techniques.

(c) In order to carry out the purposes of section 301 of this Act, the Administrator is authorized to (1) conduct in the Environmental Protection Agency, (2) make grants to persons, and (3) enter into contracts with persons, for research and demonstration projects for prevention of pollution of any waters by industry including, but not limited to, the prevention, reduction, and elimination of the discharge of pollutants. No grant shall be made for any project under this subsection unless the Administrator determines that such project will develop or demonstrate a new or improved method of treating industrial wastes or otherwise prevent pollution by industry, which method shall have industrywide application.

(d) In carrying out the provisions of this section, the Administrator shall conduct, on a priority basis, an accelerated effort to develop, refine, and achieve practical application of:

(1) waste management methods applicable to point and nonpoint sources of pollutants to eliminate the discharge of pollutants, including, but not limited to, elimination of runoff of pollutants and the effects of pollutants from inplace or accumulated sources;

(2) advanced waste treatment methods applicable to point and nonpoint sources, including inplace or accumulated sources of pollutants, and methods for reclaiming and recycling water and confining pollutants so they will not migrate to cause water or other environmental pollution; and

(3) improved methods and procedures to identify and measure the effects of pollutants on the chemical, physical, and biological integrity of water, including those pollutants created by new technological developments.

(e)(1) The Administrator is authorized to (A) make, in consultation with the Secretary of Agriculture, grants to persons for research and demonstration projects with respect to new and improved methods of preventing, reducing, and eliminating pollution

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from agriculture, and (B) disseminate, in cooperation with the Secretary of Agriculture, such information obtained under this subsection, section 104(p), and section 304 as will encourage and enable the adoption of such methods in the agricultural industry.

(2) The Administrator is authorized, (A) in consultation with other interested Federal agencies, to make grants for demonstration projects with respect to new and improved methods of preventing, reducing, storing, collecting, treating, or otherwise eliminating pollution from sewage in rural and other areas where collection of sewage in conventional, community-wide sewage collection systems is impractical, uneconomical, or otherwise infeasible, or where soil conditions or other factors preclude the use of septic tank and drainage field systems, and (B) in cooperation with other interested Federal and State agencies, to disseminate such information obtained under this subsection as will encourage and enable the adoption of new and improved methods developed pursuant to this subsection.

(f) Federal grants under subsection (a) of this section shall be subject to the following limitations:

(1) No grant shall be made for any project unless such project shall have been approved by the appropriate State water pollution control agency or agencies and by the Administrator;

(2) No grant shall be made for any project in an amount exceeding 75 per centum of cost thereof as determined by the Administrator; and

(3) No grant shall be made for any project unless the Administrator determines that such project will serve as a useful demonstration for the purpose set forth in clause (1) or (2) of subsection (a).

(g) Federal grants under subsections (c) and (d) of this section shall not exceed 75 per centum of the cost of the project.

(h) For the purpose of this section there is authorized to be appropriated $75,000,000 per fiscal year for the fiscal year ending June 30, 1973, the fiscal year ending June 30, 1974, and the fiscal year ending June 30, 1975, and from such appropriations at least 10 per centum of the funds actually appropriated in each fiscal year shall be available only for the purposes of subsection (e).

(i) The Administrator is authorized to make grants to a municipality to assist in the costs of operating and maintaining a project which received a grant under this section, section 104, or section 113 of this Act prior to the date of enactment of this subsection so as to reduce the operation and maintenance costs borne by the recipients of services from such project to costs comparable to those for projects assisted under title II of this Act.

(j) The Administrator is authorized to make a grant to any grantee who received an increased grant pursuant to section 202(a)(2) of this Act. Such grant may pay up to 100 per centum of the costs of technical evaluation of the operation of the treatment works, costs of training of persons (other than employees of the grantee), and costs of disseminating technical information on the operation of the treatment works.

(33 U.S.C. 1255)

GRANTS FOR POLLUTION CONTROL PROGRAMS

SEC. 106. (a) There are hereby authorized to be appropriated the following sums, to remain available until expended, to carry out the purposes of this section—

(1) $60,000,000 for the fiscal year ending June 30, 1973; and

(2) $75,000,000 for the fiscal year ending June 30, 1974, and the fiscal year ending June 30, 1975, $100,000,000 per fiscal year for the fiscal years 1977, 1978, 1979, and 1980, $75,000,000 per fiscal year for the fiscal years 1981 and 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $75,000,000 per fiscal year for each of the fiscal years 1986 through 1990;

for grants to States and to interstate agencies to assist them in administering programs for the prevention, reduction, and elimination of pollution, including enforcement directly or through appropriate State law enforcement officers or agencies.

(b) From the sums appropriated in any fiscal year, the Administrator shall make allotments to the several States and interstate agencies in accordance with regulations promulgated by him on the basis of the extent of the pollution problem in the respective States.

(c) The Administrator is authorized to pay to each State and interstate agency each fiscal year either—

(1) the allotment of such State or agency for such fiscal year under subsection (b), or

(2) the reasonable costs as determined by the Administrator of developing and carrying out a pollution program by such State or agency during such fiscal year,

whichever amount is the lesser.

(d) No grant shall be made under this section to any State or interstate agency for any fiscal year when the expenditure of non-Federal funds by such State or interstate agency during such fiscal year for the recurrent expenses of carrying out its pollution control program are less than the expenditure by such State or interstate agency of non-Federal funds for such recurrent program expenses during the fiscal year ending June 30, 1971.

(e) Beginning in fiscal year 1974 the Administrator shall not make any grant under this section to any State which has not provided or is not carrying out as a part of its program—

(1) the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on (including classification according to eutrophic condition), the quality of navigable waters and to the extent practicable, ground waters including biological monitoring; and provision for annually updating such data and including it in the report required under section 305 of this Act;

(2) authority comparable to that in section 504 of this Act and adequate contingency plans to implement such authority.

(f) Grants shall be made under this section on condition that—

(1) Such State (or interstate agency) filed with the Administrator within one hundred and twenty days after the date of enactment of this section:

(A) a summary report of the current status of the State pollution control program, including the criteria used by the State in determining priority of treatment works; and

(B) such additional information, data, and reports as the Administrator may require.

(2) No federally assumed enforcement as defined in section 309(a)(2) is in effect with respect to such State or interstate agency.

(3) Such State (or interstate agency) submits within one hundred and twenty days after the date of enactment of this section and before July 1 of each year thereafter for the Administrator's approval of its program for the prevention, reduction, and elimination of pollution in accordance with purposes and provisions of this Act in such form and content as the Administrator may prescribe.

(g) Any sums allotted under subsection (b) in any fiscal year which are not paid shall be reallotted by the Administrator in accordance with regulations promulgated by him.

(33 U.S.C. 1256)

MINE WATER POLLUTION CONTROL DEMONSTRATIONS

SEC. 107. (a) The Administrator in cooperation with the Appalachian Regional Commission and other Federal agencies is authorized to conduct, to make grants for, or to contract for, projects to demonstrate comprehensive approaches to the elimination or control of acid or other mine water pollution resulting from active or abandoned mining operations and other environmental pollution affecting water quality within all or part of a watershed or river basin, including siltation from surface mining. Such projects shall demonstrate the engineering and economic feasibility and practicality of various abatement techniques which will contribute substantially to effective and practical methods of acid or other mine water pollution elimination or control, and other pollution affecting water quality, including techniques that demonstrate the engineering and economic feasibility and practicality of using sewage sludge materials and other municipal wastes to diminish or prevent pollution affecting water quality from acid, sedimentation, or other pollutants and in such projects to restore affected lands to usefulness for forestry, agriculture, recreation, or other beneficial purposes.

(b) Prior to undertaking any demonstration project under this section in the Appalachian region (as defined in section 403 of the Appalachian Regional Development Act of 1965, as amended), the Appalachian Regional Commission shall determine that such demonstration project is consistent with the objectives of the Appalachian Regional Development Act of 1965, as amended.

(c) The Administrator, in selecting watersheds for the purposes of this section, shall be satisfied that the project area will not be affected adversely by the influx of acid or other mine water pollution from nearby sources.

(d) Federal participation in such projects shall be subject to the conditions—

(1) that the State shall acquire any land or interests therein necessary for such project; and

(2) that the State shall provide legal and practical protection to the project area to insure against any activities which will cause future acid or other mine water pollution.

(e) There is authorized to be appropriated $30,000,000 to carry out the provisions of this section, which sum shall be available until expended.

(33 U.S.C. 1257)

POLLUTION CONTROL IN GREAT LAKES

SEC. 108. (a) The Administrator, in cooperation with other Federal departments, agencies, and instrumentalities is authorized to enter into agreements with any State, political subdivision, interstate agency, or other public agency, or combination thereof, to carry out one or more projects to demonstrate new methods and techniques and to develop preliminary plans for the elimination or control of pollution, within all or any part of the watersheds of the Great Lakes. Such projects shall demonstrate the engineering and economic feasibility and practicality of removal of pollutants and prevention of any polluting matter from entering into the Great Lakes in the future and other reduction and remedial techniques which will contribute substantially to effective and practical methods of pollution prevention, reduction, or elimination.

(b) Federal participation in such projects shall be subject to the condition that the State, political subdivision, interstate agency, or other public agency, or combination thereof, shall pay not less than 25 per centum of the actual project costs, which payment may be in any form, including, but not limited to, land or interests therein that is needed for the project, and personal property or services the value of which shall be determined by the Administrator.

(c) There is authorized to be appropriated $20,000,000 to carry out the provisions of subsections (a) and (b) of this section, which sum shall be available until expended.

(d)(1) In recognition of the serious conditions which exist in Lake Erie, the Secretary of the Army, acting through the Chief of Engineers, is directed to design and develop a demonstration waste water management program for the rehabilitation and environmental repair of Lake Erie. Prior to the initiation of detailed engineering and design, the program, along with the specific recommendations of the Chief of Engineers and recommendations for its financing, shall be submitted to the Congress for statutory approval. This authority is in addition to, and not in lieu of, other waste water studies aimed at eliminating pollution emanating from select sources around Lake Erie.

(2) This program is to be developed in cooperation with the Environmental Protection Agency, other interested departments, agencies, and instrumentalities of the Federal Government, and the States and their political subdivisions. This program shall set forth alternative systems for managing waste water on a regional basis and shall provide local and State governments with a range of choice as to the type of system to be used for the treatment of waste water. These alternative systems shall include both advanced waste treatment technology and land disposal systems including aerated treatment-spray irrigation technology and will also include provisions for the disposal of solid wastes, including sludge. Such program should include measures to control point sources of pollution, area sources of pollution, including acid-mine drainage, urban runoff and rural runoff, and in place sources of pollution, including bottom loads, sludge banks, and polluted harbor dredgings.

(e) There is authorized to be appropriated $5,000,000 to carry out the provisions of subsection (d) of this section, which sum shall be available until expended.

(33 U.S.C. 1258)

TRAINING GRANTS AND CONTRACTS

SEC. 109. (a) The Administrator is authorized to make grants to or contracts with institutions of higher education, or combinations of such institutions, to assist them in planning, developing, strengthening, improving, or carrying out programs or projects for the preparation of undergraduate students to enter an occupation which involves the design, operation, and maintenance of treatment works, and other facilities whose purpose is water quality control. Such grants or contracts may include payment of all or part of the cost of programs or projects such as—

(A) planning for the development or expansion of programs or projects for training persons in the operation and maintenance of treatment works;

(B) training and retraining of faculty members;

(C) conduct of short-term or regular session institutes for study by persons engaged in, or preparing to engage in, the preparation of students preparing to enter an occupation involving the operation and maintenance of treatment works;

(D) carrying out innovative and experimental programs of cooperative education involving alternate periods of full-time or part-time academic study at the institution and periods of full-time or part-time employment involving the operation and maintenance of treatment works; and

(E) research into, and development of, methods of training students or faculty, including the preparation of teaching materials and the planning of curriculum.

(b)(1) The Administrator may pay 100 per centum of any additional cost of construction of treatment works required for a facility to train and upgrade waste treatment works operation and maintenance personnel and for the costs of other State treatment works operator training programs, including mobile training units, classroom rental, specialized instructors, and instructional material.

(2) The Administrator shall make no more than one grant for such additional construction in any State (to serve a group of States, where, in his judgment, efficient training programs require multi-State programs), and shall make such grant after consultation with and approval by the State or States on the basis of (A) the suitability of such facility for training operation and maintenance personnel for treatment works throughout such State or States; and (B) a commitment by the State agency or agencies to carry out at such facility a program of training approved by the Ad-

ministrator. In any case where a grant is made to serve two or more States, the Administrator is authorized to make an additional grant for a supplemental facility in each such State.

(3) The Administrator may make such grant out of the sums allocated to a State under section 205 of this Act, except that in no event shall the Federal cost of any such training facilities exceed $500,000.

(4) The Administrator may exempt a grant under this section from any requirement under section 204(a)(3) of this Act. Any grantee who received a grant under this section prior to enactment of the Clean Water Act of 1977 shall be eligible to have its grant increased by funds made available under such Act.

(33 U.S.C. 1259)

APPLICATION FOR TRAINING GRANT OR CONTRACT; ALLOCATION OF GRANTS OR CONTRACTS

SEC. 110. (1) A grant or contract authorized by section 109 may be made only upon application to the Administrator at such time or times and containing such information as he may prescribe, except that no such application shall be approved unless it—

(A) sets forth programs, activities, research, or development for which a grant is authorized under section 109 and describes the relation to any program set forth by the applicant in an application, if any, submitted pursuant to section 111;

(B) provides such fiscal control and fund accounting procedures as may be necessary to assure proper disbursement of and accounting for Federal funds paid to the applicant under this section; and

(C) provides for making such reports, in such form and containing such information, as the Administrator may require to carry out his functions under this section, and for keeping such records and for affording such access thereto as the Administrator may find necessary to assure the correctness and verification of such reports.

(2) The Administrator shall allocate grants or contracts under section 109 in such manner as will most nearly provide an equitable distribution of the grants or contracts throughout the United States among institutions of higher education which show promise of being able to use funds effectively for the purpose of this section.

(3)(A) Payments under this section may be used in accordance with regulations of the Administrator, and subject to the terms and conditions set forth in an application approved under paragraph (1), to pay part of the compensation of students employed in connection with the operation and maintenance of treatment works, other than as an employee in connection with the operation and maintenance of treatment works or as an employee in any branch of the Government of the United States, as part of a program for which a grant has been approved pursuant to this section.

(B) Departments and agencies of the United States are encouraged, to the extent consistent with efficient Administration, to enter into arrangements with institutions of higher education for the full-time, part-time, or temporary employment, whether in the

competitive or excepted service, of students enrolled in programs set forth in applications approved under paragraph (1).

(33 U.S.C. 1260)

AWARD OF SCHOLARSHIPS

SEC. 111. (1) The Administrator is authorized to award scholarships in accordance with the provisions of this section for undergraduate study by persons who plan to enter an occupation involving the operation and maintenance of treatment works. Such scholarships shall be awarded for such periods as the Administrator may determine but not to exceed four academic years.

(2) The Administrator shall allocate scholarships under this section among institutions of higher education with programs approved under the provisions of this section for the use of individuals accepted into such programs, in such manner and accordance to such plan as will insofar as practicable—

(A) provide an equitable distribution of such scholarships throughout the United States; and

(B) attract recent graduates of secondary schools to enter an occupation involving the operation and maintenance of treatment works.

(3) The Administrator shall approve a program of any institution of higher education for the purposes of this section only upon application by the institution and only upon his finding—

(A) that such program has as a principal objective the education and training of persons in the operation and maintenance of treatment works;

(B) that such program is in effect and of high quality, or can be readily put into effect and may reasonably be expected to be of high quality;

(C) that the application describes the relation of such program to any program, activity, research, or development set forth by the applicant in an application, if any, submitted pursuant to section 110 of this Act; and

(D) that the application contains satisfactory assurances that (i) the institution will recommend to the Administrator for the award of scholarships under this section, for study in such program, only persons who have demonstrated to the satisfaction of the institution a serious intent, upon completing the program, to enter an occupation involving the operation and maintenance of treatment works, and (ii) the institution will make reasonable continuing efforts to encourage recipients of scholarships under this section, enrolled in such program, to enter occupations involving the operation and maintenance of treatment works upon completing the program.

(4)(A) The Administrator shall pay to persons awarded scholarships under this section such stipends (including such allowances for subsistence and other expenses for such persons and their dependents) as he may determine to be consistent with prevailing practices under comparable federally supported programs.

(B) The Administrator shall (in addition to the stipends paid to persons under paragraph (1)) pay to the institution of higher education at which such person is pursuing his course of study such amount as he may determine to be consistent with prevailing practices under comparable federally supported programs.

(5) A person awarded a scholarship under the provisions of this section shall continue to receive the payments provided in this section only during such periods as the Administrator finds that he is maintaining satisfactory proficiency and devoting full time to study or research in the field in which such scholarship was awarded in an institution of higher education, and is not engaging in gainful employment other than employment approved by the Administrator by or pursuant to regulation.

(6) The Administrator shall by regulation provide that any person awarded a scholarship under this section shall agree in writing to enter and remain in an occupation involving the design, operation, or maintenance of treatment works for such period after completion of his course of studies as the Administrator determines appropriate.

(33 U.S.C. 1261)

DEFINITIONS AND AUTHORIZATIONS

SEC. 112. (a) As used in sections 109 through 112 of this Act—

(1) The term "institution of higher education" means an educational institution described in the first sentence of section 1201 of the Higher Education Act of 1965 (other than an institution of any agency of the United States) which is accredited by a nationally recognized accrediting agency or association approved by the Administrator for this purpose. For purposes of this subsection, the Administrator shall publish a list of nationally recognized accrediting agencies or associations which he determines to be reliable authority as to the quality of training offered.

(2) The term "academic year" means an academic year or its equivalent, as determined by the Administrator.

(b) The Administrator shall annually report his activities under sections 109 through 112 of this Act, including recommendations for needed revisions in the provisions thereof.

(c) There are authorized to be appropriated $25,000,000 per fiscal year for fiscal years ending June 30, 1973, June 30, 1974, and June 30, 1975, $6,000,000 for the fiscal year ending September 30, 1977, $7,000,000 for the fiscal year ending September 30, 1978, $7,000,000 for the fiscal year ending September 30, 1979, $7,000,000 for the fiscal year ending September 30, 1980, $7,000,000 for the fiscal year ending September 30, 1981, $7,000,000 for the fiscal year ending September 30, 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $7,000,000 per fiscal year for each of the fiscal years 1986 through 1990, to carry out sections 109 through 112 of this Act.

(33 U.S.C. 1262)

ALASKA VILLAGE DEMONSTRATION PROJECTS

SEC. 113. (a) The Administrator is authorized to enter into agreements with the State of Alaska to carry out one or more projects to demonstrate methods to provide for central community facilities for safe water and elimination or control of pollution in

those native villages of Alaska without such facilities. Such project shall include provisions for community safe water supply systems, toilets, bathing and laundry facilities, sewage disposal facilities, and other similar facilities, and educational and informational facilities and programs relating to health and hygiene. Such demonstration projects shall be for the further purpose of developing preliminary plans for providing such safe water and such elimination or control of pollution for all native villages in such State.

(b) In carrying out this section the Administrator shall cooperate with the Secretary of Health, Education, and Welfare for the purpose of utilizing such of the personnel and facilities of that Department as may be appropriate.

(c) The Administrator shall report to Congress not later than July 1, 1973, the results of the demonstration projects authorized by this section together with his recommendations, including and necessary legislation, relating to the establishment of a statewide program.

(d) There is authorized to be appropriated not to exceed $2,000,000 to carry out this section. In addition, there is authorized to be appropriated to carry out this section not to exceed $200,000 for the fiscal year ending September 30, 1978, and $220,000 for the fiscal year ending September 30, 1979.

(e) The Administrator is authorized to coordinate with the Secretary of the Department of Health, Education, and Welfare, the Secretary of the Department of Housing and Urban Development, the Secretary of the Department of the Interior, the Secretary of the Department of Agriculture, and the heads of any other departments or agencies he may deem appropriate to conduct a joint study with representatives of the State of Alaska and the appropriate Native organizations (as defined in Public Law 92-203) to develop a comprehensive program for achieving adequate sanitation services in Alaska villages. This study shall be coordinated with the programs and projects authorized by sections 104(q) and 105(e)(2) of this Act. The Administrator shall submit a report of the results of the study, together with appropriate supporting data and such recommendations as he deems desirable, to the Committee on Environment and Public Works of the Senate and to the Committee on Public Works and Transportation of the House of Representatives not later than December 31, 1979. The Administrator shall also submit recommended administrative actions, procedures, and any proposed legislation necessary to implement the recommendations of the study no later than June 30, 1980.

(f) The Administrator is authorized to provide technical, financial and management assistance for operation and maintenance of the demonstration projects constructed under this section, until such time as the recommendations of subsection (e) are implemented.

(g) For the purpose of this section, the term "village" shall mean an incorporated or unincorporated community with a population of ten to six hundred people living within a two-mile radius. The term "sanitation services" shall mean water supply, sewage disposal, solid waste disposal and other services necessary to maintain generally accepted standards of personal hygiene and public health.

(33 U.S.C. 1263)

LAKE TAHOE STUDY

SEC. 114. (a) The Administrator, in consultation with the Tahoe Regional Planning Agency, the Secretary of Agriculture, other Federal agencies, representatives of State and local governments, and members of the public, shall conduct a thorough and complete study on the adequacy of and need for extending Federal oversight and control in order to preserve the fragile ecology of Lake Tahoe.

(b) Such study shall include an examination of the interrelationships and responsibilities of the various agencies of the Federal Government and State and local governments with a view to establishing the necessity for redefinition of legal and other arrangements between these various governments, and making specific legislative recommendations to Congress. Such study shall consider the effect of various actions in terms of their environmental impact on the Tahoe Basin, treated as an ecosystem.

(c) The Administrator shall report on such study to Congress not later than one year after the date of enactment of this subsection.

(d) There is authorized to be appropriated to carry out this section not to exceed $500,000.

(33 U.S.C. 1264)

IN-PLACE TOXIC POLLUTANTS

SEC. 115. The Administrator is directed to identify the location of in-place pollutants with emphasis on toxic pollutants in harbors and navigable waterways and is authorized, acting through the Secretary of the Army, to make contracts for the removal and appropriate disposal of such materials from critical port and harbor areas. There is authorized to be appropriated $15,000,000 to carry out the provisions of this section, which sum shall be available until expended.

(33 U.S.C. 1265)

HUDSON RIVER PCB RECLAMATION DEMONSTRATION PROJECT

SEC. 116. (a) The Administrator is authorized to enter into contracts and other agreements with the State of New York to carry out a project to demonstrate methods for the selective removal of polychlorinated biphenyls contaminating bottom sediments of the Hudson River, treating such sediments as required, burying such sediments in secure landfills, and installing monitoring systems for such landfills. Such demonstration project shall be for the purpose of determining the feasibility of indefinite storage in secure landfills of toxic substances and of ascertaining the improvement of the rate of recovery of a toxic contaminated national waterway. No pollutants removed pursuant to this paragraph shall be placed in any landfill unless the Administrator first determines that disposal of the pollutants in such landfill would provide a higher standard of protection of the public health, safety, and welfare than disposal of

such pollutants by any other method including, but not limited to, incineration or a chemical destruction process.

(b) The Administrator is authorized to make grants to the State of New York to carry out this section from funds allotted to such State under section 205(a) of this Act, except that the amount of any such grant shall be equal to 75 per centum of the cost of the project and such grant shall be made on condition that non-Federal sources provide the remainder of the cost of such project. The authority of this section shall be available until September 30, 1983. Funds allotted to the State of New York under section 205(a) shall be available under this subsection only to the extent that funds are not available, as determined by the Administrator, to the State of New York for the work authorized by this section under section 115 or 311 of this Act or a comprehensive hazardous substance response and clean up fund. Any funds used under the authority of this subsection shall be deducted from any estimate of the needs of the State of New York prepared under section 616(b) of this Act. The Administrator may not obligate or expend more than $20,000,000 to carry out this section.

(33 U.S.C. 1266)

SEC. 117. CHESAPEAKE BAY.

(a) OFFICE.—The Administrator shall continue the Chesapeake Bay Program and shall establish and maintain the Environmental Protection Agency an office, division, or branch of Chesapeake Bay Programs to—

(1) collect and make available, through publications and other appropriate means, information pertaining to the environmental quality of the Chesapeake Bay (hereinafter in this subsection referred to as the "Bay");

(2) coordinate Federal and State efforts to improve the water quality of the Bay;

(3) determine the impact of sediment deposition in the Bay and identify the sources, rates, routes, and distribution patterns of such sediment deposition; and

(4) determine the impact of natural and man-induced environmental changes on the living resources of the Bay and the relationships among such changes with particular emphasis placed on the impact of pollutant loadings of nutrients, chlorine, acid precipitation, dissolved oxygen, and toxic pollutants, including organic chemicals and heavy metals, and with special attention given to the impact of such changes on striped bass.

(b) INTERSTATE DEVELOPMENT PLAN GRANTS.—

(1) AUTHORITY.—The Administrator shall, at the request of the Governor of a State affected by the interstate management plan developed pursuant to the Chesapeake Bay Program (hereinafter in this section referred to as the "plan"), make a grant for the purpose of implementing the management mechanisms contained in the plan if such State has, within 1 year after the date of the enactment of this section, approved and committed to implement all or substantially all aspects of the plan. Such grants shall be made subject to such terms and conditions as the Administrator considers appropriate.

(2) SUBMISSION OF PROPOSAL.—A State or combination of States may elect to avail itself of the benefits of this subsection by submitting to the Administrator a comprehensive proposal to implement management mechanisms contained in the plan which shall include (A) a description of proposed abatement actions which the State or combination of States commits to take within a specified time period to reduce pollution in the Bay and to meet applicable water quality standards, and (B) the estimated cost of the abatement actions proposed to be taken during the next fiscal year. If the Administrator finds that such proposal is consistent with the national policies set forth in section 101(a) of this Act and will contribute to the achievement of the national goals set forth in such section, the Administrator shall approve such proposal and shall finance the costs of implementing segments of such proposal.

(3) FEDERAL SHARE.—Grants under this subsection shall not exceed 50 percent of the costs of implementing the management mechanisms contained in the plan in any fiscal year and shall be made on condition that non-Federal sources provide the remainder of the cost of implementing the management mechanisms contained in the plan during such fiscal year.

(4) ADMINISTRATIVE COSTS.—Administrative costs in the form of salaries, overhead, or indirect costs for services provided and charged against programs or projects supported by funds made available under this subsection shall not exceed in any one fiscal year 10 percent of the annual Federal grant made to a State under this subsection.

(c) REPORTS.—Any State or combination of States that receives a grant under subsection (b) shall, within 18 months after the date of receipt of such grant and biennially thereafter, report to the Administrator on the progress made in implementing the interstate management plan developed pursuant to the Chesapeake Bay Program. The Administrator shall transmit each such report along with the comments of the Administrator on such report to Congress.

(d) AUTHORIZATION OF APPROPRIATIONS.—There are hereby authorized to be appropriated the following sums, to remain available until expended, to carry out the purposes of this section:

(1) $3,000,000 per fiscal year for each of the fiscal years 1987, 1988, 1989, and 1990, to carry out subsection (a); and

(2) $10,000,000 per fiscal year for each of the fiscal years 1987, 1988, 1989, and 1990, for grants to States under subsection (b).

(33 U.S.C. 1267)

SEC. 118. GREAT LAKES.

(a) FINDINGS, PURPOSE, AND DEFINITIONS.—

(1) FINDINGS.—The Congress finds that—

(A) the Great Lakes are a valuable national resource, continuously serving the people of the United States and other nations as an important source of food, fresh water, recreation, beauty, and enjoyment;

(B) the United States should seek to attain the goals embodied in the Great Lakes Water Quality Agreement of

1978, as amended by the Water Quality Agreement of 1987 and any other agreements and amendments, with particular emphasis on goals related to toxic pollutants; and

(C) the Environmental Protection Agency should take the lead in the effort to meet those goals, working with other Federal agencies and State and local authorities.

(2) PURPOSE.—It is the purpose of this section to achieve the goals embodied in the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987 and any other agreements and amendments, through improved organization and definition of mission on the part of the Agency, funding of State grants for pollution control in the Great Lakes area, and improved accountability for implementation of such agreement.

(3) DEFINITIONS.—For purposes of this section, the term—

(A) "Agency" means the Environmental Protection Agency;

(B) "Great Lakes" means Lake Ontario, Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, and Lake Superior, and the connecting channels (Saint Mary's River, Saint Clair River, Detroit River, Niagara River, and Saint Lawrence River to the Canadian Border);

(C) "Great Lakes System" means all the streams, rivers, lakes, and other bodies of water within the drainage basin of the Great Lakes;

(D) "Program Office" means the Great Lakes National Program Office established by this section;

(E) "Research Office" means the Great Lakes Research Office established by subsection (d);

(F) "area of concern" means a geographic area located within the Great Lakes, in which beneficial uses are impaired and which has been officially designated as such under Annex 2 of the Great Lakes Water Quality Agreement;

(G) "Great Lakes States" means the States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin;

(H) "Great Lakes Water Quality Agreement" means the bilateral agreement, between the United States and Canada which was signed in 1978 and amended by the Protocol of 1987;

(I) "Lakewide Management Plan" means a written document which embodies a systematic and comprehensive ecosystem approach to restoring and protecting the beneficial uses of the open waters of each of the Great Lakes, in accordance with article VI and Annex 2 of the Great Lakes Water Quality Agreement; and

(J) "Remedial Action Plan" means a written document which embodies a systematic and comprehensive ecosystem approach to restoring and protecting the beneficial uses of areas of concern, in accordance with article VI and Annex 2 of the Great Lakes Water Quality Agreement.

(b) GREAT LAKES NATIONAL PROGRAM OFFICE.—The Great Lakes National Program Office (previously established by the Administrator) is hereby established within the Agency. The Program Office shall be headed by a Director who, by reason of management experience and technical expertise relating to the Great Lakes, is highly qualified to direct the development of programs and plans on a variety of Great Lakes issues. The Great Lakes National Program Office shall be located in a Great Lakes State.

(c) GREAT LAKES MANAGEMENT.—

(1) FUNCTIONS.—The Program Office shall—

(A) in cooperation with appropriate Federal, State, tribal, and international agencies, and in accordance with section 101(e) of this Act, develop and implement specific action plans to carry out the responsibilities of the United States under the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987 and any other agreements and amendments,;[1]

(B) establish a Great Lakes system-wide surveillance network to monitor the water quality of the Great Lakes, with specific emphasis on the monitoring of toxic pollutants;

(C) serve as the liaison with, and provide information to, the Canadian members of the International Joint Commission and the Canadian counterpart to the Agency;

(D) coordinate actions of the Agency (including actions by headquarters and regional offices thereof) aimed at improving Great Lakes water quality; and

(E) coordinate actions of the Agency with the actions of other Federal agencies and State and local authorities, so as to ensure the input of those agencies and authorities in developing water quality strategies and obtain the support of those agencies and authorities in achieving the objectives of such agreement.

(2) GREAT LAKES WATER QUALITY GUIDANCE.—

(A) By June 30, 1991, the Administrator, after consultation with the Program Office, shall publish in the Federal Register for public notice and comment proposed water quality guidance for the Great Lakes System. Such guidance shall conform with the objectives and provisions of the Great Lakes Water Quality Agreement, shall be no less restrictive than the provisions of this Act and national water quality criteria and guidance, shall specify numerical limits on pollutants in ambient Great Lakes waters to protect human health, aquatic life, and wildlife, and shall provide guidance to the Great Lakes States on minimum water quality standards, antidegradation policies, and implementation procedures for the Great Lakes System.

(B) By June 30, 1992, the Administrator, in consultation with the Program Office, shall publish in the Federal Register, pursuant to this section and the Administrator's authority under this chapter, final water quality guidance for the Great Lakes System.

[1] See P.L. 100-688, section 1008.

(C) Within two years after such Great Lakes guidance is published, the Great Lakes States shall adopt water quality standards, antidegradation policies, and implementation procedures for waters within the Great Lakes System which are consistent with such guidance. If a Great Lakes State fails to adopt such standards, policies, and procedures, the Administrator shall promulgate them not later than the end of such two-year period. When reviewing any Great Lakes State's water quality plan, the agency shall consider the extent to which the State has complied with the Great Lakes guidance issued pursuant to this section.

(3) REMEDIAL ACTION PLANS.—

(A) For each area of concern for which the United States has agreed to draft a Remedial Action Plan, the Program Office shall ensure that the Great Lakes State in which such area of concern is located—

(i) submits a Remedial Action Plan to the Program Office by June 30, 1991;

(ii) submits such Remedial Action Plan to the International Joint Commission by January 1, 1992; and

(iii) includes such Remedial Action Plans within the State's water quality plan by January 1, 1993.

(B) For each area of concern for which Canada has agreed to draft a Remedial Action Plan, the Program Office shall, pursuant to subparagraph (c)(1)(C) of this section, work with Canada to assure the submission of such Remedial Action Plans to the International Joint Commission by June 30, 1991, and to finalize such Remedial Action Plans by January 1, 1993.

(C) For any area of concern designated as such subsequent to the enactment of this Act, the Program Office shall (i) if the United States has agreed to draft the Remedial Action Plan, ensure that the Great Lakes State in which such area of concern is located submits such Plan to the Program Office within two years of the area's designation, submits it to the International Joint Commission no later than six months after submitting it to the Program Office, and includes such Plan in the State's water quality plan no later than one year after submitting it to the Commission; and (ii) if Canada has agreed to draft the Remedial Action Plan, work with Canada, pursuant to subparagraph (c)(1)(C) of this section, to ensure the submission of such Plan to the International Joint Commission within two years of the area's designation and the finalization of such Plan no later than eighteen months after submitting it to such Commission.

(D) The Program Office shall compile formal comments on individual Remedial Action Plans made by the International Joint Commission pursuant to section 4(d) of Annex 2 of the Great Lakes Water Quality Agreement and, upon request by a member of the public, shall make such comments available for inspection and copying. The P gram Office shall also make available, upon request, formal comments made by the Environmental Protection Agency on individual Remedial Action Plans.

(4) LAKEWIDE MANAGEMENT PLANS.—The Administrator, in consultation with the Program Office shall—

(A) by January 1, 1992, publish in the Federal Register a proposed Lakewide Management Plan for Lake Michigan and solicit public comments;

(B) by January 1, 1993, submit a proposed Lakewide Management Plan for Lake Michigan to the International Joint Commission for review; and

(C) by January 1, 1994, publish in the Federal Register a final Lakewide Management Plan for Lake Michigan and begin implementation.

Nothing in this subparagraph shall preclude the simultaneous development of Lakewide Management Plans for the other Great Lakes.

(5) SPILLS OF OIL AND HAZARDOUS MATERIALS.—The Program Office, in consultation with the Coast Guard, shall identify areas within the Great Lakes which are likely to experience numerous or voluminous spills of oil or other hazardous materials from land based facilities, vessels, or other sources and, in consultation with the Great Lakes States, shall identify weaknesses in Federal and State programs and systems to prevent and respond to such spills. This information shall be included on at least a biennial basis in the report required by this section.

(6) 5-YEAR PLAN AND PROGRAM.—The Program Office shall develop, in consultation with the States, a five-year plan and program for reducing the amount of nutrients introduced into the Great Lakes. Such program shall incorporate any management program for reducing nutrient runoff from nonpoint sources established under section 319 of this Act and shall include a program for monitoring nutrient runoff into, and ambient levels in, the Great Lakes.

(7) 5-YEAR STUDY AND DEMONSTRATION PROJECTS.—(A) The Program Office shall carry out a five-year study and demonstration projects relating to the control and removal of toxic pollutants in the Great Lakes, with emphasis on the removal of toxic pollutants from bottom sediments. In selecting locations for conducting demonstration projects under this paragraph, priority consideration shall be given to projects at the following locations: Saginaw Bay, Michigan; Sheboygan Harbor, Wisconsin; Grand Calumet River, Indiana; Ashtabula River, Ohio; and Buffalo River, New York.

(B) The Program Office shall—

(i) by December 31, 1990, complete chemical, physical, and biological assessments of the contaminated sediments at the locations selected for the study and demonstration projects;

(ii) by December 31, 1990, announce the technologies that will be demonstrated at each location and the numerical standard of protection intended to be achieved at each location;

(iii) by December 31, 1992, complete full or pilot scale demonstration projects on site at each location of promising technologies to remedy contaminated sediments; and

(iv) by December 31, 1993, issue a final report to Congress on its findings.

(C) The Administrator, after providing for public review and comment, shall publish information concerning the public health and environmental consequences of contaminants in Great Lakes sediment. Information published pursuant to this subparagraph shall include specific numerical limits to protect health, aquatic life, and wildlife from the bioaccumulation of toxins. The Administrator shall, at a minimum, publish information pursuant to this subparagraph within 2 years of the date of the enactment of this title.

(8) ADMINISTRATOR'S RESPONSIBILITY.—The Administrator shall ensure that the Program Office enters into agreements with the various organizational elements of the Agency involved in Great Lakes activities and the appropriate State agencies specifically delineating—

(A) the duties and responsibilities of each such element in the Agency with respect to the Great Lakes;

(B) the time periods for carrying out such duties and responsibilities; and

(C) the resources to be committed to such duties and responsibilities.

(9) BUDGET ITEM.—The Administrator shall, in the Agency's annual budget submission to Congress, include a funding request for the Program Office as a separate budget line item.

(10) COMPREHENSIVE REPORT.—Within 90 days after the end of each fiscal year, the Administrator shall submit to Congress a comprehensive report which—

(A) describes the achievements in the preceding fiscal year in implementing the Great Lakes Water Quality Agreement of 1978 and shows by categories (including judicial enforcement, research, State cooperative efforts, and general administration) the amounts expended on Great Lakes water quality initiatives in such preceding fiscal year;

(B) describes the progress made in such preceding fiscal year in implementing the system of surveillance of the water quality in the Great Lakes System, including the monitoring of groundwater and sediment, with particular reference to toxic pollutants;

(C) describes the long-term prospects for improving the condition of the Great Lakes; and

(D) provides a comprehensive assessment of the planned efforts to be pursued in the succeeding fiscal year for implementing the Great Lakes Water Quality Agreement of 1978, which assessment shall—

(i) show by categories (including judicial enforcement, research, State cooperative efforts, and general administration) the amount anticipated to be expended on Great Lakes water quality initiatives in the fiscal year to which the assessment relates; and

(ii) include a report of current programs administered by other Federal agencies which make available resources to the Great Lakes water quality management efforts.

(11) CONFINED DISPOSAL FACILITIES.—(A) The Administrator, in consultation with the Assistant Secretary of the Army for Civil Works, shall develop and implement, within one year of the date of enactment of this paragraph, management plans for every Great Lakes confined disposal facility.

(B) The plan shall provide for monitoring of such facilities, including—

(i) water quality at the site and in the area of the site;

(ii) sediment quality at the site and in the area of the site;

(iii) the diversity, productivity, and stability of aquatic organisms at the site and in the area of the site; and

(iv) such other conditions as the Administrator deems appropriate.

(C) The plan shall identify the anticipated use and management of the site over the following twenty-year period including the expected termination of dumping at the site, the anticipated need for site management, including pollution control, following the termination of the use of the site.

(D) The plan shall identify a schedule for review and revision of the plan which shall not be less frequent than five years after adoption of the plan and every five years thereafter.

(d) GREAT LAKES RESEARCH.—

(1) ESTABLISHMENT OF RESEARCH OFFICE.—There is established within the National Oceanic and Atmospheric Administration the Great Lakes Research Office.

(2) IDENTIFICATION OF ISSUES.—The Research Office shall identify issues relating to the Great Lakes resources on which research is needed. The Research Office shall submit a report to Congress on such issues before the end of each fiscal year which shall identify any changes in the Great Lakes system with respect to such issues.

(3) INVENTORY.—The Research Office shall identify and inventory, Federal, State, university, and tribal environmental research programs (and, to the extent feasible, those of private organizations and other nations) relating to the Great Lakes system, and shall update that inventory every four years.

(4) RESEARCH EXCHANGE.—The Research Office shall establish a Great Lakes research exchange for the purpose of facilitating the rapid identification, acquisition, retrieval, dissemination, and use of information concerning research projects which are ongoing or completed and which affect the Great Lakes system.

(5) RESEARCH PROGRAM.—The Research Office shall develop, in cooperation with the Coordination Office, a comprehensive environmental research program and data base for the Great Lakes system. The data base shall include, but not be limited to, data relating to water quality, fisheries, and biota.

(6) MONITORING.—The Research Office shall conduct, through the Great Lakes Environmental Research Laboratory, the National Sea Grant College program, other Federal laboratories, and the private sector, appropriate research and monitoring activities which address priority issues and current needs relating to the Great Lakes.

(7) LOCATION.—The Research Office shall be located in a Great Lakes State.

(e) RESEARCH AND MANAGEMENT COORDINATION.—

(1) JOINT PLAN.—Before October 1 of each year, the Program Office and the Research Office shall prepare a joint research plan for the fiscal year which begins in the following calendar year.

(2) CONTENTS OF PLAN.—Each plan prepared under paragraph (1) shall—

(A) identify all proposed research dedicated to activities conducted under the Great Lakes Water Quality Agreement of 1978;

(B) include the Agency's assessment of priorities for research needed to fulfill the terms of such Agreement; and

(C) identify all proposed research that may be used to develop a comprehensive environmental data base for the Great Lakes system and establish priorities for development of such data base.

(3) HEALTH RESEARCH REPORT.—(A) Not later than September 30, 1994, the Program Office, in consultation with the Research Office, the Agency for Toxic Substances and Disease Registry, and Great Lakes States shall submit to the Congress a report assessing the adverse effects of water pollutants in the Great Lakes System on the health of persons in Great Lakes States and the health of fish, shellfish, and wildlife in the Great Lakes System. In conducting research in support of this report, the Administrator may, where appropriate, provide for research to be conducted under cooperative agreements with Great Lakes States.

(B) There is authorized to be appropriated to the Administrator to carry out this section not to exceed $3,000,000 for each of fiscal years 1992, 1993, and 1994.

(f) INTERAGENCY COOPERATION.—The head of each department, agency, or other instrumentality of the Federal Government which is engaged in, is concerned with, or has authority over programs relating to research, monitoring, and planning to maintain, enhance, preserve, or rehabilitate the environmental quality and natural resources of the Great Lakes, including the Chief of Engineers of the Army, the Chief of the Soil Conservation Service, the Commandant of the Coast Guard, the Director of the Fish and Wildlife Service, and the Administrator of the National Oceanic and Atmospheric Administration, shall submit an annual report to the Administrator with respect to the activities of that agency or office affecting compliance with the Great Lakes Water Quality Agreement of 1978.

(g) RELATIONSHIP TO EXISTING FEDERAL AND STATE LAWS AND INTERNATIONAL TREATIES.—Nothing in this section shall be construed to affect the jurisdiction, powers, or prerogatives of any department, agency, or officer of the Federal Government or of any State government, or of any tribe, nor any powers, jurisdiction, or prerogatives of any international body created by treaty with authority relating to the Great Lakes.

(h) AUTHORIZATIONS OF GREAT LAKES APPROPRIATIONS.—There are authorized to be appropriated to the Administrator to carry out this section not to exceed $11,000,000 per fiscal year for the fiscal years 1987, 1988, 1989, and 1990, and $25,000,000 for fiscal year 1991. Of the amounts appropriated each fiscal year—

(1) 40 percent shall be used by the Great Lakes National Program Office on demonstration projects on the feasibility of controlling and removing toxic pollutants;

(2) 7 percent shall be used by the Great Lakes National Program Office for the program of nutrient monitoring; and

(3) 30 percent or $3,300,000, whichever is the lesser, shall be transferred to the National Oceanic and Atmospheric Administration for use by the Great Lakes Research Office.

(33 U.S.C. 1268)

SEC. 119. LONG ISLAND SOUND.—(a) The Administrator shall continue the Management Conference of the Long Island Sound Study (hereinafter referred to as the "Conference") as established pursuant to section 320 of this Act, and shall establish an office (hereinafter referred to as the "Office") to be located on or near Long Island Sound.

(b) ADMINISTRATION AND STAFFING OF OFFICE.—The Office shall be headed by a Director, who shall be detailed by the Administrator, following consultation with the Administrators of EPA regions I and II, from among the employees of the Agency who are in civil service. The Administrator shall delegate to the Director such authority and detail such additional staff as may be necessary to carry out the duties of the Director under this section.

(c) DUTIES OF THE OFFICE.—The Office shall assist the Management Conference of the Long Island Sound Study in carrying out its goals. Specifically, the Office shall—

(1) assist and support the implementation of the Comprehensive Conservation and Management Plan for Long Island Sound developed pursuant to section 320 of this Act;

(2) conduct or commission studies deemed necessary for strengthened implementation of the Comprehensive Conservation and Management Plan including, but not limited to—

(A) population growth and the adequacy of wastewater treatment facilities,

(B) the use of biological methods for nutrient removal in sewage treatment plants,

(C) contaminated sediments, and dredging activities,

(D) nonpoint source pollution abatement and land use activities in the Long Island Sound watershed,

(E) wetland protection and restoration,

(F) atmospheric deposition of acidic and other pollutants into Long Island Sound,

(G) water quality requirements to sustain fish, shellfish, and wildlife populations, and the use of indicator species to assess environmental quality,

(H) State water quality programs, for their adequacy pursuant to implementation of the Comprehensive Conservation and Management Plan, and

(I) options for long-term financing of wastewater treatment projects and water pollution control programs.

(3) coordinate the grant, research and planning programs authorized under this section;

(4) coordinate activities and implementation responsibilities with other Federal agencies which have jurisdiction over Long Island Sound and with national and regional marine monitoring and research programs established pursuant to the Marine Protection, Research, and Sanctuaries Act;

(5) provide administrative and technical support to the conference;

(6) collect and make available to the public publications, and other forms of information the conference determines to be appropriate, relating to the environmental quality of Long Island Sound;

(7) not more than two years after the date of the issuance of the final Comprehensive Conservation and Management Plan for Long Island Sound under section 320 of this Act, and biennially thereafter, issue a report to the Congress which—

(A) summarizes the progress made by the States in implementing the Comprehensive Conservation and Management Plan;

(B) summarizes any modifications to the Comprehensive Conservation and Management Plan in the twelve-month period immediately preceding such report; and

(C) incorporates specific recommendations concerning the implementation of the Comprehensive Conservation and Management Plan; and

(8) convene conferences and meetings for legislators from State governments and political subdivisions thereof for the purpose of making recommendations for coordinating legislative efforts to facilitate the environmental restoration of Long Island Sound and the implementation of the Comprehensive Conservation and Management Plan.

(d) GRANTS.—(1) The Administrator is authorized to make grants for projects and studies which will help implement the Long Island Sound Comprehensive Conservation and Management Plan. Special emphasis shall be given to implementation, research and planning, enforcement, and citizen involvement and education.

(2) State, interstate, and regional water pollution control agencies, and other public or nonprofit private agencies, institutions, and organizations held to be eligible for grants pursuant to this subsection.

(3) Citizen involvement and citizen education grants under this subsection shall not exceed 95 per centum of the costs of such work. All other grants under this subsection shall not exceed 50 per centum of the research, studies, or work. All grants shall be

made on the condition that the non-Federal share of such costs are provided from non-Federal sources.

(e) AUTHORIZATIONS.—(1) There is authorized to be appropriated to the Administrator for the implementation of this section, other than subsection (d), such sums as may be necessary for each of the fiscal years 1991 through 2001.

(2) There is authorized to be appropriated to the Administrator for the implementation of subsection (d) not to exceed $3,000,000 for each of the fiscal years 1991 through 2001.

(33 U.S.C. 1269)

LAKE CHAMPLAIN MANAGEMENT CONFERENCE

SEC. 120. (a) ESTABLISHMENT.—There is established a Lake Champlain Management Conference to develop a comprehensive pollution prevention, control, and restoration plan for Lake Champlain. The Administrator shall convene the management conference within ninety days of the date of enactment of this section.

(b) MEMBERSHIP.—The Members of the Management Conference shall be comprised of—

(1) the Governors of the States of Vermont and New York;

(2) each interested Federal agency, not to exceed a total of five members;

(3) the Vermont and New York Chairpersons of the Vermont, New York, Quebec Citizens Advisory Committee for the Environmental Management of Lake Champlain;

(4) four representatives of the State legislature of Vermont;

(5) four representatives of the State legislature of New York;

(6) six persons representing local governments having jurisdiction over any land or water within the Lake Champlain basin, as determined appropriate by the Governors; and

(7) eight persons representing affected industries, nongovernmental organizations, public and private educational institutions, and the general public, as determined appropriate by the trigovernmental Citizens Advisory Committee for the Environmental Management of Lake Champlain, but not to be current members of the Citizens Advisory Committee.

(c) TECHNICAL ADVISORY COMMITTEE.—(1) The Management Conference shall, not later than one hundred and twenty days after the date of enactment of this section, appoint a Technical Advisory Committee.

(2) Such Technical Advisory Committee shall consist of officials of: appropriate departments and agencies of the Federal Government; the State governments of New York and Vermont; and governments of political subdivisions of such States; and public and private research institutions.

(d) RESEARCH PROGRAM.—(1)[1] The Management Conference shall establish a multi-disciplinary environmental research program for Lake Champlain. Such research program shall be planned

[1] law. No paragraph (2). See P.L. 101-596, sec. 303, 104 Stat. 3006.

and conducted jointly with the Lake Champlain Research Consortium.

(e) POLLUTION PREVENTION, CONTROL, AND RESTORATION PLAN.—(1) Not later than three years after the date of the enactment of this section, the Management Conference shall publish a pollution prevention, control, and restoration plan (hereafter in this section referred to as the "Plan") for Lake Champlain.

(2) The Plan developed pursuant to this section shall—

(A) identify corrective actions and compliance schedules addressing point and nonpoint sources of pollution necessary to restore and maintain the chemical, physical, and biological integrity of water quality, a balanced, indigenous population of shellfish, fish and wildlife, recreational, and economic activities in and on the lake;

(B) incorporate environmental management concepts and programs established in State and Federal plans and programs in effect at the time of the development of such plan;

(C) clarify the duties of Federal and State agencies in pollution prevention and control activities, and to the extent allowable by law, suggest a timetable for adoption by the appropriate Federal and State agencies to accomplish such duties within a reasonable period of time;

(D) describe the methods and schedules for funding of programs, activities, and projects identified in the Plan, including the use of Federal funds and other sources of funds; and

(E) include a strategy for pollution prevention and control that includes the promotion of pollution prevention and management practices to reduce the amount of pollution generated in the Lake Champlain basin.

(3) The Administrator, in cooperation with the Management Conference, shall provide for public review and comment on the draft Plan. At a minimum, the Management Conference shall conduct one public meeting to hear comments on the draft plan in the State of New York and one such meeting in the State of Vermont.

(4) Not less than one hundred and twenty days after the publication of the Plan required pursuant to this section, the Administrator shall approve such plan if the plan meets the requirements of this section and the Governors of the States of New York and Vermont concur.

(5) Upon approval of the plan, such plan shall be deemed to be an approved management program for the purposes of section 319(h) of this Act and such plan shall be deemed to be an approved comprehensive conservation and management plan pursuant to section 320 of this Act.

(f) GRANT ASSISTANCE.—(1) The Administrator may, in consultation with the Management Conference, make grants to State, interstate, and regional water pollution control agencies, and public or nonprofit agencies, institutions, and organizations.

(2) Grants under this subsection shall be made for assisting research, surveys, studies, and modeling and technical and supporting work necessary for the development of the Plan and for retaining expert consultants in support of litigation undertaken by the State of New York and the State of Vermont to compel cleanup or

obtain cleanup damage costs from persons responsible for pollution of Lake Champlain.

(3) The amount of grants to any person under this subsection for a fiscal year shall not exceed 75 per centum of the costs of such research, survey, study and work and shall be made available on the condition that non-Federal share of such costs are provided from non-Federal sources.

(4) The Administrator may establish such requirements for the administration of grants as he determines to be appropriate.

(g) DEFINITION.—For the purposes of this section, the term "Lake Champlain drainage basin" means all or part of Clinton, Franklin, Warren, Essex, and Washington counties in the State of New York and all or part of Franklin, Grand Isle, Chittenden, Addison, Rutland, Lamoille, Orange, Washington, Orleans, and Caledonia counties in Vermont, that contain all of the streams, rivers, lakes, and other bodies of water, including wetlands, that drain into Lake Champlain.

(h) STATUTORY INTERPRETATION.—Nothing in this section shall be construed so as to affect the jurisdiction or powers of—

(1) any department or agency of the Federal Government or any State government; or

(2) any international organization or entity related to Lake Champlain created by treaty or memorandum to which the United States is a signatory.

(i) AUTHORIZATION.—There are authorized to be appropriated to the Environmental Protection Agency to carry out this section $2,000,000 for each of fiscal years 1991, 1992, 1993, 1994, and 1995.

(33 U.S.C. 1270)

TITLE II—GRANTS FOR CONSTRUCTION OF TREATMENT WORKS

PURPOSE

SEC. 201. (a) It is the purpose of this title to require and to assist the development and implementation of waste treatment management plans and practices which will achieve the goals of this Act.

(b) Waste treatment management plans and practices shall provide for the application of the best practicable waste treatment technology before any discharge into receiving waters, including reclaiming and recycling of water, and confined disposal of pollutants so they will not migrate to cause water or other environmental pollution and shall provide for consideration of advanced waste treatment techniques.

(c) To the extent practicable, waste treatment management shall be on an areawide basis and provide control or treatment of all point and nonpoint sources of pollution, including in place or accumulated pollution sources.

(d) The Administrator shall encourage waste treatment management which results in the construction of revenue producing facilities providing for—

(1) the recycling of potential sewage pollutants through the production of agriculture, silviculture, or aquaculture products, or any combination thereof;

(2) the confined and contained disposal of pollutants not recycled;

(3) the reclamation of wastewater; and

(4) the ultimate disposal of sludge in a manner that will not result in environmental hazards.

(e) The Administrator shall encourage waste treatment management which results in integrating facilities for sewage treatment and recycling with facilities to treat, dispose of, or utilize other industrial and municipal wastes, including but not limited to solid waste and waste heat and thermal discharges. Such integrated facilities shall be designed and operated to produce revenues in excess of capital and operation and maintenance costs and such revenues shall be used by the designated regional management agency to aid in financing other environmental improvement programs.

(f) The Administrator shall encourage waste treatment management which combines "open space" and recreational considerations with such management.

(g)(1) The Administrator is authorized to make grants to any State, municipality, or intermunicipal or interstate agency for the construction of publicly owned treatment works. On and after October 1, 1984, grants under this title shall be made only for projects for secondary treatment or more stringent treatment, or any cost effective alternative thereto, new interceptors and appurtenances, and infiltration-in-flow correction. Notwithstanding the preceding sentences, the Administrator may make grants on and after October 1, 1984, for (A) any project within the definition set forth in section 212(2) of this Act, other than for a project referred to in the preceding sentence, and (B) any purpose for which a grant may be made under sections[1] 319 (h) and (i) of this Act (including any innovative and alternative approaches for the control of nonpoint sources of pollution), except that not more than 20 per centum (as determined by the Governor of the State) of the amount allotted to a State under section 205 of this Act for any fiscal year shall be obligated in such State under authority of this sentence.

(2) The Administrator shall not make grants from funds authorized for any fiscal year beginning after June 30, 1974, to any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works unless the grant applicant has satisfactorily demonstrated to the Administrator that—

(A) alternative waste management techniques have been studied and evaluated and the works proposed for grant assistance will provide for the application of the best practicable waste treatment technology over the life of the works consistent with the purposes of this title; and

(B) as appropriate, the works proposed for grant assistance will take into account and allow to the extent practicable the application of technology at a later date which will provide for

[1] So in original. Probably should be "section".

the reclaiming or recycling of water or otherwise eliminate the discharge of pollutants.

(3) The Administrator shall not approve any grant after July 1, 1973, for treatment works under this section unless the applicant shows to the satisfaction of the Administrator that each sewer collection system discharging into such treatment works is not subject to excessive infiltration.

(4) The Administrator is authorized to make grants to applicants for treatment works grants under this section for such sewer system evaluation studies as may be necessary to carry out the requirements of paragraph (3) of this subsection. Such grants shall be made in accordance with rules and regulations promulgated by the Administrator. Initial rules and regulations shall be promulgated under this paragraph not later than 120 days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972.

(5) The Administrator shall not make grants from funds authorized for any fiscal year beginning after September 30, 1978, to any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works unless the grant applicant has satisfactorily demonstrated to the Administrator that innovative and alternative wastewater treatment processes and techniques which provide for the reclaiming and reuse of water, otherwise eliminate the discharge of pollutants, and utilize recycling techniques, land treatment, new or improved methods of waste treatment management for municipal and industrial waste (discharged into municipal systems) and the confined disposal of pollutants, so that pollutants will not migrate to cause water or other environmental pollution, have been fully studied and evaluated by the applicant taking into account section 201(d) of this Act and taking into account and allowing to the extent practicable the more efficient use of energy and resources.

(6) The Administrator shall not make grants from funds authorized for any fiscal year beginning after September 30, 1978, to any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works unless the grant applicant has satisfactorily demonstrated to the Administrator that the applicant has analyzed the potential recreation and open space opportunities in the planning of the proposed treatment works.

(h) A grant may be made under this section to construct a privately owned treatment works serving one or more principal residences or small commercial establishments constructed prior to, and inhabited on the date of enactment of this subsection where the Administrator finds that—

(1) a public body otherwise eligible for a grant under subsection (g) of this section has applied on behalf of a number of such units and certified that public ownership of such works is not feasible;

(2) such public body has entered into an agreement with the Administrator which guarantees that such treatment works will be properly operated and maintained and will comply with all other requirements of section 204 of this Act and includes a system of charges to assure that each recipient of waste treatment services under such a grant will pay its proportionate share of the cost of operation and maintenance (including replacement); and

(3) the total cost and environmental impact of providing waste treatment services to such residences or commercial establishments will be less than the cost of providing a system of collection and central treatment of such wastes.

(i) The Administrator shall encourage waste treatment management methods, processes, and techniques which will reduce total energy requirements.

(j) The Administrator is authorized to make a grant for any treatment works utilizing processes and techniques meeting the guidelines promulgated under section 304(d)(3) of this Act, if the Administrator determines it is in the public interest and if in the cost effectiveness study made of the construction grant application for the purpose of evaluating alternative treatment works, the life cycle cost of the treatment works for which the grant is to be made does not exceed the life cycle cost of the most effective alternative by more than 15 per centum.

(k) No grant made after November 15, 1981, for a publicly owned treatment works, other than for facility planning and the preparation of construction plans and specifications, shall be used to treat, store, or convey the flow of any industrial user into such treatment works in excess of a flow per day equivalent to fifty thousand gallons per day of sanitary waste. This subsection shall not apply to any project proposed by a grantee which is carrying out an approved project to prepare construction plans and specifications for a facility to treat wastewater, which received its grant approval before May 15, 1980. This subsection shall not be in effect after November 15, 1981.

(l)(1) After the date of enactment of this subsection, Federal grants shall not be made for the purpose of providing assistance solely for facility plans, or plans, specifications, and estimates for any proposed project for the construction of treatment works. In the event that the proposed project receives a grant under this section for construction, the Administrator shall make an allowance in such grant for non-Federal funds expended during the facility planning and advanced engineering and design phase at the prevailing Federal share under section 202(a) of this Act, based on the percentage of total project costs which the Administrator determines is the general experience for such projects.

(2)(A) Each State shall use a portion of the funds allotted to such State each fiscal year, but not to exceed 10 per centum of such funds, to advance to potential grant applicants under this title the costs of facility planning or the preparation of plans, specifications, and estimates.

(B) Such an advance shall be limited to the allowance for such costs which the Administrator establishes under paragraph (1) of this subsection, and shall be provided only to a potential grant applicant which is a small community and which in the judgment of the State would otherwise be unable to prepare a request for a grant for construction costs under this section.

(C) In the event a grant for construction costs is made under this section for a project for which an advance has been made under this paragraph, the Administrator shall reduce the amount of such grant by the allowance established under paragraph (1) of this subsection. In the event no such grant is made, the State is authorized to seek repayment of such advance on such terms and conditions as it may determine.

(m)(1) Notwithstanding any other provisions of this title, the Administrator is authorized to make a grant from any funds otherwise allotted to the State of California under section 205 of this Act to the project (and in the amount) specified in Order WQG 81-1 of the California State Water Resources Control Board.

(2) Notwithstanding any other provision of this Act, the Administrator shall make a grant from any funds otherwise allotted to the State of California to the city of Eureka, California, in connection with project numbered C-06-2772, for the purchase of one hundred and thirty-nine acres of property as environmental mitigation for siting of the proposed treatment plant.

(3) Notwithstanding any other provision of this Act, the Administrator shall make a grant from any funds otherwise allotted to the State of California to the city of San Diego, California, in connection with that city's aquaculture sewage process (total resources recovery system) as an innovative and alternative waste treatment process.

(n)(1) On and after October 1, 1984, upon the request of the Governor of an affected State, the Administrator is authorized to use funds available to such State under section 205 to address water quality problems due to the impacts of discharges from combined storm water and sanitary sewer overflows, which are not otherwise eligible under this subsection, where correction of such discharges is a major priority for such State.

(2) Beginning fiscal year 1983, the Administrator shall have available $200,000,000 per fiscal year in addition to those funds authorized in section 207 of this Act to be utilized to address water quality problems of marine bays and estuaries subject to lower levels of water quality due to the impacts of discharges from combined storm water and sanitary sewer overflows from adjacent urban complexes, not otherwise eligible under this subsection. Such sums may be used as deemed appropriate by the Administrator as provided in paragraphs (1) and (2) of this subsection, upon the request of and demonstration of water quality benefits by the Governor of an affected State.

(o) The Administrator shall encourage and assist applicants for grant assistance under this title to develop and file with the Administrator a capital financing plan which, at a minimum—

(1) projects the future requirements for waste treatment services within the applicant's jurisdiction for a period of no less than ten years;

(2) projects the nature, extent, timing, and costs of future expansion and reconstruction of treatment works which will be necessary to satisfy the applicant's projected future requirements for waste treatment services; and

(3) sets forth with specificity the manner in which the applicant intends to finance such future expansion and reconstruction.

(p) Time Limit on Resolving Certain Disputes.—In any case in which a dispute arises with respect to the awarding of a contract for construction of treatment works by a grantee of funds under this title and a party to such dispute files an appeal with the Administrator under this title for resolution of such dispute, the Administrator shall make a final decision on such appeal within 90 days of the filing of such appeal.

(33 U.S.C. 1281)

FEDERAL SHARE

Sec. 202. (a)(1) The amount of any grant for treatment works made under this Act from funds authorized for any fiscal year beginning after June 30, 1971, and ending before October 1, 1984, shall be 75 per centum of the cost of construction thereof (as approved by the Administrator), and for any fiscal year beginning on or after October 1, 1984, shall be 55 per centum of the cost of construction thereof (as approved by the Administrator), unless modified to a lower percentage rate uniform throughout a State by the Governor of that State with the concurrence of the Administrator. Within ninety days after the enactment of this sentence the Administrator, shall issue guidelines for concurrence in any such modification, which shall provide for the consideration of the unobligated balance of sums allocated to the State under section 205 of this Act, the need for assistance under this title in such State, and the availability of State grant assistance to replace the Federal share reduced by such modification. The payment of any such reduced Federal share shall not constitute an obligation on the part of the United States or a claim on the part of any State or grantee to reimbursement for the portion of the Federal share reduced in any such State. Any grant (other than for reimbursement) made prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 from any funds authorized for any fiscal year beginning after June 30, 1971, shall, upon the request of the applicant, be increased to the applicable percentage under this section. Notwithstanding the first sentence of this paragraph, in any case where a primary, secondary, or advanced waste treatment facility or its related interceptors or a project for infiltration-in-flow correction has received a grant for erection, building, acquisition, alteration, remodeling, improvement, extension, or correction before October 1, 1984, all segments and phases of such facility, interceptors, and project for infiltration-in-flow correction shall be eligible for grants at 75 per centum of the cost of construction thereof for any grant made pursuant to a State obligation which obligation occurred before October 1, 1990. Notwithstanding the first sentence of this paragraph, in the case of a project for which an application for a grant under this title has been made to the Administrator before October 1, 1984, and which project is under judicial injunction on such date prohibiting its construction, such project shall be eligible for grants at 75 percent of the cost of construction thereof. Notwithstanding the first sentence of this paragraph, in the case of the Wyoming Valley Sanitary Authority project mandated by judicial order under a proceeding begun prior to October 1, 1984, and a project for wastewater treatment for Altoona, Pennsylvania, such projects shall be eligible for grants at 75 percent of the cost of construction thereof.

(2) The amount of any grant made after September 30, 1978, and before October 1, 1981, for any eligible treatment works or significant portion thereof utilizing innovative or alternative wastewater treatment processes and techniques referred to in section 201(g)(5) shall be 85 per centum of the cost of construction thereof, unless modified by the Governor of the State with the concurrence of the Administrator to a percentage rate no less than 15 per centum greater than the modified uniform percentage rate in which the Administrator has concurred pursuant to paragraph (1) of this subsection. The amount of any grant made after September 30, 1981, for any eligible treatment works or unit processes and techinques thereof utilizing innovative or alternative wastewater treatment processes and techniques referred to in section 201(g)(5) shall be a percentage of the cost of construction thereof equal to 20 per centum greater than the percentage in effect under paragraph (1) of this subsection for such works or unit processes and techniques, but in no event greater than 85 per centum of the cost of construction thereof. No grant shall be made under this paragraph for construction of a treatment works in any State unless the proportion of the State contribution to the non-Federal share of construction costs for all treatment works in such State receiving a grant under this paragraph is the same as or greater than the proportion of the State contribution (if any) to the non-Federal share of construction costs for all treatment works receiving grants in such State under paragraph (1) of this subsection.

(3) In addition to any grant made pursuant to paragraph (2) of this subsection, the Administrator is authorized to make a grant to fund all of the costs of the modification or replacement of any facilities constructed with a grant made pursuant to paragraph (2) if the Administrator finds that such facilities have not met design performance specifications unless such failure is attributable to negligence on the part of any person and if such failure has significantly increased capital or operating and maintenance expenditures. In addition, the Administrator is authorized to make a grant to fund all of the costs of the modification or replacement of biodisc equipment (rotating biological contractors) in any publicly owned treatment works if the Administrator finds that such equipment has failed to meet design performance specifications, unless such failure is attributable to negligence on the part of any person, and if such failure has significantly increased capital or operating and maintenance expenditures.

(4) For the purposes of this section, the term "eligible treatment works" means those treatment works in each State which meet the requirements of section 201(g)(5) of this Act and which can be fully funded from funds available for such purpose in such State.

(b) The amount of the grant for any project approved by the Administrator after January 1, 1971, and before July 1, 1971, for the construction of treatment works, the actual erection, building

or acquisition of which was not commenced prior to July 1, 1971, shall, upon the request of the applicant, be increased to the applicable percentage under subsection (a) of this section for grants for treatment works from funds for fiscal years beginning after June 30, 1971, with respect to the cost of such actual erection, building, or acquisition. Such increased amount shall be paid from any funds allocated to the State in which the treatment works is located without regard to the fiscal year for which such funds were authorized. Such increased amount shall be paid for such project only if—

(1) a sewage collection system that is a part of the same total waste treatment system as the treatment works for which such grant was approved is under construction or is to be constructed for use in conjunction with such treatment works, and if the cost of such sewage collection system exceeds the cost of such treatment works, and

(2) the State water pollution control agency or other appropriate State authority certifies that the quantity of available ground water will be insufficient, inadequate, or unsuitable for public use, including the ecological preservation and recreational use of surface water bodies, unless effluents from publicly-owned treatment works after adequate treatment are returned to the ground water consistent with acceptable technological standards.

(c) Notwithstanding any other provision of law, sums allotted to the Commonwealth of Puerto Rico under section 205 of this Act for fiscal year 1981 shall remain available for obligation for the fiscal year for which authorized and for the period of the next succeeding twenty-four months. Such sums and any unobligated funds available to Puerto Rico from allotments for fiscal years ending prior to October 1, 1981, shall be available for obligation by the Administrator of the Environmental Protection Agency only to fund the following systems: Aguadilla, Arecibo, Mayaguez, Carolina, and Camuy Hatillo. These funds may be used by the Commonwealth of Puerto Rico to fund the non-Federal share of the costs of such projects. To the extent that these funds are used to pay the non-Federal share, the Commonwealth of Puerto Rico shall repay to the Environmental Protection Agency such amounts on terms and conditions developed and approved by the Administrator in consultation with the Governor of the Commonwealth of Puerto Rico. Agreement on such terms and conditions including the payment of interest to be determined by the Secretary of the Treasury, shall be reached prior to the use of these funds for the Commonwealth's non-Federal share. No Federal funds awarded under this provision shall be used to replace local governments funds previously expended on these projects.

(33 U.S.C. 1282)

PLANS, SPECIFICATIONS, ESTIMATES, AND PAYMENTS

SEC. 203. (a)(1) Each applicant for a grant shall submit to the Administrator for his approval, plans, specifications, and estimates for each proposed project for the construction of treatment works for which a grant is applied for under section 201(g)(1) from funds allotted to the State under section 205 and which otherwise 's the requirements of this Act. The Administrator shall act upon such plans, specifications, and estimates as soon as practicable after the same have been submitted, and his approval of any such plans, specifications, and estimates shall be deemed a contractual obligation of the United States for the payment of its proportional contribution to such project.

(2) AGREEMENT ON ELIGIBLE COSTS.—

(A) LIMITATION ON MODIFICATIONS.—Before taking final action on any plans, specifications, and estimates submitted under this subsection after the 60th day following the date of the enactment of the Water Quality Act of 1987, the Administrator shall enter into a written agreement with the applicant which establishes and specifies which items of the proposed project are eligible for Federal payments under this section. The Administrator may not later modify such eligibility determinations unless they are found to have been made in violation of applicable Federal statutes and regulations.

(B) LIMITATION ON EFFECT.—Eligibility determinations under this paragraph shall not preclude the Administrator from auditing a project pursuant to section 501 of this Act, or other authority, or from withholding or recovering Federal funds for costs which are found to be unreasonable, unsupported by adequate documentation, or otherwise unallowable under applicable Federal costs principles, or which are incurred on a project which fails to meet the design specifications or effluent limitations contained in the grant agreement and permit pursuant to section 402 of this Act for such project.

(3) In the case of a treatment works that has an estimated total cost of $8,000,000 of less (as determined by the Administrator), and the population of the applicant municipality is twenty-five thousand or less (according to the most recent United States census), upon completion of an approved facility plan, a single grant may be awarded for the combined Federal share of the cost of preparing construction plans and specifications, and the building and erection of the treatment works.

(b) The Administrator shall, from time to time as the work progresses, make payments to the recipient of a grant for costs of construction incurred on a project. These payments shall at no time exceed the Federal share of the cost of construction incurred to the date of the voucher covering such payment plus the Federal share of the value of the materials which have been stockpiled in the vicinity of such construction in conformity to plans and specifications for the project.

(c) After completion of a project and approval of the final voucher by the Administrator, he shall pay out of the appropriate sums the unpaid balance of the Federal share payable on account of such project.

(d) Nothing in this Act shall be construed to require, or to authorize the Administrator to require, that grants under this Act for construction of treatment works be made only for projects which are operable units usable for sewage collection, transportation,

storage, waste treatment, or for similar purposes without additional construction.

(e) At the request of a grantee under this title, the Administrator is authorized to provide technical and legal assistance in the administration and enforcement of any contract in connection with treatment works assisted under this title, and to intervene any civil action involving the enforcement of such a contract.

(f) DESIGN/BUILD PROJECTS.—

(1) AGREEMENT.—Consistent with State law, an applicant who proposes to construct waste water treatment works may enter into an agreement with the Administrator under this subsection providing for the preparation of construction plans and specifications and the erection of such treatment works, in lieu of proceeding under the other provisions of this section.

(2) LIMITATION ON PROJECTS.—Agreements under this subsection shall be limited to projects under an approved facility plan which projects are—

(A) treatment works that have an estimated total cost of $8,000,000 or less; and

(B) any of the following types of waste water treatment systems: aerated lagoons, trickling filters, stabilization ponds, land application systems, sand filters, and subsurface disposal systems.

(3) REQUIRED TERMS.—An agreement entered into under this subsection shall—

(A) set forth an amount agreed to as the maximum Federal contribution to the project, based upon a competitively bid document of basic design data and applicable standard construction specifications and a determination of the federally eligible costs of the project at the applicable Federal share under section 202 of this Act;

(B) set forth dates for the start and completion of construction of the treatment works by the applicant and a schedule of payments of the Federal contribution to the project;

(C) contain assurances by the applicant that (i) engineering and management assistance will be provided to manage the project; (ii) the proposed treatment works will be an operable unit and will meet all the requirements of this title; and (iii) not later than 1 year after the date specified as the date of completion of construction of the treatment works, the treatment works will be operating so as to meet the requirements of any applicable permit for such treatment works under section 402 of this Act;

(D) require the applicant to obtain a bond from the contractor in an amount determined necessary by the Administrator to protect the Federal interest in the project; and

(E) contain such other terms and conditions as are necessary to assure compliance with this title (except as provided in paragraph (4) of this subsection).

(4) LIMITATION ON APPLICATION.—Subsections (a), (b), and (c) of this section shall not apply to grants made pursuant to this subsection.

(5) RESERVATION TO ASSURE COMPLIANCE.—The Administrator shall reserve a portion of the grant to assure contract compliance until final project approval as defined by the Administrator. If the amount agreed to under paragraph (3)(A) exceeds the cost of designing and constructing the treatment works, the Administrator shall reallot the amount of the excess to the State in which such treatment works are located for the fiscal year in which such audit is completed.

(6) LIMITATION ON OBLIGATIONS.—The Administrator shall not obligate more than 20 percent of the amount allotted to a State for a fiscal year under section 205 of this Act for grants pursuant to this subsection.

(7) ALLOWANCE.—The Administrator shall determine an allowance for facilities planning for projects constructed under this subsection in accordance with section 201(l).

(8) LIMITATION ON FEDERAL CONTRIBUTIONS.—In no event shall the Federal contribution for the cost of preparing construction plans and specifications and the building and erection of treatment works pursuant to this subsection exceed the amount agreed upon under paragraph (3).

(9) RECOVERY ACTION.—In any case in which the recipient of a grant made pursuant to this subsection does not comply with the terms of the agreement entered into under paragraph (3), the Administrator is authorized to take such action as may be necessary to recover the amount of the Federal contribution to the project.

(10) PREVENTION OF DOUBLE BENEFITS.—A recipient of a grant made pursuant to this subsection shall not be eligible for any other grants under this title for the same project.

(33 U.S.C. 1283)

LIMITATIONS AND CONDITIONS

SEC. 204. (a) Before approving grants for any project for any treatment works under section 201(g)(1) the Administrator shall determine—

(1) that any required areawide waste treatment management plan under section 208 of this Act (A) is being implemented for such area and the proposed treatment works are included in such plan, or (B) is being developed for such area and reasonable progress is being made toward its implementation and the proposed treatment works will be included in such plan;

(2) that (A) the State in which the project is to be located (i) is implementing any required plan under section 303(e) of this Act and the proposed treatment works are in conformity with such plan, or (ii) is developing such a plan and the proposed treatment works will be in conformity with such plan, and (B) such State is in compliance with section 305(b) of this Act;

(3) that such works have been certified by the appropriate State water pollution control agency as entitled to priority over such other works in the State in accordance with any applica- State plan under section 303(e) of this Act, except that any

priority list developed pursuant to section 303(e)(3)(H) may be modified by such State in accordance with regulations promulgated by the Administrator to give higher priority for grants for the Federal share of the cost of preparing construction drawings and specifications for any treatment works utilizing processes and techniques meeting the guidelines promulgated under section 304(d)(3) of this Act for grants for the combined Federal share of the cost of preparing construction drawings and specifications and the building and erection of any treatment works meeting the requirements of the next to the last sentence of section 203(a) of this Act which utilizes processes and techniques meeting the guidelines promulgated under section 304(d)(3) of this Act.[1]

(4) that the applicant proposing to construct such works agrees to pay the non-Federal costs of such works and has made adequate provisions satisfactory to the Administrator for assuring proper and efficient operation, including the employment of trained management and operations personnel, and the maintenance of such works in accordance with a plan of operation approved by the state water pollution control agency or, as appropriate, the interstate agency, after construction thereof;

(5) that the size and capacity of such works relate directly to the needs to be served by such works, including sufficient reserve capacity. The amount of reserve capacity provided shall be approved by the Administrator on the basis of a comparison of the cost of constructing such reserves as a part of the works to be funded and the anticipated cost of providing expanded capacity at a date when such capacity will be required, after taking into account, in accordance with regulations promulgated by the Administrator, efforts to reduce total flow of sewage and unnecessary water consumption. The amount of reserve capacity eligible for a grant under this title shall be determined by the Administrator taking into account the projected population and associated commercial and industrial establishments within the jurisdiction of the applicant to be served by such treatment works as identified in an approved facilities plan, an areawide plan under section 208, or an applicable municipal master plan of development. For the purpose of this paragraph, section 208, and any such plan, projected population shall be determined on the basis of the latest information available from the United States Department of Commerce or from the States as the Administrator, by regulation, determines appropriate. Beginning October 1, 1984, no grants shall be made under this title to construct that portion of any treatment works providing reserve capacity in excess of existing needs (including existing needs of residential, commercial, industrial, and other users) on the date of approval of a grant for the erection, building, acquisition, alteration, remodeling, improvement, or extension of a project for secondary treatment or more stringent treatment or new interceptors and appurtenances, except that in no event shall reserve capacity of a facility and

[1] So in law. The period should be a semicolon.

its related interceptors to which this subsection applies be in excess of existing needs on October 1, 1990. In any case in which an applicant proposes to provide reserve capacity greater than that eligible for Federal financial assistance under this title, the incremental costs of the additional reserve capacity shall be paid by the applicant;

(6) that no specification for bids in connection with such works shall be written in such a manner as to contain proprietary, exclusionary, or discriminatory requirements other than those based upon performance, unless such requirements are necessary to test or demonstrate a specific thing or to provide for necessary interchangeability of parts and equipment. When in the judgment of the grantee, it is impractical or uneconomical to make a clear and accurate description of the technical requirements, a "brand name or equal" description may be used as a means to define the performance or other salient requirements of a procurement, and in doing so the grantee need not establish the existence of any source other than the brand or source so named.

(b)(1) Notwithstanding any other provision of this title, the Administrator shall not approve any grant for any treatment works under section 201(g)(1) after March 1, 1973, unless he shall first have determined that the applicant (A) has adopted or will adopt a system of charges to assure that each recipient of waste treatment services within the applicant's jurisdiction, as determined by the Administrator, will pay its proportionate share (except as otherwise provided in this paragraph) of the costs of operation and maintenance (including replacement) of any waste treatment services provided by the applicant; and (B) has legal, institutional, managerial, and financial capability to insure adequate construction, operation, and maintenance of treatment works throughout the applicant's jurisdiction, as determined by the Administrator. In any case where an applicant which, as of the date of enactment of this sentence, uses a system of dedication ad valorem taxes and the Administrator determines that the applicant has a system of charges which results in the distribution of operation and maintenance costs for treatment works within the applicant's jurisdiction, to each user class, in proportion to the contribution to the total cost of operation and maintenance of such works by each user class (taking into account total waste water loading of such works, the constituent elements of the waste, and other appropriate factors), and such applicant is otherwise in compliance with clause (A) of this paragraph with respect to each industrial user, then such dedication ad valorem tax system shall be deemed to be the user charge system meeting the requirements of clause (A) of this paragraph for the residential user class and such small non-residential user classes as defined by the Administrator. In defining small non-residential users, the Administrator shall consider the volume of wastes discharged into the treatment works by such users and the constituent elements of such wastes as well as such other factors as he deems appropriate. A system of user charges which imposes a lower charge for low-income residential users (as defined by the Administrator) shall be deemed to be a user charge system meeting the requirements of clause (A) of this paragraph if the Administrator determines that such system was adopted after public notice and hearing.

(2) The Administrator shall, within one hundred and eighty days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, and after consultation with appropriate State, interstate, municipal and intermunicipal agencies, issue guidelines applicable to payment of waste treatment costs by industrial and nonindustrial receipts of waste treatment services which shall establish (A) classes of users of such services, including categories of industrial users; (B) criteria against which to determine the adequacy of charges imposed on classes and categories of users reflecting all factors that influence the cost of waste treatment, including strength, volume, and delivery flow rate characteristics of waste; and (C) model systems and rates of user charges typical of various treatment works serving municipal-industrial communities.

(3) Approval by the Administrator of a grant to an interstate agency established by interstate compact for any treatment works shall satisfy any other requirement that such works be authorized by Act of Congress.

(4) A system of charges which meets the requirement of clause (A) of paragraph (1) of this subsection may be based on something other than metering the sewage or water supply flow of residential recipients of waste treatment services, including ad valorem taxes. If the system of charges is based on something other than metering the Administrator shall require (A) the applicant to establish a system by which the necessary funds will be available for the proper operation and maintenance of the treatment works; and (B) the applicant to establish a procedure under which the residential user will be notified as to that portion of his total payment which will be allocated to the costs of the waste treatment services.

(c) The next to the last sentence of paragraph (5) of subsection (a) of this section shall not apply in any case where a primary, secondary, or advanced waste treatment facility or its related interceptors has received a grant for erection, building, acquisition, alteration, remodeling, improvement, or extension before October 1, 1984, and all segments and phases of such facility and interceptors shall be funded based on a 20-year reserve capacity in the case of such facility and a 20-year reserve capacity in the case of such interceptors, except that, if a grant for such interceptors has been approved prior to the date of enactment of the Municipal Wastewater Treatment Construction Grant Amendments of 1981, such interceptors shall be funded based on the approved reserve capacity not to exceed 40 years.

(d)(1) A grant for the construction of treatment works under this title shall provide that the engineer or engineering firm supervising construction or providing architect engineering services during construction shall continue its relationship to the grant applicant for a period of one year after the completion of construction and initial operation of such treatment works. During such period such engineer or engineering firm shall supervise operation of the treatment works, train operating personnel, and prepare curricula and training material for operating personnel. Costs associated with the implementation of this paragraph shall be eligible for Federal assistance in accordance with this title.

(2) On the date one year after the completion of construction and initial operation of such treatment works, the owner and operator of such treatment works shall certify to the Administrator whether or not such treatment works meet the design specifications and effluent limitations contained in the grant agreement and permit pursuant to section 402 of the Act for such works. If the owner and operator of such treatment works cannot certify that such treatment works meet such design specifications and effluent limitations, any failure to meet such design specifications and effluent limitations shall be corrected in a timely manner, to allow such affirmative certification, at other than Federal expense.

(3) Nothing in this section shall be construed to prohibit a grantee under this title from requiring more assurances, guarantees, or indemnity or other contractual requirements from any party to a contract pertaining to a project assisted under this title, than those provided under this subsection.

(33 U.S.C. 1284)

ALLOTMENT

SEC. 205. (a) Sums authorized to be appropriated pursuant to section 207 for each fiscal year beginning after June 30, 1972, before September 30, 1977, shall be allotted by the Administrator not later than the January 1st immediately preceding the beginning of the fiscal year for which authorized, except that the allotment for fiscal year 1973 shall be made not later than 30 days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. Such sums shall be allotted among the States by the Administrator in accordance with regulations promulgated by him, in the ratio that the estimated cost of constructing all needed publicly owned treatment works in each State bears to the estimated cost of construction of all needed publicly owned treatment works in all of the States. For the fiscal years ending June 30, 1973, and June 30, 1974, such ratio shall be determined on the basis of table III of House Public Works Committee Print No. 92–50. For the fiscal year ending June 30, 1975, such ratio shall be determined one-half on the basis of table I of House Public Works Committee Print Numbered 93–28 and one-half on the basis of table II of such print, except that no State shall receive an allotment less than that which it received for the fiscal year ending June 30, 1972, as set forth in table III of such print. Allotments for fiscal years which begin after the fiscal year ending June 30, 1975 shall be made only in accordance with a revised cost estimate made and submitted to Congress in accordance with section 516(b) of this Act and only after such revised cost estimate shall have been approved by law specifically enacted hereafter.

(b)(1) Any sums allotted to a State under subsection (a) shall be available for obligation under section 203 on and after the date of such allotment. Such sums shall continue available for obligation in such State for a period of one year after the close of the fiscal year for which such sums are authorized. Any amounts so allotted which are not obligated by the end of such one-year period shall be immediately reallotted by the Administrator, in accordance with regulations promulgated by him, generally on the basis of the ratio used in making the last allotment of sums under this section. Such reallotted sums shall be added to the last allotments made to the States. Any sum made available to a State by reallotment under this subsection shall be in addition to any funds otherwise allotted to such State for grants under this title during any fiscal year.

(2) Any sums which have been obligated under section 203 and which are released by the payment of the final voucher for the project shall be immediately credited to the State to which such sums were last allotted. Such released sums shall be added to the amounts last allotted to such State and shall be immediately available for obligation in the same manner and to the same extent as such last allotment.

(c)(1) Sums authorized to be appropriated pursuant to section 207 for the fiscal years during the period beginning October 1, 1977, and ending September 30, 1981, shall be allotted for each such year by the Administrator not later than the tenth day which begins after the date of enactment of the Clean Water Act of 1977. Not-withstanding any other provision of law, sums authorized for the fiscal years ending September 30, 1978, September 30, 1979, September 30, 1980, and September 30, 1981, shall be allotted in accordance with table 3 of Committee Print Numbered 95–30 of the Committee on Public Works and Transportation of the House of Representatives.

(2) Sums authorized to be appropriated pursuant to section 207 for the fiscal years 1982, 1983, 1984, and 1985 shall be allotted for each such year by the Administrator not later than the tenth day which begins after the date of enactment of the Municipal Wastewater Treatment Construction Grant Amendments of 1981. Notwithstanding any other provision of law, sums authorized for the fiscal year ending September 30, 1982, shall be allotted in accordance with table 3 of Committee Print Numbered 95–30 of the Committee on Public Works and Transportation of the House of Representatives. Sums authorized for the fiscal years ending September 30, 1983, September 30, 1984, September 30, 1985, and September 30, 1986, shall be allotted in accordance with the following table:

States:	*Fiscal years 1983 through 1985*[1]
Alabama	.011398
Alaska	.006101
Arizona	.006885
Arkansas	.006668
California	.072901
Colorado	.008154
Connecticut	.012487
Delaware	.004965
District of Columbia	.004965
Florida	.034407
Georgia	.017234
Hawaii	.007895
Idaho	.004965
Illinois	.046101
Indiana	.024566
Iowa	.013796
Kansas	.009201
Kentucky	.012973
Louisiana	.011205
Maine	.007788
Maryland	.024653
Massachusetts	.034608
Michigan	.043829
Minnesota	.018735
Mississippi	.009184
Missouri	.028257
Montana	.004965
Nebraska	.005214
Nevada	.004965
New Hampshire	.010186
New Jersey	.041654
New Mexico	.004965
New York	.113097
North Carolina	.018396
North Dakota	.004965
Ohio	.057383
Oklahoma	.008235
Oregon	.011515
Pennsylvania	.040377
Rhode Island	.006750
South Carolina	.010442
South Dakota	.004965
Tennessee	.014807
Texas	.038726
Utah	.006371
Vermont	.004965
Virginia	.020861
Washington	.017726
West Virginia	.015890
Wisconsin	.027557
Wyoming	.004965
Samoa	.000915
Guam	.000662
Northern Marianas	.000425
Puerto Rico	.013295
Pacific Trust Territories	.001305
Virgin Islands	.000531
United States totals	.999996

[1] So in original. Probably should be "1986".

(3) FISCAL YEARS 1987–1990.—Sums authorized to be appropriated pursuant to section 207 for the fiscal years 1987, 1988, 1989, and 1990 shall be allotted for each such year by the Administrator not later than the 10th day which begins after the

date of the enactment of this paragraph. Sums authorized for such fiscal years shall be allotted in accordance with the following table:

States:	
Alabama	.011309
Alaska	.006053
Arizona	.006831
Arkansas	.006616
California	.072333
Colorado	.008090
Connecticut	.012390
Delaware	.004965
District of Columbia	.004965
Florida	.034139
Georgia	.017100
Hawaii	.007833
Idaho	.004965
Illinois	.045741
Indiana	.024374
Iowa	.013688
Kansas	.009129
Kentucky	.012872
Louisiana	.011118
Maine	.007829
Maryland	.024461
Massachusetts	.034338
Michigan	.043487
Minnesota	.018589
Mississippi	.009112
Missouri	.028037
Montana	.004965
Nebraska	.005173
Nevada	.004965
New Hampshire	.010107
New Jersey	.041329
New Mexico	.004965
New York	.111632
North Carolina	.018253
North Dakota	.004965
Ohio	.056936
Oklahoma	.008171
Oregon	.011425
Pennsylvania	.040062
Rhode Island	.006791
South Carolina	.010361
South Dakota	.004965
Tennessee	.014692
Texas	.046226
Utah	.005329
Vermont	.004965
Virginia	.020698
Washington	.017588
West Virginia	.015766
Wisconsin	.027342
Wyoming	.004965
American Samoa	.000908
Guam	.000657
Northern Marianas	.000422
Puerto Rico	.013191
Pacific Trust Territories	.001295
Virgin Islands	.000527

(d) Sums allotted to the States for a fiscal year shall remain available for obligation for the fiscal year for which authorized and for the period of the next succeeding twelve months. The amount of any allotment not obligated by the end of such twenty-four-month period shall be immediately reallotted by the Administrator on the basis of the same ratio as applicable to sums allotted for the then current fiscal year, except that none of the funds reallotted by the Administrator for fiscal year 1978 and for fiscal years thereafter shall be allotted to any State which failed to obligate any of the funds being reallotted. Any sum made available to a State by reallotment under this subsection shall be in addition to any funds otherwise allotted to such State for grants under this title during any fiscal year.

(e) For the fiscal years 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, and 1990, no State shall receive less than one-half of 1 per centum of the total allotment under subsection (c) of this section, except that in the case of Guam, Virgin Islands, American Samoa, and the Trust Territories not more than thirty-three one-hundredths of 1 per centum in the aggregate shall be allotted to all four for these jurisdictions. For the purpose of carrying out this subsection there are authorized to be appropriated, subject to such amounts as are provided in appropriation Acts, not to exceed $75,000,000 for each fiscal years 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, and 1990. If for any fiscal year the amount appropriated under authority of this subsection is less than the amount necessary to carry out this subsection, the amount each State receives under this subsection for such year shall be the same ratio for the amount such State would have received under this subsection in such year if the amount necessary to carry it out had been appropriated as the amount appropriated for such year bears to the amount necessary to carry out this subsection for such year.

(f) Notwithstanding any other provision of this section, sums made available between January 1, 1975, and March 1, 1975, by the Administrator for obligation shall be available for obligation until September 30, 1978.

(g)(1) The Administrator is authorized to reserve each fiscal year not to exceed 2 per centum of the amount authorized under section 207 of this title for purposes of the allotment made to each State under this section on or after October 1, 1977, except in the case of any fiscal year beginning on or after October 1, 1981, and ending before October 1, 1994, in which case the percentage authorized to be reserved shall not exceed 4 per centum.[1] or $400,000 whichever amount is the greater. Sums so reserved shall be available for making grants to such State under paragraph (2) of this subsection for the same period as sums are available from such allotment under subsection (d) of this section, and any such grant shall be available for obligation only during such period. Any grant made from sums reserved under this subsection which has not been obligated by the end of the period for which available shall be added to the amount last allotted to such State under this section and shall be immediately available for obligation in the same manner and to the same extent as such last allotment. Sums authorized to be reserved by this paragraph shall be in addition to and

[1] P.L. 97-117 added this phrase with a period at the end; probably should be a comma.

not in lieu of any other funds which may be authorized to carry out this subsection.

(2) The Administrator is authorized to grant to any State from amounts reserved to such State under this subsection, the reasonable costs of administering any aspects of sections 201, 203, 204, and 212 of this Act the responsibility for administration of which the Administrator has delegated to such State. The Administrator may increase such grant to take into account the reasonable costs of administering an approved program under section 402 or 404, administering a statewide waste treatment management planning program under section 208(b)(4), and managing waste treatment construction grants for small communities.

(h) The Administrator shall set aside from funds authorized for each fiscal year beginning on or after October 1, 1978, a total (as determined by the Governor of the State) of not less than 4 percent nor more than 7½ percent of the sums allotted to any State with a rural population of 25 per centum or more of the total population of such State, as determined by the Bureau of the Census. The Administrator may set aside no more than 7½ percent of the sums allotted to any other State for which the Governor requests such action. Such sums shall be available only for alternatives to conventional sewage treatment works for municipalities having a population of three thousand five hundred or less, or for the highly dispersed sections of larger municipalities, as defined by the Administrator.

(i) SET-ASIDE FOR INNOVATIVE AND ALTERNATIVE PROJECTS.—Not less than ½ of 1 percent of funds allotted to a State for each of the fiscal years ending September 30, 1979, through September 30, 1990, under subsection (c) of this section shall be expended only for increasing the Federal share of grants for construction of treatment works utilizing innovative processes and techniques pursuant to section 202(a)(2) of this Act. Including the expenditures authorized by the preceding sentence, a total of 2 percent of the funds allotted to a State for each of the fiscal years ending September 30, 1979, and September 30, 1980, and 3 percent of the funds allotted to a State for the fiscal year ending September 30, 1981, under subsection (c) of this section shall be expended only for increasing grants for construction of treatment works pursuant to section 202(a)(2) of this Act. Including the expenditures authorized by the first sentence of this subsection, a total (as determined by the Governor of the State) of not less than 4 percent nor more than 7½ percent of the funds allotted to such State under subsection (c) of this section for each of the fiscal years ending September 30, 1982, through September 30, 1990, shall be expended only for increasing the Federal share of grants for construction of treatment works pursuant to section 202(a)(2) of this Act.

(j)(1) The Administrator shall reserve each fiscal year not to exceed 1 per centum of the sums allotted and available for obligation to each State under this section for each fiscal year beginning on or after October 1, 1981, or $100,000, whichever amount is the greater.

(2) Such sums shall be used by the Administrator to make grants to the States to carry out water quality management planning, including, but not limited to—

(A) identifying most cost effective and locally acceptable facility and non-point measures to meet and maintain water quality standards;

(B) developing an implementation plan to obtain State and local financial and regulatory commitments to implement measures developed under subparagraph (A);

(C) determining the nature, extent, and causes of water quality problems in various areas of the State and interstate region, and reporting on these annually; and

(D) determining those publicly owned treatment works which should be constructed with assistance under this title, in which areas and in what sequence, taking into account the relative degree of effluent reduction attained, the relative contributions to water quality of other point or nonpoint sources, and the consideration of alternatives to such construction, and implementing section 303(e) of this Act.

(3) In carrying out planning with grants made under paragraph (2) of this subsection, a State shall develop jointly with local, regional, and interstate entities, a plan for carrying out the program and give funding priority to such entities and designated or undesignated public comprehensive planning organizations to carry out the purposes of this subsection. In giving such priority, the State shall allocate at least 40 percent of the amount granted to such State for a fiscal year under paragraph (2) of this subsection to regional public comprehensive planning organizations in such State and appropriate interstate organizations for the development and implementation of the plan described in this paragraph. In any fiscal year for which the Governor, in consultation with such organizations and with the approval of the Administrator, determines that allocation of at least 40 percent of such amount to such organizations will not result in significant participation by such organizations in water quality management planning and not significantly assist in development and implementation of the plan described in this paragraph and achieving the goals of this Act, the allocation to such organization may be less than 40 percent of such amount.

(4) All activities undertaken under this subsection shall be in coordination with other related provisions of this Act.

(5) NONPOINT SOURCE RESERVATION.—In addition to the sums reserved under paragraph (1), the Administrator shall reserve each fiscal year for each State 1 percent of the sums allotted and available for obligation to such State under this section for each fiscal year beginning on or after October 1, 1986, or $100,000, whichever is greater, for the purpose of carrying out section 319 of this Act. Sums so reserved in a State in any fiscal year for which such State does not request the use of such sums, to the extent such sums exceed $100,000, may be used by such State for other purposes under this title.

(k) The Administrator shall allot to the State of New York from sums authorized to be appropriated for the fiscal year ending September 30, 1982, an amount necessary to pay the entire cost of conveying sewage from the Convention Center of the City of New York to the Newtown sewage treatment plant, Brooklyn-Queens area, New York. The amount allotted under this subsection shall be in

addition to and not in lieu of any other amounts authorized to be allotted to such State under this Act.

(l) MARINE ESTUARY RESERVATION.—

(1) RESERVATION OF FUNDS.—

(A) GENERAL RULE.—Prior to making allotments among the States under subsection (c) of this section, the Administrator shall reserve funds from sums appropriated pursuant to section 207 for each fiscal year beginning after September 30, 1986.

(B) FISCAL YEARS 1987 AND 1988.—For each of fiscal years 1987 and 1988 the reservation shall be 1 percent of the sums appropriated pursuant to section 207 for such fiscal year.

(C) FISCAL YEARS 1989 AND 1990.—For each of fiscal years 1989 and 1990 the reservation shall be 1½ percent of the funds appropriated pursuant to section 207 for such fiscal year.

(2) USE OF FUNDS.—Of the sums reserved under this subsection, two-thirds shall be available to address water quality problems of marine bays and estuaries subject to lower levels of water quality due to the impacts of discharges from combined storm water and sanitary sewer overflows from adjacent urban complexes, and one-third shall be available for the implementation of section 320 of this Act, relating to the national estuary program.

(3) PERIOD OF AVAILABILITY.—Sums reserved under this subsection shall be subject to the period of availability for obligation established by subsection (d) of this section.

(4) TREATMENT OF CERTAIN BODY OF WATER.—For purposes of this section and section 201(n), Newark Bay, New Jersey, and the portion of the Passaic River up to Little Falls, in the vicinity of Beatties Dam, shall be treated as a marine bay and estuary.

(m) DISCRETIONARY DEPOSITS INTO STATE WATER POLLUTION CONTROL REVOLVING FUNDS.—

(1) FROM CONSTRUCTION GRANT ALLOTMENTS.—In addition to any amounts deposited in a water pollution control revolving fund established by a State under title VI, upon request of the Governor of such State, the Administrator shall make available to the State for deposit, as capitalization grants, in such fund in any fiscal year beginning after September 30, 1986, such portion of the amounts allotted to such State under this section for such fiscal year as the Governor considers appropriate; except that (A) in fiscal year 1987 such deposit may not exceed 50 percent of the amounts allotted to such State under this section for such fiscal year, and (B) in fiscal year 1988, such deposit may not exceed 75 percent of the amounts allotted to such State under this section for this[1] fiscal year.

(2) NOTICE REQUIREMENT.—The Governor of a State may make a request under paragraph (1) for a deposit into the water pollution control revolving fund of such State—

[1] So in original. Probably should be "such".

(A) in fiscal year 1987 only if no later than 90 days after the date of the enactment of this subsection, and

(B) in each fiscal year thereafter only if 90 days before the first day of such fiscal year,

the State provides notice of its intent to make such deposit.

(3) EXCEPTION.—Sums reserved under section 205(j) of this Act shall not be available for obligation under this subsection.

(33 U.S.C. 1285)

REIMBURSEMENT AND ADVANCED CONSTRUCTION

SEC. 206. (a) Any publicly owned treatment works in a State on which construction was initiated after June 30, 1966, but before July 1, 1973, which was approved by the appropriate State water pollution control agency and which the Administrator finds meets the requirements of section 8 of this Act in effect at the time of the initiation of construction shall be reimbursed a total amount equal to the difference between the amount of Federal financial assistance, if any, received under such section 8 for such project and 50 per centum of the cost of such project, or 55 per centum of the project cost where the Administrator also determines that such treatment works was constructed in conformity with a comprehensive metropolitan treatment plan as described in section 8(f) of the Federal Water Pollution Control Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. Nothing in this subsection shall result in any such works receiving Federal grants from all sources in excess of 80 per centum of the cost of such project.

(b) Any publicly owned treatment works constructed with or eligible for Federal financial assistance under this Act in a State between June 30, 1956, and June 30, 1966, which was approved by the State water pollution control agency and which the Administrator finds meets the requirements of section 8 of this Act prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 but which was constructed without assistance under such section 8 or which received such assistance in an amount less than 30 per centum of the cost of such project shall qualify for payments and reimbursement of State or local funds used for such project from sums allocated to such State under this section in an amount which shall not exceed the difference between the amount of such assistance, if any, received for such project and 30 per centum of the cost of such project.

(c) No publicly owned treatment works shall receive any payment or reimbursement under subsection (a) or (b) of this section unless an application for such assistance is filed with the Administrator within the one year period which begins on the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. Any application filed within such one year period may be revised from time to time, as may be necessary.

(d) The Administrator shall allocate to each qualified project under subsection (a) of this section each fiscal year for which funds are appropriated under subsection (e) of this section an amount ··ch bears the same ratio to the unpaid balance of the reimburse- ·: due such project as the total of such funds for such year

bears to the total unpaid balance of reimbursement due all such approved projects on the date of enactment of such appropriation. The Administrator shall allocate to each qualified project under subsection (b) of this section each fiscal year for which funds are appropriated under subsection (e) of this section an amount which bears the same ratio to the unpaid balance of the reimbursement due such project as the total of such funds for such year bears to the total unpaid balance of reimbursement due all such approved projects on the date of enactment of such appropriation.

(e) There is authorized to be appropriated to carry out subsection (a) of this section not to exceed $2,600,000,000 and, to carry out subsection (b) of this section, not to exceed $750,000,000. The authorizations contained in this subsection shall be the sole source of funds for reimbursements authorized by this section.

(f)(1) In any case where a substantial portion of the funds allotted to a State for the current fiscal year under this title have been obligated under section 201(g), or will be so obligated in a timely manner (as determined by the Administrator), and there is construction of any treatment work project without the aid of Federal funds and in accordance with all procedures and all requirements applicable to treatment works projects, except those procedures and requirements which limit construction of projects to those constructed with the aid of previously allotted Federal funds, the Administrator, upon his approval of an application made under this subsection therefore, is authorized to pay the Federal share of the cost of construction of such project when additional funds are allotted to the State under this title if prior to the construction of the project the Administrator approves plans, specifications, and estimates therefor in the same manner as other treatment works projects. The Administrator may not approve an application under this subsection unless an authorization is in effect for the first fiscal year in the period for which the application requests payment and such requested payment for that fiscal year does not exceed the State's expected allotment from such authorization. The Administrator shall not be required to make such requested payment for any fiscal year—

(A) to the extent that such payment would exceed such State's allotment of the amount appropriated for such fiscal year; and

(B) unless such payment is for a project which, on the basis of an approved funding priority list of such State, is eligible to receive such payment based on the allotment and appropriation for such fiscal year.

To the extent that sufficient funds are not appropriated to pay the full Federal share with respect to a project for which obligations under the provisions of this subsection have been made, the Administrator shall reduce the Federal share to such amount less than 75 per centum as such appropriations do provide.

(2) In determining the allotment for any fiscal year under this title, any treatment works project constructed in accordance with this section and without the aid of Federal funds shall not be considered completed until an application under the provisions of this subsection with respect to such project has been approv· ·· the

Administrator, or the availability of funds from which this project is eligible for reimbursement has expired, whichever first occurs.

(33 U.S.C. 1286)

AUTHORIZATION

SEC. 207. There is authorized to be appropriated to carry out this title, other than sections 206(e), 208 and 209, for the fiscal year ending June 30, 1973, not to exceed $5,000,000,000, for the fiscal year ending June 30, 1974, not to exceed $6,000,000,000, and for the fiscal year ending June 30, 1975, not to exceed $7,000,000,000, and, subject to such amounts as are provided in appropriation Acts for the fiscal year ending September 30, 1977, $1,000,000,000 for the fiscal year ending September 30, 1978, $4,500,000,000 and for the fiscal years ending September 30, 1979, September 30, 1980, not to exceed $5,000,000,000; for the fiscal year ending September 30, 1981, not to exceed $2,548,837,000; and for the fiscal years ending September 30, 1982, September 30, 1983, September 30, 1984, and September 30, 1985, not to exceed $2,400,000,000 per fiscal year; and for each of the fiscal years ending September 30, 1986, September 30, 1987, and September 30, 1988, not to exceed $2,400,000,000; and for each of the fiscal years ending September 30, 1989, and September 30, 1990, not to exceed $1,200,000,000.

(33 U.S.C. 1287)

AREAWIDE WASTE TREATMENT MANAGEMENT

SEC. 208. (a) For the purpose of encouraging and facilitating the development and implementation of areawide waste treatment management plans—

(1) The Administrator, within ninety days after the date of enactment of this Act and after consultation with appropriate Federal, State, and local authorities, shall by regulation publish guidelines for the identification of those areas which, as a result of urban-industrial concentrations or other factors, have substantial water quality control problems.

(2) The Governor of each State, within sixty days after publication of the guidelines issued pursuant to paragraph (1) of this subsection, shall identify each area within the State which, as a result of urban-industrial concentrations or other factors, has substantial water quality control problems. Not later than one hundred and twenty days following such identification and after consultation with appropriate elected and other officials of local governments having jurisdiction in such areas, the Governor shall designate (A) the boundaries of each such area, and (B) a single representative organization, including elected officials from local governments or their designees, capable of developing effective areawide waste treatment management plans for such an area. The Governor may in the same manner at any later time identify any additional area (or modify an existing area) for which he determines areawide waste treatment management to be appropriate, designate the boundaries of such area, and designate an organization capable

of developing effective areawide waste treatment management plans for such area.

(3) With respect to any area which, pursuant to the guidelines published under paragraph (1) of this subsection, is located in two or more States, the Governors of the respective States shall consult and cooperate in carrying out the provisions of paragraph (2), with a view toward designating the boundaries of the interstate area having common water quality control problems and for which areawide waste treatment management plans would be most effective, and toward designating, within one hundred and eighty days after publication of guidelines issued pursuant to paragraph (1) of this subsection, of a single representative organization capable of developing effective areawide waste treatment management plans for such area.

(4) If a Governor does not act, either by designating or determining not to make a designation under paragraph (2) of this subsection, within the time required by such paragraph, or if, in the case of an interstate area, the Governors of the States involved do not designate a planning organization within the time required by paragraph (3) of this subsection, the chief elected officials of local governments within an area may by agreement designate (A) the boundaries for such an area, and (B) a single representative organization including elected officials from such local governments, or their designees, capable of developing an areawide waste treatment management plan for such area.

(5) Existing regional agencies may be designated under paragraphs (2), (3), and (4) of this subsection.

(6) The State shall act as a planning agency for all portions of such State which are not designated under paragraphs (2), (3), or (4) of this subsection.

(7) Designations under this subsection shall be subject to the approval of the Administrator.

(b)(1)(A) Not later than one year after the date of designation of any organization under subsection (a) of this section such organization shall have in operation a continuing areawide waste treatment management planning process consistent with section 201 of this Act. Plans prepared in accordance with this process shall contain alternatives for waste treatment management, and be applicable to all wastes generated within the area involved. The initial plan prepared in accordance with such process shall be certified by the Governor and submitted to the Administrator not later than two years after the planning process is in operation.

(B) For any agency designated after 1975 under subsection (a) of this section and for all portions of a State for which the State is required to act as the planning agency in accordance with subsection (a)(6), the initial plan prepared in accordance with such process shall be certified by the Governor and submitted to the Administrator not later than three years after the receipt of the initial grant award authorized under subsection (f) of this section.

(2) Any plan prepared under such process shall include, but not be limited to—

(A) the identification of treatment works necessary to meet the anticipated municipal and industrial waste treatment needs of the area over a twenty-year period, annually updated (including an analysis of alternative waste treatment systems), including any requirements for the acquisition of land for treatment purposes; the necessary waste water collection and urban storm water runoff systems; and a program to provide the necessary financial arrangements for the development of such treatment works, and an identification of open space and recreation opportunities that can be expected to result from improved water quality, including consideration of potential use of lands associated with treatment works and increased access to water-based recreation;

(B) the establishment of construction priorities for such treatment works and time schedules for the initiation and completion of all treatment works;

(C) the establishment of a regulatory program to—

(i) implement the waste treatment management requirements of section 201(c),

(ii) regulate the location, modification, and construction of any facilities within such area which may result in any discharge in such area, and

(iii) assure that any industrial or commercial waste discharged into any treatment works in such area meet applicable pretreatment requirements;

(D) the identification of those agencies necessary to construct, operate, and maintain all facilities required by the plan and otherwise to carry out the plan;

(E) the identification of the measures necessary to carry out the plan (including financing), the period of time necessary to carry out the plan, the costs of carrying out the plan within such time, and the economic, social, and environmental impact of carrying out the plan within such time;

(F) a process to (i) identify, if appropriate, agriculturally and silviculturally related nonpoint sources of pollution, including return flows from irrigated agriculture, and their cumulative effects, runoff from manure disposal areas, and from land used for livestock and crop production, and (ii) set forth procedures and methods (including land use requirements) to control to the extent feasible such sources;

(G) a process of (i) identify, if appropriate, mine-related sources of pollution including new, current, and abandoned surface and underground mine runoff, and (ii) set forth procedures and methods (including land use requirements) to control to the extent feasible such sources;

(H) a process to (i) identify construction activity related sources of pollution, and (ii) set forth procedures and methods (including land use requirements) to control to the extent feasible such sources;

(I) a process to (i) identify, if appropriate, salt water intrusion into rivers, lakes, and estuaries resulting from reduction of fresh water flow from any cause, including irrigation, obstruction, ground water extraction, and diversion, and (ii) set forth procedures and methods to control such intrusion to the

extent feasible where such procedures and methods are otherwise a part of the waste treatment management plan;

(J) a process to control the disposition of all residual waste generated in such area which could affect water quality; and

(K) a process to control the disposal of pollutants on land or in subsurface excavations within such area to protect ground and surface water quality.

(3) Areawide waste treatment management plans shall be certified annually by the Governor or his designee (or Governors or their designees, where more than one State is involved) as being consistent with applicable basin plans and such areawide waste treatment management plans shall be submitted to the Administrator for his approval.

(4)(A) Whenever the Governor of any State determines (and notifies the Administrator) that consistency with a statewide regulatory program under section 303 so requires, the requirements of clauses (F) through (K) of paragraph (2) of this subsection shall be developed and submitted by the Governor to the Administrator for approval for application to a class or category of activity throughout such State.

(B) Any program submitted under subparagraph (A) of this paragraph which, in whole or in part, is to control the discharge or other placement of dredged or fill material into the navigable waters shall include the following:

(i) A consultation process which includes the State agency with primary jurisdiction over fish and wildlife resources.

(ii) A process to identify and manage the discharge or other placement of dredged or fill material which adversely affects navigable waters, which shall complement and be coordinated with a State program under section 404 conducted pursuant to this Act.

(iii) A process to assure that any activity conducted pursuant to a best management practice will comply with the guidelines established under section 404(b)(1), and sections 307 and 403 of this Act.

(iv) A process to assure that any activity conducted pursuant to a best management practice can be terminated or modified for cause including, but not limited to, the following:

(I) violation of any condition of the best management practice;

(II) change in any activity that requires either a temporary or permanent reduction or elimination of the discharge pursuant to the best management practice.

(v) A process to assure continued coordination with Federal and Federal-State water-related planning and reviewing processes, including the National Wetlands Inventory.

(C) If the Governor of a State obtains approval from the Administrator of a statewide regulatory program which meets the requirements of subparagraph (B) of this paragraph and if such State is administering a permit program under section 404 of this Act, no person shall be required to obtain an individual permit pursuant to such section, or to comply with a general permit issued pursuant to such section, with respect to any appropriate activity within such State for which a best management practice has been approved by the Administrator under the program approved by the Administrator pursuant to this paragraph.

(D)(i) Whenever the Administrator determines after public hearing that a State is not administering a program approved under this section in accordance with the requirements of this section, the Administrator shall so notify the State, and if appropriate corrective action is not taken within a reasonable time, not to exceed ninety days, the Administrator shall withdraw approval of such program. The Administrator shall not withdraw approval of any such program unless he shall first have notified the State, and made public, in writing, the reasons for such withdrawal.

(ii) In the case of a State with a program submitted and approved under this paragraph, the Administrator shall withdraw approval of such program under this subparagraph only for a substantial failure of the State to administer its program in accordance with the requirements of this paragraph.

(c)(1) The Governor of each State, in consultation with the planning agency designated under subsection (a) of this section, at the time a plan is submitted to the Administrator, shall designate one or more waste treatment management agencies (which may be an existing or newly created local, regional or State agency or potential subdivision) for each area designated under subsection (a) of this section and submit such designations to the Administrator.

(2) The Administrator shall accept any such designation, unless, within 120 days of such designation, he finds that the designated management agency (or agencies) does not have adequate authority—

(A) to carry out appropriate portions of an areawide waste treatment management plan developed under subsection (b) of this section;

(B) to manage effectively waste treatment works and related facilities serving such area in conformance with any plan required by subsection (b) of this section;

(C) directly or by contract, to design and construct new works, and to operate and maintain new and existing works as required by any plan developed pursuant to subsection (b) of this section;

(D) to accept and utilize grants, or other funds from any source, for waste treatment management purposes;

(E) to raise revenues, including the assessment of waste treatment charges;

(F) to incur short- and long-term indebtedness;

(G) to assure in implementation of an areawide waste treatment management plan that each participating community pays its proportionate share of treatment costs;

(H) to refuse to receive any wastes from any municipality or subdivision thereof, which does not comply with any provisions of an approved plan under this section applicable to such area; and

(I) to accept for treatment industrial wastes.

(d) After a waste treatment management agency having the authority required by subsection (c) has been designated under such subsection for an area and a plan for such area has been approved under subsection (b) of this section, the Administrator shall

not make any grant for construction of a publicy owned treatment works under section 201(g)(1) within such area except to such designated agency and for works in conformity with such plan.

(e) No permit under section 402 of this Act shall be issued for any point source which is in conflict with a plan approved pursuant to subsection (b) of this section.

(f)(1) The Administrator shall make grants to any agency designated under subsection (a) of this section for payment of the reasonable costs of developing and operating a continuing areawide waste treatment management planning process under subsection (b) of this section.

(2) For the two-year period beginning on the date of the first grant is made under paragraph (1) of this subsection to an agency, if such first grant is made before October 1, 1977, the amount of each such grant to such agency shall be 100 per centum of the costs of developing and operating a continuing areawide waste treatment management planning process under subsection (b) of this section, and thereafter the amount granted to such agency shall not exceed 75 per centum of such costs in each succeeding one-year period. In the case of any other grant made to an agency under such paragraph (1) of this subsection, the amount of such grant shall not exceed 75 per centum of the costs of developing and operating a continuing areawide waste treatment management planning process in any year.

(3) Each applicant for a grant under this subsection shall submit to the Administrator for his approval each proposal for which a grant is applied for under this subsection. The Administrator shall act upon such proposal as soon as practicable after it has been submitted, and his approval of that proposal shall be deemed a contractual obligation of the United States for the payment of its contribution to such proposal, subject to such amounts as are provided in appropriation Acts. There is authorized to be appropriated to carry out this subsection not to exceed $50,000,000 for the fiscal year ending June 30, 1973, not to exceed $100,000,000 for the fiscal year ending June 30, 1974, not to exceed $150,000,000 per fiscal year for the fiscal years ending June 30, 1975, September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, not to exceed $100,000,000 per fiscal year for the fiscal years ending September 30, 1981, and September 30, 1982, and such sums as may be necessary for fiscal years 1983 through 1990.

(g) The Administrator is authorized, upon request of the Governor or the designated planning agency, and without reimbursement, to consult with, and provide technical assistance to, any agency designated under subsection (a) of this section in the development of areawide waste treatment management plans under subsection (b) of this section.

(h)(1) The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Administrator is authorized and directed, upon request of the Governor or the designated planning organization, to consult with, and provide technical assistance to, any agency designed[1] under subsection (a) of this section in devel-

[1] So in original. Probably should be "designated".

oping and operating a continuing areawide waste treatment management planning process under subsection (b) of this section.

(2) There is authorized to be appropriated to the Secretary of the Army, to carry out this subsection, not to exceed $50,000,000 per fiscal year for the fiscal years ending June 30, 1973, and June 30, 1974.

(i)(1) The Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service, shall, upon request of the Governor of a State, and without reimbursement, provide technical assistance to such State in developing a statewide program for submission to the Administrator under subsection (b)(4)(B) of this section and in implementing such program after its approval.

(2) There is authorized to be appropriated to the Secretary of the Interior $6,000,000 to complete the National Wetlands Inventory of the United States, by December 31, 1981, and to provide information from such Inventory to States as it becomes available to assist such States in the development and operation of programs under this Act.

(j)(1) The Secretary of Agriculture, with the concurrence of the Administrator, and acting through the Soil Conservation Service and such other agencies of the Department of Agriculture as the Secretary may designate, is authorized and directed to establish and administer a program to enter into contracts, subject to such amounts as are provided in advance by appropriation acts, of not less than five years nor more than ten years with owners and operators having control of rural land for the purpose of installing and maintaining measures incorporating best management practices to control nonpoint source pollution for improved water quality in those States or areas for which the Administrator has approved a plan under subsection (b) of this section where the practices to which the contracts apply are certified by the management agency designated under subsection (c)(1) of this section to be consistent with such plans and will result in improved water quality. Such contracts may be entered into during the period ending not later than September 31, 1988. Under such contracts the land owners or operator shall agree—

(i) to effectuate a plan approved by a soil conservation district, where one exists, under this section for his farm, ranch, or other land substantially in accordance with the schedule outlined therein unless any requirement thereof is waived or modified by the Secretary;

(ii) to forfeit all rights to further payments or grants under the contract and refund to the United States all payments and grants received thereunder, with interest, upon his violation of the contract at any stage during the time he has control of the land if the Secretary, after considering the recommendations of the soil conservation district, where one exists, and the Administrator, determines that such violation is of such a nature as to warrant termination of the contract, or to make refunds or accept such payment adjustments as the Secretary may deem appropriate if he determines that the violation by the owner or operator does not warrant termination of the contract;

(iii) upon transfer of his right and interest in the farm, ranch, or other land during the contract period to forfeit all rights to further payments or grants under the contract and refund to the United States all payments or grants received thereunder, with interest, unless the transferee of any such land agrees with the Secretary to assume all obligations of the contract;

(iv) not to adopt any practice specified by the Secretary on the advice of the Administrator in the contract as a practice which would tend to defeat the purposes of the contract;

(v) to such additional provisions as the Secretary determines are desirable and includes in the contract to effectuate the purposes of the program or to facilitate the practical administration of the program.

(2) In return for such agreement by the landowner or operator the Secretary shall agree to provide technical assistance and share the cost of carrying out those conservation practices and measures set forth in the contract for which he determines that cost sharing is appropriate and in the public interest and which are approved for cost sharing by the agency designated to implement the plan developed under subsection (b) of this section. The portion of such cost (including labor) to be shared shall be that part which the Secretary determines is necessary and appropriate to effectuate the installation of the water quality management practices and measures under the contract, but not to exceed 50 per centum of the total cost of the measures set forth in the contract; except the Secretary may increase the matching cost share where he determines that (1) the main benefits to be derived from the measures are related to improving offsite water quality, and (2) the matching share requirement would place a burden on the landowner which would probably prevent him from participating in the program.

(3) The Secretary may terminate any contract with a landowner or operator by mutual agreement with the owner or operator if the Secretary determines that such termination would be in the public interest, and may agree to such modification of contracts previously entered into as he may determine to be desirable to carry out the purposes of the program or facilitate the practical administration thereof or to accomplish equitable treatment with respect to other conservation, land use, or water quality programs.

(4) In providing assistance under this subsection the Secretary will give priority to those areas and sources that have the most significant effect upon water quality. Additional investigations or plans may be made, where necessary, to supplement approved water quality management plans, in order to determine priorities.

(5) The Secretary shall, where practicable, enter into agreements with soil conservation districts, State soil and water conservation agencies, or State water quality agencies to administer all or part of the program established in this subsection under regulations developed by the Secretary. Such agreements shall provide for the submission of such reports as the Secretary deems necessary, and for payment by the United States of such portion of the costs incurred in the administration of the program as the Secretary may deem appropriate.

(6) The contracts under this subsection shall be entered into only in areas where the management agency designated under subsection (c)(1) of this section assures an adequate level of participation by owners and operators having control of rural land in such areas. Within such areas the local soil conservation district, where one exists, together with the Secretary of Agriculture, will determine the priority of assistance among individual land owners and operators to assure that the most critical water quality problems are addressed.

(7) The Secretary, in consultation with the Administrator and subject to section 304(k) of this Act, shall, not later than September 30, 1978, promulgate regulations for carrying out this subsection and for support and cooperation with other Federal and non-Federal agencies for implementation of this subsection.

(8) This program shall not be used to authorize or finance projects that would otherwise be eligible for assistance under the terms of Public Law 83–566.

(9) There are hereby authorized to be appropriated to the Secretary of Agriculture $200,000,000 for fiscal year 1979, $400,000,000 for fiscal year 1980, $100,000,000 for fiscal year 1981, $100,000,000 for fiscal year 1982, and such sums as may be necessary for fiscal years 1983 through 1990, to carry out this subsection. The program authorized under this subsection shall be in addition to, and not in substitution of, other programs in such area authorized by this or any other public law.

(33 U.S.C. 1288)

BASIN PLANNING

SEC. 209. (a) The President, acting through the Water Resources Council, shall, as soon as practicable, prepare a Level B plan under the Water Resource Planning Act for all basins in the United States. All such plans shall be completed not later than January 1, 1980, except that priority in the preparation of such plans shall be given to those basins and portions thereof which are within those areas designated under paragraphs (2), (3), and (4) of subsection (a) of section 208 of this Act.

(b) The President, acting through the Water Resources Council, shall report annually to Congress on progress being made in carrying out this section. The first such report shall be submitted not later than January 31, 1973.

(c) There is authorized to be appropriated to carry out this section not to exceed $200,000,000.

(33 U.S.C. 1289)

ANNUAL SURVEY

SEC. 210. The Administrator shall annually make a survey to determine the efficiency of the operation and maintenance of treatment works constructed with grants made under this Act, as compared to the efficiency planned at the time the grant was made. The results of such annual survey shall be included in the report required under section 516(a) of this Act.

(33 U.S.C. 1290)

SEWAGE COLLECTION SYSTEMS

SEC. 211. (a) No grant shall be made for a sewage collection system under this title unless such grant (1) is for replacement or major rehabilitation of an existing collection system and is necessary to the total integrity and performance of the waste treatment works serving such community, or (2) is for a new collection system in an existing community with sufficient existing or planned capacity adequately to treat such collected sewage and is consistent with section 201 of this Act.

(b) If the Administrator uses population density as a test for determining the eligibility of a collector sewer for assistance it shall be only for the purpose of evaluating alternatives and determining the needs for such system in relation to ground or surface water quality impact.

(c) No grant shall be made under this title from funds authorized for any fiscal year during the period beginning October 1, 1977, and ending September 30, 1990, for treatment works for control of pollutant discharges from separate storm sewer systems.

(33 U.S.C. 1291)

DEFINITIONS

SEC. 212. As used in this title—

(1) The term "construction" means any one or more of the following: preliminary planning to determine the feasibility of treatment works, engineering, architectural, legal, fiscal, or economic investigations or studies, surveys, designs, plans, working drawings, specifications, procedures, field testing of innovative or alternative waste water treatment processes and techniques meeting guidelines promulgated under section 304(d)(3) of this Act, or other necessary actions, erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works, or the inspection or supervision of any of the foregoing items.

(2)(A) The term "treatment works" means any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature to implement section 201 of this act, or necessary to recycle or reuse water at the most economical cost over the estimated life of the works, including intercepting sewers, outfall sewers, sewage collection systems, pumping, power, and other equipment, and their appurtenances; extensions, improvements, remodeling, additions, and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities; and any works, including site acquisition of the land that will be an integral part of the treatment process (including land use for the storage of treated wastewater in land treatment systems prior to land application) or is used for ultimate disposal of residues resulting from such treatment.

(B) In addition to the definition contained in subparagraph (A) of this paragraph, "treatment works" means any other method or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste, including storm water runoff, or industrial waste, including waste in combined storm water and sanitary sewer systems. [illegible] which includes wholly or in part such methods or systems shall, in accordance with guidelines published by the Administrator pursuant to subparagraph (C) of this paragraph, contain adequate data and analysis demonstrating such proposal to be, over the life of such works, the most cost efficient alternative to comply with sections 301 or 302 of this Act, or the requirements of section 201 of this Act.

(C) For the purposes of subparagraph (B) of this paragraph, the Administrator shall, within one hundred and eighty days after the date of enactment of this title, publish and thereafter revise no less often than annually, guidelines for the evaluation of methods, including cost-effective analysis, described in subparagraph (B) of this paragraph.

(3) The term "replacement" as used in this title means those expenditures for obtaining and installing equipment, accessories, or appurtenances during the useful life of the treatment works necessary to maintain the capacity and performance for which such works are designed and constructed.

(33 U.S.C. 1292)

LOAN GUARANTEES FOR CONSTRUCTION OF TREATMENT WORKS

SEC. 213. (a) Subject to the conditions of this section and to such terms and conditions as the Administrator determines to be necessary to carry out the purposes of this title, the Administrator is authorized to guarantee, and to make commitments to guarantee, the principal and interest (including interest accruing between the date of default and the date of the payment in full of the guarantee) of any loan, obligation, or participation therein of any State, municipality, or intermunicipal or interstate agency issued directly and exclusively to the Federal Financing Bank to finance that part of the cost of any grant-eligible project for the construction of publicly owned treatment works not paid for with Federal financial assistance under this title (other than this section), which project the Administrator has determined to be eligible for such financial assistance under this title, including, but not limited to, projects eligible for reimbursement under section 206 of this title.

(b) No guarantee, or commitment to make a guarantee, may be made pursuant to this section—

(1) unless the Administrator certifies that the issuing body is unable to obtain on reasonable terms sufficient credit to finance its actual needs without such guarantee; and

(2) unless the Administrator determines that there is a reasonable assurance or repayment of the loan, obligation, or participation therein.

A determination of whether financing is available at reasonable rates shall be made by the Secretary of the Treasury with relationship to the current average yield on outstanding marketable obligations of municipalities of comparable maturity.

(c) The Administrator is authorized to charge reasonable fees for the investigation of an application for a guarantee and for the issuance of a commitment to make a guarantee.

(d) The Administrator, in determining whether there is a reasonable assurance of repayment, may require a commitment which

would apply to such repayment. Such commitment may include, but not be limited to, any funds received by such grantee from the amounts appropriated under section 206 of this Act.

(33 U.S.C. 1293)

PUBLIC INFORMATION

SEC. 214. The Administrator shall develop and operate within one year of the date of enactment of this section, a continuing program of public information and education on recycling and reuse of wastewater (including sludge), the use of land treatment, and methods for the reduction of wastewater volume.

(33 U.S.C. 1294)

REQUIREMENTS FOR AMERICAN MATERIALS

SEC. 215. Notwithstanding any other provision of law, no grant for which application is made after February 1, 1978, shall be made under this title for any treatment works unless only such unmanufactured articles, materials, and supplies as have been mined or produced in the United States, and only such manufactured articles, materials, and supplies as have been manufactured in the United States, substantially all from articles, materials, or supplies mined, produced, or manufactured, as the case may be, in the United States will be used in such treatment works. This section shall not apply in any case where the Administrator determines, based upon those factors the Administrator deems relevant, including the available resources of the agency, it to be inconsistent with the public interest (including multilateral government procurement agreements) or the cost to be unreasonable. or if articles, materials, or supplies of the class or kind to be used or the articles, materials, or supplies from which they are manufactured are not mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality.

(33 U.S.C. 1295)

DETERMINATION OF PRIORITY

SEC. 216. Notwithstanding any other provision of this Act, the determination of the priority to be given each category of projects for construction of publicly owned treatment works within each State shall be made solely by that State, except that if the Administrator, after a public hearing, determines that a specific project will not result in compliance with the enforceable requirements of this Act, such project shall be removed from the State's priority list and such State shall submit a revised priority list. These categories shall include, but not be limited to (A) secondary treatment, (B) more stringent treatment, (C) infiltration-in-flow correction, (D) major sewer system rehabilitation, (E) new collector sewers and appurtenances, (F) new interceptors and appurtenances, and (G) correction of combined sewer overflows. Not less than 25 per centum of funds allocated to a State in any fiscal year under this title for construction of publicly owned treatment works in such State shall be obligated for those types of projects referred to in clauses (D), (E), (F), and (G) of this section, if such projects are on such State's priority list for that year and are otherwise eligible for funding in that fiscal year. It is the policy of Congress that projects for wastewater treatment and management undertaken with Federal financial assistance under this Act by any State, municipality, or intermunicipal or interstate agency shall be projects which, in the estimation of the State, are designed to achieve optimum water quality management, consistent with the public health and water quality goals and requirements of the Act.

(33 U.S.C. 1296)

COST-EFFECTIVENESS GUIDELINES

SEC. 217. Any guidelines for cost-effectiveness analysis published by the Administrator under this title shall provide for the identification and selection of cost effective alternatives to comply with the objective and goals of this Act and sections 201(b), 201(d), 201(g)(2)(A), and 301(b)(2)(B) of this Act.

(33 U.S.C. 1297)

COST EFFECTIVENESS

SEC. 218. (a) It is the policy of Congress that a project for waste treatment and management undertaken with Federal financial assistance under this Act by any State, municipality, or intermunicipal or interstate agency shall be considered as an overall waste treatment system for waste treatment and management, and shall be that system which constitutes the most economical and cost-effective combination of devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature to implement section 201 of this Act, or necessary to recycle or reuse water at the most economical cost over the estimated life of the works, including intercepting sewers, outfall sewers, sewage collection systems, pumping power, and other equipment, and their appurtenances; extension, improvements, remodeling, additions, and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities; and any works, including site acquisition of the land that will be an integral part of the treatment process (including land use for the storage of treated wastewater in land treatment systems prior to land application) or which is used for ultimate disposal of residues resulting from such treatment; water efficiency measures and devices; and any other method or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste, including storm water runoff, or industrial waste, including waste in combined storm water and sanitary sewer systems; to meet the requirements of this Act.

(b) In accordance with the policy set forth in subsection (a) of this section, before the Administrator approves any grant to any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of any treatment works the Administrator shall determine that the facilities plan of which such treatment works are a part constitutes the most economical and cost-effective combination of treatment works over the life of the project to meet the

requirements of this Act, including, but not limited to, consideration of construction costs, operation, maintenance, and replacement costs.

(c) In furtherance of the policy set forth in subsection (a) of this section, the Administrator shall require value engineering review in connection with any treatment works, prior to approval of any grant for the erection, building, acquisition, alteration, remodeling, improvement, or extension of such treatment works, in any case in which the cost of such erection, building, acquisition, alteration, remodeling, improvement, or extension is projected to be in excess of $10,000,000. For purposes of this subsection, the term "value engineering review" means a specialized cost control technique which uses a systematic and creative approach to identify and to focus on unnecessarily high cost in a project in order to arrive at a cost saving without sacrificing the reliability or efficiency of the project.

(d) This section applies to projects for waste treatment and management for which no treatment works including a facilities plan for such project have received Federal financial assistance for the preparation of construction plans and specifications under this Act before the date of enactment of this section.

(33 U.S.C. 1298)

STATE CERTIFICATION OF PROJECTS

SEC. 219. Whenever the Governor of a State which has been delegated sufficient authority to administer the construction grant program under this title in that State certifies to the Administrator that a grant application meets applicable requirements of Federal and State law for assistance under this title, the Administrator shall approve or disapprove such application within 45 days of the date of receipt of such application. If the Administrator does not approve or disapprove such application within 45 days of receipt, the application shall be deemed approved. If the Administrator disapproves such application the Administrator shall state in writing the reasons for such disapproval. Any grant approved or deemed approved under this section shall be subject to amounts provided in appropriation Acts.

(33 U.S.C. 1299)

TITLE III—STANDARDS AND ENFORCEMENT

EFFLUENT LIMITATIONS

SEC. 301. (a) Except as in compliance with this section and sections 302, 306, 307, 318, 402, and 404 of this Act, the discharge of any pollutant by any person shall be unlawful.

(b) In order to carry out the objective of this Act there shall be achieved—

(1)(A) not later than July 1, 1977, effluent limitations for point sources, other than publicly owned treatment works, (i) which shall require the application of the best practicable control technology currently available as defined by the Administrator pursuant to section 304(b) of this Act, or (ii) in the case of a discharge into a publicly owned treatment works which meets the requirements of subparagraph (B) of this paragraph, which shall require compliance with any applicable pretreatment requirements and any requirements under section 307 of this Act; and

(B) for publicly owned treatment works in existence on July 1, 1977, or approved pursuant to section 203 of this Act prior to June 30, 1974 (for which construction must be completed within four years of approval), effluent limitations based upon secondary treatment as defined by the Administrator pursuant to section 304(d)(1) of this Act; or,

(C) not later than July 1, 1977, any more stringent limitation, including those necessary to meet water quality standards, treatment standards, or schedule of compliance, established pursuant to any State law or regulations, (under authority preserved by section 510) or any other Federal law or regulation, or required to implement any applicable water quality standard established pursuant to this Act.

(2)(A) for pollutants identified in subparagraphs (C), (D), and (F) of this paragraph, effluent limitations for categories and classes of point sources, other than publicly owned treatment works, which (i) shall require application of the best available technology economically achievable for such category or class, which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to section 304(b)(2) of this Act, which such effluent limitations shall require the elimination of discharges of all pollutants if the Administrator finds, on the basis of information available to him (including information developed pursuant to section 315), that such elimination is technologically and economically achievable for category or class of point sources as determined in accordance with regulations issued by the Administrator pursuant to section 304(b)(2) of this Act, or (ii) in the case of the introduction of a pollutant into a publicly owned treatment works which meets the requirements of subparagraph (B) of this paragraph, shall require compliance with any applicable pretreatment requirements and any other requirement under section 307 of this Act;

[(B) subparagraph (B) repealed by section 21(b) of P.L. 97-117.]

(C) with respect to all toxic pollutants referred to in table 1 of Committee Print Numbered 95-30 of the Committee on Public Works and Transportation of the House of Representatives compliance with effluent limitations in accordance with subparagraph (A) of this paragraph as expeditiously as practicable but in no case later than three years after the date such limitations are promulgated under section 304(b), and in no case later than March 31, 1989;

(D) for all toxic pollutants listed under paragraph (1) of subsection (a) of section 307 of this Act which are not referred to in subparagraph (C) of this paragraph compliance with effluent limitation in accordance with subparagraph (A) of this paragraph as expeditiously as practicable, but in no case later than three years after the date such limitations are promulgated under section 304(b), and in no case later than March 31, 1989;

(E) as expeditiously as practicable but in no case later than three years after the date such limitations are promulgated under section 304(b), and in no case later than March 31, 1989, compliance with effluent limitations for categories and classes of point sources, other than publicly owned treatment works, which in the case of pollutants identified pursuant to section 304(a)(4) of this Act shall require application of the best conventional pollutant control technology as determined in accordance with regulations issued by the Administrator pursuant to section 304(b)(4) of this Act; and

(F) for all pollutants (other than those subject to subparagraphs (C), (D), or (E) of this paragraph) compliance with effluent limitations in accordance with subparagraph (A) of this paragraph as expeditiously as practicable but in no case later than 3 years after the date such limitations are established, and in no case later than March 31, 1989.

(3)(A) for effluent limitations under paragraph (1)(A)(i) of this subsection promulgated after January 1, 1982, and requiring a level of control substantially greater or based on fundamentally different control technology than under permits for an industrial category issued before such date, compliance as expeditiously as practicable but in no case later than three years after the date such limitations are promulgated under section 304(b), and in no case later than March 31, 1989; and

(B) for any effluent limitation in accordance with paragraph (1)(A)(i), (2)(A)(i), or (2)(E) of this subsection established only on the basis of section 402(a)(1) in a permit issued after enactment of the Water Quality Act of 1987, compliance as expeditiously as practicable but in no case later than three years after the date such limitations are established, and in no case later than March 31, 1989.

(c) The Administrator may modify the requirements of subsection (b)(2)(A) of this section with respect to any point source for which a permit application is filed after July 1, 1977, upon a showing by the owner or operator of such point source satisfactory to the Administrator that such modified requirements (1) will represent the maximum use of technology within the economic capability of the owner or operator; and (2) will result in reasonable further progress toward the elimination of the discharge of pollutants.

(d) Any effluent limitation required by paragraph (2) of subsection (b) of this section shall be reviewed at least every five years and, if appropriate, revised pursuant to the procedure established under such paragraph.

(e) Effluent limitations established pursuant to this section or section 302 of this Act shall be applied to all point sources of discharge of pollutants in accordance with the provisions of this Act.

(f) Notwithstanding any other provisions of this Act it shall be unlawful to discharge any radiological, chemical, or biological warfare agent, any high-level radioactive waste, or any medical waste, into the navigable waters.

(g) MODIFICATIONS FOR CERTAIN NONCONVENTIONAL POLLUTANTS.—

(1) GENERAL AUTHORITY.—The Administrator, with the concurrence of the State, may modify the requirements of subsection (b)(2)(A) of this section with respect to the discharge from any point source of ammonia, chlorine, color, iron, and total phenols (4AAP) (when determined by the Administrator to be a pollutant covered by subsection (b)(2)(F)) and any other pollutant which the Administrator lists under paragraph (4) of this subsection.

(2) REQUIREMENTS FOR GRANTING MODIFICATIONS.—A modification under this subsection shall be granted only upon a showing by the owner or operator of a point source satisfactory to the Administrator that—

(A) such modified requirements will result at a minimum in compliance with the requirements of subsection (b)(1)(A) or (C) of this section, whichever is applicable;

(B) such modified requirements will not result in any additional requirements on any other point or nonpoint source; and

(C) such modification will not interfere with the attainment or maintenance of that water quality which shall assure protection of public water supplies, and the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities, in and on the water and such modification will not result in the discharge of pollutants in quantities which may reasonably be anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistency in the environment, acute toxicity, chronic toxicity (including carcinogenicity, mutagenicity or teratogenicity), or synergistic propensities.

(3) LIMITATION ON AUTHORITY TO APPLY FOR SUBSECTION (c) MODIFICATION.—If an owner or operator of a point source applies for a modification under this subsection with respect to the discharge of any pollutant, such owner or operator shall be eligible to apply for modification under subsection (c) of this section with respect to such pollutant only during the same time-period as he is eligible to apply for a modification under this subsection.

(4) PROCEDURES FOR LISTING ADDITIONAL POLLUTANTS.—

(A) GENERAL AUTHORITY.—Upon petition of any person, the Administrator may add any pollutant to the list of pollutants for which modification under this section is authorized (except for pollutants identified pursuant to section 304(a)(4) of this Act, toxic pollutants subject to section 307(a) of this Act, and the thermal component of discharges) in accordance with the provisions of this paragraph.

(B) REQUIREMENTS FOR LISTING.—

(i) SUFFICIENT INFORMATION.—The person petitioning for listing of an additional pollutant under this subsection shall submit to the Administrator sufficient information to make the determinations required by this subparagraph.

(ii) TOXIC CRITERIA DETERMINATION.—The Administrator shall determine whether or not the pollutant meets the criteria for listing as a toxic pollutant under section 307(a) of this Act.

(iii) LISTING AS TOXIC POLLUTANT.—If the Administrator determines that the pollutant meets the criteria for listing as a toxic pollutant under section 307(a), the Administrator shall list the pollutant as a toxic pollutant under section 307(a).

(iv) NONCONVENTIONAL CRITERIA DETERMINATION.—If the Administrator determines that the pollutant does not meet the criteria for lising as a toxic pollutant under such section and determines that adequate test methods and sufficient data are available to make the determinations required by paragraph (2) of this subsection with respect to the pollutant, the Administrator shall add the pollutant to the list of pollutants specified in paragraph (1) of this subsection for which modifications are authorized under this subsection.

(C) REQUIREMENTS FOR FILING OF PETITIONS.—A petition for lising of a pollutant under this paragraph—

(i) must be filed not later than 270 days after the date of promulgation of an applicable effluent guideline under section 304;

(ii) may be filed before promulgation of such guideline; and

(iii) may be filed with an application for a modification under paragraph (1) with respect to the discharge of such pollutant.

(D) DEADLINE FOR APPROVAL OF PETITION.—A decision to add a pollutant to the list of pollutants for which modifications under this subsection are authorized must be made within 270 days after the date of promulgation of an applicable effluent guideline under section 304.

(E) BURDEN OF PROOF.—The burden of proof for making the determinations under subparagraph (B) shall be on the petitioner.

(5) REMOVAL OF POLLUTANTS.—The Administrator may remove any pollutant from the list of pollutants for which modifications are authorized under this subsection if the Administrator determines that adequate test methods and sufficient data are no longer available for determining whether or not modifications may be granted with respect to such pollutant under paragraph (2) of this subsection.

(h) The Administrator, with the concurrence of the State, may issue a permit under section 402 which modifies the requirements of subsection (b)(1)(B) of this section with respect to the discharge of any pollutant from a publicly owned treatment works into marine waters, if the applicant demonstrates to the satisfaction of the Administrator that—

(1) there is an applicable water quality standard specific to the pollutant for which the modification is requested, which has been identified under section 304(a)(6) of this Act;

(2)(A) Where a point source (other than a publicly owned treatment works) will not achieve the requirements of subsections (b)(1)(A) and (b)(1)(C) of this section and—

(i) if a permit issued prior to July 1, 1977, to such point source is based upon a discharge into a publicly owned treatment works; or

(ii) if such point source (other than a publicly owned treatment works) had before July 1, 1977, a contract (enforceable against such point source) to discharge into a publicly owned treatment works; or

(iii) if either an application made before July 1, 1977, for a construction grant under this Act for a publicly owned treatment works, or engineering or architectural plans or working drawings made before July 1, 1977, for a publicly owned treatment works, show that such point source was to discharge into such publicly owned treatment works,

and such publicly owned treatment works is presently unable to accept such discharge without construction, and in the case of a discharge to an existing publicly owned treatment works, such treatment works has an extension pursuant to paragraph (1) of this subsection, the owner or operator of such point source may request the Administrator (or if appropriate the State) to issue or modify such a permit pursuant to such section 402 to extend such time for compliance. Any such request shall be filed with the Administrator (or if appropriate the State) within 180 days after the date of enactment of this subsection or the filing of a request by the appropriate publicly owned treatment works under paragraph (1) of this subsection, whichever is later. If the Administrator (or if appropriate the State) finds that the owner or operator of such point source has acted in good faith, he may grant such request and issue or modify such a permit, which shall contain a schedule of compliance for the point source to achieve the requirements of subsections (b)(1)(A) and (C) of this section and shall contain such other terms and conditions, including pretreatment and interim effluent limitations and water conservation requirements applicable to that point source, as the Administrator determines are necessary to carry out the provisions of this Act.

(B) No time modification granted by the Administrator (or if appropriate the State) pursuant to paragraph (2)(A) of this subsection shall extend beyond the earliest date practicable for compliance or beyond the date of any extension granted to the appropriate publicly owned treatment works pursuant to paragraph (1) of this subsection, but in no event shall it extend beyond July 1, 1988, and no such time modification shall be granted unless (i) the publicly owned treatment works will be in operation and available to the point source before July 1, 1988, and will meet the requirements to subsections (b)(1) (B) and (C) of this section after receiving the discharge from that point source; and (ii) the point source and the publicly owned treatment works have entered into an enforceable contract requiring the point source to discharge into the publicly owned treatment works, the owner or operator of such point source to pay the costs required under section 204 of this Act, and the publicly owned treatment works to accept the discharge from the point source; and (iii) the permit for such point source re-

quires point source to meet all requirements under section 307 (a) and (b) during the period of such time modification.

(j)(1) Any application filed under this section for a modification of the provisions of—

(A) subsection (b)(1)(B) under subsection (h) of this section shall be filed not later that[1] the 365th day which begins after the date of enactment of the Municipal Wastewater Treatment Construction Grant Amendments of 1981, except that a publicly owned treatment works which prior to December 31, 1982, had a contractual arrangement to use a portion of the capacity of an ocean outfall operated by another publicly owned treatment works which has applied for or received modification under subsection (h), may apply for a modification of subsection (h) in its own right not later than 30 days after the date of the enactment of the Water Quality Act of 1987, and except as provided in paragraph (5);

(B) subsection (b)(2)(A) as it applies to pollutants identified in subsection (b)(2)(F) shall be filed not later than 270 days after the date of promulgation of an applicable effluent guideline under section 304 or not later than 270 days after the date of enactment of the Clean Water Act of 1977, whichever is later.

(2) Subject to paragraph (3) of this section, any application for a modification filed under subsection (g) of this section shall not operate to stay any requirement under this Act, unless in the judgment of the Administrator such a stay or the modification sought will not result in the discharge of pollutants in quantities which may reasonably be anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistency in the environment, acute toxicity, chronic toxicity (including carcinogenicity, mutagenicity or teratogenicity), or synergistic propensities, and that there is a substantial likelihood that the applicant will succeed on the merits of such application. In the case of an application filed under subsection (g) of this section, the Administrator may condition any stay granted under this paragraph on requiring the filing of a bond or other appropriate security to assure timely compliance with the requirements from which a modification is sought.

(3) COMPLIANCE REQUIREMENTS UNDER SUBSECTION (g).—

(A) EFFECT OF FILING.—An application for a modification under subsection (g) and a petition for listing of a pollutant as a pollutant for which modifications are authorized under such subsection shall not stay the requirement that the person seeking such modification or listing comply with effluent limitations under this Act for all pollutants not the subject of such application or petition.

(B) EFFECT OF DISAPPROVAL.—Disapproval of an application for a modification under subsection (g) shall not stay the requirement that the person seeking such modification comply with all applicable effluent limitations under this Act.

[1] So in law. Probably should be "than".

(4) DEADLINE FOR SUBSECTION (g) DECISION.—An application for a modification with respect to a pollutant filed under subsection (g) must be approved or disapproved not later than 365 days after the date of such filing; except that in any case in which a petition for listing such pollutant as a pollutant for which modifications are authorized under such subsection is approved, such application must be approved or disapproved not later than 365 days after the date of approval of such petition.

(5) EXTENSION OF APPLICATION DEADLINE.—

(A) IN GENERAL.—In the 180-day period beginning on the date of the enactment of this paragraph, the city of San Diego, California, may apply for a modification pursuant to subsection (h) of the requirements of subsection (b)(1)(B) with respect to biological oxygen demand and total suspended solids in the effluent discharged into marine waters.

(B) APPLICATION.—An application under this paragraph shall include a commitment by the applicant to implement a waste water reclamation program that, at a minimum, will—

(i) achieve a system capacity of 45,000,000 gallons of reclaimed waste water per day by January 1, 2010; and

(ii) result in a reduction in the quantity of suspended solids discharged by the applicant into the marine environment during the period of the modification.

(C) ADDITIONAL CONDITIONS.—The Administrator may not grant a modification pursuant to an application submitted under this paragraph unless the Administrator determines that such modification will result in removal of not less than 58 percent of the biological oxygen demand (on an annual average) and not less than 80 percent of total suspended solids (on a monthly average) in the discharge to which the application applies.

(D) PRELIMINARY DECISION DEADLINE.—The Administrator shall announce a preliminary decision on an application submitted under this paragraph not later than 1 year after the date the application is submitted.

(k) In the case of any facility subject to a permit under section 402 which proposes to comply with the requirements of subsection (b)(2)(A) or (b)(2)(E) of this section by replacing existing production capacity with an innovative production process which will result in an effluent reduction significantly greater than that required by the limitation otherwise applicable to such facility and moves toward the national goal of eliminating the discharge of all pollutants, or with the installation of an innovative control technique that has a substantial likelihood for enabling the facility to comply with the applicable effluent limitation by achieving a significantly greater effluent reduction than that required by the applicable effluent limitation and moves toward the national goal of eliminating the discharge of all pollutants, or by achieving the required reduction with an innovative system that has the potential for significantly lower costs than the systems which have been determined by the Administrator to be economically achievable, the Administrator (or the State with an approved program under section 402, in consultation with the Administrator) may establish a date for compliance under subsection (b)(2)(A) or (b)(2)(E) of this section no later than two years after the date for compliance with such effluent limitation which would otherwise be applicable under such subsection, if it is also determined that such innovative system has the potential for industrywide application.

(l) Other than as provided in subsection (n) of this section, the Administrator may not modify any requirement of this section as it applies to any specific pollutant which is on the toxic pollutant list under section 307(a)(1) of this Act.

(m)(1) The Administrator, with the concurrence of the State, may issue a permit under section 402 which modifies the requirements of subsections (b)(1)(A) and (b)(2)(E) of this section, and of section 403, with respect to effluent limitations to the extent such limitations relate to biochemical oxygen demand and pH from discharges by an industrial discharger in such State into deep waters of the territorial seas, if the applicant demonstrates and the Administrator finds that—

(A) the facility for which modification is sought is covered at the time of the enactment of this subsection by National Pollutant Discharge Elimination System permit number CA0005894 or CA0005282;

(B) the energy and environmental costs of meeting such requirements of subsections (b)(1)(A) and (b)(2)(E) and section 403 exceed by an unreasonable amount the benefits to be obtained, including the objectives of this Act;

(C) the applicant has established a system for monitoring the impact of such discharges on a representative sample of aquatic biota;

(D) such modified requirements will not result in any additional requirements on any other point or nonpoint source;

(E) there will be no new or substantially increased discharges from the point source of the pollutant to which the modification applies above that volume of discharge specified in the permit;

(F) the discharge is into waters where there is strong tidal movement and other hydrological and geological characteristics which are necessary to allow compliance with this subsection and section 101(a)(2) of this Act;

(G) the applicant accepts as a condition to the permit a contractural obligation to use funds in the amount required (but not less than $250,000 per year for ten years) for research and development of water pollution control technology, including but not limited to closed cycle technology;

(H) the facts and circumstances present a unique situation which, if relief is granted, will not establish a precedent or the relaxation of the requirements of this Act applicable to similarly situated discharges; and

(I) no owner or operator of a facility comparable to that of the applicant situated in the United States has demonstrated that it would be put at a competitive disadvantage to the applicant (or the parent company or any subsidiary thereof) as a result of the issuance of a permit under this subsection.

(2) The effluent limitations established under a permit issued under paragraph (1) shall be sufficient to implement the applicable State water quality standards, to assure the protection of public water supplies and protection and propagation of a balanced, indigenous population of shellfish, fish, fauna, wildlife, and other aquatic organisms, and to allow recreational activities in and on the water. In setting such limitations, the Administrator shall take into account any seasonal variations and the need for an adequate margin of safety, considering the lack of essential knowledge concerning the relationship between effluent limitations and water quality and the lack of essential knowledge of the effects of discharges on beneficial uses of the receiving waters.

(3) A permit under this subsection may be issued for a period not to exceed five years, and such a permit may be renewed for one additional period not to exceed five years upon a demonstration by the applicant and a finding by the Administrator at the time of application for any such renewal that the provisions of this subsection are met.

(4) The Administrator may terminate a permit issued under this subsection if the Administrator determines that there has been a decline in ambient water quality of the receiving waters during the period of the permit even if a direct cause and effect relationship cannot be shown: *Provided*, That if the effluent from a source with a permit issued under this subsection is contributing to a decline in ambient water quality of the receiving waters, the Administrator shall terminate such permit.

(n) FUNDAMENTALLY DIFFERENT FACTORS.—

(1) GENERAL RULE.—The Administrator, with the concurrance of the State, may establish an alternative requirement under subsection (b)(2) or section 307(b) for a facility that modifies the requirements of national effluent limitation guidelines or categorical pretreatment standards that would otherwise be applicable to such facility, if the owner or operator of such facility demonstrates to the satisfaction of the Administrator that—

(A) the facility is fundamentally different with respect to the factors (other than cost) specified in section 304(b) or 304(g) and considered by the Administrator in establishing such national effluent limitation guidelines or categorical pretreatment standards;

(B) the application—

(i) is based solely on information and supporting data submitted to the Administrator during the rule making for establishment of the applicable national effluent limitation guidelines or categorical pretreatment standard specifically raising the factors that are fundamentally different for such facility; or

(ii) is based on information and supporting data referred to in clause (i) and information and supporting data the applicant did not have a reasonable opportunity to submit during such rulemaking;

(C) the alternative requirement is no less stringent than justified by the fundamental difference; and

(D) the alternative requirement will not result in a non-water quality environmental impact which is markedly more adverse than the impact considered by the Administrator in establishing such national affluent limitation guideline or categorical pretreatment standard.

(2) TIME LIMIT FOR APPLICATIONS.—An application for an alternative requirement which modifies the requirements of an effluent limitation or pretreatment standard under this subsection must be submitted to the Administrator within 180 days after the date on which such limitation or standard is established or revised, as the case may be.

(3) TIME LIMIT FOR DECISION.—The Administrator shall approve or deny by final agency action an application submitted under this subsection within 180 days after the date such application is filed with the Administrator.

(4) SUBMISSION OF INFORMATION.—The Administrator may allow an applicant under this subsection to submit information and supporting data until the earlier of the date the application is approved or denied or the last day that the Administrator has to approve or deny such application.

(5) TREATMENT OF PENDING APPLICATIONS.—For the purposes of this subsection, an application for an alternative requirement based on fundamentally different factors which is pending on the date of the enactment of this subsection shall be treated as having been submitted to the Administrator on the 180th day following such date of enactment. The applicant may amend the application to take into account the provisions of this subsection.

(6) EFFECT OF SUBMISSION OF APPLICATION.—An application for an alternative requirement under this subsection shall not stay the applicant's obligation to comply with the effluent limitation guideline or categorical pretreatment standard which is the subject of the application.

(7) EFFECT OF DENIAL.—If an application for an alternative requirement which modifies the requirements of an effluent limitation or pretreatment standard under this subsection is denied by the Administrator, the applicant must comply with such limitation or standard as established or revised, as the case may be.

(8) REPORTS.—By January 1, 1997, and January 1 of every odd-numbered year thereafter, the Administrator shall submit to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of Representatives a report on the status of applications for alternative requirements which modify the requirements of effluent limitations under section 301 or 304 of this Act or any national categorical pretreatment standard under section 307(b) of this Act filed before, on, or after such date of enactment.

(o) APPLICATION FEES.—The Administrator shall prescribe and collect from each applicant fees reflecting the reasonable administrative costs incurred in reviewing and processing applications for modifications submitted to the Administrator pursuant to subsections (c), (g), (i), (k), (m), and (n) of section 301, section 304(d)(4), and section 316(a) of this Act. All amounts collected by the Administrator under this subsection shall be deposited into a special fund of the Treasury entitled "Water Permits and Related Services" which shall thereafter be available for appropriation to carry out activities of the Environmental Protection Agency for which such fees were collected.

(p) MODIFIED PERMIT FOR COAL REMINING OPERATIONS.—

(1) IN GENERAL.—Subject to paragraphs (2) through (4) of this subsection, the Administrator, or the State in any case which the State has an approved permit program under section 402(b), may issue a permit under section 402 which modifies the requirements of subsection (b)(2)(A) of this section with respect to the pH level of any pre-existing discharge, and with respect to pre-existing discharges of iron and manganese from the remined area of any coal remining operation or with respect to the pH level or level of iron or manganese in any pre-existing discharge affected by the remining operation. Such modified requirements shall apply the best available technology economically achievable on a case-by-case basis, using best professional judgment, to set specific numerical effluent limitations in each permit.

(2) LIMITATIONS.—The Administrator or the State may only issue a permit pursuant to paragraph (1) if the applicant demonstrates to the satisfaction of the Administrator or the State, as the case may be, that the coal remining operation will result in the potential for improved water quality from the remining operation but in no event shall such a permit allow the pH level of any discharge, and in no event shall such a permit allow the discharges of iron and manganese, to exceed the levels being discharged from the remined area before the coal remining operation begins. No discharge from, or affected by, the remining operation shall exceed State water quality standards established under section 303 of this Act.

(3) DEFINITIONS.—For purposes of this subsection—

(A) COAL REMINING OPERATION.—The term "coal remining operation" means a coal mining operation which begins after the date of the enactment of this subsection at a site on which coal mining was conducted before the effective date of the Surface Mining Control and Reclamation Act of 1977.

(B) REMINED AREA.—The term "remined area" means only that area of any coal remining operation on which coal mining was conducted before the effective date of the Surface Mining Control and Reclamation Act of 1977.

(C) PRE-EXISTING DISCHARGE.—The term "pre-existing discharge" means any discharge at the time of permit application under this subsection.

(4) APPLICABILITY OF STRIP MINING LAWS.—Nothing in this subsection shall affect the application of the Surface Mining Control and Reclamation Act of 1977 to any coal remining operation, including the application of such Act to suspended solids.

(33 U.S.C. 1311)

WATER QUALITY RELATED EFFLUENT LIMITATIONS

SEC. 302. (a) Whenever, in the judgment of the Administrator or as identified under section 304(l), discharges of pollutants from a point source or group of point sources, with the application of effluent limitations required under section 301(b)(2) of this Act, would interfere with the attainment or maintenance of that water quality in a specific portion of the navigable waters which shall assure protection of public health, public water supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, effluent limitations (including alternative effluent control strategies) for such point source or sources shall be established which can reasonably be expected to contribute to the attainment or maintenance of such water quality.

(b) MODIFICATIONS OF EFFLUENT LIMITATIONS.—

(1) NOTICE AND HEARING.—Prior to establishment of any effluent limitation pursuant to subsection (a) of this section, the Administrator shall publish such proposed limitation and within 90 days of such publication hold a public hearing.

(2) PERMITS.—

(A) NO REASONABLE RELATIONSHIP.—The Administrator, with the concurrence of the State, may issue a permit which modifies the effluent limitations required by subsection (a) of this section for pollutants other than toxic pollutants if the applicant demonstrates at such hearing that (whether or not technology or other alternative control strategies are available) there is no reasonable relationship between the economic and social costs and the benefits to be obtained (including attainment of the objective of this Act) from achieving such limitation.

(B) REASONABLE PROGRESS.—The Administrator, with the concurrence of the State, may issue a permit which modifies the effluent limitations required by subsection (a) of this section for toxic pollutants for a single period not to exceed 5 years if the applicant demonstrates to the satisfaction of the Administrator that such modified requirements (i) will represent the maximum degree of control within the economic capability of the owner and operator of the source, and (ii) will result in reasonable further progress beyond the requirements of section 301(b)(2) toward the requirements of subsection (a) of this section.

(c) The establishment of effluent limitations under this section shall not operate to delay the application of any effluent limitation established under section 301 of this Act.

(33 U.S.C. 1312)

WATER QUALITY STANDARDS AND IMPLEMENTATION PLANS

SEC. 303. (a)(1) In order to carry out the purpose of this Act, any water quality standard applicable to interstate waters which was adopted by any State and submitted to, and approved by, or is awaiting approval by, the Administrator pursuant to this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, shall remain in effect unless the Administrator determined that such standard is not consistent with the applicable requirements of this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. If the Administrator makes such a determination he shall, within three months after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, notify the State and specify the changes needed to meet such requirements. If such changes are not adopted by the State within ninety days after the date of such notification, the Administrator shall promulgate such changes in accordance with subsection (b) of this section.

(2) Any State which, before the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, has adopted, pursuant to its own law, water quality standards applicable to intrastate waters shall submit such standards to the Administrator within thirty days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. Each such standard shall remain in effect, in the same manner and to the same extent as any other water quality standard established under this Act unless the Administrator determines that such standard is inconsistent with the applicable requirements of this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972. If the Administrator makes such a determination he shall not later than the one hundred and twentieth day after the date of submission of such standards, notify the State and specify the changes needed to meet such requirements. If such changes are not adopted by the State within ninety days after such notification, the Administrator shall promulgate such changes in accordance with subsection (b) of this section.

(3)(A) Any State which prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 has not adopted pursuant to its own laws water quality standards applicable to intrastate waters shall, not later than one hundred and eighty days after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, adopt and submit such standards to the Administrator.

(B) If the Administrator determines that any such standards are consistent with the applicable requirements of this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, he shall approve such standards.

(C) If the Administrator determines that any such standards are not consistent with the applicable requirements of this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, he shall, not later than the ninetieth day after the date of submission of such standards, notify the State and specify the changes to meet such re[illegible]irements. If such changes are not adopted by the State within [illegible] days after the date of notification, the Administrator shall

promulgate such standards pursuant to subsection (b) of this section.

(b)(1) The Administrator shall promptly prepare and publish proposed regulations setting forth water quality standards for a State in accordance with the applicable requirements of this Act as in effect immediately prior to the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, if—

(A) the State fails to submit water quality standards within the times prescribed in subsection (a) of this section,

(B) a water quality standard submitted by such State under subsection (a) of this section is determined by the Administrator not to be consistent with the applicable requirements of subsection (a) of this section.

(2) The Administrator shall promulgate any water quality standard published in a proposed regulation not later than one hundred and ninety days after the date he publishes any such proposed standard, unless prior to such promulgation, such State has adopted a water quality standard which the Administrator determines to be in accordance with subsection (a) of this section.

(c)(1) The Governor of a State or the State water pollution control agency of such State shall from time to time (but at least once each three year period beginning with the date of enactment of the Federal Water Pollution Control Act Amendments of 1972) hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards. Results of such review shall be made available to the Administrator.

(2)(A) Whenever the State revises or adopts a new standard, such revised or new standard shall be submitted to the Administrator. Such revised or new water quality standard shall consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses. Such standards shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act. Such standards shall be established taking into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation.

(B) Whenever a State reviews water quality standards pursuant to paragraph (1) of this subsection, or revises or adopts new standards pursuant to this paragraph, such State shall adopt criteria for all toxic pollutants listed pursuant to section 307(a)(1) of this Act for which criteria have been published under section 304(a), the discharge or presence of which in the affected waters could reasonably be expected to interfere with those designated uses adopted by the State, as necessary to support such designated uses. Such criteria shall be specific numerical criteria for such toxic pollutants. Where such numerical criteria are not available, whenever a State reviews water quality standards pursuant to paragraph (1), or revises or adopts new standards pursuant to this paragraph, such State shall adopt criteria based on biological monitoring or assessment methods consistent with information published pursuant to section 304(a)(8). Nothing in this section shall be construed to limit or delay the use of effluent limitations or other permit conditions based on or involving biological monitoring or assessment methods or previously adopted numerical criteria.

(3) If the Administrator, within sixty days after the date of submission of the revised or new standard, determines that such standard meets the requirements of this Act, such standard shall thereafter be the water quality standard for the applicable waters of that State. If the Administrator determines that any such revised or new standard is not consistent with the applicable requirements of this Act, he shall not later than the ninetieth day after the date of submission of such standard notify the State and specify the changes to meet such requirements. If such changes are not adopted by the State within ninety days after the date of notification, the Administrator shall promulgate such standard pursuant to paragraph (4) of this subsection.

(4) The Administrator shall promptly prepare and publish proposed regulations setting forth a revised or new water quality standard for the navigable waters involved—

(A) if a revised or new water quality standard submitted by such State under paragraph (3) of this subsection for such waters is determined by the Administrator not to be consistent with the applicable requirements of this Act, or

(B) in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of this Act.

The Administrator shall promulgate any revised or new standard under this paragraph not later than ninety days after he publishes such proposed standards, unless prior to such promulgation, such State has adopted a revised or new water quality standard which the Administrator determines to be in accordance with this Act.

(d)(1)(A) Each State shall identify those waters within its boundaries for which the effluent limitations required by section 301(b)(1)(A) and section 301(b)(1)(B) are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters.

(B) Each State shall identify those waters or parts thereof within its boundaries for which controls on thermal discharges under section 301 are not stringent enough to assure protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife.

(C) Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

(D) Each State shall estimate for the waters identified in paragraph (1)(D) of this subsection the total maximum daily thermal load required to assure protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife. Such estimates shall take into account the normal water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters or parts thereof. Such estimates shall include a calculation of the maximum heat input that can be made into each such part and shall include a margin of safety which takes into account any lack of knowledge concerning the development of thermal water quality criteria for such protection and propagation in the identified waters or parts thereof.

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(2) Each State shall submit to the Administrator from time to time, with the first such submission not later than one hundred and eighty days after the date of publication of the first identification of pollutants under section 304(a)(2)(D), for his approval the waters identified and the loads established under paragraphs (1)(A), (1)(B), (1)(C), and (1)(D) of this subsection. The Administrator shall either approve or disapprove such identification and load not later than thirty days after the date of submission. If the Administrator approves such identification and load, such State shall incorporate them into its current plan under subsection (e) of this section. If the Administrator disapproves such identification and load, he shall not later than thirty days after the date of such disapproval identify such waters in such State and establish such loads for such waters as he determines necessary to implement the water quality standards applicable to such waters and upon such identification and establishment the State shall incorporate them into its current plan under subsection (e) of this section.

(3) For the specific purpose of developing information, each State shall identify all waters within its boundaries which it has not identified under paragraph (1)(A) and (1)(B) of this subsection and estimate for such waters the total maximum daily load with seasonal variations and margins of safety, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation and for thermal discharges, at a level that would assure protection and propagation of a balanced indigenous population of fish, shellfish and wildlife.

(4) LIMITATIONS ON REVISION OF CERTAIN EFFLUENT LIMITATIONS.—

(A) STANDARD NOT ATTAINED.—For waters identified under paragraph (1)(A) where the applicable water quality standard has not yet been attained, any effluent limitation based on a total maximum daily load or other waste load allocation established under this section may be revised only if (i) the cumulative effect of all such revised effluent limitations based on such total maximum daily load or waste load allocation will assure the attainment of such water quality standard, or (ii) the designated use which is not being attained is removed in accordance with regulations established under this section.

(B) STANDARD ATTAINED.—For waters identified under paragraph (1)(A) where the quality of such waters equals or exceeds levels necessary to protect the designated use for such waters or otherwise required by applicable water quality standard, any effluent limitation based on a total maximum daily load or other waste load allocation established under this section, or any water quality standard established under this section, or any other permitting standard may be revised only if such revision is subject to and consistent with the antidegradation policy established under this section.

(e)(1) Each State shall have a continuing planning process approved under paragraph (2) of this subsection which is consistent with this Act.

(2) Each State shall submit not later than 120 days after the date of the enactment of the Water Pollution Control Amendments of 1972 to the Administrator for his approval a proposed continuing planning process which is consistent with this Act. Not later than thirty days after the date of submission of such a process the Administrator shall either approve or disapprove such process. The Administrator shall from time to time review each State's approved planning process for the purpose of insuring that such planning process is at all times consistent with this Act. The Administrator shall not approve any State permit program under title IV of this Act for any State which does not have an approved continuing planning process under this section.

(3) The Administrator shall approve any continuing planning process submitted to him under this section which will result in plans for all navigable waters within such State, which include, but are not limited to, the following:

(A) effluent limitations and schedules of compliance at least as stringent as those required by section 301(b)(1), section 301(b)(2), section 306, and section 307, and at least as stringent as any requirements contained in any applicable water quality standard in effect under authority of this section;

(B) the incorporation of all elements of any applicable areawide waste management plans under section 208, and applicable basin plans under section 209 of this Act;

(C) total maximum daily load for pollutants in accordance with subsection (d) of this section;

(D) procedures for revision;

(E) adequate authority for intergovernmental cooperation;

(F) adequate implementation, including schedules of compliance, for revised or new water quality standards, under subsection (c) of this section;

(G) controls over the disposition of all residual waste from any water treatment processing;

(H) an inventory and ranking, in order of priority, of needs for construction of waste treatment works required to meet the applicable requirements of sections 301 and 302.

(f) Nothing in this section shall be construed to affect any effluent limitation, or schedule of compliance required by any State to be implemented prior to the dates set forth in sections 301(b)(1) and 301(b)(2) nor to preclude any State from requiring compliance with any effluent limitation or schedule of compliance at dates earlier than such dates.

(g) Water quality standards relating to heat shall be consistent with the requirements of section 316 of this Act.

(h) For the purposes of this Act the term "water quality standards" includes thermal water quality standards.

(33 U.S.C. 1313)

INFORMATION AND GUIDELINES

SEC. 304. (a)(1) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after the date of enactment of this title (and from time to time thereafter revise) criteria for water quality accurately reflecting the latest scientific knowledge (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water; (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters.

(2) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after the date of enactment of this title (and from time to time thereafter revise) information (A) on the factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters, ground waters, waters of the contiguous zone, and the oceans; (B) on the factors necessary for the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters and to allow recreational activities in and on the water; and (C) on the measurement and classification of water quality; and (D) for the purpose of section 303, on and the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

(3) Such criteria and information and revisions thereof shall be issued to the States and shall be published in the Federal Register and otherwise made available to the public.

(4) The Administrator shall, within 90 days after the date of enactment of the Clean Water Act of 1977 and from time to time thereafter, publish and revise as appropriate information identifying conventional pollutants, including but not limited to, pollutants classified as biological oxygen demanding, suspended solids, fecal coliform, and pH. The thermal component of any discharge shall not be identified as a conventional pollutant under this paragraph.

(5)(A) The Administrator, to the extent practicable before consideration of any request under section 301(g) of this Act and within six months after the date of enactment of the Clean Water Act of 1977, shall develop and publish information on the factors necessary for the protection of public water supplies, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and to allow recreational activities, in and on the water.

(B) The Administrator, to the extent practicable before consideration of any application under section 301(h) of this Act and within six months after the date of enactment of Clean Water Act of 1977, shall develop and publish information on the factors necessary for the protection of public water supplies, and the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife, and to allow recreational activities, in and on the water.

(6) The Administrator shall, within three months after enactment of the Clean Water Act of 1977 and annually thereafter, for purposes of section 301(h) of this Act publish and revise as appropriate information identifying each water quality standard in effect under this Act of State law, the specific pollutants associated with such water quality standard, and the particular waters to which such water quality standard applies.

(7) GUIDANCE TO STATES.—The Administrator, after consultation with appropriate State agencies and on the basis of criteria and information published under paragraphs (1) and (2) of this subsection, shall develop and publish, within 9 months after the date of the enactment of the Water Quality Act of 1987, guidance to the States on performing the identification required by section 304(l)(1) of this Act.

(8) INFORMATION ON WATER QUALITY CRITERIA.—The Administrator, after consultation with appropriate State agencies and within 2 years after the date of the enactment of the Water Quality Act of 1987, shall develop and publish information on methods for establishing and measuring water quality criteria for toxic pollutants on other bases than pollutant-by-pollutant criteria, including biological monitoring and assessment methods.

(b) For the purposes of adopting or revising effluent limitations under this Act the Administrator shall, after consultation with appropriate Federal and State agencies and other interested persons, publish within one year of enactment of this title, regulations, providing guidelines for effluent limitations, and, at least annually thereafter, revise, if appropriate, such regulations. Such regulations shall—

(1)(A) identify, in terms of amounts of constituents and chemical, physical, and biological characteristics of pullutants, the degree of effluent reduction attainable through the application of the best practicable control technology currently available for classes and categories to point sources (other than publicly owned treatment works); and

(B) specify factors to be taken into account in determining the control measures and practices to be applicable to point sources (other than publicly owned treatment works) within such categories of classes. Factors relating to the assessment of best practical control technology currently available to comply with subsection (b)(1) of section 301 of this Act shall include consideration of the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, and shall also take into account the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate;

(2)(A) identify, in terms of amounts of constituents and chemical, physical, and biological characteristics of pollutants, the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operating methods, and other alternatives for classes and categories of point sources (other than publicly owned treatment works); and

(B) specify factors to be taken into account in determining the best measures and practices available to comply with subsection (b)(2) of section 301 of this Act to be applicable to any point source (other than publicly owned treatment works) within such categories of classes. Factors relating to the assessment of best available technology shall take into account the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate;

(3) identify control measures and practices available to eliminate the discharge of pollutants from categories and classes of point sources, taking into account the cost of achieving such elimination of the discharge of pollutants; and

(4)(A) identify, in terms of amounts of constituents and chemical, physical, and biological characteristics of pollutants, the degree of effluent reduction attainable through the application of the best conventional pollutant control technology (including measures and practices) for classes and categories of point sources (other than publicly owned treatment works); and

(B) specify factors to be taken into account in determining the best conventional pollutant control technology measures and practices to comply with section 301(b)(2)(E) of this Act to be applicable to any point source (other than publicly owned treatment works) within such categories or classes. Factors relating to the assessment of best conventional pollutant control technology (including measures and practices) shall include consideration of the reasonableness of the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction of such pollutants from the discharge from publicly owned treatment works to the cost and level of reduction of such pollutants from a class or category of industrial sources, and shall take into account the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate.

(c) The Administrator, after consultation, with appropriate Federal and State agencies and other interested persons, shall issue to the States and appropriate water pollution control agencies within 270 days after enactment of this title (and from time to time thereafter) information on the processes, procedures, or operating methods which result in the elimination or reduction of the discharge of pollutants to implement standards of performance under section 306 of this Act. Such information shall include technical and other data, including costs, as are available on alternative methods of elimination or reduction of the discharge of pollutants. Such information, and revisions thereof, shall be published in the Federal Register and otherwise shall be made available to the public.

(d)(1) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall publish within sixty days after enactment of this title (and from time to time thereafter) information, in terms of amounts of constituents and chemical, physical, and biological characteristics of pollutants, on the degree of effluent reduction attainable through the application of secondary treatment.

(2) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall publish within nine months after the date of enactment of this title (and from time to time thereafter) information on alternative waste treatment management techniques and systems available to implement section 201 of this Act.

(3) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall promulgate witin one hundred and eighty days after the date of enactment of this subsection guidelines for identifying and evaluating innovative and alternative wastewater treatment process and techniques referred to in section 201(g)(5) of this Act.

(4) For the purposes of this subsection, such biological treatment facilities as oxidation ponds, lagoons, and ditches and trickling filters shall be deemed the equivalent of secondary treatment. The Administrator shall provide guidance under paragraph (1) of this subsection on design criteria for such facilities, taking into account pollutant removal efficiencies and, consistent with the objective of the Act, assuring that water quality will not be adversely affected by deeming such facilities as the equivalent of secondary treatment.

(e) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, may publish regulations, supplemental to any effluent limitations specified under subsections (b) and (c) of this section for a class or category of point sources, for any specific pollutant which the Administrator is charged with a duty to regulate as a toxic or hazardous pollutant under section 307(a)(1) or 311 of this Act, to control plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage which the Administrator determines are associated with or ancillary to the industrial manufacturing or treatment process within such class or category of point sources and may contribute significant amounts of such pollutants, to navigable waters. Any applicable controls established under this subsection

shall be included as a requirement for the purposes of section 301, 302, 307, or 403, as the case may be, in any permit issued to a point source pursuant to section 402 of this Act.

(f) The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall issue to appropriate Federal agencies, the States, water pollution control agencies, and agencies designated under section 208 of this Act, within one year after the effective date of this subsection (and from time to time thereafter) information including (1) guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollutants, and (2) processes, procedures, and methods to control pollution resulting from—

(A) agricultural and silvicultural activities, including runoff from fields and crop and forest lands;

(B) mining activities, including runoff and siltation from new, currently operating, and abandoned surface and underground mines;

(C) all construction activity, including runoff from the facilities resulting from such construction;

(D) the disposal of pollutants in wells or in subsurface excavations;

(E) salt water intrusion resulting from reductions of fresh water flow from any cause, including extraction of ground water, irrigation, obstruction, and diversion; and

(F) changes in the movement, flow, or circulation of any navigable waters or ground waters, including changes caused by the construction of dams, levees, channels, causeways, or flow diversion facilities.

Such information and revisions thereof shall be published in the Federal Register and otherwise made available to the public.

(g)(1) For the purpose of assisting States in carrying out programs under section 402 of this Act, the Administrator shall publish, within one hundred and twenty days after the date of enactment of this title, and review at least annually thereafter and, if appropriate, revise guidelines for pretreatment of pollutants which he determines are not susceptible to treatment by publicly owned treatment works. Guidelines under this subsection shall be established to control and prevent the discharge into the navigable waters, the contiguous zone, or the ocean (either directly or through publicly owned treatment works) of any pollutant which interferes with, passes through, or otherwise is incompatible with such works.

(2) When publishing guidelines under this subsection, the Administrator shall designate the category or categories of treatment works to which the guidelines shall apply.

(h) The Administrator shall, within one hundred and eighty days from the date of enactment of this title, promulgate guidelines establishing test procedures for the analysis of pollutants that shall include the factors which must be provided in any certification pursuant to section 401 of this Act or permit application pursuant to section 402 of this Act.

(i) The Administrator shall (1) within sixty days after the enactment of this title promulgate guidelines for the purpose of establishing uniform application forms and other minimum requirements for the acquisition of information from owners and operators of point-sources of discharge subject to any State program under section 402 of this Act, and (2) within sixty days from the date of enactment of this title promulgate guidelines establishing the minimum procedural and other elements of any State program under section 402 of this Act which shall include:

(A) monitoring requirements;

(B) reporting requirements (including procedures to make information available to the public);

(C) enforcement provisions; and

(D) funding, personnel qualifications, and manpower requirements (including a requirement that no board or body which approves permit applications or portions thereof shall include, as a member, any person who receives, or has during the previous two years received, a significant portion of his income directly or indirectly from permit holders or applicants for a permit).

(j) LAKE RESTORATION GUIDANCE MANUAL.—The Administrator shall, within 1 year after the date of the enactment of the Water Quality Act of 1987 and biennially thereafter, publish and disseminate a lake restoration guidance manual describing methods, procedures, and processes to guide State and local efforts to improve, restore, and enhance water quality in the Nation's publicly owned lakes.

(k)(1) The Administrator shall enter into agreements with the Secretary of Agriculture, the Secretary of the Army, and the Secretary of the Interior, and the heads of such other departments, agencies, and instrumentalities of the United States as the Administrator determines, to provide for the maximum utilization of other Federal laws and programs for the purpose of achieving and maintaining water quality through appropriate implementation of plans approved under section 208 of this Act and nonpoint source pollution management programs approved under section 319 of this Act.

(2) The Administrator is authorized to transfer to the Secretary of Agriculture, the Secretary of the Army, and the Secretary of the Interior and the heads of such other departments, agencies, and instrumentalities of the United States as the Administrator determines, any funds appropriated under paragraph (3) of this subsection to supplement funds otherwise appropriated to programs authorized pursuant to any agreement under paragraph (1).

(3) There is authorized to be appropriated to carry out the provisions of this subsection, $100,000,000 per fiscal year for the fiscal years 1979 through 1983 and such sums as may be necessary for fiscal years 1984 through 1990.

(l) INDIVIDUAL CONTROL STRATEGIES FOR TOXIC POLLUTANTS.—

(1) STATE LIST OF NAVIGABLE WATERS AND DEVELOPMENT OF STRATEGIES.—Not later than 2 years after the date of the enactment of this subsection, each State shall submit to the Administrator for review, approval, and implementation under this subsection—

(A) a list of those waters within the State which after the application of effluent limitations required under section 301(b)(2) of this Act cannot reasonably be anticipated to attain or maintain (i) water quality standards for such waters reviewed, revised, or adopted in accordance with

section 303(c)(2)(B) of this Act, due to toxic pollutants, or (ii) that water quality which shall assure protection of public health, public water supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water;

(B) a list of all navigable waters in such State for which the State does not expect the applicable standard under section 303 of this Act will be achieved after the requirements of sections 301(b), 306, and 307(b) are met, due entirely or substantially to discharges from point sources of any toxic pollutants listed pursuant to section 307(a);

(C) for each segment of the navigable waters included on such lists, a determination of the specific point sources discharging any such toxic pollutant which is believed to be preventing or impairing such water quality and the amount of each toxic pollutant discharged by each such source; and

(D) for each such segment, an individual control strategy which the State determines will produce a reduction in the discharge of toxic pollutants from point sources identified by the State under this paragraph through the establishment of effluent limitations under section 402 of this Act and water quality standards under section 303(c)(2)(B) of this Act, which reduction is sufficient, in combination with existing controls on point and nonpoint sources of pollution, to achieve the applicable water quality standard as soon as possible, but not later than 3 years after the date of the establishment of such strategy.

(2) APPROVAL OR DISAPPROVAL.—Not later than 120 days after the last day of the 2-year period referred to in paragraph (1), the Administrator shall approve or disapprove the control strategies submitted under paragraph (1) by any State.

(3) ADMINISTRATOR'S ACTION.—If a State fails to submit control strategies in accordance with paragraph (1) or the Administrator does not approve the control strategies submitted by such State in accordance with paragraph (1), then, not later than 1 year after the last day of the period referred to in paragraph (2), the Administrator, in cooperation with such State and after notice and opportunity for public comment, shall implement the requirements of paragraph (1) in such State. In the implementation of such requirements, the Administrator shall, at a minimum, consider for listing under this subsection any navigable waters for which any person submits a petition to the Administrator for listing not later than 120 days after such last day.

(m) SCHEDULE FOR REVIEW OF GUIDELINES.—

(1) PUBLICATION.—Within 12 months after the date of the enactment of the Water Quality Act of 1987, and biennially thereafter, the Administrator shall publish in the Federal Register a plan which shall—

(A) establish a schedule for the annual review and revision of promulgated effluent guidelines, in accordance with subsection (b) of this section;

(B) identify categories of sources discharging toxic or nonconventional pollutants for which guidelines under subsection (b)(2) of this section and section 306 have not previously been published; and

(C) establish a schedule for promulgation of effluent guidelines for categories identified in subparagraph (B), under which promulgation of such guidelines shall be no later than 4 years after such date of enactment for categories identified in the first published plan or 3 years after the publication of the plan for categories identified in later published plans.

(2) PUBLIC REVIEW.—The Administrator shall provide for public review and comment on the plan prior to final publication.

(33 U.S.C. 1314)

WATER QUALITY INVENTORY

SEC. 305. (a) The Administrator, in cooperation with the States and with the assistance of appropriate Federal agencies, shall prepare a report to be submitted to the Congress on or before January 1, 1974, which shall—

(1) describe the specific quality, during 1973, with appropriate supplemental descriptions as shall be required to take into account seasonal, tidal, and other variations, of all navigable waters and the waters of the contiguous zone;

(2) include an inventory of all point sources of discharge (based on a qualitative and quantitative analysis of discharges) of pollutants, into all navigable waters and the waters of the contiguous zone; and

(3) identify specifically those navigable waters, the quality of which—

(A) is adequate to provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow recreational activities in and on the water;

(B) can reasonably be expected to attain such level by 1977 or 1983; and

(C) can reasonably be expected to attain such level by any later date.

(b)(1) Each State shall prepare and submit to the Administrator by April 1, 1975, and shall bring up to date by April 1, 1976, and biennially thereafter, a report which shall include—

(A) a description of the water quality of all navigable waters in such State during the preceding year, with appropriate supplemental descriptions as shall be required to take into account seasonal, tidal, and other variations, correlated with the quality of water required by the objective of this Act (as identified by the Administrator pursuant to criteria published under section 304(a) of this Act) and the water quality described in subparagraph (B) of this paragraph;

(B) an analysis of the extent to which all navigable waters of such State provide for the protection and propagation of a

balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water;

(C) an analysis of the extent to which the elimination of the discharge of pollutants and a level of water quality which provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water, have been or will be achieved by the requirements of this Act, together with recommendations as to additional action necessary to achieve such objectives and for what waters such additional action is necessary;

(D) an estimate of (i) the environmental impact, (ii) the economic and social costs necessary to achieve the objective of this Act in such State, (iii) the economic and social benefits of such achievement, and (iv) an estimate of the date of such achievement; and

(E) a description of the nature and extent of nonpoint sources of pollutants, and recommendations as to the programs which must be undertaken to control each category of such sources, including an estimate of the costs of implementing such programs.

(2) The Administrator shall transmit such State reports, together with an analysis thereof, to Congress on or before October 1, 1975, and October 1, 1976, and biennially thereafter.

(33 U.S.C. 1315)

NATIONAL STANDARDS OF PERFORMANCE

SEC. 306. (a) For purposes of this section:

(1) The term "standard of performance" means a standard for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

(2) The term "new source" means any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance under this section which will be applicable to such sources, if such standard is thereafter promulgated in accordance with this section.

(3) The term "source" means any building, structure, facility, or installation from which there is or may be the discharge of pollutants.

(4) The term "owner or operator" means any person who owns, leases, operates, controls, or supervises a source.

(5) The term "construction" means any placement, assembly, or installation of facilities or equipment (including contractual obligations to purchase such facilities or equipment) at the premises where such equipment will be used, including preparation work at such premises.

(b)(1)(A) The Administrator shall, within ninety days after the date of enactment of this title publish (and from time to time thereafter shall revise) a list of categories of sources, which shall, at the minimum, include:

pulp and paper mills;
paperboard, builders paper and board mills;
meat product and rendering processing;
dairy product processing;
grain mills;
canned and preserved fruits and vegetables processing;
canned and preserved seafood processing;
sugar processing;
textile mills;
cement manufacturing;
feedlots;
electroplating;
organic chemicals manufacturing;
inorganic chemicals manufacturing;
plastic and synthetic materials manufacturing;
soap and detergent manufacturing
fertilizer manufacturing;
petroleum refining;
iron and steel manufacturing;
nonferrous metals manufacturing;
phosphate manufacturing;
steam electric powerplants;
ferroalloy manufacturing;
leather tanning and finishing;
glass and asbestos manufacturing;
rubber processing; and
timber products processing.

(B) As soon as practicable, but in no case more than one year, after a category of sources is included in a list under subparagraph (A) of this paragraph, the Administrator shall propose and publish regulations establishing Federal standards of performance for new sources within such category. The Administrator shall afford interested persons an opportunity for written comment on such proposed regulations. After considering such comments, he shall promulgate, within one hundred and twenty days after publication of such proposed regulations, such standards with such adjustments as he deems appropriate. The Administrator shall, from time to time, as technology and alternatives change, revise such standards following the procedure required by this subsection for promulgation of such standards. Standards of performance, or revisions thereof, shall become effective upon promulgation. In establishing or revising Federal standards of performance for new sources under this section, the Administrator shall take into consideration the cost of achieving such effluent reduction, and any non-water quality environmental impact and energy requirements.

(2) The Administrator may distinguish among classes, types, and sizes within categories of new sources for the purpose of establishing such standards and shall consider the type of process employed (including whether batch or continuous).

(3) The provisions of this section shall apply to any new source owned or operated by the United States.

(c) Each State may develop and submit to the Administrator a procedure under State law for applying and enforcing standards of performance for new sources located in such State. If the Administrator finds that the procedure and the law of any State require the application and enforcement of standards of performance to at least the same extent as required by this section, such State is authorized to apply and enforce such standards of performance (except with respect to new sources owned or operated by the United States).

(d) Notwithstanding any other provision of this Act, any point source the construction of which is commenced after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 and which is so constructed as to meet all applicable standards of performance shall not be subject to any more stringent standard of performance during a ten-year period beginning on the date of completion of such construction or during the period of depreciation or amortization of such facility for the purposes of section 167 or 169 (or both) of the Internal Revenue Code of 1954, whichever period ends first.

(e) After the effective date of standards of performance promulgated under this section, it shall be unlawful for any owner or operator of any new source to operate such source in violation of any standard of performance applicable to such source.

(33 U.S.C. 1316)

TOXIC AND PRETREATMENT EFFLUENT STANDARDS

SEC. 307. (a)(1) On and after the date of enactment of the Clean Water Act of 1977, the list of toxic pollutants or combination of pollutants subject to this Act shall consist of those toxic polllutants listed in table 1 of Committee Print Numbered 95–30 of the Committee on Public Works and Transportation of the House of Representatives, and the Administrator shall publish, not later than the thirtieth day after the date of enactment of the Clean Water Act of 1977, that list. From time to time thereafter, the Administrator may revise such list and the Administrator is authorized to add to or remove from such list any pollutant. The Administrator in publishing any revised list, including the addition or removal of any pollutant from such list, shall take into account the toxicity of the pollutant, its persistence, degradability, the usual or potential presence of the affected organisms in any waters, the importance of the affected organisms, and the nature and extent of the effect of the toxic pollutant on such organisms. A determination of the Administrator under this paragraph shall be final except that if, on judicial review, such determination was based on arbitrary and capricious action of the Administrator, the Administrator shall make a redetermination.

(2) Each toxic pollutant listed in accordance with paragraph (1) of this subsection shall be subject to effluent limitations resulting from the application of the best available technology economically achieveable for the applicable category or class of point sources established in accordance with section 301(b)(2)(A) and 304(b)(2) of this Act. The Administrator, in his discretion, may publish in the Federal Register a proposed effluent standard (which may include a prohibition) establishing requirements for a toxic pollutant which, if an effluent limitation is applicable to a class or category of point sources, shall be applicable to such category or class only

if such standard imposes more stringent requirements. Such published effluent standard (or prohibition) shall take into account the toxicity of the pollutant, its persistence, degradability, the usual or potential presence of the affected organisms in any waters, the importance of the affected organisms and the nature and extent of the effect of the toxic pollutant on such organisms, and the extent to which effective control is being or may be achieved under other regulatory authority. The Administrator shall allow a period of not less than sixty days following publication of any such proposed effluent standard (or prohibition) for written comment by interested persons on such proposed standard. In addition, if within thirty days of publication of any such proposed effluent standard (or prohibition) any interested person so requests, the Administrator shall hold a public hearing in connection therewith. Such a public hearing shall provide an opportunity for oral and written presentations, such cross-examination as the Administrator determines is appropriate on disputed issues of material fact, and the transcription of a verbatim record which shall be available to the public. After consideration of such comments and any information and material presented at any public hearing held on such proposed standard or prohibition, the Administrator shall promulgate such standards (or prohibition) with such modifications as the Administrator finds are justified. Such promulgation by the Administrator shall be made within two hundred and seventy days after publication of proposed standard (or prohibition). Such standard (or prohibition) shall be final except that if, on judicial review, such standard was not based on substantial evidence, the Administrator shall promulgate a revised standard. Effluent limitations shall be established in accordance with sections 301(b)(2)(A) and 304(b)(2) for every toxic pollutant referred to in table 1 of Committee Print Numbered 95–30 of the Committee on Public Works and Transportation of the House of Representatives as soon as practicable after the date of enactment of the Clean Water Act of 1977, but no later than July 1, 1980. Such effluent limitations or effluent standards (or prohibitions) shall be established for every other toxic pollutant listed under paragraph (1) of this subsection as soon as practicable after it is so listed.

(3) Each such effluent standard (or prohibition) shall be reviewed and, if appropriate, revised at least every three years.

(4) Any effluent standard promulgated under this section shall be at that level which the Administrator determines provides an ample margin of safety.

(5) When proposing or promulgating any effluent standard (or prohibition) under this section, the Administrator shall designate the category or categories of sources to which the effluent standard (or prohibition) shall apply. Any disposal of dredged material may be included in such a category of sources after consultation with the Secretary of the Army.

(6) Any effluent standard (or prohibition) established pursuant to this section shall take effect on such date or dates as specified in the order promulgating such standard, but in no case, more than one year from the date of such promulgation. If the Administrator determines that compliance within one year from the date of promulgation is technologically infeasible for a category of sources, the

Administrator may establish the effective date of the effluent standard (or prohibition) for such category at the earliest date upon which compliance can be feasibly attained by sources within such category, but in no event more than three years after the date of such promulgation.

(7) Prior to publishing any regulations pursuant to this section the Administrator shall, to the maximum extent practicable within the time provided, consult with appropriate advisory committees, States, independent experts, and Federal departments and agencies.

(b)(1) The Administrator shall, within one hundred and eighty days after the date of enactment of this title and from time to time thereafter, publish proposed regulations establishing pretreatment standards for introduction of pollutants into treatment works (as defined in section 212 of this Act) which are publicly owned for those pollutants which are determined not to be susceptible to treatment by such treatment works or which would interfere with the operation of such treatment works. Not later than ninety days after such publication, and after opportunity for public hearing, the Administrator shall promulgate such pretreatment standards. Pretreatment standards under this subsection shall specify a time for compliance not to exceed three years from the date of promulgation and shall be established to prevent the discharge of any pollutant through treatment works (as defined in section 212 of this Act) which are publicly owned, which pollutant interfers with, passes through, or otherwise is incompatible with such works. If, in the case of any toxic pollutant under subsection (a) of this section introduced by a source into a publicly owned treatment works, the treatment by such works removes all or any part of such toxic pollutant and the discharge from such works does not violate that effluent limitation or standard which would be applicable to such toxic pollutant if it were discharged by such source other than through a publicly owned treatment works, and does not prevent sludge use or disposal by such works in accordance with section 405 of this Act, then the pretreatment requirements for the sources actually discharging such toxic pollutant into such publicly owned treatment works may be revised by the owner or operator of such works to reflect the removal of such toxic pollutant by such works.

(2) The Administrator shall, from time to time, as control technology, processes, operating methods, or other alternative change, revise such standards following the procedures established by this subsection for promulgation of such standards.

(3) When proposing or promulgating any pretreatment standard under this section, the Administrator shall designate the category or categories of sources to which such standard shall apply.

(4) Nothing in this subsection shall affect any pretreatment requirement established by any State or local law not in conflict with any pretreatment standard established under this subsection.

(c) In order to ensure that any source introducing pollutants into a publicly owned treatment works, which source would be a new source subject to section 306 if it were to discharge pollutants, will not cause a violation of the effluent limitations established for any such treatment works, the Administrator shall promulgate pretreatment standards for the category of such sources simultaneously with the promulgation of standards of performance under section 306 for the equivalent category of new sources. Such pretreatment standards shall prevent the discharge of any pollutant into such treatment works, which pollutant may interfere with, pass through, or otherwise be incompatible with such works.

(d) After the effective date of any effluent standard or prohibition or pretreatment standard promulgated under this section, it shall be unlawful for any owner or operator of any source to operate any source in violation of any such effluent standard or prohibition or pretreatment standard.

(e) COMPLIANCE DATE EXTENSION FOR INNOVATIVE PRETREATMENT SYSTEMS.—In the case of any existing facility that proposes to comply with the pretreatment standards of subsection (b) of this section by applying an innovative system that meets the requirements of section 301(k) of this Act, the owner or operator of the publicly owned treatment works receiving the treated effluent from such facility may extend the date for compliance with the applicable pretreatment standard established under this section for a period not to exceed 2 years—

(1) if the Administrator determines that the innovative system has the potential for industrywide application, and

(2) if the Administrator (or the State in consultation with the Administrator, in any case in which the State has a pretreatment program approved by the Administrator)—

(A) determines that the proposed extension will not cause the publicly owned treatment works to be in violation of its permit under section 402 or of section 405 or to contribute to such a violation, and

(B) concurs with the proposed extension.

(33 U.S.C. 1317)

INSPECTIONS, MONITORING, AND ENTRY

SEC. 308. (a) Whenever required to carry out the objective of this Act, including but not limited to (1) developing or assisting in the development of any effluent limitation, or other limitation, prohibition, or effluent standard, pretreatment standard, or standard of performance under this Act; (2) determining whether any person is in violation of any such effluent limitation, or other limitation, prohibition or effluent standard, pretreatment standard, or standard of performance; (3) any requirement established under this section; or (4) carrying out sections 305, 311, 402, 404 (relating to State permit programs), 405, and 504 of this Act—

(A) the Administrator shall require the owner or operator of any point source to (i) establish and maintain such records, (ii) make such reports, (iii) install, use, and maintain such monitoring equipment or methods (including where appropriate, biological monitoring methods), (iv) sample such effluents (in accordance with such methods, at such locations, at such intervals, and in such manner as the Administrator shall prescribe), and (v) provide such other information as he may reasonably require; and

(B) the Administrator or his authorized representative (including an authorized contractor acting as a representative of the Administrator), upon presentation of his credentials—

(i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained under clause (A) of this subsection are located, and

(ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required under clause (A), and sample any effluents which the owner or operator of such source is required to sample under such clause.

(b) Any records, reports, or information obtained under this section (1) shall, in the case of effluent data, be related to any applicable effluent limitations, toxic, pretreatment, or new source performance standards, and (2) shall be available to the public, except that upon a showing satisfactory to the Administrator by any person that records, reports, or information, or particular part thereof (other than effluent data), to which the Administrator has access under this section, if made public would divulge methods or processes entitled to protection as trade secrets of such person, the Administrator shall consider such record, report, or information, or particular portion thereof confidential in accordance with the purposes of section 1905 of title 18 of the United States Code. Any authorized representative of the Administrator (including an authorized contractor acting as a representative of the Administrator) who knowingly or willfully publishes, divulges, discloses, or makes known in any manner or to any extent not authorized by law any information which is required to be considered confidential under this subsection shall be fined not more than $1,000 or imprisoned not more than 1 year, or both. Nothing in this subsection shall prohibit the Administrator or an authorized representative of the Administrator (including any authorized contractor acting as a representative of the Administrator) from disclosing records, reports, or information to other officers, employees, or authorized representatives of the United States concerned with carrying out this Act or when relevant in any proceeding under this Act.

(c) Each State may develop and submit to the Administrator procedures under State law for inspection, monitoring, and entry with respect to point sources located in such State. If the Administrator finds that the procedures and the law of any State relating to inspection, monitoring, and entry are applicable to at least the same extent as those required by this section, such State is authorized to apply and enforce its procedures for inspection, monitoring, and entry with respect to point sources located in such State (except with respect to point sources owned or operated by the United States).

(d) ACCESS BY CONGRESS.—Notwithstanding any limitation contained in this section or any other provision of law, all information reported to or otherwise obtained by the Administrator (or any representative of the Administrator) under this Act shall be made available, upon written request of any duly authorized committee of Congress, to such committee.

(33 U.S.C. 1318)

FEDERAL ENFORCEMENT

SEC. 309. (a)(1) Whenever, on the basis of any information available to him, the Administrator finds that any person is in violation of any condition or limitation which implements section 301, 302, 306, 307, 308, 318, or 405 of this Act in a permit issued by a State under an approved permit program under section 402 or 404 of this Act, he shall proceed under his authority in paragraph (3) of this subsection or he shall notify the person in alleged violation and such State of such finding. If beyond the thirtieth day after the Administrator's notification the State has not commenced appropriate enforcement action, the Administrator shall issue an order requiring such person to comply with such condition or limitation or shall bring a civil action in accordance with subsection (b) of this section.

(2) Whenever, on the basis of information available to him, the Administrator finds that violations of permit conditions or limitations as set forth in paragraph (1) of this subsection are so widespread that such violations appear to result from a failure of the State to enforce such permit conditions or limitations effectively, he shall so notify the State. If the Administrator finds such failure extends beyond the thirtieth day after such notice, he shall give public notice of such finding. During the period beginning with such public notice and ending when such State satisfies the Administrator that it will enforce such conditions and limitations (hereafter referred to in this section as the period of "federally assumed enforcement"), except where an extension has been granted under paragraph (5)(B) of this subsection, the Administrator shall enforce any permit condition or limitation with respect to any person—

(A) by issuing an order to comply with such condition or limitation, or

(B) by bringing a civil action under subsection (b) of this section.

(3) Whenever on the basis of any information available to him the Administrator finds that any person is in violation of section 301, 302, 306, 307, 308, 318, or 405 of this Act, or is in violation of any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by him or by a State or in a permit issued under section 404 of this Act by a State, he shall issue an order requiring such person to comply with such section or requirement, or he shall bring a civil action in accordance with subsection (b) of this section.

(4) A copy of any order issued under this subsection shall be sent immediately by the Administrator to the State in which the violation occurs and other affected States. In any case in which an order under this subsection (or notice to a violator under paragraph (1) of this subsection) is issued to a corporation, a copy of such order (or notice) shall be served on any appropriate corporate officers. An order issued under this subsection relating to a violation of section 308 of this Act shall not take effect until the person to whom it is issued has had an opportunity to confer with the Administrator concerning the alleged violation.

(5)(A) Any order issued under this subsection shall be by personal service, shall state with reasonable specificity the nature of

the violation, and shall specify a time for compliance not to exceed thirty days in the case of a violation of an interim compliance schedule or operation and maintenance requirement and not to exceed a time the Administrator determines to be reasonable in the case of a violation of a final deadline, taking into account the seriousness of the violation and any good faith efforts to comply with applicable requirements.

(B) The Administrator may, if he determines (i) that any person who is a violator of, or any person who is otherwise not in compliance with, the time requirements under this Act or in any permit issued under this Act, has acted in good faith, and has made a commitment (in the form of contracts or other securities) of necessary resources to achieve compliance by the earliest possible date after July 1, 1977, but not later than April 1, 1979; (ii) that any extension under this provision will not result in the imposition of any additional controls on any other point or nonpoint source; (iii) that an application for a permit under section 402 of this Act was filed for such person prior to December 31, 1974; and (iv) that the facilities necessary for compliance with such requirements are under construction, grant an extension of the date referred to in section 301(b)(1)(A) to a date which will achieve compliance at the earliest time possible but not later than April 1, 1979.

(6) Whenever, on the basis of information available to him, the Administrator finds (A) that any person is in violation of section 301(b)(1) (A) or (C) of this Act, (B) that such person cannot meet the requirements for a time extension under section 301(i)(2) of this Act, and (C) that the most expeditious and appropriate means of compliance with this Act by such person is to discharge into a publicly owned treatment works, then, upon request of such person, the Administrator may issue an order requiring such person to comply with this Act at the earliest date practicable, but not later than July 1, 1983, by discharging into a publicly owned treatment works if such works concur with such order. Such order shall include a schedule of compliance.

(b) The Administrator is authorized to commence a civil action for appropriate relief, including a permanent or temporary injunction, for any violation for which he is authorized to issue a compliance order under subsection (a) of this section. Any action under this subsection may be brought in the district court of the United States for the district in which the defendant is located or resides or is doing business, and such court shall have jurisdiction to restrain such violation and to require compliance. Notice of the commencement of such action shall be given immediately to the appropriate State.

(c) CRIMINAL PENALTIES.—

(1) NEGLIGENT VIOLATIONS.—Any person who—

(A) negligently violates section 301, 302, 306, 307, 308, 311(b)(3), 318, or 405 of this Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by the Administrator or by a State, or any requirement imposed in a pretreatment program approved under section 402(a)(3) or 402(b)(8) of this Act or in a permit issued under section

404 of this Act by the Secretary of the Army or by a State; or

(B) negligently introduces into a sewer system or into a publicly owned treatment works any pollutant or hazardous substance which such person knew or reasonably should have known could cause personal injury or property damage or, other than in compliance with all applicable Federal, State, or local requirements or permits, which causes such treatment works to violate any effluent limitation or condition in any permit issued to the treatment works under section 402 of this Act by the Administrator or a State;

shall be punished by a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $50,000 per day of violation, or by imprisonment of not more than 2 years, or by both.

(2) KNOWING VIOLATIONS.—Any person who—

(A) knowingly violates section 301, 302, 306, 307, 308, 311(b)(3), 318, or 405 of this Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by the Administrator or by a State, or any requirement imposed in a pretreatment program approved under section 402(a)(3) or 402(b)(8) of this Act or in a permit issued under section 404 of this Act by the Secretary of the Army or by a State; or

(B) knowingly introduces into a sewer system or into a publicly owned treatment works any pollutant or hazardous substance which such person knew or reasonably should have known could cause personal injury or property damage or, other than in compliance with all applicable Federal, State, or local requirements or permits, which causes such treatment works to violate any effluent limitation or condition in a permit issued to the treatment works under section 402 of this Act by the Administrator or a State;

shall be punished by a fine of not less that $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $100,000 per day of violation, or imprisonment of not more than 6 years, or by both.

(3) KNOWING ENDANGERMENT.—

(A) GENERAL RULE.—Any person who knowingly violates section 301, 302, 306, 307, 308, 311(b)(3), 318, or 405 of this Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by the Administrator or by a State, or in a permit issued under section 404 of this Act by the Secretary of the Army or by a State, and who knows at that

time that he thereby places another person in imminent danger of death or serious bodily injury, shall, upon conviction, be subject to a fine of not more than $250,000 or imprisonment of not more than 15 years, or both. A person which is an organization shall, upon conviction of violating this subparagraph, be subject to a fine of not more than $1,000,000. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, the maximum punishment shall be doubled with respect to both fine and imprisonment.

(B) ADDITIONAL PROVISIONS.—For the purpose of subparagraph (A) of this paragraph—

(i) in determining whether a defendant who is an individual knew that his conduct placed another person in imminent danger of death or serious bodily injury—

(I) the person is responsible only for actual awareness or actual belief that he possessed; and

(II) knowledge possessed by a person other than the defendant but not by the defendant himself may not be attributed to the defendant;

except that in proving the defendant's possession of actual knowledge, circumstantial evidence may be used, including evidence that the defendant took affirmative steps to shield himself from relevant information;

(ii) it is an affirmative defense to prosecution that the conduct charged was consented to by the person endangered and that the danger and conduct charged were reasonably foreseeable hazards of—

(I) an occupation, a business, or a profession; or

(II) medical treatment or medical or scientific experimentation conducted by professionally approved methods and such other person had been made aware of the risks involved prior to giving consent;

and such defense may be established under this subparagraph by a preponderance of the evidence;

(iii) the term "organization" means a legal entity, other than a government, established or organized for any purpose, and such term includes a corporation, company, association, firm, partnership, joint stock company, foundation, institution, trust, society, union, or any other association of persons; and

(iv) the term "serious bodily injury" means bodily injury which involves a substantial risk of death, unconsciousness, extreme physical pain, protracted and obvious disfigurement, or protracted loss or impairment of the function of a bodily member, organ, or mental faculty.

(4) FALSE STATEMENTS.—Any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or

required to be maintained under this Act or who knowingly falsifies, tampers with, or renders inaccurate any monitoring device or method required to be maintained under this Act, shall upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both.

(5) TREATMENT OF SINGLE OPERATIONAL UPSET.—For purposes of this subsection, a single operational upset which leads to simultaneous violations of more than one pollutant parameter shall be treated as a single violation.

(6) RESPONSIBLE CORPORATE OFFICER AS "PERSON".—For the purpose of this subsection, the term "person" means, in addition to the definition contained in section 502(5) of this Act, any responsible corporate officer.

(7) HAZARDOUS SUBSTANCE DEFINED.—For the purpose of this subsection, the term "hazardous substance" means (A) any substance designated pursuant to section 311(b)(2)(A) of this Act, (B) any element, compound, mixture, solution, or substance designated pursuant to section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, (C) any hazardous waste having the characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act (but not including any waste the regulation of which under the Solid Waste Disposal Act has been suspended by Act of Congress), (D) any toxic pollutant listed under section 307(a) of this Act, and (E) any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to section 7 of the Toxic Substances Control Act.

(d) Any person who violates section 301, 302, 306, 307, 308, 311(b)(3), 318 or 405 of this Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by the Administrator, or by a State, or in a permit issued under section 404 of this Act by a State,,[1] or any requirement imposed in a pretreatment program approved under section 402(a)(3) or 402(b)(8) of this Act, and any person who violates any order issued by the Administrator under subsection (a) of this section, shall be subject to a civil penalty not to exceed $25,000 per day for each violation. In determining the amount of a civil penalty the court shall consider the seriousness of the violation or violations, the economic benefit (if any) resulting from the violation, any history of such violations, any good-faith efforts to comply with the applicable requirements, the economic impact of the penalty on the violator, and such other matters as justice may require. For purposes of this subsection, a single operational upset which leads to simultaneous violations of more than one pollutant parameter shall be treated as a single violation.

[1] So in law. See P.L. 100–4, sec. 313(a)(1), 101 Stat. 45.

(e) Whenever a municipality is a party to a civil action brought by the United States under this section, the State in which such municipality is located shall be joined as a party. Such State shall be liable for payment of any judgment, or any expenses incurred as a result of complying with any judgment, entered against the municipality in such action to the extent that the laws of that State prevent the municipality from raising revenues needed to comply with such judgment.

(f) Whenever, on the basis of an information available to him, the Administrator finds that an owner or operator of any source is introducing a pollutant into a treatment works in violation of subsection (d) of section 307, the Administrator may notify the owner or operator of such treatment works and the State of such violation. If the owner or operator of the treatment works does not commence appropriate enforcement action within 30 days of the date of such notification, the Administrator may commence a civil action for appropriate relief, including but not limited to, a permanent or temporary injunction, against the owner or operator of such treatment works. In any such civil action the Administrator shall join the owner or operator of such source as a party to the action. Such action shall be brought in the district court of the United States in the district in which the treatment works is located. Such court shall have jurisdiction to restrain such violation and to require the owner or operator of the treatment works and the owner or operator of the source to take such action as may be necessary to come into compliance with this Act. Notice of commencement of any such action shall be given to the State. Nothing in this subsection shall be construed to limit or prohibit any other authority the Administrator may have under this Act.

(g) ADMINISTRATIVE PENALTIES.—

(1) VIOLATIONS.—Whenever on the basis of any information available—

(A) the Administrator finds that any person has violated section 301, 302, 306, 307, 308, 318, or 405 of this Act, or has violated any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act by the Administrator or by a State, or in a permit issued under section 404 by a State, or

(B) the Secretary of the Army (hereinafter in this subsection referred to as the "Secretary") finds that any person has violated any permit condition or limitation in a permit issued under section 404 of this Act by the Secretary,

the Administrator or Secretary, as the case may be, may, after consultation with the State in which the violation occurs, assess a class I civil penalty or a class II civil penalty under this subsection.

(2) CLASSES OF PENALTIES.—

(A) CLASS I.—The amount of a class I civil penalty under paragraph (1) may not exceed $10,000 per violation, except that the maximum amount of any class I civil penalty under this subparagraph shall not exceed $25,000. Before issuing an order assessing a civil penalty under this subparagraph, the Administrator or the Secretary, as the case may be, shall give to the person to be assessed such penalty written notice of the Administrator's or Secretary's proposal to issue such order and the opportunity to request, within 30 days of the date the notice is received by such person, a hearing on the proposed order. Such hearing shall not be subject to section 554 or 556 of title 5, United States Code, but shall provide a reasonable opportunity to be heard and to represent evidence.

(B) CLASS II.—The amount of a class II civil penalty under paragraph (1) may not exceed $10,000 per day for each day during which the violation continues; except that the maximum amount of any class II civil penalty under this subparagraph shall not exceed $125,000. Except as otherwise provided in this subsection, a class II civil penalty shall be assessed and collected in the same manner, and subject to the same provisions, as in the case of civil penalties assessed and collected after notice and opportunity for a hearing on the record in accordance with section 554 of title 5, United States Code. The Administrator and the Secretary may issue rules for discovery procedures for hearings under this subparagraph.

(3) DETERMINING AMOUNT.—In determining the amount of any penalty assessed under this subsection, the Administrator or the Secretary, as the case may be, shall take into account the nature, circumstances, extent and gravity of the violation, or violations, and, with respect to the violator, ability to pay, any prior history of such violations, the degree of culpability, economic benefit or savings (if any) resulting from the violation, and such other matters as justice may require. For purposes of this subsection, a single operational upset which leads to simultaneous violations of more than one pollutant parameter shall be treated as a single violation.

(4) RIGHTS OF INTERESTED PERSONS.—

(A) PUBLIC NOTICE.—Before issuing an order assessing a civil penalty under this subsection the Administrator or Secretary, as the case may be, shall provide public notice of and reasonable opportunity to comment on the proposed issuance of such order.

(B) PRESENTATION OF EVIDENCE.—Any person who comments on a proposed assessment of a penalty under this subsection shall be given notice of any hearing held under this subsection and of the order assessing such penalty. In any hearing held under this subsection, such person shall have a reasonable opportunity to be heard and to present evidence.

(C) RIGHTS OF INTERESTED PERSONS TO A HEARING.—If no hearing is held under paragraph (2) before issuance of an order assessing a penalty under this subsection, any person who commented on the proposed assessment may petition, within 30 days after the issuance of such order, the Administrator or Secretary, as the case may be, to set aside such order and to provide a hearing on the penalty. If the evidence presented by the petitioner in support of the petition is material and was not considered in the issuance of the order, the Administrator or Secretary shall immediately set aside such order and provide a hearing in accordance with paragraph (2)(A) in the case of a class I civil penalty and paragraph (2)(B) in the case of a class II civil penalty. If the Administrator or Secretary denies a hearing under this subparagraph, the Administrator or Secretary shall provide to the petitioner, and publish in the Federal Register, notice of and the reasons for such denial.

(5) FINALITY OF ORDER.—An order issued under this subsection shall become final 30 days after its issuance unless a petition for judicial review is filed under paragraph (8) or a hearing is requested under paragraph (4)(C). If such a hearing is denied, such order shall become final 30 days after such denial.

(6) EFFECT OF ORDER.—

(A) LIMITATION ON ACTIONS UNDER OTHER SECTIONS.—Action taken by the Administrator or the Secretary, as the case may be, under this subsection shall not affect or limit the Administrator's or Secretary's authority to enforce any provision of this Act; except that any violation—

(i) with respect to which the Administrator or the Secretary has commenced and is diligently prosecuting an action under this subsection,

(ii) with respect to which a State has commenced and is diligently prosecuting an action under a State law comparable to this subsection, or

(iii) for which the Administrator, the Secretary, or the State has issued a final order not subject to further judicial review and the violator has paid a penalty assessed under this subsection, or such comparable State law, as the case may be,

shall not be the subject of a civil penalty action under subsection (d) of this section or section 311(b) or section 505 of this Act.

(B) APPLICABILITY OF LIMITATION WITH RESPECT TO CITIZEN SUITS.—The limitations contained in subparagraph (A) on civil penalty actions under section 505 of this Act shall not apply with respect to any violation for which—

(i) a civil action under section 505(a)(1) of this Act has been filed prior to commencement of an action under this subsection, or

(ii) notice of an alleged violation of section 505(a)(1) of this Act has been given in accordance with section 505(b)(1)(A) prior to commencement of an action under this subsection and an action under section 505(a)(1) with respect to such alleged violation is filed before the 120th day after the date on which such notice is given.

(7) EFFECT OF ACTION ON COMPLIANCE.—No action by the Administrator or the Secretary under this subsection shall affect any person's obligation to comply with any section of this Act or with the terms and conditions of any permit issued pursuant to section 402 or 404 of this Act.

(8) JUDICIAL REVIEW.—Any person against whom a civil penalty is assessed under this subsection or who commented on the proposed assessment of such penalty in accordance with paragraph (4) may obtain review of such assessment—

(A) in the case of assessment of a class I civil penalty, in the United States District Court for the District of Columbia or in the district in which the violation is alleged to have occurred, or

(B) in the case of assessment of a class II civil penalty, in United States Court of Appeals for the District of Columbia Circuit or for any other circuit in which such person resides or transacts business,

by filing a notice of appeal in such court within the 30-day period beginning on the date the civil penalty order is issued and by simultaneously sending a copy of such notice by certified mail to the Administrator or the Secretary, as the case may be, and the Attorney General. The Administrator or the Secretary shall promptly file in such court a certified copy of the record on which the order was issued. Such court shall not set aside or remand such order unless there is not substantial evidence in the record, taken as a whole, to support the finding of a violation or unless the Administrator's or Secretary's assessment of the penalty constitutes an abuse of discretion and shall not impose additional civil penalties for the same violation unless the Administrator's or Secretary's assessment of the penalty constitutes an abuse of discretion.

(9) COLLECTION.—If any person fails to pay an assessment of a civil penalty—

(A) after the order making the assessment has become final, or

(B) after a court in an action brought under paragraph (8) has entered a final judgment in favor of the Administrator or the Secretary, as the case may be,

the Administrator or the Secretary shall request the Attorney General to bring a civil action in an appropriate district court to recover the amount assessed (plus interest at currently prevailing rates from the date of the final order or the date of the final judgment, as the case may be). In such an action, the validity, amount, and appropriateness of such penalty shall not be subject to review. Any person who fails to pay on a timely basis the amount of an assessment of a civil penalty as described in the first sentence of this paragraph shall be required to pay, in addition to such amount and interest, attorneys fees and costs for collection proceedings and a quarterly nonpayment penalty for each quarter during which such failure to pay persists. Such nonpayment penalty shall be in an amount equal to 20 percent of the aggregate amount of such person's penalties and nonpayment penalties which are unpaid as of the beginning of such quarter.

(10) SUBPOENAS.—The Administrator or Secretary, as the case may be, may issue subpoenas for the attendance and testimony of witnesses and the production of relevant papers, books, or documents in connection with hearings under this subsection. In case of contumacy or refusal to obey a subpoena issued pursuant to this paragraph and served upon any person, the district court of the United States for any district in which such person is found, resides, or transacts business, upon application by the United States and after notice to such person, shall have jurisdiction to issue an order requiring such person to appear and give testimony before the administrative law judge or to appear and produce documents before the administrative law judge, or both, and any failure to obey such order of the court may be punished by such court as a contempt thereof.

(11) PROTECTION OF EXISTING PROCEDURES.—Nothing in this subsection shall change the procedures existing on the day before the date of the enactment of the Water Quality Act of 1987 under other subsections of this section for issuance and enforcement of orders by the Administrator.

(33 U.S.C. 1319)

INTERNATIONAL POLLUTION ABATEMENT

SEC. 310. (a) Whenever the Administrator, upon receipts of reports, surveys, or studies from any duly constituted international agency, has reason to believe that pollution is occurring which endangers the health or welfare of persons in a foreign country, and the Secretary of State requests him to abate such pollution, he shall give formal notification thereof to the State water pollution control agency of the State or States in which such discharge or discharges originate and to the appropriate interstate agency, if any. He shall also promptly call such a hearing, if he believes that such pollution is occurring in sufficient quantity to warrant such action, and if such foreign country has given the United States essentially the same rights with respect to the prevention and control of pollution occurring in that country as is given that country by this subsection. The Administrator, through the Secretary of State, shall invite the foreign country which may be adversely affected by the pollution to attend and participate in the hearing, and the representative of such country shall, for the purpose of the hearing and any further proceeding resulting from such hearing, have all the rights of a State water pollution control agency. Nothing in this subsection shall be construed to modify, amend, repeal, or otherwise affect the provisions of the 1909 Boundary Waters Treaty between Canada and the United States or the Water Utilization Treaty of 1944 between Mexico and the United States (59 Stat. 1219), relative to the control and abatement of pollution in waters covered by those treaties.

(b) The calling of a hearing under this section shall not be construed by the courts, the Administrator, or any person as limiting, modifying, or otherwise affecting the functions and responsibilities of the Administrator under this section to establish and enforce water quality requirements under this Act.

(c) The Administrator shall publish in the Federal Register a notice of a public hearing before a hearing board of five or more persons appointed by the Administrator. A majority of the members of the board and the chairman who shall be designated by the Administrator shall not be officers or employees of Federal, State, or local governments. On the basis of the evidence presented at such hearing, the board shall within sixty days after completion of the hearing make findings of fact as to whether or not such pollution is occurring and shall thereupon by decision, incorporating its findings therein, make such recommendations to abate the pollution as may be appropriate and shall transmit such decision and the record of the hearings to the Administrator. All such decisions shall be public. Upon receipt of such decision, the Administrator shall promptly implement the board's decision in accordance with the provisions of this Act.

(d) In connection with any hearing called under this subsection, the board is authorized to require any persons whose alleged activities result in discharges causing or contributing to pollution to file with it in such forms as it may prescribe, a report based on existing data, furnishing such information as may reasonably be required as to the character, kind, and quantity of such discharges and the use of facilities or other means to prevent or reduce such discharges by the person filing such a report. Such report shall be made under oath or otherwise, as the board may prescribe, and shall be filed with the board within such reasonable period as it may prescribe, unless additional time is granted by it. Upon a showing satisfactory to the board by the person filing such report that such report or portion thereof (other than effluent data), to which the Adminsitrator has access under this section, if made public would divulge trade secrets or secret processes of such person, the board shall consider such report or portion thereof confidential for the purposes of section 1905 of title 18 of the United States Code. If any person required to file any report under this paragraph shall fail to do so within the time fixed by the board for filing the same, and such failure shall continue for thirty days after notice of such default, such person shall forfeit to the United States the sum of $1,000 for each and every day of the continuance of such failure, which forfeiture shall be payable into the Treasury of the United States, and shall be recoverable in a civil suit in the name of the United States in the district court of the United States where such person has his principal office or in any district in which he does business. The Administrator may upon application therefor remit or mitigate any forfeiture provided for under this subsection.

(e) Board members, other than officers or employees of Federal, State, or local governments, shall be for each day (including traveltime) during which they are performing board business, entitled to receive compensation at a rate fixed by the Administrator but not in excess of the maximum rate of pay for grade GS–18, as provided in the General Schedule under section 5332 of title 5 of the United States Code, and shall, notwithstanding the limitations of sections 5703 and 5704 of title 5 of the United States Code, be fully reimbursed for travel, subsistence, and related expenses.

(f) When any such recommendation adopted by the Administrator involves the institution of enforcement proceedings against any person to obtain the abatement of pollution subject to such recommendation, the Administrator shall institute such proceedings if he believes that the evidence warrants such proceedings. The district court of the United States shall consider and determine de

novo all relevant issues, but shall receive in evidence the record of the proceedings before the conference or hearing board. The court shall have jurisdiction to enter such judgment and orders enforcing such judgment as it deems appropriate or to remand such proceedings to the Administrator for such further action as it may direct.

(33 U.S.C. 1320)

OIL AND HAZARDOUS SUBSTANCE LIABILITY

SEC. 311. (a) For the purpose of this section, the term—

(1) "oil" means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil;

(2) "discharge" includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying or dumping, but excludes (A) discharges in compliance with a permit under section 402 of this Act, (B) discharges resulting from circumstances identified and reviewed and made a part of the public record with respect to a permit issued or modified under section 402 of this Act, and subject to a condition in such permit, and (C) continuous or anticipated intermittent discharges from a point source, identified in a permit or permit application under section 402 of this Act, which are caused by events occurring within the scope of relevant operating or treatment systems;

(3) "vessel" means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water other than a public vessel;

(4) "public vessel" means a vessel owned or bareboat-chartered and operated by the United States, or by a State or political subdivision thereof, or by a foreign nation, except when such vessel is engaged in commerce;

(5) "United States" means the States, the District of Columbia, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, Guam, American Samoa, the Virgin Islands, and the Trust Territory of the Pacific Islands;

(6) "owner or operator" means (A) in the case of a vessel, any person owning, operating, or chartering by demise, such vessel, and (B) in the case of an onshore facility, and an offshore facility, any person owning or operating such onshore facility or offshore facility, and (C) in the case of any abandoned offshore facility, the person who owned or operated such facility immediately prior to such abandonment;

(7) "person" includes an individual, firm, corporation, association, and a partnership;

(8) "remove" or "removal" refers to containment and removal of the oil or hazardous substances from the water and shorelines or the taking of such other actions as may be necessary to minimize or mitigate damage to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, and public and private property, shorelines, and beaches;

(9) "contiguous zone" means the entire zone established or to be established by the United States under article 24 of the Convention on the Territorial Sea and the Contiguous Zone;

(10) "onshore facility" means any facility (including, but not limited to, motor vehicles and rolling stock) of any kind located in, on, or under, any land within the United States other than submerged land;

(11) "offshore facility" means any facility of any kind located in, on, or under, any of the navigable waters of the United States, and any facility of any kind which is subject to the jurisdiction of the United States and is located in, on, or under any other waters, other than a vessel or a public vessel;

(12) "act of God" means an act occasioned by an unanticipated grave natural disaster;

(13) "barrel" means 42 United States gallons at 60 degrees Fahrenheit;

(14) "hazardous substance" means any substance designated pursuant to subsection (b)(2) of this section;

(15) "inland oil barge" means a non-self-propelled vessel carrying oil in bulk as cargo and certificated to operate only in the inland waters of the United States, while operating in such waters;

(16) "inland waters of the United States" means those waters of the United States lying inside the baseline from which the territorial sea is measured and those water outside such baseline which are a part of the Gulf Intracoastal Waterway;

(17) "otherwise" subject to the jurisdiction of the United States" means subject to the jurisdiction of the United States by virtue of United States citizenship, United States vessel documentation or numbering, or as provided for by international agreement to which the United States is a party;

(18) "Area Committee" means an Area Committee established under subsection (j);

(19) "Area Contingency Plan" means an Area Contingency Plan prepared under subsection (j);

(20) "Coast Guard District Response Group" means a Coast Guard District Response Group established under subsection (j);

(21) "Federal On-Scene Coordinator" means a Federal On-Scene Coordinator designated in the National Contingency Plan;

(22) "National Contingency Plan" means the National Contingency Plan prepared and published under subsection (d);

(23) "National Response Unit" means the National Response Unit established under subsection (j); and

(24) "worst case discharge" means—

(A) in the case of a vessel, a discharge in adverse weather conditions of its entire cargo; and

(B) in the case of an offshore facility or onshore facility, the largest foreseeable discharge in adverse weather conditions.

(b)(1) The Congress hereby declares that it is the policy of the United States that there should be no discharges of oil or hazardous substances into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone, or in connection with activities under the Outer Continental Shelf Lands Act or the Deepwater Port Act of 1974, or

which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Fishery Conservation and Management Act of 1976).

(2)(A) The Administrator shall develop, promulgate, and revise as may be appropriate, regulations designating as hazardous substances, other than oil as defined in this section, such elements and compounds which, when discharged in any quantity into or upon the navigable waters of the United States or adjoining shorelines or the waters of the contiguous zone or in connection with activities under the Outer Continental Shelf Lands Act or the Deepwater Port Act of 1974, or which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Fishery Conservation and Management Act of 1976), present an imminent and substantial danger to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, shorelines, and beaches.

(B) The Administrator shall within 18 months after the date of enactment of this paragraph, conduct a study and report to the Congress on methods, mechanisms, and procedures to create incentives to achieve a higher standard of care in all aspects of the management and movement of hazardous substances on the part of owners, operators, or persons in charge of onshore facilities, offshore facilities, or vessels. The Administrator shall include in such study (1) limits of liability, (2) liability for third party damages, (3) penalties and fees, (4) spill prevention plans, (5) current practices in the insurance and banking industries, and (6) whether the penalty enacted in subclause (bb) of clause (iii) of subparagraph (B) of subsection (b)(2) of section 311 of Public Law 92–500 should be enacted.

(3) The discharge of oil or hazardous substances (i) into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone, or (ii) in connection with activities under the Outer Continental Shelf Lands Act or the Deepwater Port Act of 1974, or which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Fishery Conservation and Management Act of 1976), in such quantities as may be harmful as determined by the President under paragraph (4) of this subsection, is prohibited, except (A) in the case of such discharges into the waters of the contiguous zone or which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Fishery Conservation and Management Act of 1976), where permitted under the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973, and (B) where permitted in quantities and at times and locations or under such circumstances or conditions as the President may, by regulation, determine not to be harmful. Any regulations issued under this subsection shall be consistent with maritime safety and with marine and navigation laws and regulations and applicable water quality standards.

(4) The President shall by regulation determine for the purposes of this section those quantities of oil and any hazardous sub-

stances the discharge of which may be harmful to the public health or welfare or the environment of the United States, including but not limited to fish, shellfish, wildlife, and public and private property, shorelines, and beaches.

(5) Any person in charge of a vessel or of an onshore facility or an offshore facility shall, as soon as he has knowledge of any discharge of oil or a hazardous substance from such vessel or facility in violation of paragraph (3) of this subsection, immediately notify the appropriate agency of the United States Government of such discharge. The Federal agency shall immediately notify the appropriate State agency of any State which is, or may reasonably be expected to be, affected by the discharge of oil or a hazardous substance. Any such person (A) in charge of a vessel from which oil or a hazardous substance is discharged in violation of pragraph (3)(i) of this subsection, or (B) in charge of a vessel from which oil or a hazardous substance is discharged in violation of paragraph (3)(ii) of this subsection and who is otherwise subject to the jurisdiction of the United States at the time of the discharge, or (C) in charge of an onshore facility or an offshore facility, who fails to notify immediately such agency of such discharge shall, upon conviction, be fined in accordance with title 18, United States Code, or imprisoned for not more than 5 years, or both. Notification received pursuant to this paragraph shall not be used against any such natural person in any criminal case, except a prosecution for perjury or for giving a false statement.

(6) ADMINISTRATIVE PENALTIES.—

(A) VIOLATIONS.—Any owner, operator, or person in charge of any vessel, onshore facility, or offshore facility—

(i) from which oil or a hazardous substance is discharged in violation of paragraph (3), or

(ii) who fails or refuses to comply with any regulation issued under subsection (j) to which that owner, operator, or person in charge is subject,

may be assessed a class I or class II civil penalty by the Secretary of the department in which the Coast Guard is operating or the Administrator.

(B) CLASSES OF PENALTIES.—

(i) CLASS I.—The amount of a class I civil penalty under subparagraph (A) may not exceed $10,000 per violation, except that the maximum amount of any class I civil penalty under this subparagraph shall not exceed $25,000. Before assessing a civil penalty under this clause, the Administrator or Secretary, as the case may be, shall give to the person to be assessed such penalty written notice of the Administrator's or Secretary's proposal to assess the penalty and the opportunity to request, within 30 days of the date the notice is received by such person, a hearing on the proposed penalty. Such hearing shall not be subject to section 554 or 556 of title 5, United States Code, but shall provide a reasonable opportunity to be heard and to present evidence.

(ii) CLASS II.—The amount of a class II civil penalty under subparagraph (A) may not exceed $10,000

per day for each day during which the violation continues; except that the maximum amount of any class II civil penalty under this subparagraph shall not exceed $125,000. Except as otherwise provided in this subsection, a class II civil penalty shall be assessed and collected in the same manner, and subject to the same provisions, as in the case of civil penalties assessed and collected after notice and opportunity for a hearing on the record in accordance with section 554 of title 5, United States Code. The Administrator and Secretary may issue rules for discovery procedures for hearings under this paragraph.

(C) RIGHTS OF INTERESTED PERSONS.—

(i) PUBLIC NOTICE.—Before issuing an order assessing a class II civil penalty under this paragraph the Administrator or Secretary, as the case may be, shall provide public notice of and reasonable opportunity to comment on the proposed issuance of such order.

(ii) PRESENTATION OF EVIDENCE.—Any person who comments on a proposed assessment of a class II civil penalty under this paragraph shall be given notice of any hearing held under this paragraph and of the order assessing such penalty. In any hearing held under this paragraph, such person shall have a reasonable opportunity to be heard and to present evidence.

(iii) RIGHTS OF INTERESTED PERSONS TO A HEARING.—If no hearing is held under subparagraph (B) before issuance of an order assessing a class II civil penalty under this paragraph, any person who commented on the proposed assessment may petition, within 30 days after the issuance of such order, the Administrator or Secretary, as the case may be, to set aside such order and to provide a hearing on the penalty. If the evidence presented by the petitioner in support of the petition is material and was not considered in the issuance of the order, the Administrator or Secretary shall immediately set aside such order and provide a hearing in accordance with subparagraph (B)(ii). If the Administrator or Secretary denies a hearing under this clause, the Administrator or Secretary shall provide to the petitioner, and publish in the Federal Register, notice of and the reasons for such denial.

(D) FINALITY OF ORDER.—An order assessing a class II civil penalty under this paragraph shall become final 30 days after its issuance unless a petition for judicial review is filed under subparagraph (G) or a hearing is requested under subparagraph (C)(iii). If such a hearing is denied, such order shall become final 30 days after such denial.

(E) EFFECT OF ORDER.—Action taken by the Administrator or Secretary, as the case may be, under this paragraph shall not affect or limit the Administrator's or Secretary's authority to enforce any provision of this Act; except that any violation—

(i) with respect to which the Administrator or Secretary has commenced and is diligently prosecuting an action to assess a class II civil penalty under this paragraph, or

(ii) for which the Administrator or Secretary has issued a final order assessing a class II civil penalty not subject to further judicial review and the violator has paid a penalty assessed under this paragraph,

shall not be the subject of a civil penalty action under section 309(d), 309(g), or 505 of this Act or under paragraph (7).

(F) EFFECT OF ACTION ON COMPLIANCE.—No action by the Administrator or Secretary under this paragraph shall affect any person's obligation to comply with any section of this Act.

(G) JUDICIAL REVIEW.—Any person against whom a civil penalty is assessed under this paragraph or who commented on the proposed assessment of such penalty in accordance with subparagraph (C) may obtain review of such assessment—

(i) in the case of assessment of a class I civil penalty, in the United States District Court for the District of Columbia or in the district in which the violation is alleged to have occurred, or

(ii) in the case of assessment of a class II civil penalty, in United States Court of Appeals for the District of Columbia Circuit or for any other circuit in which such person resides or transacts business,

by filing a notice of appeal in such court within the 30-day period beginning on the date the civil penalty order is issued and by simultaneously sending a copy of such notice by certified mail to the Administrator or Secretary, as the case may be, and the Attorney General. The Administrator or Secretary shall promptly file in such court a certified copy of the record on which the order was issued. Such court shall not set aside or remand such order unless there is not substantial evidence in the record, taken as a whole, to support the finding of a violation or unless the Administrator's or Secretary's assessment of the penalty constitutes an abuse of discretion and shall not impose additional civil penalties for the same violation unless the Administrator's or Secretary's assessment of the penalty constitutes an abuse of discretion.

(H) COLLECTION.—If any person fails to pay an assessment of a civil penalty—

(i) after the assessment has become final, or

(ii) after a court in an action brought under subparagraph (G) has entered a final judgment in favor of the Administrator or Secretary, as the case may be,

the Administrator or Secretary shall request the Attorney General to bring a civil action in an appropriate district court to recover the amount assessed (plus interest at currently prevailing rates from the date of the final order or the date of the final judgment, as the case may be). In such an action, the validity, amount, and appropriateness of such penalty shall not be subject to review. Any person who fails to pay on a timely basis the amount of an assessment of a civil penalty as described in the first sentence of this subparagraph shall be required to pay, in addition to such amount and interest, attorneys fees and costs for collection proceedings and a quarterly nonpayment penalty for each quarter during which such failure to pay persists. Such nonpayment penalty shall be in an amount equal to 20 percent of the aggregate amount of such person's penalties and nonpayment penalties which are unpaid as of the beginning of such quarter.

(I) SUBPOENAS.—The Administrator or Secretary, as the case may be, may issue subpoenas for the attendance and testimony of witnesses and the production of relevant papers, books, or documents in connection with hearings under this paragraph. In case of contumacy or refusal to obey a subpoena issued pursuant to this subparagraph and served upon any person, the district court of the United States for any district in which such person is found, resides, or transacts business, upon application by the United States and after notice to such person, shall have jurisdiction to issue an order requiring such person to appear and give testimony before the administrative law judge or to appear and produce documents before the administrative law judge, or both, and any failure to obey such order of the court may be punished by such court as a contempt thereof.

(7) CIVIL PENALTY ACTION.—

(A) DISCHARGE, GENERALLY.—Any person who is the owner, operator, or person in charge of any vessel, onshore facility, or offshore facility from which oil or a hazardous substance is discharged in violation of paragraph (3), shall be subject to a civil penalty in an amount up to $25,000 per day of violation or an amount up to $1,000 per barrel of oil or unit of reportable quantity of hazardous substances discharged.

(B) FAILURE TO REMOVE OR COMPLY.—Any person described in subparagraph (A) who, without sufficient cause—

(i) fails to properly carry out removal of the discharge under an order of the President pursuant to subsection (c); or

(ii) fails to comply with an order pursuant to subsection (e)(1)(B);

shall be subject to a civil penalty in an amount up to $25,000 per day of violation or an amount up to 3 times the costs incurred by the Oil Spill Liability Trust Fund as a result of such failure.

(C) FAILURE TO COMPLY WITH REGULATION.—Any person who fails or refuses to comply with any regulation issued under subsection (j) shall be subject to a civil penalty in an amount up to $25,000 per day of violation.

(D) GROSS NEGLIGENCE.—In any case in which a violation of paragraph (3) was the result of gross negligence or willful misconduct of a person described in subparagraph (A), the person shall be subject to a civil penalty of not less than $100,000, and not more than $3,000 per barrel of oil or unit of reportable quantity of hazardous substance discharged.

(E) JURISDICTION.—An action to impose a civil penalty under this paragraph may be brought in the district court of the United States for the district in which the defendant is located, resides, or is doing business, and such court shall have jurisdiction to assess such penalty.

(F) LIMITATION.—A person is not liable for a civil penalty under this paragraph for a discharge if the person has been assessed a civil penalty under paragraph (6) for the discharge.

(8) DETERMINATION OF AMOUNT.—In determining the amount of a civil penalty under paragraphs (6) and (7), the Administrator, Secretary, or the court, as the case may be, shall consider the seriousness of the violation or violations, the economic benefit to the violator, if any, resulting from the violation, the degree of culpability involved, any other penalty for the same incident, any history of prior violations, the nature, extent, and degree of success of any efforts of the violator to minimize or mitigate the effects of the discharge, the economic impact of the penalty on the violator, and any other matters as justice may require.

(9) MITIGATION OF DAMAGE.—In addition to establishing a penalty for the discharge of oil or a hazardous substance, the Administrator or the Secretary of the department in which the Coast Guard is operating may act to mitigate the damage to the public health or welfare caused by such discharge. The cost of such mitigation shall be deemed a cost incurred under subsection (c) of this section for the removal of such substance by the United States Government.

(10) RECOVERY OF REMOVAL COSTS.—Any costs of removal incurred in connection with a discharge excluded by subsection (a)(2)(C) of this section shall be recoverable from the owner or operator of the source of the discharge in an action brought under section 309(b) of this Act.

(11) LIMITATION.—Civil penalties shall not be assessed under both this section and section 309 for the same discharge.

(12)[1] WITHHOLDING CLEARANCE.—If any owner, operator, or person in charge of a vessel is liable for a civil penalty under this subsection, or if reasonable cause exists to believe that the owner, operator, or person in charge may be subject to a civil penalty under this subsection, the Secretary of the Treasury, upon the request of the Secretary of the department in which the Coast Guard

[1] Indentation so in law.

is operating or the Administrator, shall with respect to such vessel refuse or revoke—

(A) the clearance required by section 4197 of the Revised Statutes of the United States (46 U.S.C. App. 91);

(B) a permit to proceed under section 4367 of the Revised Statutes of the United States (46 U.S.C. App. 313); and

(C) a permit to depart required under section 443 of the Tariff Act of 1930 (19 U.S.C. 1443);

as applicable. Clearance or a permit refused or revoked under this paragraph may be granted upon the filing of a bond or other surety satisfactory to the Secretary of the department in which the Coast Guard is operating or the Administrator.

(c) FEDERAL REMOVAL AUTHORITY.—

(1) GENERAL REMOVAL REQUIREMENT.—(A) The President shall, in accordance with the National Contingency Plan and any appropriate Area Contingency Plan, ensure effective and immediate removal of a discharge, and mitigation or prevention of a substantial threat of a discharge, of oil or a hazardous substance—

(i) into or on the navigable waters;

(ii) on the adjoining shorelines to the navigable waters;

(iii) into or on the waters of the exclusive economic zone; or

(iv) that may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States.

(B) In carrying out this paragraph, the President may—

(i) remove or arrange for the removal of a discharge, and mitigate or prevent a substantial threat of a discharge, at any time;

(ii) direct or monitor all Federal, State, and private actions to remove a discharge; and

(iii) remove and, if necessary, destroy a vessel discharging, or threatening to discharge, by whatever means are available.

(2) DISCHARGE POSING SUBSTANTIAL THREAT TO PUBLIC HEALTH OR WELFARE.—(A) If a discharge, or a substantial threat of a discharge, of oil or a hazardous substance from a vessel, offshore facility, or onshore facility is of such a size or character as to be a substantial threat to the public health or welfare of the United States (including but not limited to fish, shellfish, wildlife, other natural resources, and the public and private beaches and shorelines of the United States), the President shall direct all Federal, State, and private actions to remove the discharge or to mitigate or prevent the threat of the discharge.

(B) In carrying out this paragraph, the President may, without regard to any other provision of law governing contracting procedures or employment of personnel by the Federal Government—

(i) remove or arrange for the removal of the discharge, or mitigate or prevent the substantial threat of the discharge; and

(ii) remove and, if necessary, destroy a vessel discharging, or threatening to discharge, by whatever means are available.

(3) ACTIONS IN ACCORDANCE WITH NATIONAL CONTINGENCY PLAN.—(A) Each Federal agency, State, owner or operator, or other person participating in efforts under this subsection shall act in accordance with the National Contingency Plan or as directed by the President.

(B) An owner or operator participating in efforts under this subsection shall act in accordance with the National Contingency Plan and the applicable response plan required under subsection (j), or as directed by the President, except that the owner or operator may deviate from the applicable response plan if the President or the Federal On-Scene Coordinator determines that deviation from the response plan would provide for a more expeditious or effective response to the spill or mitigation of its environmental effects.

(4) EXEMPTION FROM LIABILITY.—(A) A person is not liable for removal costs or damages which result from actions taken or omitted to be taken in the course of rendering care, assistance, or advice consistent with the National Contingency Plan or as otherwise directed by the President.

(B) Subparagraph (A) does not apply—

(i) to a responsible party;

(ii) to a response under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.);

(iii) with respect to personal injury or wrongful death; or

(iv) if the person is grossly negligent or engages in willful misconduct.

(C) A responsible party is liable for any removal costs and damages that another person is relieved of under subparagraph (A).

(5) OBLIGATION AND LIABILITY OF OWNER OR OPERATOR NOT AFFECTED.—Nothing in this subsection affects—

(A) the obligation of an owner or operator to respond immediately to a discharge, or the threat of a discharge, of oil; or

(B) the liability of a responsible party under the Oil Pollution Act of 1990.

(6) RESPONSIBLE PARTY DEFINED.—For purposes of this subsection, the term "responsible party" has the meaning given that term under section 1001 of the Oil Pollution Act of 1990.

(d) NATIONAL CONTINGENCY PLAN.—

(1) PREPARATION BY PRESIDENT.—The President shall prepare and publish a National Contingency Plan for removal of oil and hazardous substances pursuant to this section.

(2) CONTENTS.—The National Contingency Plan shall provide for efficient, coordinated, and effective action to minimize damage from oil and hazardous substance discharges, including containment, dispersal, and removal of oil and hazardous substances, and shall include, but not be limited to, the following:

(A) Assignment of duties and responsibilities among Federal departments and agencies in coordination with State and local agencies and port authorities including, but not limited to, water pollution control and conservation and trusteeship of natural resources (including conservation of fish and wildlife).

(B) Identification, procurement, maintenance, and storage of equipment and supplies.

(C) Establishment or designation of Coast Guard strike teams, consisting of—

(i) personnel who shall be trained, prepared, and available to provide necessary services to carry out the National Contingency Plan;

(ii) adequate oil and hazardous substance pollution control equipment and material; and

(iii) a detailed oil and hazardous substance pollution and prevention plan, including measures to protect fisheries and wildlife.

(D) A system of surveillance and notice designed to safeguard against as well as ensure earliest possible notice of discharges of oil and hazardous substances and imminent threats of such discharges to the appropriate State and Federal agencies.

(E) Establishment of a national center to provide coordination and direction for operations in carrying out the Plan.

(F) Procedures and techniques to be employed in identifying, containing, dispersing, and removing oil and hazardous substances.

(G) A schedule, prepared in cooperation with the States, identifying—

(i) dispersants, other chemicals, and other spill mitigating devices and substances, if any, that may be used in carrying out the Plan,

(ii) the waters in which such dispersants, other chemicals, and other spill mitigating devices and substances may be used, and

(iii) the quantities of such dispersant, other chemicals, or other spill mitigating device or substance which can be used safely in such waters,

which schedule shall provide in the case of any dispersant, chemical, spill mitigating device or substance, or waters not specifically identified in such schedule that the President, or his delegate, may, on a case-by-case basis, identify the dispersants, other chemicals, and other spill mitigating devices and substances which may be used, the waters in which they may be used, and the quantities which can be used safely in such waters.

(H) A system whereby the State or States affected by a discharge of oil or hazardous substance may act where necessary to remove such discharge and such State or States may be reimbursed in accordance with the Oil Pollution Act of 1990, in the case of any discharge of oil from a vessel or facility, for the reasonable costs incurred for that removal, from the Oil Spill Liability Trust Fund.

(I) Establishment of criteria and procedures to ensure immediate and effective Federal identification of, and response to, a discharge, or the threat of a discharge, that results in a substantial threat to the public health or welfare of the United States, as required under subsection (c)(2).

(J) Establishment of procedures and standards for removing a worst case discharge of oil, and for mitigating or preventing a substantial threat of such a discharge.

(K) Designation of the Federal official who shall be the Federal On-Scene Coordinator for each area for which an Area Contingency Plan is required to be prepared under subsection (j).

(L) Establishment of procedures for the coordination of activities of—

(i) Coast Guard strike teams established under subparagraph (C);

(ii) Federal On-Scene Coordinators designated under subparagraph (K);

(iii) District Response Groups established under subsection (j); and

(iv) Area Committees established under subsection (j).

(M) A fish and wildlife response plan, developed in consultation with the United States Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, and other interested parties (including State fish and wildlife conservation officials), for the immediate and effective protection, rescue, and rehabilitation of, and the minimization of risk of damage to, fish and wildlife resources and their habitat that are harmed or that may be jeopardized by a discharge.

(3) REVISIONS AND AMENDMENTS.—The President may, from time to time, as the President deems advisable, revise or otherwise amend the National Contingency Plan.

(4) ACTIONS IN ACCORDANCE WITH NATIONAL CONTINGENCY PLAN.—After publication of the National Contingency Plan, the removal of oil and hazardous substances and actions to minimize damage from oil and hazardous substance discharges shall, to the greatest extent possible, be in accordance with the National Contingency Plan.

(e) CIVIL ENFORCEMENT.—

(1) ORDERS PROTECTING PUBLIC HEALTH.—In addition to any action taken by a State or local government, when the President determines that there may be an imminent and substantial threat to the public health or welfare of the United States, including fish, shellfish, and wildlife, public and private property, shorelines, beaches, habitat, and other living and nonliving natural resources under the jurisdiction or control of the United States, because of an actual or threatened discharge of oil or a hazardous substance from a vessel or facility in violation of subsection (b), the President may—

(A) require the Attorney General to secure any relief from any person, including the owner or operator of the vessel or facility, as may be necessary to abate such endangerment; or

(B) after notice to the affected State, take any other action under this section, including issuing administrative orders, that may be necessary to protect the public health and welfare.

(2) JURISDICTION OF DISTRICT COURTS.—The district courts of the United States shall have jurisdiction to grant any relief under this subsection that the public interest and the equities of the case may require.

(f)(1) Except where an owner or operator can prove that a discharge was caused solely by (A) an act of God, (B) an act of war, (C) negligence on the part of the United States Government, or (D) an act or omission of a third party without regard to whether any such act or omission was or was not negligent, or any combination of the foregoing clauses, such owner or operator of any vessel from which oil or a hazardous substance is discharged in violation of subsection (b)(3) of this section shall, notwithstanding any other provision of law, be liable to the United States Government for the actual costs incurred under subsection (c) for the removal of such oil or substance by the United States Government in an amount not to exceed, in the case of an inland oil barge $125 per gross ton of such barge, or $125,000, whichever is greater, and in the case of any other vessel, $150 per gross ton of such vessel (or, for a vessel carrying oil or hazardous substances as cargo, $250,000), whichever is greater, except that where the United States can show that such discharge was the result of willful negligence or willful misconduct within the privity and knowledge of the owner, such owner or operator shall be liable to the United States Government for the full amount of such costs. Such costs shall constitute a maritime lien on such vessel which may be recovered in an action in rem in the district court of the United States for any district within which any vessel may be found. The United States may also bring an action against the owner or operator of such vessel in any court of competent jurisdiction to recover such costs.

(2) Except where an owner or operator of an onshore facility can prove that a discharge was caused solely by (A) an act of God, (B) an act of war, (C) negligence on the part of the United States Government, or (D) an act or omission of a third party without regard to whether any such act or omission was or was not negligent, or any combination of the foregoing clauses, such owner or operator of any such facility from which oil or a hazardous substance is discharged in violation of subsection (b)(3) of this section shall be liable to the United States Government for the actual costs incurred under subsection (c) for the removal of such oil or substance by the United States Government in an amount not to exceed $50,000,000, except that where the United States can show that such discharge was the result of willful negligence or willful misconduct within the privity and knowledge of the owner, such owner or operator shall be liable to the United States Government for the full amount of such costs. The United States may bring an action against the owner or operator of such facility in any court of competent juris-

diction to recover such costs. The Administrator is authorized, by regulation, after consultation with the Secretary of Commerce and the Small Business Administration, to establish reasonable and equitable classifications, of those onshore facilities having a total fixed storage capacity of 1,000 barrels or less which he determines because of size, type, and location do not present a substantial risk of the discharge of oil or hazardous substance in violation of subsection (b)(3) of this section, and apply with respect to such classifications differing limits of liability which may be less than the amount contained in this paragraph.

(3) Except where an owner or operator of an onshore facility can prove that a discharge was caused solely by (A) an act of God, (B) an act of war, (C) negligence on the part of the United States Government, or (D) an act or omission of a third party without regard to whether any such act or omission was or was not negligent, or any combination of the foregoing clauses, such owner or operator of any such facility from which oil or a hazardous substance is discharged in violation of subsection (b)(3) of this section shall, notwithstanding any other provision of law, be liable to the United States Government for the actual costs incurred under subsection (c) for the removal of such oil or substance by the United States Government in an amount not to exceed $50,000,000, except that where the United States can show that such discharge was the result of willful negligence or willful misconduct within the privity and knowledge of the owner, such owner or operator shall be liable to the United States Government for the full amount of such costs. The United States may bring an action against the owner or operator of such facility in any court of competent jurisdiction to recover such costs.

(4) The costs of removal of oil or a hazardous substance for which the owner or operator of a vessel or onshore or offshore facility is liable under subsection (f) of this section shall include any costs or expenses incurred by the Federal Government or any State government in the restoration or replacement of natural resources damaged or destroyed as a result of a discharge of oil or a hazardous substance in violation of subsection (b) of this section.

(5) The President, or the authorized representative of any State, shall act on behalf of the public as trustee of the natural resources to recover for the costs of replacing or restoring such resources. Sums recovered shall be used to restore, rehabilitate, or acquire the equivalent of such natural resources by the appropriate agencies of the Federal Government, or the State government.

(g) Where the owner or operator of a vessel (other than an inland oil barge) carrying oil or hazardous substances as cargo or an onshore or offshore facility which handles or stores oil or hazardous substances in bulk, from which oil or a hazardous substance is discharged in violation of subsection (b) of this section, alleges that such discharge was caused solely by an act or omission of a third party, such owner or operator shall pay to the United States Government the actual costs incurred under subsection (c) for removal of such oil or substance and shall be entitled by subrogation to all rights of the United States Government to recover such costs from such third party under this subsection. In any case where an owner or operator of a vessel, of an onshore facility, or of an offshore facility, from which oil or a hazardous substance is discharged in violation of subsection (b)(3) of this section, proves that such discharge of oil or hazardous substance was caused solely by an act or omission of a third party, or was caused solely by such an act or omission in combination with an act of God, an act of war, or negligence on the part of the United States Government, such third party shall, not withstanding any other provision of law, be liable to the United States Government for the actual costs incurred under subsection (c) for removal of such oil or substance by the United States Government, except where such third party can prove that such discharge was caused solely by (A) an act of God, (B) an act of war, (C) negligence on the part of the United States Government, or (D) an act or omission of another party without regard to whether such an act or omission was or was not negligent, or any combination of the foregoing clauses. If such third party was the owner or operator of a vessel which caused the discharge of oil or a hazardous substance in violation of subsection (b)(3) of this section, the liability of such third party under this subsection shall not exceed, in the case of an inland oil barge $125 per gross ton of such barge, $125,000, whichever is greater, and in the case of any other vessel, $150 per gross ton of such vessel (or, for a vessel carrying oil or hazardous substances as cargo, $250,000), whichever is greater. In any other case the liability of such third party shall not exceed the limitation which would have been applicable to the owner or operator of the vessel or the onshore or offshore facility from which the discharge actually occurred if such owner or operator were liable. If the United States can show that the discharge of oil or a hazardous substance in violation of subsection (b)(3) of this section was the result of willful negligence or willful misconduct within the privity and knowledge of such third party, such third party shall be liable to the United States Government for the full amount of such removal costs. The United States may bring an action against the third party in any court of competent jurisdiction to recover such removal costs.

(h) The liabilities established by this section shall in no way affect any rights which (1) the owner or operator of a vessel or of an onshore facility or an offshore facility may have against any third party whose acts may in any way have caused or contributed to such discharge, or (2) The [1] United States Government may have against any third party whose actions may in any way have caused or contributed to the discharge of oil or hazardous substance.

(i) In any case where an owner or operator of a vessel or an onshore facility or an offshore facility from which oil or a hazardous substance is discharged in violation of subsection (b)(3) of this section acts to remove such oil or substance in accordance with regulations promulgated pursuant to this section, such owner or operator shall be entitled to recover the reasonable costs incurred in such removal upon establishing, in a suit which may be brought against the United States Government in the United States Claims Court, that such discharge was caused solely by (A) an act of God, (B) an act of war, (C) negligence on the part of the United States Government, or (D) an act or omission of a third party without re-

[1] So in law. Should not be capitalized.

gard to whether such act or omission was or was not negligent, or of any combination of the foregoing clauses.

(j) NATIONAL RESPONSE SYSTEM.—

(1) IN GENERAL.—Consistent with the National Contingency Plan required by subsection (c)(2) of this section, as soon as practicable after the effective date of this section, and from time to time thereafter, the President shall issue regulations consistent with maritime safety and with marine and navigation laws (A) establishing methods and procedures for removal of discharged oil and hazardous substances, (B) establishing criteria for the development and implementation of local and regional oil and hazardous substance removal contingency plans, (C) establishing procedures, methods, and equipment and other requirements for equipment to prevent discharges of oil and hazardous substances from vessels and from onshore facilities and offshore facilities, and to contain such discharges, and (D) governing the inspection of vessels carrying cargoes of oil and hazardous substances and the inspection of such cargoes in order to reduce the likelihood of discharges of oil from vessels in violation of this section.

(2) NATIONAL RESPONSE UNIT.—The Secretary of the department in which the Coast Guard is operating shall establish a National Response Unit at Elizabeth City, North Carolina. The Secretary, acting through the National Response Unit—

(A) shall compile and maintain a comprehensive computer list of spill removal resources, personnel, and equipment that is available worldwide and within the areas designated by the President pursuant to paragraph (4), and of information regarding previous spills, including data from universities, research institutions, State governments, and other nations, as appropriate, which shall be disseminated as appropriate to response groups and area committees, and which shall be available to Federal and State agencies and the public;

(B) shall provide technical assistance, equipment, and other resources requested by a Federal On-Scene Coordinator;

(C) shall coordinate use of private and public personnel and equipment to remove a worst case discharge, and to mitigate or prevent a substantial threat of such a discharge, from a vessel, offshore facility, or onshore facility operating in or near an area designated by the President pursuant to paragraph (4);

(D) may provide technical assistance in the preparation of Area Contingency Plans required under paragraph (4);

(E) shall administer Coast Guard strike teams established under the National Contingency Plan;

(F) shall maintain on file all Area Contingency Plans approved by the President under this subsection; and

(G) shall review each of those plans that affects its responsibilities under this subsection.

(3) COAST GUARD DISTRICT RESPONSE GROUPS.—(A) The Secretary of the department in which the Coast Guard is operating shall establish in each Coast Guard district a Coast Guard District Response Group.

(B) Each Coast Guard District Response Group shall consist of—

(i) the Coast Guard personnel and equipment, including firefighting equipment, of each port within the district;

(ii) additional prepositioned equipment; and

(iii) a district response advisory staff.

(C) Coast Guard district response groups—

(i) shall provide technical assistance, equipment, and other resources when required by a Federal On-Scene Coordinator;

(ii) shall maintain all Coast Guard response equipment within its district;

(iii) may provide technical assistance in the preparation of Area Contingency Plans required under paragraph (4); and

(iv) shall review each of those plans that affect its area of geographic responsibility.

(4) AREA COMMITTEES AND AREA CONTINGENCY PLANS.—(A) There is established for each area designated by the President an Area Committee comprised of members appointed by the President from qualified personnel of Federal, State, and local agencies.

(B) Each Area Committee, under the direction of the Federal On-Scene Coordinator for its area, shall—

(i) prepare for its area the Area Contingency Plan required under subparagraph (C);

(ii) work with State and local officials to enhance the contingency planning of those officials and to assure preplanning of joint response efforts, including appropriate procedures for mechanical recovery, dispersal, shoreline cleanup, protection of sensitive environmental areas, and protection, rescue, and rehabilitation of fisheries and wildlife; and

(iii) work with State and local officials to expedite decisions for the use of dispersants and other mitigating substances and devices.

(C) Each Area Committee shall prepare and submit to the President for approval an Area Contingency Plan for its area. The Area Contingency Plan shall—

(i) when implemented in conjunction with the National Contingency Plan, be adequate to remove a worst case discharge, and to mitigate or prevent a substantial threat of such a discharge, from a vessel, offshore facility, or onshore facility operating in or near the area;

(ii) describe the area covered by the plan, including the areas of special economic or environmental importance that might be damaged by a discharge;

(iii) describe in detail the responsibilities of an owner or operator and of Federal, State, and local agencies in removing a discharge, and in mitigating or preventing a substantial threat of a discharge;

(iv) list the equipment (including firefighting equipment), dispersants or other mitigating substances and devices, and personnel available to an owner or operator and Federal, State, and local agencies, to ensure an effective and immediate removal of a discharge, and to ensure mitigation or prevention of a substantial threat of a discharge;

(v) compile a list of local scientists, both inside and outside Federal Government service, with expertise in the environmental effects of spills of the types of oil typically transported in the area, who may be contacted to provide information or, where appropriate, participate in meetings of the scientific support team convened in response to a spill, and describe the procedures to be followed for obtaining an expedited decision regarding the use of dispersants;

(vi) describe in detail how the plan is integrated into other Area Contingency Plans and vessel, offshore facility, and onshore facility response plans approved under this subsection, and into operating procedures of the National Response Unit;

(vii) include any other information the President requires; and

(viii) be updated periodically by the Area Committee.

(D) The President shall—

(i) review and approve Area Contingency Plans under this paragraph; and

(ii) periodically review Area Contingency Plans so approved.

(5) TANK VESSEL AND FACILITY RESPONSE PLANS.—(A) The President shall issue regulations which require an owner or operator of a tank vessel or facility described in subparagraph (B) to prepare and submit to the President a plan for responding, to the maximum extent practicable, to a worst case discharge, and to a substantial threat of such a discharge, of oil or a hazardous substance.

(B) The tank vessels and facilities referred to in subparagraph (A) are the following:

(i) A tank vessel, as defined under section 2101 of title 46, United States Code.

(ii) An offshore facility.

(iii) An onshore facility that, because of its location, could reasonably be expected to cause substantial harm to the environment by discharging into or on the navigable waters, adjoining shorelines, or the exclusive economic zone.

(C) A response plan required under this paragraph shall—

(i) be consistent with the requirements of the National Contingency Plan and Area Contingency Plans;

(ii) identify the qualified individual having full authority to implement removal actions, and require immediate communications between that individual and the appropriate Federal official and the persons providing personnel and equipment pursuant to clause (iii);

(iii) identify, and ensure by contract or other means approved by the President the availability of, private personnel and equipment necessary to remove to the maximum extent practicable a worst case discharge (including a discharge resulting from fire or explosion), and to mitigate or prevent a substantial threat of such a discharge;

(iv) describe the training, equipment testing, periodic unannounced drills, and response actions of persons on the vessel or at the facility, to be carried out under the plan to ensure the safety of the vessel or facility and to mitigate or prevent the discharge, or the substantial threat of a discharge;

(v) be updated periodically; and

(vi) be resubmitted for approval of each significant change.

(D) With respect to any response plan submitted under this paragraph for an onshore facility that, because of its location, could reasonably be expected to cause significant and substantial harm to the environment by discharging into or on the navigable waters or adjoining shorelines or the exclusive economic zone, and with respect to each response plan submitted under this paragraph for a tank vessel or offshore facility, the President shall—

(i) promptly review such response plan;

(ii) require amendments to any plan that does not meet the requirements of this paragraph;

(iii) approve any plan that meets the requirements of this paragraph; and

(iv) review each plan periodically thereafter.

(E)[1] A tank vessel, offshore facility, or onshore facility required to prepare a response plan under this subsection may not handle, store, or transport oil unless—

(i) in the case of a tank vessel, offshore facility, or onshore facility for which a response plan is reviewed by the President under subparagraph (D), the plan has been approved by the President; and

(ii) the vessel or facility is operating in compliance with the plan.

(F) Notwithstanding subparagraph (E), the President may authorize a tank vessel, offshore facility, or onshore facility to operate without a response plan approved under this paragraph, until not later than 2 years after the date of the submission to the President of a plan for the tank vessel or facility, if the owner or operator certifies that the owner or operator has ensured by contract or other means approved by the President the availability of private personnel and equipment necessary to respond, to the maximum extent practicable, to a worst case discharge or a substantial threat of such a discharge.

(G) The owner or operator of a tank vessel, offshore facility, or onshore facility may not claim as a defense to liability under title I of the Oil Pollution Act of 1990 that the owner

[1] Subparagraph (E) of section 311(j)(5) shall take effect 36 months (August 18, 1993) after the date of the enactment of Public Law 101-380. See P.L. 101-380, sec. 4202(b)(4)(C), 104 Stat. 532.

or operator was acting in accordance with an approved response plan.

(H) The Secretary shall maintain, in the Vessel Identification System established under chapter 125 of title 46, United States Code, the dates of approval and review of a response plan under this paragraph for each tank vessel that is a vessel of the United States.

(6) EQUIPMENT REQUIREMENTS AND INSPECTION.—Not later than 2 years after the date of enactment of this section, the President shall require—

(A) periodic inspection of containment booms, skimmers, vessels, and other major equipment used to remove discharges; and

(B) vessels operating on navigable waters and carrying oil or a hazardous substance in bulk as cargo to carry appropriate removal equipment that employs the best technology economically feasible and that is compatible with the safe operation of the vessel.

(7) AREA DRILLS.—The President shall periodically conduct drills of removal capability, without prior notice, in areas for which Area Contingency Plans are required under this subsection and under relevant tank vessel and facility response plans. The drills may include participation by Federal, State, and local agencies, the owners and operators of vessels and facilities in the area, and private industry. The President may publish annual reports on these drills, including assessments of the effectiveness of the plans and a list of amendments made to improve plans.

(8) UNITED STATES GOVERNMENT NOT LIABLE.—The United States Government is not liable for any damages arising from its actions or omissions relating to any response plan required by this section.

[Subsection (k) was repealed by sec. 2002(b)(2) of P.L. 101-380.]

(l) The President is authorized to delegate the administration of this section to the heads of those Federal departments, agencies, and instrumentalities which he determines to be appropriate. Each such department, agency, and instrumentality, in order to avoid duplication of effort, shall, whenever appropriate, utilize the personnel, services, and facilities of other Federal departments, agencies, and instrumentalities.

(m) ADMINISTRATIVE PROVISIONS.—

(1) FOR VESSELS.—Anyone authorized by the President to enforce the provisions of this section with respect to any vessel may, except as to public vessels—

(A) board and inspect any vessel upon the navigable waters of the United States or the waters of the contiguous zone,

(B) with or without a warrant, arrest any person who in the presence or view of the authorized person violates the provisions of this section or any regulation issued thereunder, and

(C) execute any warrant or other process issued by an officer or court of competent jurisdiction.

(2) FOR FACILITIES.—

(A) RECORDKEEPING.—Whenever required to carry out the purposes of this section, the Administrator or the Secretary of the Department in which the Coast Guard is operating shall require the owner or operator of a facility to which this section applies to establish and maintain such records, make such reports, install, use, and maintain such monitoring equipment and methods, and provide such other information as the Administrator or Secretary, as the case may be, may require to carry out the objectives of this section.

(B) ENTRY AND INSPECTION.—Whenever required to carry out the purposes of this section, the Administrator or the Secretary of the Department in which the Coast Guard is operating or an authorized representative of the Administrator or Secretary, upon presentation of appropriate credentials, may—

(i) enter and inspect any facility to which this section applies, including any facility at which any records are required to be maintained under subparagraph (A); and

(ii) at reasonable times, have access to and copy any records, take samples, and inspect any monitoring equipment or methods required under subparagraph (A).

(C) ARRESTS AND EXECUTION OF WARRANTS.—Anyone authorized by the Administrator or the Secretary of the department in which the Coast Guard is operating to enforce the provisions of this section with respect to any facility may—

(i) with or without a warrant, arrest any person who violates the provisions of this section or any regulation issued thereunder in the presence or view of the person so authorized; and

(ii) execute any warrant or process issued by an officer or court of competent jurisdiction.

(D) PUBLIC ACCESS.—Any records, reports, or information obtained under this paragraph shall be subject to the same public access and disclosure requirements which are applicable to records, reports, and information obtained pursuant to section 308.

(n) The several district courts of the United States are invested with jurisdiction for any actions, other than actions pursuant to subsection (i)(1), arising under this section. In the case of Guam and the Trust Territory of the Pacific Islands, such actions may be brought in the district court of Guam, and in the case of the Virgin Islands such actions may be brought in the district court of the Virgin Islands. In the case of American Samoa and the Trust Territory of the Pacific Islands, such actions may be brought in the District Court of the United States for the District of Hawaii and such court shall have jurisdiction of such actions. In the case of the Canal Zone, such actions may be brought in the United States District Court for the District of the Canal Zone.

(o)(1) Nothing in this section shall affect or modify in any way the obligations of any owner or operator of any vessel, or of any owner or operator of any onshore facility or offshore facility to any person or agency under any provision of law for damages to any publicly owned or privately owned property resulting from a discharge of any oil or hazardous substance or from the removal of any such oil or hazardous substance.

(2) Nothing in this section shall be construed as preempting any State or political subdivision thereof from imposing any requirement or liability with respect to the discharge of oil or hazardous substance into any waters within such State, or with respect to any removal activites related to such discharge.

(3) Nothing in this section shall be construed as affecting or modifying any other existing authority of any Federal department, agency, or instrumentality, relative to onshore or offshore facilities under this Act or any other provision of law, or to affect any State or local law not in conflict with this section.

[Subsection (p) was repealed by sec. 2002(b)(4) of Public Law 101-380, 104 Stat. 507.]

(q) The President is authorized to establish, with repect to any class or category of onshore or offshore facilities, a maximum limit of liability under subsections (f)(2) and (3) of this section of less than $50,000,0000, but not less than, $8,000,000.

(r) Nothing in this section shall be construed to impose, or authorize the imposition of any limitation on liability under the Outer Continental Shelf Lands Act or the Deepwater Port Act of 1974.

(s) The Oil Spill Liability Trust Fund established under section 9509 of the Internal Revenue Code of 1986 (26 U.S.C. 9509) shall be available to carry out subsections (b), (c), (d), (j), and (l) as those subsections apply to discharges, and substantial threats of discharges, of oil. Any amounts received by the United States under this section shall be deposited in the Oil Spill Liability Trust Fund.

(33 U.S.C. 1321)

MARINE SANITATION DEVICES

SEC. 312. (a) For the purpose of this section, the term—

(1) "new vessel" includes every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on the navigable waters, the construction of which is initiated after promulgation of standards and regulations under this section;

(2) "existing vessel" includes every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on the navigable waters, the construction of which is initiated before promulgation of standards and regulations under this section;

(3) "public vessel" means a vessel owned or bareboat chartered and operated by the United States, by a State or political subdivision thereof, or by a foreign nation, except when such vessel is engaged in commerce;

(4) "United States" includes the States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Canal Zone, and the Trust Territory of the Pacific Islands;

(5) "marine sanitation device" includes any equipment for installation on board a vessel which is designed to receive, retain, treat, or discharge sewage, and any process to treat such sewage;

(6) "sewage" means human body wastes and the wastes from toilets and other receptacles intended to receive or retain body wastes except that, with respect to commercial vessels on the Great Lakes, such term shall include graywater;

(7) "manufacture" means any person engaged in the manufacturing, assembling, or importation of marine sanitation devices or of vessels subject to standards and regulations promulgated under this section;

(8) "person" means an individual, partnership, firm, corporation, association, or agency of the United States, but does not include an individual on board a public vessel;

(9) "discharge" includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying or dumping;

(10) "commercial vessels" means those vessels used in the business of transporting property for compensation or hire, or in transporting property in the business of the owner, lessee, or operator of the vessel;

(11) "graywater" means galley, bath, and shower water;

(12) "discharge incidental to the normal operation of a vessel"—

(A) means a discharge, including—

(i) graywater, bilge water, cooling water, weather deck runoff, ballast water, oil water separator effluent, and any other pollutant discharge from the operation of a marine propulsion system, shipboard maneuvering system, crew habitability system, or installed major equipment, such as an aircraft carrier elevator or a catapult, or from a protective, preservative, or absorptive application to the hull of the vessel; and

(ii) a discharge in connection with the testing, maintenance, and repair of a system described in clause (i) whenever the vessel is waterborne; and

(B) does not include—

(i) a discharge of rubbish, trash, garbage, or other such material discharged overboard;

(ii) an air emission resulting from the operation of a vessel propulsion system, motor driven equipment, or incinerator; or

(iii) a discharge that is not covered by part 122.3 of title 40, Code of Federal Regulations (as in effect on the date of the enactment of subsection (n));

(13) "marine pollution control device" means any equipment or management practice, for installation or use on board a vessel of the Armed Forces, that is—

(A) designed to receive, retain, treat, control, or discharge a discharge incidental to the normal operation of a vessel; and

(B) determined by the Administrator and the Secretary of Defense to be the most effective equipment or management practice to reduce the environmental impacts of the discharge consistent with the considerations set forth in subsection (n)(2)(B); and

(14) "vessel of the Armed Forces" means—

(A) any vessel owned or operated by the Department of Defense, other than a time or voyage chartered vessel; and

(B) any vessel owned or operated by the Department of Transportation that is designated by the Secretary of the department in which the Coast Guard is operating as a vessel equivalent to a vessel described in subparagraph (A).

(b)(1) As soon as possible, after the enactment of this section and subject to the provisions of section 104(j) of this Act, the Administrator, after consultation with the Secretary of the department in which the Coast Guard is operating, after giving appropriate consideration to the economic costs involved, and within the limits of available technology, shall promulgate Federal standards of performance for marine sanitation devices (hereinafter in this section referred to as "standards") which shall be designed to prevent the discharge of untreated or inadequately treated sewage into or upon the navigable waters from new vessels and existing vessels, except vessels not equipped with installed toilet facilities. Such standards and standards established under subsection (c)(1)(B) of this section shall be consistent with maritime safety and the marine and navigation laws and regulations and shall be coordinated with the regulations issued under this subsection by the Secretary of the department in which the Coast Guard is operating. The Secretary of the department in which the Coast Guard is operating shall promulgate regulations, which are consistent with standards promulgated under this subsection and subsection (c) of this section and with maritime safety and the marine and navigation laws and regulations governing the design, construction, installation, and operation of any marine sanitation device on board such vessels.

(2) Any existing vessel equipped with a marine sanitation device on the date of promulgation of initial standards and regulations under this section, which device is in compliance with such initial standards and regulations, shall be deemed in compliance with this section until such time as the device is replaced or is found not to be in compliance with such initial standards and regulations.

(c)(1)(A) Initial standards and regulations under this section shall become effective for new vessels two years after promulgation; and for existing vessels five years after promulgation. Revisions of standards and regulations shall be effective upon promulgation, unless another effective date is specified, except that no revision shall take effect before the effective date of the standard or regulation being revised.

(B) The Administrator shall, with respect to commercial vessels on the Great Lakes, establish standards which require at a minimum the equivalent of secondary treatment as defined under section 304(d) of this Act. Such standards and regulations shall take effect for existing vessels after such time as the Administrator determines to be reasonable for the upgrading of marine sanitation devices to attain such standard.

(2) The Secretary of the department in which the Coast Guard is operating with regard to his regulatory authority established by this section, after consultation with the Administrator, may distinguish among classes, types, and sizes of vessels as well as between new and existing vessels, and may waive applicability of standards and regulations as necessary or appropriate for such classes, types, and sizes of vessels (including existing vessels equipped with marine sanitation devices on the date of promulgation of the initial standards required by this section), and, upon application, for individual vessels.

(d) The provisions of this section and the standards and regulations promulgated hereunder apply to vessels owned and operated by the United States unless the Secretary of Defense finds that compliance would not be in the interest of national security. With respect to vessels owned and operated by the Department of Defense, regulations under the last sentence of subsection (b)(1) of this section and certifications under subsection (g)(2) of this section shall be promulgated and issued by the Secretary of Defense.

(e) Before the standards and regulations under this section are promulgated, the Administrator and the Secretary of the department in which the Coast Guard is operating shall consult with the Secretary of State; the Secretary of Health, Education, and Welfare; the Secretary of Defense; the Secretary of the Treasury; the Secretary of Commerce; other interested Federal agencies; and the States and industries interested; and otherwise comply with the requirements of section 553 of title 5 of the United States Code.

(f)(1)(A) Except as provided in subparagraph (B), after the effective date of the initial standards and regulations promulgated under this section, no State or political subdivision thereof shall adopt or enforce any statute or regulation of such State or political subdivision with respect to the design, manufacture, or installation or use of any marine sanitation device on any vessel subject to the provisions of this section.

(B) A State may adopt and enforce a statute or regulation with respect to the design, manufacture, or installation or use of any marine sanitation device on a houseboat, if such statute or regulation is more stringent than the standards and regulations promulgated under this section. For purposes of this paragraph, the term "houseboat" means a vessel which, for a period of time determined by the State in which the vessel is located, is used primarily as a residence and is not used primarily as a means of transportation.

(2) If, after promulgation of the initial standards and regulations and prior to their effective date, a vessel is equipped with a marine sanitation device in compliance with such standards and regulations and the installation and operation of such device is in accordance with such standards and regulations, such standards and regulations shall, for the purposes of paragraph (1) of this subsection, become effective with respect to such vessel on the date of such compliance.

(3) After the effective date of the initial standards and regulations promulgated under this section, if any State determines that the protection and enhancement of the quality of some or all of the waters within such State require greater environmental protection, such State may completely prohibit the discharge from all vessels of any sewage, whether treated or not, into such waters, except that no such prohibition shall apply until the Administrator determines that adequate facilities for the safe and sanitary removal and treatment of sewage from all vessels are reasonably available for such water to which such prohibition would apply. Upon application of the State, the Administrator shall make such determination within 90 days of the date of such application.

(4)(A) If the Administrator determines upon application by a State that the protection and enhancement of the quality of specified waters within such State requires such a prohibition, he shall by regulation completely prohibit the discharge from a vessel of any sewage (whether treated or not) into such waters.

(B) Upon application by a State, the Administrator shall, by regulation, establish a drinking water intake zone in any waters within such State and prohibit the discharge of sewage from vessels within that zone.

(g)(1) No manufacturer of a marine sanitation device shall sell, offer for sale, or introduce or deliver for introduction in interstate commerce, or import into the United States for sale or resale any marine sanitation device manufactured after the effective date of the standards and regulations promulgated under this section unless such device is in all material respects substantially the same as a test device certified under this subsection.

(2) Upon application of the manufacturer, the Secretary of the department in which the Coast Guard is operating shall so certify a marine sanitation device if he determines, in accordance with the provisions of this paragraph, that it meets the appropriate standards and regulations promulgated under this section. The Secretary of the department in which the Coast Guard is operating shall test or require such testing of the device in accordance with procedures set forth by the Administrator as to standards of performance and for such other purposes as may be appropriate. If the Secretary of the department in which the Coast Guard is operating determines that the device is satisfactory from the standpoint of safety and any other requirements of maritime law or regulation, and after consideration of the design, installation, operation, material, or other appropriate factors, he shall certify the device. Any device manufactured by such manufacturer which is in all material respects substantially the same as the certified test device shall be deemed to be in conformity with the appropriate standards and regulations established under this section.

(3) Every manufacturer shall establish and maintain such records, make such reports, and provide such information as the Administrator or the Secretary of the department in which the Coast Guard is operating may reasonably require to enable him to determine whether such manufacturer has acted or is acting in compliance with this section and regulations issued thereunder and shall, upon request of an officer or employee duly designated by the Administrator or the Secretary of the department in which the

Coast Guard is operating, permit such officer or employee at reasonable times to have access to and copy such records. All information reported to or otherwise obtained by the Administrator or the Secretary of the department in which the Coast Guard is operating or their representatives pursuant to this subsection which contains or relates to a trade secret or other matter referred in section 1905 of title 18 of the United States Code shall be considered confidential for the purpose of that section, except that such information may be disclosed to other officers or employees concerned with carrying out this section. This paragraph shall not apply in the case of the construction of a vessel by an individual for his own use.

(h) After the effective date of standards and regulations promulgated under this section, it shall be unlawful—

(1) for the manufacturer of any vessel subject to such standards and regulations to manufacture for sale, to sell or offer for sale, or to distribute for sale or resale any such vessel unless it is equipped with a marine sanitation device which is in all material respects substantially the same as the appropriate test device certified pursuant to this section;

(2) for any person, prior to the sale or delivery of a vessel subject to such standards and regulations to the ultimate purchaser, wrongfully to remove or render inoperative any certified marine sanitation device or element of design of such device installed in such vessel;

(3) for any person to fail or refuse to permit access to or copying of records or to fail to make reports or provide information required under this section; and

(4) for a vessel subject to such standards and regulations to operate on the navigable waters of the United States, if such vessel is not equipped with an operable marine sanitation device certified pursuant to this section.

(i) The district courts of the United States shall have jurisdictions to restrain violations of subsection (g)(1) of this section and subsections (h)(1) through (3) of this section. Actions to restrain such violations shall be brought by, and in, the name of the United States. In case of contumacy or refusal to obey a subpena served upon any person under this subsection, the district court of the United States for any district in which such person is found or resides or transacts business, upon application by the United States and after notice to such person, shall have jurisdiction to issue an order requiring such person to appear and give testimony or to appear and produce documents, and any failure to obey such order of the court may be punished by such court as a contempt thereof.

(j) Any person who violates subsection (g)(1), clause (1) or (2) of subsection (h), or subsection (n)(8) shall be liable to a civil penalty of not more than $5,000 for each violation. Any person who violates clause (4) of subsection (h) of this section or any regulation issued pursuant to this section shall be liable to a civil penalty of not more than $2,000 for each violation. Each violation shall be a separate offense. The Secretary of the department in which the Coast Guard is operating may assess and compromise any such penalty. No penalty shall be assessed until the person charged shall have been given notice and an opportunity for a hearing on such charge. In determining the amount of the penalty, or the amount agreed upon in compromise, the gravity of the violation, and the demonstrated good faith of the person charged in attempting to achieve rapid compliance, after notification of a violation, shall be considered by said Secretary.

(k) The provisions of this section shall be enforced by the Secretary of the department in which the Coast Guard is operating and he may utilize by agreement, with or without reimbursement, law enforcement officers or other personnel and facilities of the Administrator, other Federal agencies, or the States to carry out the provisions of this section. The provisions of this section may also be enforced by a State.

(l) Anyone authorized by the Secretary of the department in which the Coast Guard is operating to enforce the provisions of this section may, except as to public vessels, (1) board and inspect any vessel upon the navigable waters of the United States and (2) execute any warrant or other process issued by an officer or court of competent jurisdiction.

(m) In the case of Guam and the Trust Territory of the Pacific Islands, actions arising under this section may be brought in the district court of Guam, and in the case of the Virgin Islands such actions may be brought in the district court of the Virgin Islands. In the case of American Samoa and the Trust Territory of the Pacific Islands, such actions may be brought in the District Court of the United States for the District of Hawaii and such court shall have jurisdiction of such actions. In the case of the Canal Zone, such actions may be brought in the District Court for the District of the Canal Zone.

(n) UNIFORM NATIONAL DISCHARGE STANDARDS FOR VESSELS OF THE ARMED FORCES.—

(1) APPLICABILITY.—This subsection shall apply to vessels of the Armed Forces and discharges, other than sewage, incidental to the normal operation of a vessel of the Armed Forces, unless the Secretary of Defense finds that compliance with this subsection would not be in the national security interests of the United States.

(2) DETERMINATION OF DISCHARGES REQUIRED TO BE CONTROLLED BY MARINE POLLUTION CONTROL DEVICES.—

(A) IN GENERAL.—The Administrator and the Secretary of Defense, after consultation with the Secretary of the department in which the Coast Guard is operating, the Secretary of Commerce, and interested States, shall jointly determine the discharges incidental to the normal operation of a vessel of the Armed Forces for which it is reasonable and practicable to require use of a marine pollution control device to mitigate adverse impacts on the marine environment. Notwithstanding subsection (a)(1) of section 553 of title 5, United States Code, the Administrator and the Secretary of Defense shall promulgate the determinations in accordance with such section. The Secretary of Defense shall require the use of a marine pollution control device on board a vessel of the Armed Forces in any case in which it is determined that the use of such a device is reasonable and practicable.

(B) CONSIDERATIONS.—In making a determination under subparagraph (A), the Administrator and the Secretary of Defense shall take into consideration—

(i) the nature of the discharge;

(ii) the environmental effects of the discharge;

(iii) the practicability of using the marine pollution control device;

(iv) the effect that installation or use of the marine pollution control device would have on the operation or operational capability of the vessel;

(v) applicable United States law;

(vi) applicable international standards; and

(vii) the economic costs of the installation and use of the marine pollution control device.

(3) PERFORMANCE STANDARDS FOR MARINE POLLUTION CONTROL DEVICES.—

(A) IN GENERAL.—For each discharge for which a marine pollution control device is determined to be required under paragraph (2), the Administrator and the Secretary of Defense, in consultation with the Secretary of the department in which the Coast Guard is operating, the Secretary of State, the Secretary of Commerce, other interested Federal agencies, and interested States, shall jointly promulgate Federal standards of performance for each marine pollution control device required with respect to the discharge. Notwithstanding subsection (a)(1) of section 553 of title 5, United States Code, the Administrator and the Secretary of Defense shall promulgate the standards in accordance with such section.

(B) CONSIDERATIONS.—In promulgating standards under this paragraph, the Administrator and the Secretary of Defense shall take into consideration the matters set forth in paragraph (2)(B).

(C) CLASSES, TYPES, AND SIZES OF VESSELS.—The standards promulgated under this paragraph may—

(i) distinguish among classes, types, and sizes of vessels;

(ii) distinguish between new and existing vessels; and

(iii) provide for a waiver of the applicability of the standards as necessary or appropriate to a particular class, type, age, or size of vessel.

(4) REGULATIONS FOR USE OF MARINE POLLUTION CONTROL DEVICES.—The Secretary of Defense, after consultation with the Administrator and the Secretary of the department in which the Coast Guard is operating, shall promulgate such regulations governing the design, construction, installation, and use of marine pollution control devices on board vessels of the Armed Forces as are necessary to achieve the standards promulgated under paragraph (3).

(5) DEADLINES; EFFECTIVE DATE.—

(A) DETERMINATIONS.—The Administrator and the Secretary of Defense shall—

(i) make the initial determinations under paragraph (2) not later than 2 years after the date of the enactment of this subsection; and

(ii) every 5 years—

(I) review the determinations; and

(II) if necessary, revise the determinations based on significant new information.

(B) STANDARDS.—The Administrator and the Secretary of Defense shall—

(i) promulgate standards of performance for a marine pollution control device under paragraph (3) not later than 2 years after the date of a determination under paragraph (2) that the marine pollution control device is required; and

(ii) every 5 years—

(I) review the standards; and

(II) if necessary, revise the standards, consistent with paragraph (3)(B) and based on significant new information.

(C) REGULATIONS.—The Secretary of Defense shall promulgate regulations with respect to a marine pollution control device under paragraph (4) as soon as practicable after the Administrator and the Secretary of Defense promulgate standards with respect to the device under paragraph (3), but not later than 1 year after the Administrator and the Secretary of Defense promulgate the standards. The regulations promulgated by the Secretary of Defense under paragraph (4) shall become effective upon promulgation unless another effective date is specified in the regulations.

(D) PETITION FOR REVIEW.—The Governor of any State may submit a petition requesting that the Secretary of Defense and the Administrator review a determination under paragraph (2) or a standard under paragraph (3), if there is significant new information, not considered previously, that could reasonably result in a change to the particular determination or standard after consideration of the matters set forth in paragraph (2)(B). The petition shall be accompanied by the scientific and technical information on which the petition is based. The Administrator and the Secretary of Defense shall grant or deny the petition not later than 2 years after the date of receipt of the petition.

(6) EFFECT ON OTHER LAWS.—

(A) PROHIBITION ON REGULATION BY STATES OR POLITICAL SUBDIVISIONS OF STATES.—Beginning on the effective date of—

(i) a determination under paragraph (2) that it is not reasonable and practicable to require use of a marine pollution control device regarding a particular discharge incidental to the normal operation of a vessel of the Armed Forces; or

(ii) regulations promulgated by the Secretary of Defense under paragraph (4);

except as provided in paragraph (7), neither a State nor a political subdivision of a State may adopt or enforce any statute or regulation of the State or political subdivision with respect to the discharge or the design, construction, installation, or use of any marine pollution control device required to control discharges from a vessel of the Armed Forces.

(B) FEDERAL LAWS.—This subsection shall not affect the application of section 311 to discharges incidental to the normal operation of a vessel.

(7) ESTABLISHMENT OF STATE NO-DISCHARGE ZONES.—

(A) STATE PROHIBITION.—

(i) IN GENERAL.—After the effective date of—

(I) a determination under paragraph (2) that it is not reasonable and practicable to require use of a marine pollution control device regarding a particular discharge incidental to the normal operation of a vessel of the Armed Forces; or

(II) regulations promulgated by the Secretary of Defense under paragraph (4);

if a State determines that the protection and enhancement of the quality of some or all of the waters within the State require greater environmental protection, the State may prohibit 1 or more discharges incidental to the normal operation of a vessel, whether treated or not treated, into the waters. No prohibition shall apply until the Administrator makes the determinations described in subclauses (II) and (III) of subparagraph (B)(i).

(ii) DOCUMENTATION.—To the extent that a prohibition under this paragraph would apply to vessels of the Armed Forces and not to other types of vessels, the State shall document the technical or environmental basis for the distinction.

(B) PROHIBITION BY THE ADMINISTRATOR.—

(i) IN GENERAL.—Upon application of a State, the Administrator shall by regulation prohibit the discharge from a vessel of 1 or more discharges incidental to the normal operation of a vessel, whether treated or not treated, into the waters covered by the application if the Administrator determines that—

(I) the protection and enhancement of the quality of the specified waters within the State require a prohibition of the discharge into the waters;

(II) adequate facilities for the safe and sanitary removal of the discharge incidental to the normal operation of a vessel are reasonably available for the waters to which the prohibition would apply; and

(III) the prohibition will not have the effect of discriminating against a vessel of the Armed Forces by reason of the ownership or operation by the Federal Government, or the military function, of the vessel.

(ii) APPROVAL OR DISAPPROVAL.—The Administrator shall approve or disapprove an application submitted under clause (i) not later than 90 days after the date on which the application is submitted to the Administrator. Notwithstanding clause (i)(II), the Administrator shall not disapprove an application for the sole reason that there are not adequate facilities to remove any discharge incidental to the normal operation of a vessel from vessels of the Armed Forces.

(C) APPLICABILITY TO FOREIGN FLAGGED VESSELS.—A prohibition under this paragraph—

(i) shall not impose any design, construction, manning, or equipment standard on a foreign flagged vessel engaged in innocent passage unless the prohibition implements a generally accepted international rule or standard; and

(ii) that relates to the prevention, reduction, and control of pollution shall not apply to a foreign flagged vessel engaged in transit passage unless the prohibition implements an applicable international regulation regarding the discharge of oil, oily waste, or any other noxious substance into the waters.

(8) PROHIBITION RELATING TO VESSELS OF THE ARMED FORCES.—After the effective date of the regulations promulgated by the Secretary of Defense under paragraph (4), it shall be unlawful for any vessel of the Armed Forces subject to the regulations to—

(A) operate in the navigable waters of the United States or the waters of the contiguous zone, if the vessel is not equipped with any required marine pollution control device meeting standards established under this subsection; or

(B) discharge overboard any discharge incidental to the normal operation of a vessel in waters with respect to which a prohibition on the discharge has been established under paragraph (7).

(9) ENFORCEMENT.—This subsection shall be enforceable, as provided in subsections (j) and (k), against any agency of the United States responsible for vessels of the Armed Forces notwithstanding any immunity asserted by the agency.

(33 U.S.C. 1322)

FEDERAL FACILITIES POLLUTION CONTROL

SEC. 313. (a) Each department, agency, or instrumentality of the executive, legislative, and judicial branches of the Federal Government (1) having jurisdiction over any property or facility, or (2) engaged in any activity resulting, or which may result, in the discharge or runoff of pollutants, and each officer, agent, or employee thereof in the performance of his official duties, shall be subject to, and comply with, all Federal, State, interstate, and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water pollution in the same manner, and to the same extent as any nongovernmental entity including the payment of reasonable service charges. The preceding sentence shall apply (A) to any requirement whether substantive or procedural (including any recordkeeping or reporting requirement, any requirement respecting permits and any other requirement, whatsoever), (B) to the exercise of any Federal, State, or local administrative authority, and (C) to any process and sanction, whether enforced in Federal, State, or local courts or in any other manner. This subsection shall apply notwithstanding any immunity of such agencies, officers, agents, or employees under any law or rule of law. Nothing in this section shall be construed to prevent any department, agency, or instrumentality of the Federal Government, or any officer, agent, or employee thereof in the performance of his official duties, from removing to the appropriate Federal district court any proceeding to which the department, agency, or instrumentality or officer, agent, or employee thereof is subject pursuant to this section, and any such proceeding may be removed in accordance with 28 U.S.C. 1441 et seq. No officer, agent, or employee of the United States shall be personally liable for any civil penalty arising from the performance of his official duties, for which he is not otherwise liable, and the United States shall be liable only for those civil penalties arising under Federal law or imposed by a State or local court to enforce an order or the process of such court. The President may exempt any effluent source of any department, agency, or instrumentality in the executive branch from compliance with any such a requirement if he determines it to be in the paramount interest of the United States to do so; except that no exemption may be granted from the requirements of section 306 or 307 of this Act. No such exemptions shall be granted due to lack of appropriation unless the President shall have specifically requested such appropriation as a part of the budgetary process and the Congress shall have failed to make available such requested appropriation. Any exemption shall be for a period not in excess of one year, but additional exemptions may be granted for periods of not to exceed one year upon the President's making a new determination. The President shall report each January to the Congress all exemptions from the requirements of this section granted during the preceding calendar year, together with his reason for granting such exemption. In addition to any such exemption of a particular effluent source, the President may, if he determines it to be in the paramount interest of the United States to do so, issue regulations exempting from compliance with the requirements of this section any weaponry, equipment, aircraft, vessels, vehicles, or other classes or categories of property, and access to such property, which are owned or operated by the Armed Forces of the United States (including the Coast Guard) or by the National Guard of any State and which are uniquely military in nature. The President shall reconsider the need for such regulations at three-year intervals.

(b)(1) The Administrator shall coordinate with the head of each department, agency, or instrumentality of the Federal Government having jurisdiction over any property or facility utilizing federally owned wastewater facilities to develop a program of cooperation for utilizing wastewater control systems utilizing those innovative treatment processes and techniques for which guidelines have been promulgated under section 304(d)(3). Such program shall include an inventory of property and facilities which could utilize such processes and techniques.

(2) Construction shall not be initiated for facilities for treatment of wastewater at any Federal property or facility after September 30, 1979, if alternative methods for wastewater treatment at such property or facility utilizing innovative treatment processes and techniques, including but not limited to methods utilizing recycle and reuse techniques and land treatment are not utilized, unless the life cycle cost of the alternative treatment works exceeds the life cycle cost of the most cost effective alternative by more than 15 per centum. The Administrator may waive the application of this paragraph in any case where the Administrator determines it to be in the public interest, or that compliance with this paragraph would interfere with the orderly compliance with the conditions of a permit issued pursuant to section 402 of this Act.

(33 U.S.C. 1323)

CLEAN LAKES

SEC. 314. (a) ESTABLISHMENT AND SCOPE OF PROGRAM.—

(1) STATE PROGRAM REQUIREMENTS.—Each State on a biennial basis shall prepare and submit to the Administrator for his approval—

(A) an identification and classification according to eutrophic condition of all publicly owned lakes in such State;

(B) a description of procedures, processes, and methods (including land use requirements), to control sources of pollution of such lakes;

(C) a description of methods and procedures, in conjunction with appropriate Federal agencies, to restore the quality of such lakes;

(D) methods and procedures to mitigate the harmful effects of high acidity, including innovative methods of neutralizing and restoring buffering capacity of lakes and methods of removing from lakes toxic metals and other toxic substances mobilized by high acidity;

(E) a list and description of those publicily owned lakes in such State for which uses are known to be impaired, including those lakes which are known not to meet applicable water quality standards or which require implementation of control programs to maintain compliance with applicable standards and those lakes in which water quality has deteriorated as a result of high acidity that may reasonably be due to acid deposition; and

(F) an assessment of the status and trends of water quality in lakes in such State, including but not limited to, the nature and extent of pollution loading from point and nonpoint sources and the extent to which the use of lakes is impaired as a result of such pollution, particularly with respect to toxic pollution.

(2) SUBMISSION AS PART OF 305(b)(1) REPORT.—The information required under paragraph (1) shall be included in the report required under section 305(b)(1) of this Act, beginning with the report required under such section by April 1, 1988.

(3) REPORT OF ADMINISTRATOR.—Not later than 180 days after receipt from the States of the biennial information required under paragraph (1), the Administrator shall submit to the Committee on Public Works and Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate a report on the status of water quality in lakes in the United States, including the effectiveness of the methods and procedures described in paragraph (1)(D).

(4) ELIGIBILITY REQUIREMENT.—Beginning after April 1, 1988, a State must have submitted the information required under paragraph (1) in order to receive grant assistance under this section.

(b) The Administrator shall provide financial assistance to States in order to carry out methods and procedures approved by him under subsection (a) of this section. The Administrator shall provide financial assistance to States to prepare the identification and classification surveys required in subsection (a)(1) of this section.

(c)(1) The amount granted to any State for any fiscal year under subsection (b) of this section shall not exceed 70 per centum of the funds expended by such State in such year for carrying out approved methods and procedures under subsection (a) of this section.

(2) There is authorized to be appropriated $50,000,000 for the fiscal year ending June 30, 1973; $100,000,000 for the fiscal year 1974; $150,000,000 for the fiscal year 1975, $50,000,000 for fiscal year 1977, $60,000,000 for fiscal year 1978, $60,000,000 for fiscal year 1979, $60,000,000 for fiscal year 1980, $30,000,000 for fiscal year 1981, $30,000,000 for fiscal year 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $30,000,000 per fiscal year for each of the fiscal years 1986 through 1990 for grants to States under subsection (b) of this section which such sums shall remain available until expended. The Administrator shall provide for an equitable distribution of such sums to the States with approved methods and procedures under subsection (a) of this section.

(d) DEMONSTRATION PROGRAM.—

(1) GENERAL REQUIREMENTS.—The Administrator is authorized and directed to establish and conduct at locations throughout the Nation a lake water quality demonstration program. The program shall, at a minimum—

(A) develop cost effective technologies for the control of pollutants to preserve or enhance lake water quality while optimizing multiple lakes uses;

(B) control nonpoint sources of pollution which are contributing to the degradation of water quality in lakes;

(C) evaluate the feasibility of implementing regional consolidated pollution control strategies;

(D) demonstrate environmentally preferred techniques for the removal and disposal of contaminated lake sediments;

(E) develop improved methods for the removal of silt, stumps, aquatic growth, and other obstructions which impair the quality of lakes;

(F) construct and evaluate silt traps and other devices or equipment to prevent or abate the deposit of sediment in lakes; and

(G) demonstrate the costs and benefits of utilizing dredged material from lakes in the reclamation of despoiled land.

(2) GEOGRAPHICAL REQUIREMENTS.—Demonstration projects authorized by this subsection shall be undertaken to reflect a variety of geographical and environmental conditions. As a priority, the Administrator shall undertake demonstration projects at Lake Champlain, New York and Vermont; Lake Houston, Texas; Beaver Lake, Arkansas; Greenwood Lake and Belcher Creek, New Jersey; Deal Lake, New Jersey; Alcyon Lake, New Jersey; Gorton's Pond, Rhode Island; Lake Washington, Rhode Island; Lake Bomoseen, Vermont; Sauk Lake, Minnesota; and Lake Worth, Texas.

(3) REPORTS.—By January 1, 1997, and January 1 of every odd-numbered year thereafter, the Administrator shall report to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate on work undertaken pursuant to this subsection. Upon completion of the program authorized by this subsection, the Administrator shall submit to such committees a final report on the results of such program, along with recommendations for further measures to improve the water quality of the Nation's lakes.

(4) AUTHORIZATION OF APPROPRIATIONS.—

(A) IN GENERAL.—There is authorized to be appropriated to carry out this subsection not to exceed $40,000,000 for fiscal years beginning after September 30, 1986, to remain available until expended.

(B) SPECIAL AUTHORIZATIONS.—

(i) AMOUNT.—There is authorized to be appropriated to carry out subsection (b) with respect to subsection (a)(1)(D) not to exceed $15,000,000 for fiscal years beginning after September 30, 1986, to remain available until expended.

(ii) DISTRIBUTION OF FUNDS.—The Administrator shall provide for an equitable distribution of sums appropriated pursuant to this subparagraph among States carrying out approved methods and procedures. Such distribution shall be based on the relative needs of each such State for the mitigation of the harmful effects on lakes and other surface waters of high acidity that may reasonably be due to acid deposition or acid mine drainage.

(iii) GRANTS AS ADDITIONAL ASSISTANCE.—The amount of any grant to a State under this subparagraph shall be in addition to, and not in lieu of, any other Federal financial assistance.

(33 U.S.C. 1324)

NATIONAL STUDY COMMISSION

SEC. 315. (a) There is established a National Study Commission, which shall make a full and complete investigation and study of all of the technological aspects of achieving, and all aspects of the total economic, social, and environmental effects of achieving or not achieving, the effluent limitations and goals set forth for 1983 in section 301(b)(2) of this Act.

(b) Such Commission shall be composed of fifteen members, including five members of the Senate, who are members of the Public Works committee, appointed by the President of the Senate, five members of the House, who are members of the Public Works committee, appointed by the Speaker of the House, and five members of the public appointed by the President. The Chairman of such Commission shall be elected from among its members.

(c) In the conduct of such study, the Commission is authorized to contract with the National Academy of Sciences and the National Academy of Engineering (acting through the National Research Council), the National Institute of Ecology, Brookings Institution, and other nongovernmental entities, for the investigation of matters within their competence.

(d) The heads of the departments, agencies and instrumentalities of the executive branch of the Federal Government shall cooperate with the Commission in carrying out the requirements of this section, and shall furnish to the Commission such information as the Commission deems necessary to carry out this section.

(e) A report shall be submitted to the Congress of the results of such investigation and study, together with recommendations, not later than three years after the date of enactment of this title.

(f) The members of the Commission who are not officers or employees of the United States, while attending conferences or meetings of the Commission or while otherwise serving at the request of the Chairman shall be entitled to receive compensation at a rate not in excess of the maximum rate of pay for grade GS–18, as provided in the General Schedule under section 5332 of title V of the United States Code, including traveltime and while away from their homes or regular places of business they may be allowed travel expenses, including per diem in lieu of subsistence as authorized by law (5 U.S.C. 73b–2) for persons in the Government service employed intermittently.

(g) In addition to authority to appoint personnel subject to the provisions of title 5, United States Code, governing appointments in the competitive service, and to pay such personnel in accordance with the provisions of chapter 51 and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, the Commission shall have authority to enter into contracts with private or public organizations who shall furnish the Commission with such administrative and technical personnel as may be necessary to carry out the purpose of this section. Personnel furnished by such organizations under this subsection are not, and shall not be considered to be, Federal employees for any purposes, but in the performance of their duties shall be guided by the standards which apply to employees of the legislative branches under rules 41 and 43 of the Senate and House of Representatives, respectively.

(h) There is authorized to be appropriated, for use in carrying out this section, not to exceed $17,250,000.

(33 U.S.C. 1325)

THERMAL DISCHARGES

SEC. 316. (a) With respect to any point source otherwise subject to the provisions of section 301 or section 306 of this Act, whenever the owner or operator of any such source, after opportunity for public hearing, can demonstrate to the satisfaction of the Administrator (or, if appropriate, the State) that any effluent limitation proposed for the control of the thermal component of any discharge from such source will require effluent limitations more stringent than necessary to assure the projection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made, the Administrator (or, if appropriate, the State) may impose an effluent limitation under such sections for such plant, with respect to the thermal component of such discharge (taking into account the interaction of such thermal component with other pollutants), that will assure the projection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on that body of water.

(b) Any standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

(c) Notwithstanding any other provision of this Act, any point source of a discharge having a thermal component, the modification of which point source is commenced after the date of enactment of the Federal Water Pollution Control Act Amendments of 1972 and which, as modified, meets effluent limitations established under section 301 or, if more stringent, effluent limitations established under section 303 and which effluent limitations will assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in or on the water into which the discharge is made, shall not be subject to any more stringent effluent limitation with respect to the thermal component of its discharge during a ten year period beginning on the date of completion of such modification or during the period of depreciation or amortization of such facility for the purpose of section 167 or 169 (or both) of the Internal Revenue Code of 1954, whichever period ends first.

(33 U.S.C. 1326)

FINANCING STUDY

SEC. 317. (a) The Administrator shall continue to investigate and study the feasibility of alternate methods of financing the cost of preventing, controlling and abating pollution as directed in the Water Quality Improvement Act of 1970 (Public Law 91–224), including, but not limited to, the feasibility of establishing a pollution abatement trust fund. The results of such investigation and study

shall be reported to the Congress not later than two years after enactment of this title, together with recommendations of the Administrator for financing the programs for preventing, controlling and abating pollution for the fiscal years beginning after fiscal year 1976, including any necessary legislation.

(b) There is authorized to be appropriated for use in carrying out this section, not to exceed $1,000,000.

(33 U.S.C. 1327)

AQUACULTURE

SEC. 318. (a) The Administrator is authorized, after public hearings, to permit the discharge of a specific pollutant or pollutants under controlled conditions associated with an approved aquaculture project under Federal or State supervision pursuant to section 402 of this Act.

(b) The Administrator shall by regulation establish any procedures and guidelines which the Administrator deems necessary to carry out this section. Such regulations shall require the application to such discharge of each criterion, factor, procedure, and requirement applicable to a permit issued under section 402 of this title, as the Administrator determines necessary to carry out the objective of this Act.

(c) Each State desiring to administer its own permit program within its jurisdiction for discharge of a specific pollutant or pollutants under controlled conditions associated with an approved aquaculture project may do so if upon submission of such program the Administrator determines such program is adequate to carry out the objective of this Act.

(33 U.S.C. 1328)

SEC. 319. NONPOINT SOURCE MANAGEMENT PROGRAMS.

(a) STATE ASSESSMENT REPORTS.—

(1) CONTENTS.—The Governor of each State shall, after notice and opportunity for public comment, prepare and submit to the Administrator for approval, a report which—

(A) identifies those navigable waters within the State which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain applicable water quality standards or the goals and requirements of this Act;

(B) identifies those categories and subcategories of nonpoint sources or, where appropriate, particular nonpoint sources which add significant pollution to each portion of the navigable waters identified under subparagraph (A) in amounts which contribute to such portion not meeting such water quality standards or such goals and requirements;

(C) describes the process, including intergovernmental coordination and public participation, for identifying best management practices and measures to control each category and subcategory of nonpoint sources and, where appropriate, particular nonpoint sources identified under subparagraph (B) and to reduce, to the maximum extent practicable, the level of pollution resulting from such category, subcategory, or source; and

(D) identifies and describes State and local programs for controlling pollution added from nonpoint sources to, and improving the quality of, each such portion of the navigable waters, including but not limited to those programs which are receiving Federal assistance under subsections (h) and (i).

(2) INFORMATION USED IN PREPARATION.—In developing the report required by this section, the State (A) may rely upon information developed pursuant to sections 208, 303(e), 304(f), 305(b), and 314, and other information as appropriate, and (B) may utilize appropriate elements of the waste treatment management plans developed pursuant to sections 208(b) and 303, to the extent such elements are consistent with and fulfill the requirements of this section.

(b) STATE MANAGEMENT PROGRAMS.—

(1) IN GENERAL.—The Governor of each State, for that State or in combination with adjacent States, shall, after notice and opportunity for public comment, prepare and submit to the Administrator for approval a management program which such State proposes to implement in the first four fiscal years beginning after the date of submission of such management program for controlling pollution added from nonpoint sources to the navigable waters within the State and improving the quality of such waters.

(2) SPECIFIC CONTENTS.—Each management program proposed for implementation under this subsection shall include each of the following:

(A) An identification of the best management practices and measures which will be undertaken to reduce pollutant loadings resulting from each category, subcategory, or particular nonpoint source designated under paragraph (1)(B), taking into account the impact of the practice on ground water quality.

(B) An identification of programs (including, as appropriate, nonregulatory or regulatory programs for enforcement, technical assistance, financial assistance, education, training, technology transfer, and demonstration projects) to achieve implementation of the best management practices by the categories, subcategories, and particular nonpoint sources designated under subparagraph (A).

(C) A schedule containing annual milestones for (i) utilization of the program implementation methods identified in subparagraph (B), and (ii) implementation of the best management practices identified in subparagraph (A) by the categories, subcategories, or particular nonpoint sources designated under paragraph (1)(B). Such schedule shall provide for utilization of the best management practices at the earliest practicable date.

(D) A certification of the attorney general of the State or States (or the chief attorney of any State water pollution control agency which has independent legal counsel) that the laws of the State or States, as the case may be,

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provide adequate authority to implement such management program or, if there is not such adequate authority, a list of such additional authorities as will be necessary to implement such management program. A schedule and commitment by the State or States to seek such additional authorities as expeditiously as practicable.

(E) Sources of Federal and other assistance and funding (other than assistance provided under subsections (h) and (i)) which will be available in each of such fiscal years for supporting implementation of such practices and measures and the purposes for which such assistance will be used in each of such fiscal years.

(F) An identification of Federal financial assistance programs and Federal development projects for which the State will review individual assistance applications or development projects for their effect on water quality pursuant to the procedures set forth in Executive Order 12372 as in effect on September 17, 1983, to determine whether such assistance applications or development projects would be consistent with the program prepared under this subsection; for the purposes of this subparagraph, identification shall not be limited to the assistance programs or development projects subject to Executive Order 12372 but may include any programs listed in the most recent Catalog of Federal Domestic Assistance which may have an effect on the purposes and objectives of the State's nonpoint source pollution management program.

(3) UTILIZATION OF LOCAL AND PRIVATE EXPERTS.—In developing and implementing a management program under this subsection, a State shall, to the maximum extent practicable, involve local public and private agencies and organizations which have expertise in control of nonpoint sources of pollution.

(4) DEVELOPMENT ON WATERSHED BASIS.—A State shall, to the maximum extent practicable, develop and implement a management program under this subsection on a watershed-by-watershed basis within such State.

(c) ADMINISTRATIVE PROVISIONS.—

(1) COOPERATION REQUIREMENT.—Any report required by subsection (a) and any management program and report required by subsection (b) shall be developed in cooperation with local, substate regional, and interstate entities which are actively planning for the implementation of nonpoint source pollution controls and have either been certified by the Administrator in accordance with section 208, have worked jointly with the State on water quality management planning under section 205(j), or have been designated by the State legislative body or Governor as water quality management planning agencies for their geographic areas.

(2) TIME PERIOD FOR SUBMISSION OF REPORTS AND MANAGEMENT PROGRAMS.—Each report and management program shall be submitted to the Administrator during the 18-month period beginning on the date of the enactment of this section.

(d) APPROVAL OR DISAPPROVAL OF REPORTS AND MANAGEMENT PROGRAMS.—

(1) DEADLINE.—Subject to paragraph (2), not later than 180 days after the date of submission to the Administrator of any report or management program under this section (other than subsections (h), (i), and (k)), the Administrator shall either approve or disapprove such report or management program, as the case may be. The Administrator may approve a portion of a management program under this subsection. If the Administrator does not disapprove a report, management program, or portion of a management program in such 180-day period, such report, management program, or portion shall be deemed approved for purposes of this section.

(2) PROCEDURE FOR DISAPPROVAL.—If, after notice and opportunity for public comment and consultation with appropriate Federal and State agencies and other interested persons, the Administrator determines that—

(A) the proposed management program or any portion thereof does not meet the requirements of subsection (b)(2) of this section or is not likely to satisfy, in whole or in part, the goals and requirements of this Act;

(B) adequate authority does not exist, or adequate resources are not available, to implement such program or portion;

(C) the schedule for implementing such program or portion is not sufficiently expeditious; or

(D) the practices and measures proposed in such program or portion are not adequate to reduce the level of pollution in navigable waters in the State resulting from nonpoint sources and to improve the quality of navigable waters in the State;

the Administrator shall within 6 months of the receipt of the proposed program notify the State of any revisions or modifications necessary to obtain approval. The State shall thereupon have an additional 3 months to submit its revised management program and the Administrator shall approve or disapprove such revised program within three months of receipt.

(3) FAILURE OF STATE TO SUBMIT REPORT.—If a Governor of a State does not submit the report required by subsection (a) within the period specified by subsection (c)(2), the Administrator shall, within 30 months after the date of the enactment of this section, prepare a report for such State which makes the identifications required by paragraphs (1)(A) and (1)(B) of subsection (a). Upon completion of the requirement of the preceding sentence and after notice and opportunity for comment, the Administrator shall report to Congress on his actions pursuant to this section.

(e) LOCAL MANAGEMENT PROGRAMS; TECHNICAL ASSISTANCE.—If a State fails to submit a management program under subsection (b) or the Administrator does not approve such a management program, a local public agency or organization which has expertise in, and authority to, control water pollution resulting from nonpoint sources in any area of such State which the Administrator determines is of sufficient geographic size may, with approval of such

State, request the Administrator to provide, and the Administrator shall provide, technical assistance to such agency or organization in developing for such area a management program which is described in subsection (b) and can be approved pursuant to subsection (d). After development of such management program, such agency or organization shall submit such management program to the Administrator for approval. If the Administrator approves such management program, such agency or organization shall be eligible to receive financial assistance under subsection (h) for implementation of such management program as if such agency or organization were a State for which a report submitted under subsection (a) and a management program submitted under subsection (b) were approved under this section. Such financial assistance shall be subject to the same terms and conditions as assistance provided to a State under subsection (h).

(f) TECHNICAL ASSISTANCE FOR STATE.—Upon request of a State, the Administrator may provide technical assistance to such State in developing a management program approved under subsection (b) for those portions of the navigable waters requested by such State.

(g) INTERSTATE MANAGEMENT CONFERENCE.—

(1) CONVENING OF CONFERENCE; NOTIFICATION; PURPOSE.—If any portion of the navigable waters in any State which is implementing a management program approved under this section is not meeting applicable water quality standards or the goals and requirements of this Act as a result, in whole or in part, of pollution from nonpoint sources in another State, such State may petition the Administrator to convene, and the Administrator shall convene, a management conference of all States which contribute significant pollution resulting from nonpoint sources to such portion. If, on the basis of information available, the Administrator determines that a State is not meeting applicable water quality standards or the goals and requirements of this Act as a result, in whole or in part, of significant pollution from nonpoint sources in another State, the Administrator shall notify such States. The Administrator may convene a management conference under this paragraph not later than 180 days after giving such notification, whether or not the State which is not meeting such standards requests such conference. The purpose of such conference shall be to develop an agreement among such States to reduce the level of pollution in such portion resulting from nonpoint sources and to improve the water quality of such portion. Nothing in such agreement shall supersede or abrogate rights to quantities of water which have been established by interstate water compacts, Supreme Court decrees, or State water laws. This subsection shall not apply to any pollution which is subject to the Colorado River Basin Salinity Control Act. The requirement that the Administrator convene a management conference shall not be subject to the provisions of section 505 of this Act.

(2) STATE MANAGEMENT PROGRAM REQUIREMENT.—To the extent that the States reach agreement through such conference, the management programs of the States which are parties to such agreements and which contribute significant

pollution to the navigable waters or portions thereof not meeting applicable water quality standards or goals and requirements of this Act will be revised to reflect such agreement. Such management programs shall be consistent with Federal and State law.

(h) GRANT PROGRAM.—

(1) GRANTS FOR IMPLEMENTATION OF MANAGEMENT PROGRAMS.—Upon application of a State for which a report submitted under subsection (a) and a management program submitted under subsection (b) is approved under this section, the Administrator shall make grants, subject to such terms and conditions as the Administrator considers appropriate, under this subsection to such State for the purpose of assisting the State in implementing such management program. Funds reserved pursuant to section 205(j)(5) of this Act may be used to develop and implement such management program.

(2) APPLICATIONS.—An application for a grant under this subsection in any fiscal year shall be in such form and shall contain such other information as the Administrator may require, including an identification and description of the best management practices and measures which the State proposes to assist, encourage, or require in such year with the Federal assistance to be provided under the grant.

(3) FEDERAL SHARE.—The Federal share of the cost of each management program implemented with Federal assistance under this subsection in any fiscal year shall not exceed 60 percent of the cost incurred by the State in implementing such management program and shall be made on condition that the non-Federal share is provided from non-Federal sources.

(4) LIMITATION ON GRANT AMOUNTS.—Notwithstanding any other provision of this subsection, not more than 15 percent of the amount appropriated to carry out this subsection may be used to make grants to any one State, including any grants to any local public agency or organization with authority to control pollution from nonpoint sources in any area of such State.

(5) PRIORITY FOR EFFECTIVE MECHANISMS.—For each fiscal year beginning after September 30, 1987, the Administrator may give priority in making grants under this subsection, and shall give consideration in determining the Federal share of any such grant, to States which have implemented or are proposing to implement management programs which will—

(A) control particularly difficult or serious nonpoint source pollution problems, including, but not limited to, problems resulting from mining activities;

(B) implement innovative methods or practices for controlling nonpoint sources of pollution, including regulatory programs where the Administrator deems appropriate;

(C) control interstate nonpoint source pollution problems; or

(D) carry out ground water quality protection activities which the Administrator determines are part of a comprehensive nonpoint source pollution control program, including research, planning, ground water assessments, demonstration programs, enforcement, technical assistance, education, and training to protect ground water quality from nonpoint sources of pollution.

(6) AVAILABILITY FOR OBLIGATION.—The funds granted to each State pursuant to this subsection in a fiscal year shall remain available for obligation by such State for the fiscal year for which appropriated. The amount of any such funds not obligated by the end of such fiscal year shall be available to the Administrator for granting to other States under this subsection in the next fiscal year.

(7) LIMITATION ON USE OF FUNDS.—States may use funds from grants made pursuant to this section for financial assistance to persons only to the extent that such assistance is related to the costs of demonstration projects.

(8) SATISFACTORY PROGRESS.—No grant may be made under this subsection in any fiscal year to a State which in the preceding fiscal year received a grant under this subsection unless the Administrator determines that such State made satisfactory progress in such preceding fiscal year in meeting the schedule specified by such State under subsection (b)(2).

(9) MAINTENANCE OF EFFORT.—No grant may be made to a State under this subsection in any fiscal year unless such State enters into such agreements with the Administrator as the Administrator may require to ensure that such State will maintain its aggregate expenditures from all other sources for programs for controlling pollution added to the navigable waters in such State from nonpoint sources and improving the quality of such waters at or above the average level of such expenditures in its two fiscal years preceding the date of enactment of this subsection.

(10) REQUEST FOR INFORMATION.—The Administrator may request such information, data, and reports as he considers necessary to make the determination of continuing eligibility for grants under this section.

(11) REPORTING AND OTHER REQUIREMENTS.—Each State shall report to the Administrator on an annual basis concerning (A) its progress in meeting the schedule of milestones submitted pursuant to subsection (b)(2)(C) of this section, and (B) to the extent that appropriate information is available, reductions in nonpoint source pollutant loading and improvements in water quality for those navigable waters or watersheds within the State which were identified pursuant to subsection (a)(1)(A) of this section resulting from implementation of the management program.

(12) LIMITATION ON ADMINISTRATIVE COSTS.—For purposes of this subsection, administrative costs in the form of salaries, overhead, or indirect costs for services provided and charged against activities and programs carried out with a grant under this subsection shall not exceed in any fiscal year 10 percent of the amount of the grant in such year, except that costs of implementing enforcement and regulatory activities, education, training, technical assistance, demonstration projects, and technology transfer programs shall not be subject to this limitation.

(i) GRANTS FOR PROTECTING GROUNDWATER QUALITY.—

(1) ELIGIBLE APPLICANTS AND ACTIVITIES.—Upon application of a State for which a report submitted under subsection (a) and a plan submitted under subsection (b) is approved under this section, the Administrator shall make grants under this subsection to such State for the purpose of assisting such State in carrying out groundwater quality protection activities which the Administrator determines will advance the State toward implementation of a comprehensive nonpoint source pollution control program. Such activities shall include, but not be limited to, research, planning, groundwater assessment, demonstration programs, enforcement, technical assistance, education and training to protect the quality of groundwater and to prevent contamination of groundwater from nonpoint sources of pollution.

(2) APPLICATIONS.—An application for a grant under this subsection shall be in such form and shall contain such information as the Administrator may require.

(3) FEDERAL SHARE; MAXIMUM AMOUNT.—The Federal share of the cost of assisting a State in carrying out groundwater protection activities in any fiscal year under this subsection shall be 50 percent of the costs incurred by the State in carrying out such activities, except that the maximum amount of Federal assistance which any State may receive under this subsection in any fiscal year shall not exceed $150,000.

(4) REPORT.—The Administrator shall include in each report transmitted under subsection (m) a report on the activites and programs implemented under this subsection during the preceding fiscal year.

(j) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out subsections (h) and (i) not to exceed $70,000,000 for fiscal year 1988, $100,000,000 per fiscal year for each of fiscal years 1989 and 1990, and $130,000,000 for fiscal year 1991; except that for each of such fiscal years not to exceed $7,500,000 may be made available to carry out subsection (i). Sums appropriated pursuant to this subsection shall remain available until expended.

(k) CONSISTENCY OF OTHER PROGRAMS AND PROJECTS WITH MANAGEMENT PROGRAMS.—The Administrator shall transmit to the Office of Management and Budget and the appropriate Federal departments and agencies a list of those assistance programs and development projects identified by each State under subsection (b)(2)(F) for which individual assistance applications and projects will be reviewed pursuant to the procedures set forth in Executive Order 12372 as in effect on September 17, 1983. Beginning not later than sixty days after receiving notification by the Administrator, each Federal department and agency shall modify existing regulations to allow States to review individual development projects and assistance applications under the identified Federal assistance programs and shall accommodate, according to the requirements and definitions of Executive Order 12372, as in effect on September 17, 1983, the concerns of the State regarding the consistency of such applications or projects with the State nonpoint source pollution management program.

(l) COLLECTION OF INFORMATION.—The Administrator shall collect and make available, through publications and other appropriate means, information pertaining to management practices and implementation methods, including, but not limited to, (1) information concerning the costs and relative efficiencies of best management practices for reducing nonpoint source pollution; and (2) available data concerning the relationship between water quality and implementation of various management practices to control nonpoint sources of pollution.

(m) REPORTS OF ADMINISTRATOR.—

(1) ANNUAL REPORTS.—Not later than January 1, 1988, and each January 1 thereafter, the Administrator shall transmit to the Committee on Public Works and Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate, a report for the preceding fiscal year on the activities and programs implemented under this section and the progress made in reducing pollution in the navigable waters resulting from nonpoint sources and improving the quality of such waters.

(2) FINAL REPORT.—Not later than January 1, 1990, the Administrator shall transmit to Congress a final report on the activities carried out under this section. Such report, at a minimum, shall—

(A) describe the management programs being implemented by the States by types and amount of affected navigable waters, categories and subcategories of nonpoint sources, and types of best management practices being implemented;

(B) describe the experiences of the States in adhering to schedule and implementing best management practices;

(C) describe the amount and purpose of grants awarded pursuant to subsections (h) and (i) of this section;

(D) identify, to the extent that information is available, the progress made in reducing pollutant loads and improving water quality in the navigable waters;

(E) indicate what further actions need to be taken to attain and maintain in those navigable waters (i) applicable water quality standards, and (ii) the goals and requirements of this Act;

(F) include recommendations of the Administrator concerning future programs (including enforcement programs) for controlling pollution from nonpoint sources; and

(G) identify the activities and programs of departments, agencies, and instrumentalities of the United States which are inconsistent with the management programs submitted by the States and recommend modifications so that such activities and programs are consistent with and assist the States in implementation of such management programs.

(n) SET ASIDE FOR ADMINISTRATIVE PERSONNEL.—Not less than 5 percent of the funds appropriated pursuant to subsection (j) for any fiscal year shall be available to the Administrator to maintain personnel levels at the Environmental Protection Agency at levels which are adequate to carry out this section in such year.

(33 U.S.C. 1329)

SEC. 320. NATIONAL ESTUARY PROGRAM.

(a) MANAGEMENT CONFERENCE.—

(1) NOMINATION OF ESTUARIES.—The Governor of any State may nominate to the Administrator an estuary lying in whole or in part within the State as an estuary of national significance and request a management conference to develop a comprehensive management plan for the estuary. The nomination shall document the need for the conference, the likelihood of success, and information relating to the factors in paragraph (2).

(2) CONVENING OF CONFERENCE.—

(A) IN GENERAL.—In any case where the Administrator determines, on his own initiative or upon nomination of a State under paragraph (1), that the attainment or maintenance of that water quality in an estuary which assures protection of public water supplies and the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife and allows recreational activities, in and on the water, requires the control of point and nonpoint sources of pollution to supplement existing controls of pollution in more than one State, the Administrator shall select such estuary and convene a management conference.

(B) PRIORITY CONSIDERATION.—The Administrator shall give priority consideration under this section to Long Island Sound, New York and Connecticut; Narragansett Bay, Rhode Island; Buzzards Bay, Massachusetts; Massachusetts Bay, Massachusetts (including Cape Cod Bay and Boston Harbor);[1] Puget Sound, Washington; New York-New Jersey Harbor, New York and New Jersey; Delaware Bay, Delaware and New Jersey; Delaware Inland Bays, Delaware; Albermarle Sound, North Carolina; Sarasota Bay, Florida; San Francisco Bay, California; Santa Monica Bay, California; Galveston Bay, Texas;[2] Barataria-Terrebonne Bay estuary complex, Louisiana; Indian River Lagoon, Florida; and Peconic Bay, New York.

(3) BOUNDARY DISPUTE EXCEPTION.—In any case in which a boundary between two States passes through an estuary and such boundary is disputed and is the subject of an action in any court, the Administrator shall not convene a management conference with respect to such estuary before a final adjudication has been made of such dispute.

(b) PURPOSES OF CONFERENCE.—The purposes of any management conference convened with respect to an estuary under this subsection shall be to—

[1] Both P.L. 100–653 and P.L. 100–668 inserted the same Massachusetts Bay phrase after Buzzards Bay; so that the phrase appears twice.

[2] P.L. 100–688, section 2001(3) inserted the Louisiana, Florida, New York bays after "Galveston, Texas;" which technically could not be executed.

(1) assess trends in water quality, natural resources, and uses of the estuary;

(2) collect, characterize, and assess data on toxics, nutrients, and natural resources within the estuarine zone to identify the causes of environmental problems;

(3) develop the relationship between the inplace loads and point and nonpoint loadings of pollutants to the estuarine zone and the potential uses of the zone, water quality, and natural resources;

(4) develop a comprehensive conservation and management plan that recommends priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the estuary, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish and wildlife, and recreational activities in the estuary, and assure that the designated uses of the estuary are protected;

(5) develop plans for the coordinated implementation of the plan by the States as well as Federal and local agencies participating in the conference;

(6) monitor the effectiveness of actions taken pursuant to the plan; and

(7) review all Federal financial assistance programs and Federal development projects in accordance with the requirements of Executive Order 12372, as in effect on September 17, 1983, to determine whether such assistance program or project would be consistent with and further the purposes and objectives of the plan prepared under this section.

For purposes of paragraph (7), such programs and projects shall not be limited to the assistance programs and development projects subject to Executive Order 12372, but may include any programs listed in the most recent Catalog of Federal Domestic Assistance which may have an effect on the purposes and objectives of the plan developed under this section.

(c) MEMBERS OF CONFERENCE.—The members of a management conference convened under this section shall include, at a minimum, the Administrator and representatives of—

(1) each State and foreign nation located in whole or in part in the estuarine zone of the estuary for which the conference is convened;

(2) international, interstate, or regional agencies or entities having jurisdiction over all or a significant part of the estuary;

(3) each interested Federal agency, as determined appropriate by the Administrator;

(4) local governments having jurisdiction over any land or water within the estuarine zone, as determined appropriate by the Administrator; and

(5) affected industries, public and private educational institutions, and the general public, as determined appropriate by the Administrator.

(d) UTILIZATION OF EXISTING DATA.—In developing a conservation and management plan under this section, the management conference shall survey and utilize existing reports, data, and studies relating to the estuary that have been developed by or made available to Federal, interstate, State, and local agencies.

(e) PERIOD OF CONFERENCE.—A management conference convened under this section shall be convened for a period not to exceed 5 years. Such conference may be extended by the Administrator, and if terminated after the initial period, may be reconvened by the Administrator at any time thereafter, as may be necessary to meet the requirements of this section.

(f) APPROVAL AND IMPLEMENTATION OF PLANS.—

(1) APPROVAL.—Not later than 120 days after the completion of a conservation and management plan and after providing for public review and comment, the Administrator shall approve such plan if the plan meets the requirements of this section and the affected Governor or Governors concur.

(2) IMPLEMENTATION.—Upon approval of a conservation and management plan under this section, such plan shall be implemented. Funds authorized to be appropriated under titles II and VI and section 319 of this Act may be used in accordance with the applicable requirements of this Act to assist States with the implementation of such plan.

(g) GRANTS.—

(1) RECIPIENTS.—The Administrator is authorized to make grants to State, interstate, and regional water pollution control agencies and entities, State coastal zone management agencies, interstate agencies, other public or nonprofit private agencies, institutions, organizations, and individuals.

(2) PURPOSES.—Grants under this subsection shall be made to pay for assisting research, surveys, studies, and modeling and other technical work necessary for the development of a conservation and management plan under this section.

(3) FEDERAL SHARE.—The amount of grants to any person (including a State, interstate, or regional agency or entity) under this subsection for a fiscal year shall not exceed 75 percent of the costs of such research, survey, studies, and work and shall be made on condition that the non-Federal share of such costs are provided from non-Federal sources.

(h) GRANT REPORTING.—Any person (including a State, interstate, or regional agency or entity) that receives a grant under subsection (g) shall report to the Administrator not later than 18 months after receipt of such grants and biennially there after on the progress being made under this section.

(i) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Administrator not to exceed $12,000,000 per fiscal year for each of fiscal years 1987, 1988, 1989, 1990, and 1991 for—

(1) expenses related to the administration of management conferences under this section, not to exceed 10 percent of the amount appropriated under this subsection;

(2) making grants under subsection (g); and

(3) monitoring the implementation of a conservation and management plan by the management conference or by the Administrator, in any case in which the conference has been terminated.

The Administrator shall provide up to $5,000,000 per fiscal year of the sums authorized to be appropriated under this subsection to the Administrator of the National Oceanic and Atmospheric Administration to carry out subsection (j).

(j) RESEARCH.—

(1) PROGRAMS.—In order to determine the need to convene a management conference under this section or at the request of such a management conference, the Administrator shall coordinate and implement, through the National Marine Pollution Program Office and the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration, as appropriate, for one or more estuarine zones—

(A) a long-term program of trend assessment monitoring measuring variations in pollutant concentrations, marine ecology, and other physical or biological environmental paramenters which may affect estuarine zones, to provide the Administrator the capacity to determine the potential and actual effects of alternative management strategies and measures;

(B) a program of ecosystem assessment assisting in the development of (i) baseline studies which determine the state of estuarine zones and the effects of natural and anthropogenic changes, and (ii) predictive models capable of translating information on specific discharges or general pollutant loadings within estuarine zones into a set of probable effects on such zones;

(C) a comprehensive water quality sampling program for the continuous monitoring of nutrients, chlorine, acid precipitation dissolved oxygen, and potentially toxic pollutants (including organic chemicals and metals) in estuarine zones, after consultation with interested State, local, interstate, or international agencies and review and analysis of all environmental sampling data presently collected from estuarine zones; and

(D) a program of research to identify the movements of nutrients, sediments and pollutants through estuarine zones and the impact of nutrients, sediments, and pollutants on water quality, the ecosystem, and designated or potential uses of the estuarine zones.

(2) REPORTS.—The Administrator, in cooperation with the Administrator of the National Oceanic and Atmospheric Administration, shall submit to the Congress no less often than biennially a comprehensive report on the activities authorized under this subsection including—

(A) a listing of priority monitoring and research needs;

(B) an assessment of the state and health of the Nation's estuarine zones, to the extent evaluated under this subsection;

(C) a discussion of pollution problems and trends in pollutant concentrations with a direct or indirect effect on water quality, the ecosystem, and designated or potential uses of each estuarine zone, to the extent evaluated under this subsection; and

(D) an evaluation of pollution abatement activities and management measures so far implemented to determine the degree of improvement toward the objectives expressed in subsection (b)(4) of this section.

(k) DEFINITIONS.—For purposes of this section, the terms "estuary" and "estuarine zone" have the meanings such terms have in section 104(n)(4) of this Act, except that the term "estuarine zone" shall also include associated aquatic ecosystems and those portions of tributaries draining into the estuary up to the historic height of migration of anadromous fish or the historic head of tidal influence, whichever is higher.

(33 U.S.C. 1330)

TITLE IV—PERMITS AND LICENSES

CERTIFICATION

SEC. 401. (a)(1) Any applicant for a Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any discharge into the navigable waters, shall provide the licensing or permitting agency a certification from the State in which the discharge originates or will originate, or, if appropriate, from the interstate water pollution control agency having jurisdiction over the navigable waters at the point where the discharge originates or will originate, that any such discharge will comply with the applicable provisions of sections 301, 302, 303, 306, and 307 of this Act. In the case of any such activity for which there is not an applicable effluent limitation or other limitation under sections 301(b) and 302, and there is not an applicable standard under sections 306 and 307, the State shall so certify, except that any such certification shall not be deemed to satisfy section 511(c) of this Act. Such State or interstate agency shall establish procedures for public notice in the case of all applications for certification by it and, to the extent it deems appropriate, procedures for public hearings in connection with specific applications. In any case where a State or interstate agency has no authority to give such a certification, such certification shall be from the Administrator. If the State, interstate agency, or Administrator, as the case may be, fails or refuses to act on a request for certification, within a reasonable period of time (which shall not exceed one year) after receipt of such request, the certification requirements of this subsection shall be waived with respect to such Federal application. No license or permit shall be granted until the certification required by this section has been obtained or has been waived as provided in the preceding sentence. No license or permit shall be granted if certification has been denied by the State, interstate agency, or the Administrator, as the case may be.

(2) Upon receipt of such application and certification the licensing or permitting agency shall immediately notify the Administrator of such application and certification. Whenever such a discharge may affect, as determined by the Administrator, the quality of the waters of any other State, the Administrator within thirty days of the date of notice of application for such Federal license or permit shall so notify such other State, the licensing or permitting agency, and the applicant. If, within sixty days after receipt of such notification, such other State determines that such discharge will affect the quality of its waters so as to violate any water quality requirement in such State, and within such sixty-day period notifies the Administrator and the licensing or permitting agency in writing of its objection to the issuance of such license or permit and requests a public hearing on such objection, the licensing or permitting agency shall hold such a hearing. The Administrator shall at such hearing submit his evaluation and recommendations with respect to any such objection to the licensing or permitting agency. Such agency, based upon the recommendations of such State, the Administrator, and upon any additional evidence, if any, presented to the agency at the hearing, shall condition such license or permit in such manner as may be necessary to insure compliance with applicable water quality requirements. If the imposition of conditions cannot insure such compliance such agency shall not issue such license or permit.

(3) The certification obtained pursuant to paragraph (1) of this subsection with respect to the construction of any facility shall fulfill the requirements of this subsection with respect to certification in connection with any other Federal license or permit required for the operation of such facility unless, after notice to the certifying State, agency, or Administrator, as the case may be, which shall be given by the Federal agency to whom application is made for such operating license or permit, the State, or if appropriate, the interstate agency or the Administrator, notifies such agency within sixty days after receipt of such notice that there is no longer reasonable assurance that there will be compliance with the applicable provisions of sections 301, 302, 303, 306, and 307 of this Act because of changes since the construction license or permit certification was issued in (A) the construction or operation of the facility, (B) the characteristics of the waters into which such discharge is made, (C) the water quality criteria applicable to such waters or (D) applicable effluent limitations or other requirements. This paragraph shall be inapplicable in any case where the applicant for such operating license or permit has failed to provide the certifying State, or, if appropriate, the interstate agency or the Administrator, with notice of any proposed changes in the construction or operation of the facility with respect to which a construction license or permit has been granted, which changes may result in violation of section 301, 302, 303, 306, or 307 of this Act.

(4) Prior to the initial operation of any federally licensed or permitted facility or activity which may result in any discharge into the navigable waters and with respect to which a certification has been obtained pursuant to paragraph (1) of this subsection, which facility or activity is not subject to a Federal operating license or permit, the licensee or permittee shall provide an opportunity for such certifying State, or, if appropriate, the interstate agency or the Administrator to review the manner in which the facility or activity shall be operated or conducted for the purposes of assuring that applicable effluent limitations or other limitations or other applicable water quality requirements will not be violated. Upon notification by the certifying State, or if appropriate, the interstate agency or the Administrator that the operation of any such federally licensed or permitted facility or activity will violate

applicable effluent limitations or other limitations or other water quality requirements such Federal agency may, after public hearing, suspend such license or permit. If such license or permit is suspended, it shall remain suspended until notification is received from the certifying State, agency, or Administrator, as the case may be, that there is reasonable assurance that such facility or activity will not violate the applicable provisions of section 301, 302, 303, 306, or 307 of this Act.

(5) Any Federal license or permit with respect to which a certification has been obtained under paragraph (1) of this subsection may be suspended or revoked by the Federal agency issuing such license or permit upon the entering of a judgment under this Act that such facility or activity has been operated in violation of the applicable provisions of section 301, 302, 303, 306, or 307 of this Act.

(6) Except with respect to a permit issued under section 402 of this Act, in any case where actual construction of a facility has been lawfully commenced prior to April 3, 1970, no certification shall be required under this subsection for a license or permit issued after April 3, 1970, to operate such facility, except that any such license or permit issued without certification shall terminate April 3, 1973, unless prior to such termination date the person having such license or permit submits to the Federal agency which issued such license or permit a certification and otherwise meets the requirements of this section.

(b) Nothing in this section shall be construed to limit the authority of any department or agency pursuant to any other provision of law to require compliance with any applicable water quality requirements. The Administrator shall, upon the request of any Federal department or agency, or State or interstate agency, or applicant, provide, for the purpose of this section, any relevant information on applicable effluent limitations, or other limitations, standards, regulations, or requirements, or water quality criteria, and shall, when requested by any such department or agency or State or interstate agency, or applicant, comment on any methods to comply with such limitations, standards, regulations, requirements, or criteria.

(c) In order to implement the provisions of this section, the Secretary of the Army, acting throught the Chief of Engineers, is authorized, if he deems it to be in the public interest, to permit the use of spoil disposal areas under his jurisdiction by Federal licenses or permittees, and to make an appropriate charge for such use. Moneys received from such licensees or permittees shall be deposited in the Treasury as miscellaneous receipts.

(d) Any certification provided under this section shall set forth any effluent limitations and other limitations, and monitoring requirements necessary to assure that any applicant for a Federal license or permit will comply with any applicable effluent limitations and other limitations, under section 301 or 302 of this Act, standard of performance under section 306 of this Act, or prohibition, effluent standard, or pretreatment standard under section 307 of this and with any other appropriate requirement of State law set

forth in such certification, and shall become a condition on any Federal license or permit subject to the provisions of this section.

(33 U.S.C. 1341)

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

SEC. 402. (a)(1) Except as provided in sections 318 and 404 of this Act, the Administrator may, after opportunity for public hearing, issue a permit for the discharge of any pollutant, or combination of pollutants, notwithstanding section 301(a), upon condition that such discharge will meet either (A) all applicable requirements under sections 301, 302, 306, 307, 308, and 403 of this Act, or (B) prior to the taking of necessary implementing actions relating to all such requirements, such conditions as the Administrator determines are necessary to carry out the provisions of this Act.

(2) The Administrator shall prescribe conditions for such permits to assure compliance with the requirements of paragraph (1) of this subsection, including conditions on data and information collection, reporting, and such other requirements as he deems appropriate.

(3) The permit program of the Administrator under paragraph (1) of this subsection, and permits issued thereunder, shall be subject to the same terms, conditions, and requirements as apply to a State permit program and permits issued thereunder under subsection (b) of this section.

(4) All permits for discharges into the navigable waters issued pursuant to section 13 of the Act of March 3, 1899, shall be deemed to be permits issued under this title, and permits issued under this title shall be deemed to be permits issued under section 13 of the Act of March 3, 1899, and shall continue in force and effect for their term unless revoked, modified, or suspended in accordance with the provisions of this Act.

(5) No permit for a discharge into the navigable waters shall be issued under section 13 of the Act of March 3, 1899, after the date of enactment of this title. Each application for a permit under section 13 of the Act of March 3, 1899, pending on the date of enactment of this Act shall be deemed to be an application for a permit under this section. The Administrator shall authorize a State, which he determines has the capability of administering a permit program which will carry out the objective of this Act, to issue permits for discharges into the navigable waters within the jurisdiction of such State. The Administrator may exercise the authority granted him by the preceding sentence only during the period which begins on the date of enactment of this Act and ends either on the ninetieth day after the date of the first promulgation of guidelines required by section 304(h)(2) of this Act, or the date of approval by the Administrator of a permit program for such State under subsection (b) of this section, whichever date first occurs, and no such authorization to a State shall extend beyond the last day of such period. Each such permit shall be subject to such conditions as the Administrator determines are necessary to carry out the provisions of this Act. No such permit shall issue if the Administrator objects to such issuance.

(b) At any time after the promulgation of the guidelines required by subsection (h)(2) of section 304 of this Act, the Governor of each State desiring to administer its own permit program for discharges into navigable waters within its jurisdiction may submit to the Administrator a full and complete discription of the program it proposes to establish and administer under State law or under an interstate compact. In addition, such State shall submit a statement from the attorney general (or the attorney for those State water pollution control agencies which have independent legal counsel), or from the chief legal officer in the case of an interstate agency, that the laws of such State, or the interstate compact, as the case may be, provide adequate authority to carry out the described program. The Administrator shall approve each such submitted program unless he determines that adequate authority does not exist:

(1) To issue permits which—

(A) apply, and insure compliance with, any applicable requirements of sections 301, 302, 306, 307, and 403;

(B) are for fixed terms not exceeding five years; and

(C) can be terminated or modified for cause including, but not limited to, the following:

(i) violation of any condition of the permit;

(ii) obtaining a permit by misrepresentation, or failure to disclose fully all relevant facts;

(iii) change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge;

(D) control the disposal of pollutants into wells;

(2)(A) To issue permits which apply, and insure compliance with, all applicable requirements of section 308 of this Act, or

(B) To inspect, monitor, enter, and require reports to at least the same extent as required in section 308 of this Act;

(3) To insure that the public, and any other State the waters of which may be affected, receive notice of each application for a permit and to provide an opportunity for public hearing before a ruling on each such application;

(4) To insure that the Administrator receives notice of each application (including a copy thereof) for a permit;

(5) To insure that any State (other than the permitting State), whose waters may be affected by the issuance of a permit may submit written recommendations to the permitting State (and the Administrator) with respect to any permit application and, if any part of such written recommendations are not accepted by the permitting State, that the permitting State will notify such affected State (and the Administrator) in writing of its failure to so accept such recommendations together with its reasons for so doing;

(6) To insure that no permit will be issued if, in the judgment of the Secretary of the Army acting through the Chief of Engineers, after consultation with the Secretary of the department in which the Coast Guard is operating, anchorage and navigation of any of the navigable waters would be substantially impaired thereby;

(7) To abate violations of the permit or the permit program, including civil and criminal penalties and other ways and means of enforcement;

(8) To insure that any permit for a discharge from a publicly owned treatment works includes conditions to require the identification in terms of character and volume of pollutants of any significant source introducing pollutants subject to pretreatment standards under section 307(b) of this Act into such works and a program to assure compliance with such pretreatment standards by each such source, in addition to adequate notice to the permitting agency of (A) new introductions into such works of pollutants from any source which would be a new source as defined in section 306 if such source were discharging pollutants, (B) new introductions of pollutants into such works from a source which would be subject to section 301 if it were discharging such pollutants, or (C) a substantial change in volume or character of pollutants being introduced into such works by a source introducing pollutants into such works at the time of issuance of the permit. Such notice shall include information on the quality and quantity of effluent to be introduced into such treatment works and any anticipated impact of such change in the quantity or quality of effluent to be discharged from such publicly owned treatment works; and

(9) To insure that any industrial user of any publicly owned treatment works will comply with sections 204(b), 307, and 308.

(c)(1) Not later than ninety days after the date on which a State has submitted a program (or revision thereof) pursuant to subsection (b) of this section, the Administrator shall suspend the issuance of permits under subsection (a) of this section as to those discharges subject to such program unless he determines that the State permit program does not meet the requirements of subsection (b) of this section or does not conform to the guidelines issued under section 304(i)(2) of this Act. If the Administrator so determines, he shall notify the State or any revisons or modifications necessary to conform to such requirements or guidelines.

(2) Any State permit program under this section shall at all times be in accordance with this section and guidelines promulgated pursuant to section 304(h)(2) of this Act.

(3) Whenever the Administrator determines after public hearing that a State is not administering a program approved under this section in accordance with requirements of this section, he shall so notify the State and, if appropriate corrective action is not taken within a reasonable time, not to exceed ninety days, the Administrator shall withdraw approval of such program. The Administrator shall not withdraw approval of any such program unless he shall first have notified the State, and made public, in writing, the reasons for such withdrawal.

(4) LIMITATIONS ON PARTIAL PERMIT PROGRAM RETURNS AND WITHDRAWALS.—A State may return to the Administrator administration, and the Administrator may withdraw under paragraph (3) of this subsection approval, of—

(A) a State partial permit program approved under subsection (n)(3) only if the entire permit program being administered by the State department or agency at the time is returned or withdrawn; and

(B) a State partial permit program approved under subsection (n)(4) only if an entire phased component of the permit program being administered by the State at the time is returned or withdrawn.

(d)(1) Each State shall transmit to the Administrator a copy of each permit application received by such State and provide notice to the Administrator of every action related to the consideration of such permit application, including each permit proposed to be issued by such State.

(2) No permit shall issue (A) if the Administrator within ninety days of the date of his notification under subsection (b)(5) of this section objects in writing to the issuance of such permit, or (B) if the Administrator within ninety days of the date of transmittal of the proposed permit by the State objects in writing to the issuance of such permit as being outside the guidelines and requirements of this Act. Whenever the Administrator objects to the issuance of a permit under this paragraph such written objection shall contain a statement of the reasons for such objection and the effluent limitations and conditions which such permit would include if it were issued by the Administrator.

(3) The Administrator may, as to any permit application, waive paragraph (2) of this subsection.

(4) In any case where, after the date of enactment of this paragraph, the Administrator, pursuant to paragraph (2) of this subsection, objects to the issuance of a permit, on request of the State, a public hearing shall be held by the Administrator on such objection. If the State does not resubmit such permit revised to meet such objection within 30 days after completion of the hearing, or, if no hearing is requested within 90 days after the date of such objection, the Administrator may issue the permit pursuant to subsection (a) of this section for such source in accordance with the guidelines and requirements of this Act.

(e) In accordance with guidelines promulgated pursuant to subsection (h)(2) of section 304 of this Act, the Administrator is authorized to waive the requirements of subsection (d) of this section at the time he approves a program pursuant to subsection (b) of this section for any category (including any class, type, or size within such category) of point sources within the State submitting such program.

(f) The Administrator shall promulgate regulations establishing categories of point sources which he determines shall not be subject to the requirements of subsection (d) of this section in any State with a program approved pursuant to subsection (b) of this section. The Administrator may distinguish among classes, types, and sizes within any category of point sources.

(g) Any permit issued under this section for the discharge of pollutants into the navigable waters from a vessel or other floating craft shall be subject to any applicable regulations promulgated by the Secretary of the Department in which the Coast Guard is operating, establishing specifications for safe transportation, handling, carriage, storage, and stowage of pollutants.

(h) In the event any condition of a permit for discharges from a treatment works (as defined in section 212 of this Act) which is publicly owned is violated, a State with a program approved under subsection (b) of this section or the Administrator, where no State program is approved or where the Administrator determines pursu-

ant to section 309(a) of this Act that a State with an approved program has not commenced appropriate enforcement action with respect to such permit, may proceed in a court of competent jurisdiction to restrict or prohibit the introduction of any pollutant into such treatment works by a source not utilizing such treatment works prior to the finding that such condition was violated.

(i) Nothing in this section shall be construed to limit the authority of the Administrator to take action pursuant to section 309 of this Act.

(j) A copy of each permit application and each permit issued under this section shall be available to the public. Such permit application or permit, or portion thereof, shall further be available on request for the purpose of reproduction.

(k) Compliance with a permit issued pursuant to this section shall be deemed compliance, for purposes of sections 309 and 505, with sections 301, 302, 306, 307, and 403, except any standard imposed under section 307 for a toxic pollutant injurious to human health. Until December 31, 1974, in any case where a permit for discharge has been applied for pursuant to this section, but final administrative disposition of such application has not been made, such discharge shall not be a violation of (1) section 301, 306, or 402 of this Act, or (2) section 13 of the Act of March 3, 1899, unless the Administrator or other plaintiff proves that final administrative disposition of such application has not been made because of the failure of the applicant to furnish information reasonably required or requested in order to process the application. For the 180-day period beginning on the date of enactment of the Federal Water Pollution Control Act Amendments of 1972, in the case of any point source discharging any pollutant or combination of pollutants immediately prior to such date of enactment which source is not subject to section 13 of the Act of March 3, 1899, the discharge by such source shall not be a violation of this Act if such a source applies for a permit for discharge pursuant to this section within such 180-day period.

(l) LIMITATION ON PERMIT REQUIREMENT.—

(1) AGRICULTURAL RETURN FLOWS.—The Administrator shall not require a permit under this section for discharges composed entirely of return flows from irrigated agriculture, nor shall the Administrator directly or indirectly, require any State to require such a permit.

(2) STORMWATER RUNOFF FROM OIL, GAS, AND MINING OPERATIONS.—The Administrator shall not require a permit under this section, nor shall the Administrator directly or indirectly require any State to require a permit, for discharges of stormwater runoff from mining operations or oil and gas exploration, production, processing, or treatment operations or transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with, or do not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations.

(m) ADDITIONAL PRETREATMENT OF CONVENTIONAL POLLUTANTS NOT REQUIRED.—To the extent a treatment works (as defined in section 212 of this Act) which is publicly owned is not meeting the requirements of a permit issued under this section for such treatment works as a result of inadequate design or operation of such treatment works, the Administrator, in issuing a permit under this section, shall not require pretreatment by a person introducing conventional pollutants identified pursuant to a section 304(a)(4) of this Act into such treatment works other than pretreatment required to assure compliance with pretreatment standards under subsection (b)(8) of this section and section 307(b)(1) of this Act. Nothing in this subsection shall affect the Administrator's authority under sections 307 and 309 of this Act, affect State and local authority under sections 307(b)(4) and 510 of this Act, relieve such treatment works of its obligations to meet requirements established under this Act, or otherwise preclude such works from pursuing whatever feasible options are available to meet its responsibility to comply with its permit under this section.

(n) PARTIAL PERMIT PROGRAM.—

(1) STATE SUBMISSION.—The Governor of a State may submit under subsection (b) of this section a permit program for a portion of the discharges into the navigable waters in such State.

(2) MINIMUM COVERAGE.—A partial permit program under this subsection shall cover, at a minimum, administration of a major category of the discharges into the navigable waters of the State or a major component of the permit program required by subsection (b).

(3) APPROVAL OF MAJOR CATEGORY PARTIAL PERMIT PROGRAMS.—The Administrator may approve a partial permit program covering administration of a major category of discharges under this subsection if—

(A) such program represents a complete permit program and covers all of the discharges under the jurisdiction of a department or agency of the State; and

(B) the Administrator determines that the partial program represents a significant and identifiable part of the State program required by subsection (b).

(4) APPROVAL OF MAJOR COMPONENT PARTIAL PERMIT PROGRAMS.—The Administrator may approve under this subsection a partial and phased permit program covering administration of a major component (including discharge categories) of a State permit program required by subsection (b) if—

(A) the Administrator determines that the partial program represents a significant and identifiable part of the State program required by subsection (b); and

(B) the State submits, and the Administrator approves, a plan for the State to assume administration by phases of the remainder of the State program required by subsection (b) by a specified date not more than 5 years after submission of the partial program under this subsection and agrees to make all reasonable efforts to assume such administration by such date.

(o) ANTI-BACKSLIDING.—

(1) GENERAL PROHIBITION.—In the case of effluent limitations established on the basis of subsection (a)(1)(B) of this section, a permit may not be renewed, reissued, or modified on the basis of effluent guidelines promulgated under section 304(b) subsequent to the original issuance of such permit, to contain effluent limitations which are less stringent than the comparable effluent limitations in the previous permit. In the case of effluent limitations established on the basis of section 301(b)(1)(C) or section 303(d) or (e), a permit may not be renewed, reissued, or modified to contain effluent limitations which are less stringent than the comparable effluent limitations in the previous permit except in compliance with section 303(d)(4).

(2) EXCEPTIONS.—A permit with respect to which paragraph (1) applies may be renewed, reissued, or modified to contain a less stringent effluent limitation applicable to a pollutant if—

(A) material and substantial alterations or additions to the permitted facility occurred after permit issuance which justify the application of a less stringent effluent limitation;

(B)(i) information is available which was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and which would have justified the application of a less stringent effluent limitation at the time of permit issuance; or

(ii) the Administrator determines that technical mistakes or mistaken interpretations of law were made in issuing the permit under subsection (a)(1)(B);

(C) a less stringent effluent limitation is necessary because of events over which the permittee has no control and for which there is no reasonably available remedy;

(D) the permittee has received a permit modification under section 301(c), 301(g), 301(h), 301(i), 301(k), 301(n), or 316(a); or

(E) the permittee has installed the treatment facilities required to meet the effluent limitations in the previous permit and has properly operated and maintained the facilities but has nevertheless been unable to achieve the previous effluent limitations, in which case the limitations in the reviewed, reissued, or modified permit may reflect the level of pollutant control actually achieved (but shall not be less stringent than required by effluent guidelines in effect at the time of permit renewal, reissuance, or modification).

Subparagraph (B) shall not apply to any revised waste load allocations or any alternative grounds for translating water quality standards into effluent limitations, except where the cumulative effect of such revised allocations results in a decrease in the amount of pollutants discharged into the concerned waters, and such revised allocations are not the result of a discharger eliminating or substantially reducing its discharge of pollutants due to complying with the requirements of this Act or for reasons otherwise unrelated to water quality.

(3) LIMITATIONS.—In no event may a permit with respect to which paragraph (1) applies be renewed, reissued, or modified to contain an effluent limitation which is less stringent than required by effluent guidelines in effect at the time the permit is renewed, reissued, or modified. In no event may such a permit to discharge into waters be renewed, reissued, or modified to contain a less stringent effluent limitation if the implementation of such limitation would result in a violation of a water quality standard under section 303 applicable to such waters.

(p) MUNICIPAL AND INDUSTRIAL STORMWATER DISCHARGES.—

(1) GENERAL RULE.—Prior to October 1, 1994, the Administrator or the State (in the case of a permit program approved under section 402 of this Act) shall not require a permit under this section for discharges composed entirely of stormwater.

(2) EXCEPTIONS.—Paragraph (1) shall not apply with respect to the following stormwater discharges:

(A) A discharge with respect to which a permit has been issued under this section before the date of the enactment of this subsection.

(B) A discharge associated with industrial activity.

(C) A discharge from a municipal separate storm sewer system serving a population of 250,000 or more.

(D) A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000.

(E) A discharge for which the Administrator or the State, as the case may be, determines that the stormwater discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

(3) PERMIT REQUIREMENTS.—

(A) INDUSTRIAL DISCHARGES.—Permits for discharges associated with industrial activity shall meet all applicable provisions of this section and section 301.

(B) MUNICIPAL DISCHARGE.—Permits for discharges from municipal storm sewers—

(i) may be issued on a system- or jurisdiction-wide basis;

(ii) shall include a requirement to effectively prohibit non-stormwater discharges into the storm sewers; and

(iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

(4) PERMIT APPLICATION REQUIREMENTS.—

(A) INDUSTRIAL AND LARGE MUNICIPAL DISCHARGES.—Not later than 2 years after the date of the enactment of this subsection, the Administrator shall establish regulations setting forth the permit application requirements for stormwater discharges described in paragraphs (2)(B) and

(2)(C). Applications for permits for such discharges shall be filed no later than 3 years after such date of enactment. Not later than 4 year after such date of enactment the Administrator or the State, as the case may be, shall issue or deny each such permit. Any such permit shall provide for compliance as expeditiously as practicable, but in no event later than 3 years after the date of issuance of such permit.

(B) OTHER MUNICIPAL DISCHARGES.—Not later than 4 years after the date of the enactment of this subsection, the Administrator shall establish regulations setting forth the permit application requirements for stormwater discharges described in paragraph (2)(D). Applications for permits for such discharges shall be filed no later than 5 years after such date of enactment. Not later than 6 years after such date of enactment, the Administrator or the State, as the case may be, shall issue or deny each such permit. Any such permit shall provide for compliance as expeditiously as practicable, but in no event later than 3 years after the date of issuance of such permit.

(5) STUDIES.—The Administrator, in consultation with the States, shall conduct a study for the purposes of—

(A) identifying those stormwater discharges or classes of stormwater discharges for which permits are not required pursuant to paragraphs (1) and (2) of this subsection;

(B) determining, to the maximum extent practicable, the nature and extent of pollutants in such discharges; and

(C) establishing procedures and methods to control stormwater discharges to the extent necessary to mitigate impacts on water quality.

Not later than October 1, 1988, the Administrator shall submit to Congress a report on the results of the study described in subparagraphs (A) and (B). Not later than October 1, 1989, the Administrator shall submit to Congress a report on the results of the study described in subparagraph (C).

(6) REGULATIONS.—Not later than October 1, 1993, the Administrator, in consultation with State and local officials, shall issue regulations (based on the results of the studies conducted under paragraph (5)) which designate stormwater discharges, other than those discharges described in paragraph (2), to be regulated to protect water quality and shall establish a comprehensive program to regulate such designated sources. The program shall, at a minimum, (A) establish priorities, (B) establish requirements for State stormwater management programs, and (C) establish expeditious deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements, as appropriate.

(33 U.S.C. 1342)

OCEAN DISCHARGE CRITERIA

SEC. 403. (a) No permit under section 402 of this Act for a discharge into the territorial sea, the waters of the contiguous zone, or the oceans shall be issued, after promulgation of guidelines established under subsection (c) of this section, except in compliance with such guidelines. Prior to the promulgation of such guidelines, a permit may be issued under such section 402 if the Administrator determines it to be in the public interest.

(b) The requirements of subsection (d) of section 402 of this Act may not be waived in the case of permits for discharges into the territorial sea.

(c)(1) The Administrator shall, within one hundred and eighty days after enactment of this Act (and from time to time thereafter), promulgate guidelines for determining the degradation of the waters of the territorial seas, the contiguous zone, and the oceans, which shall include:

(A) the effect of disposal of pollutants on human health or welfare, including but not limited to plankton, fish, shellfish, wildlife, shorelines, and beaches;

(B) the effect of disposal of pollutants on marine life including the transfer, concentration, and dispersal of pollutants or their byproducts through biological, physical, and chemical processes; changes in marine ecosystem diversity, productivity, and stability; and species and community population changes;

(C) the effect of disposal, of pollutants on esthetic, recreation, and economic values;

(D) the persistence and permanence of the effects of disposal of pollutants;

(E) the effect of the disposal at varying rates, of particular volumes and concentrations of pollutants;

(F) other possible locations and methods of disposal or recycling of pollutants including land-based alternatives; and

(G) the effect on alternate uses of the oceans, such as mineral exploitation and scientific study.

(2) In any event where insufficient information exists on any proposed discharge to make a reasonable judgment on any of the guidelines established pursuant to this subsection no permit shall be issued under section 402 of this Act.

(33 U.S.C. 1343)

PERMITS FOR DREDGED OR FILL MATERIAL

SEC. 404. (a) The Secretary may issue permits, after notice and opportunity for public hearings for the discharge of dredged or fill material into the navigable waters at specified disposal sites. Not later than the fifteenth day after the date an applicant submits all the information required to complete an application for a permit under this subsection, the Secretary shall publish the notice required by this subsection.

(b) Subject to subsection (c) of this section, each such disposal site shall be specified for each such permit by the Secretary (1) through the application of guidelines developed by the Administrator, in conjunction with the Secretary which guidelines shall be based upon criteria comparable to the criteria applicable to the territorial seas, the contiguous zone, and the ocean under section 403(c), and (2) in any case where such guidelines under clause (1) alone would prohibit the specification of a site, through the application additionally of the economic impact of the site on navigation and anchorage.

(c) The Administrator is authorized to prohibit the specification (including the withdrawal of specification) of any defined area as a disposal site, and he is authorized to deny or restrict the use of any defined area for specification (including the withdrawal of specification) as a disposal site, whenever he determines, after notice and opportunity for public hearings, that the discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas. Before making such determination, the Administrator shall consult with the Secretary. The Administrator shall set forth in writing and make public his findings and his reasons for making any determination under this subsection.

(d) The term "Secretary" as used in this section means the Secretary of the Army, acting through the Chief of Engineers.

(e)(1) In carrying out his functions relating to the discharge of dredged or fill material under this section, the Secretary may, after notice and opportunity for public hearing, issue general permits on a State, regional, or nationwide basis for any category of activities involving discharges of dredged or fill material if the Secretary determines that the activities in such category are similar in nature, will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effect on the environment. Any general permit issued under this subsection shall (A) be based on the guidelines described in subsection (b)(1) of this section, and (B) set forth the requirements and standards which shall apply to any activity authorized by such general permit.

(2) No general permit issued under this subsection shall be for a period of more than five years after the date of its issuance and such general permit may be revoked or modified by the Secretary if, after opportunity for public hearing, the Secretary determines that the activities authorized by such general permit have an adverse impact on the environment or such activities are more appropriately authorized by individual permits.

(f)(1) Except as provided in paragraph (2) of this subsection, the discharge of dredge or fill material—

(A) from normal farming, silviculture, and ranching activities such as plowing, seeding, cultivating, minor drainage, harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices;

(B) for the purpose of maintenance, including emergency reconstruction of recently damaged parts, of currently serviceable structures such as dikes, dams, levees, groins, riprap, breakwaters, causeways, and bridge abutments or approaches, and transportation structures;

(C) for the purpose of construction or maintenance of farm or stock ponds or irrigation ditches, or the maintenance of drainage ditches;

(D) for the purpose of construction of temporary sedimentation basins on a construction site which does not include placement of fill material into the navigable waters;

(E) for the purpose of construction or maintenance of farm roads or forest roads, or temporary roads for moving mining equipment, where such roads are constructed and maintained, in accordance with best management practices, to assure that flow and circulation patterns and chemical and biological characteristics of the navigable waters are not impaired, that the reach of the navigable waters is not reduced, and that any adverse effect on the aquatic environment will be otherwise minimized;

(F) resulting from any activity with respect to which a State has an approved program under section 208(b)(4) which meets the requirements of subparagraphs (B) and (C) of such section,

is not prohibited by or otherwise subject to regulation under this section or section 301(a) or 402 of this Act (except for effluent standards or prohibitions under section 307).

(2) Any discharge of dredged or fill material into the navigable waters incidental to any activity having as its purpose bringing an area of the navigable waters into a use to which it was not previously subject, where the flow or circulation of navigable waters may be impaired or the reach of such waters be reduced, shall be required to have a permit under this section.

(g)(1) The Governor of any State desiring to administer its own individual and general permit program for the discharge of dredged or fill material into the navigable waters (other than those waters which are presently used, or are susceptible to use in their natural condition or by reasonable improvement as a means to transport interstate or foreign commerce shoreward to their ordinary high water mark, including all waters which are subject to the ebb and flow of the tide shoreward to their mean high water mark, or mean higher high water mark on the west coast, including wetlands adjacent thereto), within its jurisdiction may submit to the Administrator a full and complete description of the program it proposes to establish and administer under State law or under an interstate compact. In addition, such State shall submit a statement from the attorney general (or the attorney for those State agencies which have independent legal counsel), or from the chief legal officer in the case of an interstate agency, that the laws of such State, or the interstate compact, as the case may be, provide adequate authority to carry out the described program.

(2) Not later than the tenth day after the date of the receipt of the program, and statement submitted by any State under paragraph (1) of this subsection, the Administrator shall provide copies of such program and statement to the Secretary and the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service.

(3) Not later than the ninetieth day after the date of the receipt by the Administrator of the program and statement submitted by any State, under paragraph (1) of this subsection, the Secretary and the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service, shall submit any comments with respect to such program and statement to the Administrator in writing.

(h)(1) Not later than the one-hundred-twentieth day after the date of the receipt by the Administrator of a program and statement submitted by any State under paragraph (1) of this subsection, the Administrator shall determine, taking into account any comments submitted by the Secretary and the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service, pursuant to subsection (g) of this section, whether such State has the following authority with respect to the issuance of permits pursuant to such program:

(A) To issue permits which—

(i) apply, and assure compliance with, any applicable requirements of this section, including, but not limited to, the guidelines established under subsection (b)(1) of this section, and sections 307 and 403 of this Act;

(ii) are for fixed terms not exceeding five years; and

(iii) can be terminated or modified for cause including, but not limited to, the following:

(I) violation of any condition of the permit;

(II) obtaining a permit by misrepresentation, or failure to disclose fully all relevant facts;

(III) change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge.

(B) To issue permits which apply, and assure compliance with, all applicable requirements of section 308 of this Act, or to inspect, monitor, enter, and requrie reports to at least the same extent as required in section 308 of this Act.

(C) To assure that the public, and any other State the waters of which may be affected, receive notice of each application for a permit and to provide an opportunity for public hearing before a ruling on each such application.

(D) To assure that the Administrator receives notice of each application (including a copy thereof) for a permit.

(E) To assure that any State (other than the permitting State), whose waters may be affected by the issuance of a permit may submit written recommendation to the permitting State (and the Administrator) with respect to any permit application and, if any part of such written recommendations are not accepted by the permitting State, that the permitting State will notify such affected State (and the Administrator) in writing of its failure to so accept such recommendations together with its reasons for so doing.

(F) To assure that no permit will be issued if, in the judgment of the Secretary, after consultation with the Secretary of the department in which the Coast Guard is operating, anchorage and navigation of any of the navigable waters would be substantially impaired thereby.

(G) To abate violations of the permit or the permit program, including civil and criminal penalties and other ways and means of enforcement.

(H) To assure continued coordination with Federal and Federal-State water-related planning and review processes.

(2) If, with respect to a State program submitted under subsection (g)(1) of this section, the Administrator determines that such State—

(A) has the authority set forth in paragraph (1) of this subsection, the Administrator shall approve the program and so notify (i) such State, and (ii) the Secretary, who upon subsequent notification from such State that it is administering such program, shall suspend the issuance of permits under subsection (a) and (e) of this section for activities with respect to which a permit may be issued pursuant to such State program; or

(B) does not have the authority set forth in paragraph (1) of this subsection, the Administrator shall so notify such State, which notification shall also describe the revisions or modifications necessary so that such State may resubmit such program for a determination by the Administrator under this subsection.

(3) If the Administrator fails to make a determination with respect to any program submitted by a State under subsection (g)(1) of this section within one-hundred-twenty days after the date of the receipt of such program, such program shall be deemed approved pursuant to paragraph (2)(A) of this subsection and the Administrator shall so notify such State and the Secretary who, upon subsequent notification from such State that it is administering such program, shall suspend the issuance of permits under subsection (a) and (e) of this section for activities with respect to which a permit may be issued by such State.

(4) After the Secretary receives notification from the Administrator under paragraph (2) or (3) of this subsection that a State permit program has been approved, the Secretary shall transfer any applications for permits pending before the Secretary for activities with respect to which a permit may be issued pursuant to such State program to such State for appropriate action.

(5) Upon notification from a State with a permit program approved under this subsection that such State intends to administer and enforce the terms and conditions of a general permit issed by the Secretary under subsection (e) of this section with respect to activities in such State to which such general permit applies, the Secretary shall suspend the administration and enforcement of such general permit with respect to such activities.

(i) Whenever the Administrator determines after public hearing that a State is not administering a program approved under section (h)(2)(A) of this section, in accordance with this section, including, but not limited to, the guidelines established under subsection (b)(1) of this section, the Administrator shall so notify the State, and, if appropriate corrective action is not taken within a reasonable time, not to exceed ninety days after the date of the receipt of such notification, the Administrator shall (1) withdraw approval of such program until the Administrator determines such corrective action has been taken, and (2) notify the Secretary that the Secretary shall resume the program for the issuance of permits under subsections (a) and (e) of this section for activities with respect to which the State was issuing permits and that such authority of the Secretary shall continue in effect until such time as the Administrator makes the determination described in clause (1) of this subsection and such State again has an approved program.

(j) Each State which is administering a permit program pursuant to this section shall transmit to the Administrator (1) a copy of each permit application received by such State and provide notice to the Administrator of every action related to the consideration of such permit application, including each permit proposed to be issued by such State, and (2) a copy of each proposed general permit which such State intends to issue. Not later than the tenth day after the date of the receipt of such permit application or such proposed general permit, the Administrator shall provide copies of such permit application or such proposed general permit to the Secretary and the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service. If the Administrator intends to provide written comments to such State with respect to such permit application or such proposed general permit, he shall so notify such State not later than the thirtieth day after the date of the receipt of such application or such proposed general permit and provide such written comments to such State, after consideration of any comments made in writing with respect to such application or such proposed general permit by the Secretary and the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service, not later than the ninetieth day after the date of such receipt. If such State is so notified by the Administrator, it shall not issue the proposed permit until after the receipt of such comments from the Administrator, or after such ninetieth day, whichever first occurs. Such State shall not issue such proposed permit after such ninetieth day if it has received such written comments in which the Administrator objects (A) to the issuance of such proposed permit and such proposed permit is one that has been submitted to the Administrator pursuant to subsection (h)(1)(E), or (B) to the issuance of such proposed permit as being outside the requirements of this section, including, but not limited to, the guidelines developed under subsection (b)(1) of this section unless it modifies such proposed permit in accordance with such comments. Whenever the Administrator objects to the issuance of a permit under the preceding sentence such written objection shall contain a statement of the reasons for such objection and the conditions which such permit would include if it were issued by the Administrator. In any case where the Administrator objects to the issuance of a permit, on request of the State, a public hearing shall be held by the Administrator on such objection. If the State does not resubmit such permit revised to meet such objection within 30 days after completion of the hearing or, if no hearing is requested within 90 days after the date of such objection, the Secretary may issue the permit pursuant to subsection (a) or (e) of this section, as the case may be, for such source in accordance with the guidelines and requirements of this Act.

(k) In accordance with guidelines promulgated pursuant to subsection (i)(2) of section 304 of this Act, the Administrator is authorized to waive the requirements of subsection (j) of this section at the time of the approval of a program pursuant to subsection (h)(2)(A) of this section for any category (including any class, type, or size within such category) of discharge within the State submitting such program.

(l) The Administrator shall promulgate regulations establishing categories of discharges which he determines shall not be subject to the requirements of subsection (j) of this section in any State with a program approved pursuant to subsection (h)(2)(A) of this section. The Administrator may distinguish among classes, types, and sizes within any category of discharges.

(m) Not later than the ninetieth day after the date on which the Secretary notifies the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service that (1) an application for a permit under subsection (a) of this section has been received by the Secretary, or (2) the Secretary proposes to issue a general permit under subsection (e) of this section, the Secretary of the Interior, acting through the Director of the United States Fish and Wildlife Service, shall submit any comments with respect to such application or such proposed general permit in writing to the Secretary.

(n) Nothing in this section shall be construed to limit the authority of the Administrator to take action pursuant to section 309 of this Act.

(o) A copy of each permit application and each permit issued under this section shall be available to the public. Such permit application or portion thereof, shall further be available on request for the purpose of reproduction.

(p) Compliance with a permit issued pursuant to this section, including any activity carried out pursuant to a general permit issued under this section, shall be deemed compliance, for purposes of sections 309 and 505, with sections 301, 307, and 403.

(q) Not later than the one-hundred-eightieth day after the date of enactment of this subsection, the Secretary shall enter into agreements with the Administrator, the Secretaries of the Departments of Agriculture, Commerce, Interior, and Transportation, and the heads of other appropriate Federal agencies to minimize, to the maximum extent practicable, duplication, needless paperwork, and delays in the issuance of permits under this section. Such agreements shall be developed to assure that, to the maximum extent practicable, a decision with respect to an application for a permit under subsection (a) of this section will be made not later than the ninetieth day after the date the notice of such application is published under subsection (a) of this section.

(r) The discharge of dredged or fill material as part of the construction of a Federal project specifically authorized by Congress, whether prior to or on or after the date of enactment of this subsection, is not prohibited by or otherwise subject to regulation under this section, or a State program approved under this section, or section 301(a) or 402 of the Act (except for effluent standards or prohibitions under section 307), if information on the effects of such discharge, including consideration of the guidelines developed under subsection (b)(1) of this section, is included in an environmental impact statement for such project pursuant to the National Environmental Policy Act of 1969 and such environmental impact statement has been submitted to Congress before the actual discharge of dredged or fill material in connection with the construction of such project and prior to either authorization of such project or an appropriation of funds for each construction.

(s)(1) Whenever on the basis of any information available to him the Secretary finds that any person is in violation of any condition or limitation set forth in a permit issued by the Secretary under this section, the Secretary shall issue an order requiring such persons to comply with such condition or limitation, or the Secretary shall bring a civil action in accordance with paragraph (3) of this subsection.

(2) A copy of any order issued under this subsection shall be sent immediately by the Secretary to the State in which the violation occurs and other affected States. Any order issued under this subsection shall be by personal service and shall state with reasonable specificity the nature of the violation, specify a time for compliance, not to exceed thirty days, which the Secretary determines is reasonable, taking into account the seriousness of the violation and any good faith efforts to comply with applicable requirements. In any case in which an order under this subsection is issued to a corporation, a copy of such order shall be served on any appropriate corporate officers.

(3) The Secretary is authorized to commence a civil action for appropriate relief, including a permanent or temporary injunction for any violation for which he is authorized to issue a compliance order under paragraph (1) of this subsection. Any action under this paragraph may be brought in the district court of the United States for the district in which the defendant is located or resides or is doing business, and such court shall have jurisdiction to restrain such violation and to require compliance. Notice of the commencement of such acton[1] shall be given immediately to the appropriate State.

(4) Any person who violates any condition or limitation in a permit issued by the Secretary under this section, and any person who violates any order issued by the Secretary under paragraph (1) of this subsection, shall be subject to a civil penalty not to exceed $25,000 per day for each violation. In determining the amount of a civil penalty the court shall consider the seriousness of the violation or violations, the economic benefit (if any) resulting from the violaltion, any history of such violations, any good-faith efforts to comply with the applicable requirements, the economic impact of the penalty on the violator, and such other matters as justice may require.

(t) Nothing in the section shall preclude or deny the right of any State or interstate agency to control the discharge of dredged or fill material in any portion of the navigable waters within the jurisdiction of such State, including any activity of any Federal agency, and each such agency shall comply with such State or interstate requirements both substantive and procedural to control the discharge of dredged or fill material to the same extent that any person is subject to such requirements. This section shall not be construed as affecting or impairing the authority of the Secretary to maintain navigation.

(33 U.S.C. 1344)

[1] So in law. Probably should be "action".

DISPOSAL OF SEWAGE SLUDGE

SEC. 405. (a) Notwithstanding any other provision of this Act or of any other law, in the case where the disposal of sewage sludge resulting from the operation of a treatment works as defined in section 212 of this Act (including the removal of in-place sewage sludge from one location and its deposit at another location) would result in any pollutant from such sewage sludge entering the navigable waters, such disposal is prohibited except in accordance with a permit issued by the Administrator under section 402 of this Act.

(b) The Administrator shall issue regulations governing the issuance of permits for the disposal of sewage sludge subject to subsection (a) of this section and section 402 of this Act. Such regulations shall require the application to such disposal of each criterion, factor, procedure, and requirement applicable to a permit issued under section 402 of this title.

(c) Each State desiring to administer its own permit program for disposal of sewage sludge subject to subsection (a) of this section within its jurisdiction may do so in accordance with section 402 of this Act.

(d) REGULATIONS.—

(1) REGULATIONS.—The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after the date of enactment of this subsection and from time to time thereafter, regulations poroviding guidelines for the disposal of sludge and the utilization of sludge for various purposes. Such regulations shall—

(A) identify uses for sludge, including disposal;

(B) specify factors to be taken into account in determining the measures and practices applicable to each such use or disposal (including publication of information on costs);

(C) identify concentrations of pollutants which interfere with each such use or disposal.

The Administrator is authorized to revise any regulation issued under this subsection.

(2) IDENTIFICATION AND REGULATION OF TOXIC POLLUTANTS.—

(A) ON BASIS OF AVAILABLE INFORMATION.—

(i) PROPOSED REGULATIONS.—Not later than November 30, 1986, the Administrator shall identify those toxic pollutants which, on the basis of available information on their toxicity, persistence, concentration, mobility, or potential for exposure, may be present in sewage sludge in concentrations which may adversely affect public health or the environment, and propose regulations specifying acceptable management practices for sewage sludge containing each such toxic pollutant and establishing numerical limitations for each such pollutant for each use identified under paragraph (1)(A).

(ii) FINAL REGULATIONS.—Not later than August 31, 1987, and after opportunity for public hearing, the

Administrator shall promulgate the regulations required by subparagraph (A)(i).

(B) OTHERS.—

(i) PROPOSED REGULATIONS.—Not later than July 31, 1987, the Administrator shall identify those toxic pollutants not identified under subparagraph (A)(i) which may be present in sewage sludge in concentrations which may adversely affect public health or the environment, and propose regulations specifying acceptable management practices for sewage sludge containing each such toxic pollutant and establishing numerical limitations for each pollutant for each such use identified under paragraph (1)(A).

(ii) FINAL REGULATIONS.—Not later than June 15, 1988, the Administrator shall promulate the regulations required by subparagraph (B)(i).

(C) REVIEW.—From time to time, but not less often than every 2 years, the Administrator shall review the regulations promulgated under this paragraph for the purpose of identifying additional toxic pollutants and promulgating regulations for such pollutants consistent with the requirements of this paragraph.

(D) MINIMUM STANDARDS; COMPLIANCE DATE.—The management practices and numerical criteria established under subparagraphs (A), (B), and (C) shall be adequate to protect public health and the environment from any reasonably anticipated adverse effects of each pollutant. Such regulations shall require compliance as expeditiously as practicable but in no case later than 12 months after their publication, unless such regulations require the construction of new pollution control facilities, in which case the regulations shall require compliance as expeditiously as practicable but in no case later than two years from the date of their publication.

(3) ALTERNATIVE STANDARDS.—For purposes of this subsection, if, in the judgment of the Administrator, it is not feasible to prescribe or enforce a numerical limitation for a pollutant identified under paragraph (2), the Administrator may instead promulgate a design, equipment, management practice, or operational standard, or combination thereof, which in the Administrator's judgment is adequate to protect public health and the environment from any reasonably anticipated adverse effects of such pollutant. In the event the Administrator promulgates a design or equipment standard under this subsection, the Administrator shall include as part of such standard such requirements as will assure the proper operation and maintenance of any such element of design or equipment.

(4) CONDITIONS ON PERMITS.—Prior to the promulgation of the regulations required by paragraph (2), the Administrator shall impose conditions in permits issued to publicly owned treatment works under section 402 of this Act or take such other measures as the Administrator deems appropriate to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge.

(5) LIMITATION ON STATUTORY CONSTRUCTION.—Nothing in this section is intended to waive more stringent requirements established by this Act or any other law.

(e) MANNER OF SLUDGE DISPOSAL.—The determination of the manner of disposal or use of sludge is a local determination, except that it shall be unlawful for any person to dispose of sludge from a publicly owned treatment works or any other treatment works treating domestic sewage for any use for which regulations have been established pursuant to subsection (d) of this section, except in accordance with such regulations.

(f) IMPLEMENTATION OF REGULATIONS.—

(1) THROUGH SECTION 402 PERMITS.—Any permit issued under section 402 of this Act to a publicly owned treatment works or any other treatment works treating domestic sewage shall include requirements for the use and disposal of sludge that implement the regulations established pursuant to subsection (d) of this section, unless such requirements have been included in a permit issued under the appropriate provisions of subtitle C of the Solid Waste Disposal Act, part C of the Safe Drinking Water Act, the Marine Protection, Research, and Sanctuaries Act of 1972, or the Clean Air Act, or under State permit programs approved by the Administrator, where the Administrator determines that such programs assure compliance with any applicable requirements of this section. Not later than December 15, 1986, the Administrator shall promulgate procedures for approval of State programs pursuant to this paragraph.

(2) THROUGH OTHER PERMITS.—In the case of a treatment works described in paragraph (1) that is not subject to section 402 of this Act and to which none of the other above listed permit programs nor approved State permit authority apply, the Administrator may issue a permit to such treatment works solely to impose requirements for the use and disposal of sludge that implement the regulations established pursuant to subsection (d) of this section. The Administrator shall include in the permit appropriate requirements to assure compliance with the regulations established pursuant to subsection (d) of this section. The Administrator shall establish procedures for issuing permits pursuant to this paragraph.

(g) STUDIES AND PROJECTS.—

(1) GRANT PROGRAM; INFORMATION GATHERING.—The Administrator is authorized to conduct or initiate scientific studies, demonstration projects, and public information and education projects which are designed to promote the safe and beneficial management or use of sewage sludge for such purposes as aiding the restoration of abandoned mine sites, conditioning soil for parks and recreation areas, agricultural and horticultural uses, and other beneficial purposes. For the purposes of carrying out this subsection, the Administrator may make grants to State water pollution control agencies, other public or nonprofit agencies, institutions, organizations, and individuals. In cooperation with other Federal departments and agencies, other public and private agencies, institutions, and organizations, the Administrator is authorized to collect and

disseminate information pertaining to the safe and beneficial use of sewage sludge.

(2) AUTHORIZATION OF APPROPRIATIONS.—For the purposes of carrying out the scientific studies, demonstration projects, and public information and education projects authorized in this section, there is authorized to be appropriated for fiscal years beginning after September 30, 1986, not to exceed $5,000,000.

(33 U.S.C. 1345)

TITLE V—GENERAL PROVISIONS

ADMINISTRATION

SEC. 501. (a) The Administrator is authorized to prescribe such regulations as are necessary to carry out his functions under this Act.

(b) The Administrator, with the consent of the head of any other agency of the United States, may utilize such officers and employees of such agency as may be found necessary to assist in carrying out the purposes of this Act.

(c) Each recipient of financial assistance under this Act shall keep such records as the Administrator shall prescribe, including records which fully disclose the amount and disposition by such recipient of the proceeds of such assistance, the total cost of the project or undertaking in connection with which such assistance is given or used, and the amount of that portion of the cost of the project or undertaking supplied by other sources, and such other records as will facilitate an effective audit.

(d) The Administrator and the Comptroller General of the United States, or any of their duly authorized representatives, shall have access, for the purpose of audit and examination, to any books, documents, papers, and records of the recipients that are pertinent to the grants received under this Act. For the purpose of carrying out audits and examinations with respect to recipients of Federal assistance under this Act, the Administrator is authorized to enter into noncompetitive procurement contracts with independent State audit organizations, consistent with chapter 75 of title 31, United States Code. Such contracts may only be entered into to the extent and in such amounts as may be provided in advance in appropriation Acts.

(e)(1) It is the purpose of this subsection to authorize a program which will provide official recognition by the United States Government to those industrial organizations and political subdivisions of States which during the preceding year demonstrated an outstanding technological achievement or an innovative process, method, or device in their waste treatment and pollution abatement programs. The Administrator shall, in consultation with the appropriate State water pollution control agencies, establish regulations under which such recognition may be applied for and granted, except that no applicant shall be eligible for an award under this subsection if such applicant is not in total compliance with all applicable water quality requirements under this Act, or otherwise does not have a satisfactory record with respect to environmental quality.

(2) The Administrator shall award a certificate or plaque of suitable design to each industrial organization or political subdivision which qualifies for such recognition under regulations established under this subsection.

(3) The President of the United States, the Governor of the appropriate State, the Speaker of the House of Representatives, and the President pro tempore of the Senate shall be notified of the award by the Administrator and the awarding of such recognition shall be published in the Federal Register.

(f) Upon the request of a State water pollution control agency, personnel of the Environmental Protection Agency may be detailed to such agency for the purpose of carrying out the provisions of this Act.

(33 U.S.C. 1361)

GENERAL DEFINITIONS

SEC. 502. Except as otherwise specifically provided, when used in this Act:

(1) The term "State water pollution control agency" means the State agency designated by the Governor having responsibility for enforcing State laws relating to the abatement of pollution.

(2) The term "interstate agency" means an agency of two or more States established by or pursuant to an agreement or compact approved by the Congress, or any other agency of two or more States, having substantial powers or duties pertaining to the control of pollution as determined and approved by the Adminstrator.

(3) The term "State" means a State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands.

(4) The term "municipality" means a city, town, borough, county, parish, district, association, or other public body created by or pursuant to State law and having jurisdiction over disposal of sewage, industrial wastes, or other wastes, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of this Act.

(5) The term "person" means an individual, corporation, partnership, association, State, municipality, commission, or political subdivision of a State, or any interstate body.

(6) The term "pollutant" means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water. This term does not mean (A) "sewage from vessels or a discharge incidental to the normal operation of a vessel of the Armed Forces" within the meaning of section 312 of this Act; or (B) water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well, if the well used either to facilitate production or for disposal purpose is approved by authority of the State in which the well is located, and if such State determines

that such injection or disposal will not result in the degradation of ground or surface water resources.

(7) The term "navigable waters" means the waters of the United States, including the territorial seas.

(8) The term "territorial seas" means the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three miles.

(9) The term "contiguous zone" means the entire zone established or to be established by the United States under article 24 of the Convention of the Territorial Sea and the Contiguous Zone.

(10) The term "ocean" means any portion of the high seas beyond the contiguous zone.

(11) The term "effluent limitation" means any restriction established by a State or the Administrator on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources into navigable waters, the waters of the contiguous zone, or the ocean, including schedules of compliance.

(12) The term "discharge of a pollutant" and the term "discharge of pollutants" each means (A) any addition of any pollutant to navigable waters from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft.

(13) The term "toxic pollutant" means those pollutants, or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring.

(14) The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

(15) The term "biological monitoring" shall mean the determination of the effects on aquatic life, including accumulation of pollutants in tissue, in receiving waters due to the discharge of pollutants (A) by techniques and procedures, including sampling of organisms representative of appropriate levels of the food chain appropriate to the volume and the physical, chemical, and biological characteristics of the effluent, and (B) at appropriate frequencies and locations.

(16) The term "discharge" when used without qualification includes a discharge of a pollutant, and a discharge of pollutants.

(17) The term "schedule of compliance" means a schedule of remedial measures including an enforceable sequence of actions or

operations leading to compliance with an effluent limitation, other limitation, prohibition, or standard.

(18) The term "industrial user" means those industries identified in the Standard Industrial Classification Manual, Bureau of the Budget, 1967, as amended and supplemented, under the category "Division D—Manufacturing" and such other classes of significant waste producers as, by regulation, the Administrator deems appropriate.

(19) The term "pollution" means the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.

(20) The term "medical waste" means isolation wastes; infectious agents; human blood and blood products; pathological wastes; sharps; body parts; contaminated bedding; surgical wastes and potentially contaminated laboratory wastes; dialysis wastes; and such additional medical items as the Administrator shall prescribe by regulation.

(33 U.S.C. 1362)

WATER POLLUTION CONTROL ADVISORY BOARD

SEC. 503. (a)(1) There is hereby established in the Environmental Protection Agency a Water Pollution Control Advisory Board, composed of the Administrator or his designee, who shall be Chairman, and nine members appointed by the President, none of whom shall be Federal officers or employees. The appointed members, having due regard for the purposes of this Act, shall be selected from among representatives of various State, interstate, and local governmental agencies, of public or private interests contributing to, affected by, or concerned with pollution, and of other public and private agencies, organizations, or groups demonstrating an active interest in the field of pollution prevention and control, as well as other individuals who are expert in this field.

(2)(A) Each member appointed by the President shall hold office for a term of three years, except that (i) any member appointed to fill a vacancy occurring prior to the expiration of the term for which his predecessor was appointed shall be appointed for the remainder of such term, and (ii) the terms of office of the members first taking office after June 30, 1956, shall expire as follows: three at the end of one year after such date, three at the end of two years after such date, and three at the end of three years after such date, as designated by the President at the time of appointment, and (iii) the term of any member under the preceding provisions shall be extended until the date on which his successor's appointment is effective. None of the members appointed by the President shall be eligible for reappointment within one year after the end of his preceding term.

(B) The members of the Board who are not officers or employees of the United States, while attending conferences or meetings of the Board or while otherwise serving at the request of the Administrator, shall be entitled to receive compensation at a rate to be fixed by the Administrator, but not exceeding $100 per diem, including traveltime, and while away from their homes or regular places of business they may be allowed travel expenses, including

per diem in lieu of subsistence, as authorized by law (5 U.S.C. 73b–2) for persons in the Government service employed intermittently.

(b) The Board shall advise, consult with, and make recommendations to the Administrator on matters of policy relating to the activities and functions of the Administrator under this Act.

(c) Such clerical and technical assistance as may be necessary to discharge the duties of the Board shall be provided from the personnel of the Environmental Protection Agency.

(33 U.S.C. 1363)

EMERGENCY POWERS

SEC. 504. (a) Notwithstanding any other provision of this Act, the Administrator upon receipt of evidence that a pollution source or combination of sources is presenting an imminent and substantial endangerment to the health of persons or to the welfare of persons where such endangerment is to the livelihood of such persons, such as inability to market shellfish, may bring suit on behalf of the United States in the appropriate district court to immediately restrain any person causing or contributing to the alleged pollution to stop the discharge of pollutants causing or contributing to such pollution or to take such other action as may be necessary.

[Subsection (b) repealed by §304(a) of P.L. 96–510, Dec. 11, 1980, 94 Stat. 2809]

(33 U.S.C. 1364)

CITIZEN SUITS

SEC. 505. (a) Except as provided in subsection (b) of this section and section 309(g)(6), any citizen may commence a civil action on his own behalf—

(1) against any person (including (i) the United States, and (ii) any other governmental instrumentality or agency to the extent permitted by the eleventh amendment to the Constitution) who is alleged to be in violation of (A) an effluent standard or limitation under this Act or (B) an order issued by the Administrator or a State with respect to such a standard or limitation, or

(2) against the Administrator where there is alleged a failure of the Administrator to perform any act or duty under this Act which is not discretionary with the Administrator.

The district courts shall have jurisdiction, without regard to the amount in controversy or the citizenship of the parties, to enforce such an effluent standard or limitation, or such an order, or to order the Administrator to perform such act or duty, as the case may be, and to apply any appropriate civil penalties under section 309(d) of this Act.

(b) No action may be commenced—

(1) under subsection (a)(1) of this section—

(A) prior to sixty days after the plaintiff has given notice of the alleged violation (i) to the Administrator, (ii) to the State in which the alleged violation occurs, and (iii) to any alleged violator of the standard, limitation, or order, or

(B) if the Administrator or State has commenced and is diligently prosecuting a civil or criminal action in a court of the United States, or a State to require compliance with the standard, limitation, or order, but in any such action in a court of the United States any citizen may intervene as a matter of right.

(2) under subsection (a)(2) of this section prior to sixty days after the plaintiff has given notice of such action to the Administrator,

except that such action may be brought immediately after such notification in the case of an action under this section respecting a violation of sections 306 and 307(a) of this Act. Notice under this subsection shall be given in such manner as the Administrator shall prescribe by regulation.

(c)(1) Any action respecting a violation by a discharge source of an effluent standard or limitation or an order respecting such standard or limitation may be brought under this section only in the judicial district in which such source is located.

(2) In such action under this section, the Administrator, if not a party, may intervene as a matter of right.

(3) PROTECTION OF INTERESTS OF UNITED STATES.—Whenever any action is brought under this section in a court of the United States, the plaintiff shall serve a copy of the complaint on the Attorney General and the Administrator. No consent judgment shall be entered in an action in which the United States is not a party prior to 45 days following the receipt of a copy of the proposed consent judgment by the Attorney General and the Administrator.

(d) The court, in issuing any final order in any action brought pursuant to this section, may award costs of litigation (including reasonable attorney and expert witness fees) to any prevailing or substantially prevailing party, whenever the court determines such award is appropriate. The court may, if a temporary restraining order or preliminary injunction is sought, require the filing of a bond or equivalent security in accordance with the Federal Rules of Civil Procedure.

(e) Nothing in this section shall restrict any right which any person (or class of persons) may have under any statute or common law to seek enforcement of any effluent standard or limitation or to seek any other relief (including relief against the Administrator or a State agency).

(f) For purposes of this section, the term "effluent standard or limitation under this Act" means (1) effective July 1, 1973, an unlawful act under subsection (a) of section 301 of this Act; (2) an effluent limitation or other limitation under section 301 or 302 of this Act; (3) standard or performance under section 306 of this Act; (4) prohibition, effluent standard or pretreatment standards under section 307 of this Act; (5) certification under section 401 of this Act; (6) a permit or condition thereof issued under section 402 of this Act, which is in effect under this Act (including a requirement

applicable by reason of section 313 of this Act); or (7) a regulation under section 405(d) of this Act,.[1]

(g) For the purposes of this section the term "citizen" means a person or persons having an interest which is or may be adversely affected.

(h) A Governor of a State may commence a civil action under subsection (a), without regard to the limitations of subsection (b) of this section, against the Administrator where there is alleged a failure of the Administrator to enforce an effluent standard or limitation under this Act the violation of which is occurring in another State and is causing an adverse effect on the public health or welfare in his State, or is causing a violation of any water quality requirement in his State.

(33 U.S.C. 1365)

APPEARANCE

SEC. 506. The Administrator shall request the Attorney General to appear and represent the United States in any civil or criminal action instituted under this Act to which the Administrator is a party. Unless the Attorney General notifies the Administrator within a reasonable time, that he will appear in a civil action, attorneys who are officers or employees of the Environmental Protection Agency shall appear and represent the United States in such action.

(33 U.S.C. 1366)

EMPLOYEE PROTECTION

SEC. 507. (a) No person shall fire, or in any other way discriminate against, or cause to be fired or discriminated against, any employee or any authorized representative or employees by reason of the fact that such employee or representative has filed, instituted, or caused to be filed or instituted any proceeding under this Act, or has testified or is about to testify in any proceeding resulting from the administration or enforcement of the provisions of this Act.

(b) Any employee or a representative of employees who believes that he has been fired or otherwise discriminated against by any person in violation of subsection (a) of this section may, within thirty days after such alleged violation occurs, apply to the Secretary of Labor for a review of such firing or alleged discrimination. A copy of the application shall be sent to such person who shall be the respondent. Upon receipt of such application, the Secretary of Labor shall cause such investigation to be made as he deems appropriate. Such investigation shall provide an opportunity for a public hearing at the request of any party to such review to enable the parties to present information relating to such alleged violation. The parties shall be given written notice of the time and place of the hearing at least five days prior to the hearing. Any such hearing shall be of record and shall be subject to section 554 of title 5 of the United States Code. Upon receiving the report of such investigation, the Secretary of Labor shall make findings of fact. If

[1] So in law. See P.L. 100–4, sec. 406(d)(2), 101 Stat. 73.

he finds that such violation did occur, he shall issue a decision, incorporating an order therein and his findings, requiring the party committing such violation to take such affirmative action to abate the violation as the Secretary of Labor deems appropriate, including, but not limited to, the rehiring or reinstatement of the employee or representative of employees to his former position with compensation. If he finds that there was no such violation, he shall issue an order denying the application. Such order issued by the Secretary of Labor under this subparagraph shall be subject to judicial review in the same manner as orders and decisions of the Administrator are subject to judicial review under this Act.

(c) Whenever an order is issued under this section to abate such violation, at the request of the applicant, a sum equal to the aggregate amount of all costs and expenses (including the attorney's fees), as determined by the Secretary of Labor, to have been reasonably incurred by the applicant for, or in connection with, the institution and prosecution of such proceedings, shall be assessed against the person committing such violation.

(d) This section shall have no application to any employee who, acting without direction from his employer (or his agent) deliberately violates any prohibition of effluent limitation or other limitation under section 301 or 302 of this Act, standards of performance under section 306 of this Act, effluent standard, prohibition or pretreatment standard under section 307 of this Act, or any other prohibition or limitation established under this Act.

(e) The Administrator shall conduct continuing evaluations of potential loss or shifts of employment which may result from the issuance of any effluent limitation or order under this Act, including, where appropriate, investigating threatened plant closures or reductions in employment allegedly resulting from such limitation or order. Any employee who is discharged or laid off, threatened with discharge or lay-off, or otherwise discriminated against by any person because of the alleged results of any effluent limitation or order issued under this Act, or any representative of such employee, may request the Administrator to conduct a full investigation of the matter. The Administrator shall thereupon investigate the matter and, at the request of any party, shall hold public hearings on not less than five days notice, and shall at such hearings require the parties, including the employer involved, to present information relating to the actual or potential effect of such limitation or order on employment and on any alleged discharge, lay-off, or other discrimination and the detailed reasons or justification therefor. Any such hearing shall be of record and shall be subject to section 554 of title 5 of the United States Code. Upon receiving the report of such investigation, the Administrator shall make findings of fact as to the effect of such effluent limitation or order on employment and on the alleged discharge, lay-off, or discrimination and shall make such recommendations as he deems appropriate. Such report, findings, and recommendations shall be available to the public. Nothing in this subsection shall be construed to require or authorize the Administrator to modify or withdraw any effluent limitation or order issued under this Act.

([illegible] U.S.C. 1367)

FEDERAL PROCUREMENT

SEC. 508. (a) No Federal agency may enter into any contract with any person, who has been convicted of any offense under section 309(c) of this Act, for the procurement of goods, materials, and services if such contract is to be performed at any facility at which the violation which gave rise to such conviction occurred, and if such facility is owned, leased, or supervised by such person. The prohibition in the preceding sentence shall continue until the Administrator certifies that the condition giving rise to such conviction has been corrected.

(b) The Administrator shall establish procedures to provide all Federal agencies with the notification necessary for the purposes of subsection (a) of this section.

(c) In order to implement the purposes and policy of this Act to protect and enhance the quality of the Nation's water, the President shall, not more than one hundred and eighty days after enactment of this Act, cause to be issued an order (1) requiring each Federal agency authorized to enter into contracts and each Federal agency which is empowered to extend Federal assistance by way of grant, loan, or contract to effectuate the purpose and policy of this Act in such contracting or assistance activities, and (2) setting forth procedures, sanctions, penalties, and such other provisions, as the President determines necessary to carry out such requirement.

(d) The President may exempt any contract, loan, or grant from all or part of the provisions of this section where he determines such exemption is necessary in the paramount interest of the United States and he shall notify the Congress of such exemption.

(e) The President shall annually report to the Congress on measures taken in compliance with the purpose and intent of this section, including, but not limited to, the progress and problems associated with such compliance.

(f)(1) No certification by a contractor, and no contract clause, may be required in the case of a contract for the acquisition of commercial items in order to implement a prohibition or requirement of this section or a prohibition or requirement issued in the implementation of this section.

(2) In paragraph (1), the term "commercial item" has the meaning given such term in section 4(12) of the Office of Federal Procurement Policy Act (41 U.S.C. 403(12)).

(33 U.S.C. 1368)

ADMINISTRATIVE PROCEDURE AND JUDICIAL REVIEW

SEC. 509. (a)(1) For purposes of obtaining information under section 305 of this Act, or carrying out section 507(e) of this Act, the Administrator may issue subpenas for the attendance and testimony of witnesses and the production of relevant papers, books, and documents, and he may administer oaths. Except for effluent data, upon a showing satisfactory to the Administrator that such papers, books, documents, or information or particular part thereof, if made public, would divulge trade secrets or secret processes, the Administrator shall consider such record, report, or information or particular portion thereof confidential in accordance with the purposes of section 1905 of title 18 of the United States Code, except that such paper, book, document, or information may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out this Act, or when relevant in any proceeding under this Act. Witnesses summoned shall be paid the same fees and mileage that are paid witnesses in the courts of the United States. In case of contumacy or refusal to obey a subpena served upon any person under this subsection, the district court of the United States for any district in which such person is found or resides or transacts business, upon application by the United States and after notice to such person, shall have jurisdiction to issue an order requiring such person to appear and give testimony before the Administrator, to appear and produce papers, books, and documents before the Administrator, or both, and any failure to obey such order of the court may be punished by such court as a contempt thereof.

(2) The district courts of the United States are authorized, upon application by the Administrator, to issue subpenas for attendance and testimony of witnesses and the production of relevant papers, books, and documents, for purposes of obtaining information under sections 304 (b) and (c) of this Act. Any papers, books, documents, or other information or part thereof, obtained by reason of such a subpena shall be subject to the same requirements as are provided in paragraph (1) of this subsection.

(b)(1) Review of the Administrator's action (A) in promulgating any standard of performance under section 306, (B) in making any determination pursuant to section 306(b)(1)(C), (C) in promulgating any effluent standard, prohibition, or pretreatment standard under section 307, (D) in making any determination as to a State permit program submitted under section 402(b), (E) in approving or promulgating any effluent limitation or other limitation under sections 301, 302, 306, or 405, (F) in issuing or denying any permit under section 402, and (G) in promulgating any individual control strategy under section 304(l), may be had by any interested person in the Circuit Court of Appeals of the United States for the Federal judicial district in which such person resides or transacts business which is directly affected by such action upon application by such person. Any such application shall be made within 120 days from the date of such determination, approval, promulgation, issuance or denial, or after such date only if such application is based solely on grounds which arose after such 120th day.

(2) Action of the Administrator with respect to which review could have been obtained under paragraph (1) of this subsection shall not be subject to judicial review in any civil or criminal proceeding for enforcement.

(3) AWARD OF FEES.—In any judicial proceeding under this subsection, the court may award costs of litigation (including reasonable attorney and expert witness fees) to any prevailing or substantially prevailing party whenever it determines that such award is appropriate.

(c) In any judicial proceeding brought under subsection (b) of this section in which review is sought of a determination under this Act required to be made on the record after notice and opportunity

additional evidence, and shows to the satisfaction of the court that such additional evidence is material and that there were reasonable grounds for the failure to adduce such evidence in the proceeding before the Administrator, the court may order such additional evidence (and evidence in rebuttal thereof) to be taken before the Administrator, in such manner and upon such terms and conditions as the court may deem proper. The Administrator may modify his findings as to the facts, or make new findings, by reason of the additional evidence so taken and he shall file such modified or new findings, and his recommendation, if any, for the modification or setting aside of his original determination with the return of such additional evidence.

(33 U.S.C. 1369)

STATE AUTHORITY

SEC. 510. Except as expressly provided in this Act, nothing in this Act shall (1) preclude or deny the right of any State or political subdivision thereof or interstate agency to adopt or enforce (A) any standard or limitation respecting discharges of pollutants, or (B) any requirement respecting control or abatement of pollution; except that if an effluent limitation, or other limitation, effluent standard, prohibition, pretreatment standard, or standard of performance is in effect under this Act, such State or political subdivision or interstate agency may not adopt or enforce any effluent limitation, or other limitation, effluent standard, prohibition, pretreatment standard, or standard of performance which is less stringent than the effluent limitation, or other limitation, effluent standard prohibition, pretreatment standard, or standard of performance under this Act; or (2) be construed as impairing or in any manner affecting any right or jurisdiction of the States with respect to the waters (including boundary waters) of such States.

(33 U.S.C. 1370)

OTHER AFFECTED AUTHORITY

SEC. 511. (a) This Act shall not be construed as (1) limiting the authority or functions of any officer or agency of the United States under any other law or regulation not inconsistent with this Act; (2) affecting or impairing the authority of the Secretary of the Army (A) to maintain navigation or (B) under the Act of March 3, 1899 (30 Stat. 1112); except that any permit issued under section 404 of this Act shall be conclusive as to the effect on water quality of any discharge resulting from any activity subject to section 10 of the Act of March 3, 1899, or (3) affecting or impairing the provisions of any treaty of the United States.

(b) Discharges of pollutants into the navigable waters subject to the Rivers and Harbors Act of 1910 (36 Stat. 593; 33 U.S.C. 421) and the Supervisory Harbors, Act of 1888 (25 Stat. 209; 33 U.S.C. 441–451b) shall be regulated pursuant to this Act, and not subject to such Act of 1910 and the Act of 1888 except as to effect on navigation and anchorage.

(c)(1) Except for the provision of Federal financial assistance for the purpose of assisting the construction of publicly owned issuance of a permit under section 402 of this Act for the discharge of any pollutant by a new source as defined in section 306 of this Act, no action of the Administrator taken pursuant to this Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969 (83 Stat. 852); and

(2) Nothing in the National Environmental Policy Act of 1969 (83 Stat. 852) shall be deemed to—

(A) authorize any Federal agency authorized to license or permit the conduct of any activity which may result in the discharge of a pollutant into the navigable waters to review any effluent limitation or other requirement established pursuant to this Act or the adequacy of any certification under section 401 of ths Act; or

(B) authorize any such agency to impose, as a condition precedent to the issuance of any license or permit, any effluent limitation other than any such limitation established pursuant to this Act.

(d) Notwithstanding this Act or any other provisions of law, the Administrator (1) shall not require any State to consider in the development of the ranking in order of priority of needs for the construction of treatment works (as defined in title II of this Act), any water pollution control agreement which may have been entered into between the United States and any other nation, and (2) shall not consider any such agreement in the approval of any such priority ranking.

(33 U.S.C. 1371)

SEPARABILITY

SEC. 512. If any provision of this Act, or the application of any provision of this Act to any person or circumstance, is held invalid, the application of such provision to other persons or circumstances, and the remainder of this Act shall not be affected thereby.

(33 U.S.C. 1251 note)

LABOR STANDARDS

SEC. 513. The Administrator shall take such action as may be necessary to insure that all laborers and mechanics employed by contractors or subcontractors on treatment works for which grants are made under this Act shall be paid wages at rates not less than those prevailing for the same type of work on similar construction in the immediate locality, as determied by the Secretry of Labor, in accordance with the Act of March 3, 1931, as amended, known as the Davis-Bacon Act (46 Stat. 1494; 40 U.S.C., sec. 276a through 276a–5). The Secretary of Labor shall have, with respect to the labor standards specified in this subsection, the authority and functions set forth in Reorganization Plan Numbered 14 of 1950 (15 F.R. 3176) and section 2 of the Act of June 13, 1934, as amended (48 Stat. 948; 40 U.S.C. 276c).

(33 U.S.C. 1372)

PUBLIC HEALTH AGENCY COORDINATION

SEC. 514. The permitting agency under section 402 shall assist the applicant for a permit under such section in coordinating the requirements of this Act with those of the appropriate public health agencies.

(33 U.S.C. 1373)

EFFLUENT STANDARDS AND WATER QUALITY INFORMATION ADVISORY COMMITTEE

SEC. 515. (a)(1) There is established on Effluent Standards and Water Quality Information Advisory Committee, which shall be composed of a Chairman and eight members who shall be appointed by the Administrator within sixty days after the date of enactment of this Act.

(2) All members of the Committee shall be selected from the scientific community, qualified by education, training, and experience to provide assess, and evaluate scientific and technical information on effluent standards and limitations.

(3) Members of the Committee shall serve for a term of four years, and may be reappointed.

(b)(1) No later than one hundred and eighty days prior to the date on which the Administrator is required to publish any proposed regulations required by section 304(b) of this Act, any proposed standard of performance for new sources required by section 306 of this Act, or any proposed toxic effluent standard required by section 307 of this Act, he shall transmit to the Committee a notice of intent to propose such regulations. The Chairman of the Committee within ten days after receipt of such notice may publish a notice of a public hearing by the Committee, to be held within thirty days.

(2) No later than one hundred and twenty days after receipt of such notice, the Committee shall transmit to the Administrator such scientific and technical information as is in its possession, including that presented at any public hearing, related to the subject matter contained in such notice.

(3) Information so transmitted to the Administrator shall constitute a part of the administrative record and comments on any proposed regulations or standards as information to be considered with other comments and information in making any final determinations.

(4) In preparing information for transmittal, the Committee shall avail itself of the technical and scientific services of any Federal agency, including the United States Geological Survey and any national environmental laboratories which may be established.

(c)(1) The Committee shall appoint and prescribe the duties of a Secretary, and such legal counsel as it deems necessary. The Committee shall appoint such other employees as it deems necessary to exercise and fulfill its powers and responsibilities. The compensation of all employees appointed by the Committee shall be fixed in accordance with chapter 51 and subchapter III of chapter 53 of title V of the United States Code.

(2) Members of the Committee shall be entitled to receive compensation at a rate to be fixed by the President but not in excess

of the maximum rate of pay grade for GS–18, as provided in the General Schedule under section 5332 of title V of the United States Code.

(d) Five members of the Committee shall constitute a quorum, and official actions of the Committee shall be taken only on the affirmative vote of at least five members. A special panel composed of one or more members upon order of the Committee shall conduct any hearing authorized by this section and submit the transcript of such hearing to the entire Committee for its action thereon.

(e) The Committee is authorized to make such rules as are necessary for the orderly transaction of its business.

(33 U.S.C. 1374)

REPORTS TO CONGRESS

SEC. 516. (a) Within ninety days following the convening of each session of Congress, the Administrator shall submit to the Congress a report, in addition to any other report required by this Act, on measures taken toward implementing the objective of this Act, including, but not limited to, (1) the progress and problems associated with developing comprehensive plans under section 102 of this Act, areawide plans under section 208 of this Act, basin plans under section 209 of this Act, and plans under section 303(e) of this Act; (2) a summary of actions taken and results achieved in the field of water pollution control research, experiments, studies, and related matters by the Administrator and other Federal agencies and by other persons and agencies under Federal grants or contracts; (3) the progress and problems associated with the development of effluent limitations and recommended control techniques; (4) the status of State programs, including a detailed summary of the progress obtained as compared to that planned under the State program plans for development and enforcement of water quality requirements; (5) the identification and status of enforcement actions pending or completed under such Act during the preceding year; (6) the status of State, interstate, and local pollution control programs established pursuant to, and assisted by, this Act; (7) a summary of the results of the survey required to be taken under section 210 of this Act; (8) his activities including recommendations under sections 109 through 111 of this Act; and (9) all reports and recommendations made by the Water Pollution Control Advisory Board.

(b)(1) The Administrator, in cooperation with the States, including water pollution control agencies and other water pollution control planning agencies, shall make (A) a detailed estimate of the cost of carrying out the provisions of this Act; (B) a detailed estimate, biennially revised, of the cost of construction of all needed publicly owned treatment works in all of the States and of the cost of construction of all needed publicly owned treatment works in each of the States; (C) a comprehensive study of the economic impact on affected units of government of the cost of installation of treatment facilities; and (D) a comprehensive analysis of the national requirements for and the cost of treating municipal, industrial, and other effluent to attain the water quality objectives as established by this Act or applicable State law. The Administrator shall submit such detailed estimate and such comprehensive study of such cost to the Congress no later than February 10 of each odd-numbered year. Whenever the Administrator, pursuant to this subsection, requests and receives an estimate of cost from a State, he shall furnish copies of such estimate together with such detailed estimate to Congress.

(2) Notwithstanding the second sentence of paragraph (1) of this subsection, the Administrator shall make a preliminary detailed estimate called for by subparagraph (B) of such paragraph and shall submit such preliminary detailed estimate to the Congress no later than September 3, 1974. The Administrator shall require each State to prepare an estimate of cost for such State, and shall utilize the survey form EPA–1, O.M.B. No. 158–R0017, prepared for the 1973 detailed estimate, except that such estimate shall include all costs of compliance with section 201(g)(2)(A) of this Act and water quality standards established pursuant to section 303 of this Act, and all costs of treatment works as defined in section 212(2), including all eligible costs of constructing sewage collection systems and correcting excessive infiltration or inflow and all eligible costs of correcting combined storm and sanitary sewer problems and treating storm water flows. The survey form shall be distributed by the Administrator to each State no later than January 31, 1974.

(c) The Administrator shall submit to the Congress by October 1, 1978, a report on the status of combined sewer overflows in municipal treatment works operations. The report shall include (1) the status of any projects funded under this Act to address combined sewer overflows, (2) a listing by State of combined sewer overflow needs identified in the 1977 State priority listings, (3) an estimate for each applicable municipality of the number of years necessary, assuming an annual authorization and appropriation for the construction grants program of $5,000,000,000 to correct combined sewer overflow problems, (4) an analysis using representative municipalities faced with major combined sewer overflow needs, of the annual discharges of pollutants from overflows in comparison to treated affluent discharges, (5) an analysis of the technological alternatives available to municipalities to correct major combined sewer overflow problems, and (6) any recommendations of the Administrator for legislation to address the problem of combined sewer overflows, including whether a separate authorization and grant program should be established by the Congress to address combined sewer overflows.

(d) The Administrator, in cooperation with the States, including water pollution control agencies, and other water pollution control planning agencies, and water supply and water resources agencies of the States and the United States shall submit to Congress, within two years of the date of enactment of this section, a report with recommendations for legislation on a program to require coordination between water supply and wastewater control plans as a condition to grants for construction of treatment works under this Act. No such report shall be submitted except after opportunity for public hearings on such proposed report.

(e) STATE REVOLVING FUND REPORT.—

(1) IN GENERAL.—Not later than February 10, 1990, the Administrator shall submit to Congress a report on the financial status and operations of water pollution control revolving funds established by the States under the title VI of this Act. The Administrator shall prepare such report in cooperation with the States, including water pollution control agencies and other water pollution control planning and financing agencies.

(2) CONTENTS.—The report under this subsection shall also include the following:

(A) an inventory of the facilities that are in significant noncompliance with the enforceable requirements of this Act;

(B) an estimate of the cost of construction necessary to bring such facilities into compliance with such requirements;

(C) an assessment of the availability of sources of funds for financing such needed construction, including an estimate of the amount of funds available for providing assistance for such construction through September 30, 1999, from the water pollution control revolving funds established by the States under title VI of this Act;

(D) an assessment of the operations, loan portfolio, and loan conditions of such revolving funds;

(E) an assessment of the effect on user charges of the assistance provided by such revolving funds compared to the assistance provided with funds appropriated pursuant to section 207 of this Act; and

(F) an assessment of the efficiency of the operation and maintenance of treatment works constructed with assistance provided by such revolving funds compared to the efficiency of the operation and maintenance of treatment works constructed with assistance provided under section 201 of this Act.

(33 U.S.C. 1375)

GENERAL AUTHORIZATION

SEC. 517. There are authorized to be appropriated to carry out this Act, other than sections 104, 105, 106(a), 107, 108, 112, 113, 114, 115, 206, 207, 208 (f) and (h), 209, 304, 311 (c), (d), (i), (l), and (k), 314, 315, and 317, $250,000,000 for the fiscal year ending June 30, 1973, $300,000,000 for the fiscal year ending June 30, 1974, $350,000,000 for the fiscal year ending June 30, 1975, $100,000,000 for the fiscal year ending September 30, 1977, $150,000,000 for the fiscal year ending September 30, 1978, $150,000,000 for the fiscal year ending September 30, 1979, $150,000,000 for the fiscal year ending September 30, 1980, $150,000,000 for the fiscal year ending September 30, 1981, $161,000,000 for the fiscal year ending September 30, 1982, such sums as may be necessary for fiscal years 1983 through 1985, and $135,000,000 per fiscal year for each of the fiscal years 1986 through 1990.

(33 U.S.C. 1376)

SEC. 518. INDIAN TRIBES.

(a) POLICY.—Nothing in this section shall be construed to affect the application of section 101(g) of this Act, and all of the provisions of this section shall be carried out in accordance with the provisions of such section 101(g). Indian tribes shall be treated as States for purposes of such section 101(g).

(b) ASSESSMENT OF SEWAGE TREATMENT NEEDS; REPORT.—The Administrator, in cooperation with the Director of the Indian Health Service, shall assess the need for sewage treatment works to serve Indian tribes, the degree to which such needs will be met through funds allotted to States under section 205 of this Act and priority lists under section 216 of this Act, and any obstacles which prevent such needs from being met. Not later than one year after the date of the enactment of this section, the Administrator shall submit a report to Congress on the assessment under this subsection, along with recommendations specifying (1) how the Administrator intends to provide assistance to Indian tribes to develop waste treatment management plans and to construct treatment works under this Act, and (2) methods by which the participation in and administration of programs under this Act by Indian tribes can be maximized.

(c) RESERVATION OF FUNDS.—The Administrator shall reserve each fiscal year beginning after September 30, 1986, before allotments to the States under section 205(e), one-half of one percent of the sums appropriated under section 207. Sums reserved under this subsection shall be available only for grants for the develoment of waste treatment management plans and for the construction of sewage treatment works to serve Indian tribes, as defined in subsection (h) and former Indian reservations in Oklahoma (as determined by the Secretary of the Interior) and Alaska Native Villages as defined in Public Law 92–203.

(d) COOPERATIVE AGREEMENTS.—In order to ensure the consistent implementation of the requirements of this Act, an Indian tribe and the State or States in which the lands of such tribe are located may enter into a cooperative agreement, subject to the review and approval of the Administrator, to jointly plan and administer the requirements of this Act.

(e) TREATMENT AS STATES.—The Administrator is authorized to treat an Indian tribe as a State for purposes of title II and sections 104, 106, 303, 305, 308, 309, 314, 319, 401, 402, and 404 of this Act to the degree necessary to carry out the objectives of this section, but only if—

(1) the Indian tribe has a governing body carrying out substantial governmental duties and powers;

(2) the functions to be exercised by the Indian tribe pertain to the management and protection of water resources which are held by an Indian tribe, held by the United States in trust for Indians, held by a member of an Indian tribe if such property interest is subject to a trust restriction on alienation, or otherwise within the borders of an Indian reservation; and

(3) the Indian tribe is reasonably expected to be capable, in the Administrator's judgment, of carrying out the functions to be exercised in a manner consistent with the terms and purposes of this Act and of all applicable regulations.

Such treatment as a State may include the direct provision of funds reserved under subsection (c) to the governing bodies of Indian tribes, and the determination of priorities by Indian tribes, where not determined by the Administrator in cooperation with the Director of the Indian Health Service. The Administrator, in cooperation with the Director of the Indian Health Service, is authorized to make grants under title II of this Act in an amount not to exceed 100 percent of the cost of a project. Not later than 18 months after the date of the enactment of this section, the Administrator shall, in consultation with Indian tribes, promulgate final regulations which specify how Indian tribes shall be treated as States for purposes of this Act. The Administrator shall, in promulgating such regulations, consult affected States sharing common water bodies and provide a mechanism for the resolution of any unreasonable consequences that may arise as a result of differing water quality standards that may be set by States and Indian tribes located on common bodies of water. Such mechanism shall provide for explicit consideration of relevant factors including, but not limited to, the effects of differing water quality permit requirements on upstream and downstream dischargers, economic impacts, and present and historical uses and quality of the waters subject to such standards. Such mechanism should provide for the avoidance of such unreasonable consequences in a manner consistent with the objective of this Act.

(f) GRANTS FOR NONPOINT SOURCE PROGRAMS.—The Administrator shall make grants to an Indian tribe under section 319 of this Act as though such tribe was a State. Not more than one-third of one percent of the amount appropriated for any fiscal year under section 319 may be used to make grants under this subsection. In addition to the requirements of section 319, an Indian tribe shall be required to meet the requirements of paragraphs (1), (2), and (3) of subsection (d)[1] of this section in order to receive such a grant.

(g) ALASKA NATIVE ORGANIZATIONS.—No provision of this Act shall be construed to—

(1) grant, enlarge, or diminish, or in any way affect the scope of the governmental authority, if any, of any Alaska Native organization, including any federally-recognized tribe, traditional Alaska Native council, or Native council organized pursuant to the Act of June 18, 1934 (48 Stat. 987), over lands or persons in Alaska;

(2) create or validate any assertion by such organization or any form of governmental authority over lands or persons in Alaska; or

(3) in any way affect any assertion that Indian country, as defined in section 1151 of title 18, United States Code, exists or does not exist in Alaska.

(h) DEFINITIONS.—For purposes of this section, the term—

(1) "Federal Indian reservation" means all land within the limits of any Indian reservation under the jurisdiction of the United States Government, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation; and

(2) "Indian tribe" means any Indian tribe, band, group, or community recognized by the Secretary of the Interior and exercising governmental authority over a Federal Indian reservation.

(33 U.S.C. 1377)

SHORT TITLE

SEC. 519. This Act may be cited as the "Federal Water Pollution Control Act" (commonly referred to as the Clean Water Act).

(33 U.S.C. 1251 note)

TITLE VI—STATE WATER POLLUTION CONTROL REVOLVING FUNDS

SEC. 601. GRANTS TO STATES FOR ESTABLISHMENT OF REVOLVING FUNDS.

(a) GENERAL AUTHORITY.—Subject to the provisions of this title, the Administrator shall make capitalization grants to each State for the purpose of establishing a water pollution control revolving fund for providing assistance (1) for construction of treatment works (as defined in section 212 of this Act) which are publicly owned, (2) for implementing a management program under section 319, and (3) for developing and implementing a conservation and management plan under section 320.

(b) SCHEDULE OF GRANT PAYMENTS.—The Administrator and each State shall jointly establish a schedule of payments under which the Administrator will pay to the State the amount of each grant to be made to the State under this title. Such schedule shall be based on the State's intended use plan under section 606(c) of this Act, except that—

(1) such payments shall be made in quarterly installments, and

(2) such payments shall be made as expeditiously as possible, but in no event later than the earlier of—

(A) 8 quarters after the date such funds were obligated by the State, or

(B) 12 quarters after the date such funds were allotted to the State.

(33 U.S.C. 1381)

SEC. 602. CAPITALIZATION GRANT AGREEMENTS.

(a) GENERAL RULE.—To receive a capitalization grant with funds made available under this title and section 205(m) of this Act, a State shall enter into an agreement with the Administrator which shall include but not be limited to the specifications set forth in subsection (b) of this section.

(b) SPECIFIC REQUIREMENTS.—The Administrator shall enter into an agreement under this section with a State only after the State has established to the satisfaction of the Administrator that—

(1) the State will accept grant payments with funds to be made available under this title and section 205(m) of this Act in accordance with a payment schedule established jointly by the Administrator under section 601(b) of this Act and will de-

posit all such payments in the water pollution control revolving fund established by the State in accordance with this title;

(2) the State will deposit in the fund from State moneys an amount equal to at least 20 percent of the total amount of all capitalization grants which will be made to the State with funds to be made available under this title and section 205(m) of this Act on or before the date on which each quarterly grant payment will be made to the State under this title;

(3) the State will enter into binding commitments to provide assistance in accordance with the requirements of this title in an amount equal to 120 percent of the amount of each such grant payment within 1 year after the receipt of such grant payment;

(4) all funds in the fund will be expended in an expeditious and timely manner;

(5) all funds in the fund as a result of capitalization grants under this title and section 205(m) of this Act will first be used to assure maintenance of progress, as determined by the Governor of the State, toward compliance with enforceable deadlines, goals, and requirements of this Act, including the municipal compliance deadline;

(6) treatment works eligible under section 603(c)(1) of this Act which will be constructed in whole or in part before fiscal year 1995 with funds directly made available by capitalization grants under this title and section 205(m) of this Act will meet the requirements of, or otherwise be treated (as determined by the Governor of the State) under sections 201(b), 201(g)(1), 201(g)(2), 201(g)(3), 201(g)(5), 201(g)(6), 201(n)(1), 201(o), 204(a)(1), 204(a)(2), 204(b)(1), 204(d)(2), 211, 218, 511(c)(1), and 513 of this Act in the same manner as treatment works constructed with assistance under title II of this Act;

(7) in addition to complying with the requirements of this title, the State will commit or expend each quarterly grant payment which it will receive under this title in accordance with laws and procedures applicable to the commitment or expenditure of revenues of the State;

(8) in carrying out the requirements of section 606 of this Act, the State will use accounting, audit, and fiscal procedures conforming to generally accepted government accounting standards;

(9) the State will require as a condition of making a loan or providing other assistance, as described in section 603(d) of this Act, from the fund that the recipient of such assistance will maintain project accounts in accordance with generally accepted government accounting standards; and

(10) the State will make annual reports to the Administrator on the actual use of funds in accordance with section 606(d) of this Act.

(33 U.S.C. 1382)

SEC. 603. WATER POLLUTION CONTROL REVOLVING LOAN FUNDS.[1]

(a) REQUIREMENTS FOR OBLIGATION OF GRANT FUNDS.—Before a State may receive a capitalization grant with funds made available under this title and section 205(m) of this Act, the State shall first establish a water pollution control revolving fund which complies with the requirements of this section.

(b) ADMINISTRATOR.—Each State water pollution control revolving fund shall be administered by an instrumentality of the State with such powers and limitations as may be required to operate such fund in accordance with the requirements and objectives of this Act.

(c) PROJECTS ELIGIBLE FOR ASSISTANCE.—The amounts of funds available to each State water pollution control revolving fund shall be used only for providing financial assistance (1) to any municipality, intermunicipal, interstate, or State agency for construction of publicly owned treatment works (as defined in section 212 of this Act), (2) for the implementation of a management program established under section 319 of this Act, and (3) for development and implementation of a conservation and management plan under section 320 of this Act. The fund shall be established, maintained, and credited with repayments, and the fund balance shall be available in perpetuity for providing such financial assistance.[2]

(d) TYPES OF ASSISTANCE.—Except as otherwise limited by State law, a water pollution control revolving fund of a State under this section may be used only—

(1) to make loans, on the condition that—

(A) such loans are made at or below market interest rates, including interest free loans, at terms not to exceed 20 years;

(B) annual principal and interest payments will commence not later than 1 year after completion of any project and all loans will be fully amortized not later than 20 years after project completion;

(C) the recipient of a loan will establish a dedicated source of revenue for repayment of loans; and

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[1] See section 104B of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1414G) for additional amounts that are to be deposited into a State's fund and treatment of such deposits.

[2] Section 1006 of the Ocean Dumping Ban Act of 1988 (P.L. 100–688) is as follows:

SEC. 1006. USE OF STATE WATER POLLUTION CONTROL REVOLVING FUND GRANTS FOR DEVELOPING ALTERNATIVE SYSTEMS.

(a) GENERAL REQUIREMENT.—Notwithstanding the provisions of title VI of the Federal Water Pollution Control Act, each of the States of New York and New Jersey shall use 10 percent of the amount of a grant payment made to such State under such title for each of the fiscal years 1990 and 1991 and 10 percent of the State's contribution associated with such grant payment in the 6-month period beginning on the date of receipt of such grant payment for making loans and providing other assistance as described in section 603(d) of the Federal Water Pollution Control Act to any governmental entity in such State which has entered into a compliance agreement or enforcement agreement under section 104B of the Marine Protection, Research, and Sanctuaries Act of 1972 for identifying, developing, and implementing pursuant to such section alternative systems for management of sewage sludge.

(b) LIMITATION.—If, after the last day of the 6-month period beginning on the date of receipt of a grant payment by the State of New York or New Jersey under title VI of the Federal Water Pollution Control Act for each of fiscal years 1990 and 1991, 10 percent of the amount of such grant payment and the State's contribution associated with such grant payment has not been used for providing assistance described in subsection (a) as a result of insufficient applications for such assistance from persons eligible for such assistance, the 10 percent limitations set forth in subsection (a) shall not be applicable with respect to such grant payment and associated State contribution.

(D) the fund will be credited with all payments of principal and interest on all loans;

(2) to buy or refinance the debt obligation of municipalities and intermunicipal and interstate agencies within the State at or below market rates, where such debt obligations were incurred after March 7, 1985;

(3) to guarantee, or purchase insurance for, local obligations where such action would improve credit market access or reduce interest rates;

(4) as a source of revenue or security for the payment of principal and interest on revenue or general obligation bonds issued by the State if the proceeds of the sale of such bonds will be deposited in the fund;

(5) to provide loan guarantees for similar revolving funds established by municipalities or intermunicipal agencies;

(6) to earn interest on fund accounts; and

(7) for the reasonable costs of administering the fund and conducting activities under this title, except that such amounts shall not exceed 4 percent of all grant awards to such fund under this title.

(e) LIMITATION TO PREVENT DOUBLE BENEFITS.—If a State makes, from its water pollution revolving fund, a loan which will finance the cost of facility planning and the preparation of plans, specifications, and estimates for construction of publicly owned treatment works, the State shall ensure that if the recipient of such loan receives a grant under section 201(g) of this Act for construction of such treatment works and an allowance under section 201(l)(1) of this Act for non-federal funds expended for such planning and preparation, such recipient will promptly repay such loan to the extent of such allowance.

(f) CONSISTENCY WITH PLANNING REQUIREMENTS.—A State may provide financial assistance from its water pollution control revolving fund only with respect to a project which is consistent with plans, if any, developed under sections 205(j), 208, 303(e), 319, and 320 of this Act.

(g) PRIORITY LIST REQUIREMENT.—The State may provide financial assistance from its water pollution control revolving fund only with respect to a project for construction of a treatment works described in subsection (c)(1) if such project is on the State's priority list under section 216 of this Act. Such assistance may be provided regardless of the rank of such project on such list.

(h) ELIGIBILITY OF NON-FEDERAL SHARE OF CONSTRUCTION GRANT PROJECTS.—A State water pollution control revolving fund may provide assistance (other than under subsection (d)(1) of this section) to a municipality or intermunicipal or interstate agency with respect to the non-Federal share of the costs of a treatment works project for which such municipality or agency is receiving assistance from the Administrator under any other authority only if such assistance is necessary to allow such project to proceed.

(33 U.S.C. 1383)

SEC. 604. ALLOTMENT OF FUNDS.

(a) FORMULA.—Sums authorized to be appropriated to carry out this section for each of fiscal years 1989 and 1990 shall be allotted by the Administrator in accordance with section 205(c) of this Act.

(b) RESERVATION OF FUNDS FOR PLANNING.—Each State shall reserve each fiscal year 1 percent of the sums allotted to such State under this section for such fiscal year, or $100,000, whichever amount is greater, to carry out planning under sections 205(j) and 303(e) of this Act.

(c) ALLOTMENT PERIOD.—

(1) PERIOD OF AVAILABILITY FOR GRANT AWARD.—Sums allotted to a State under this section for a fiscal year shall be available for obligation by the State during the fiscal year for which sums are authorized and during the following fiscal year.

(2) REALLOTMENT OF UNOBLIGATED FUNDS.—The amount of any allotment not obligated by the State by the last day of the 2-year period of availability established by paragraph (1) shall be immediately reallotted by the Administrator on the basis of the same ratio as is applicable to sums allotted under title II of this Act for the second fiscal year of such 2-year period. None of the funds reallotted by the Administrator shall be reallotted to any State which has not obligated all sums allotted to such State in the first fiscal year of such 2-year period.

(33 U.S.C. 1384)

SEC. 605. CORRECTIVE ACTION.

(a) NOTIFICATION OF NONCOMPLIANCE.—If the Administrator determines that a State has not complied with its agreement with the Administrator under section 602 of this Act or any other requirement of this title, the Administrator shall notify the State of such noncompliance and the necessary corrective action.

(b) WITHHOLDING OF PAYMENTS.—If a State does not take corrective action within 60 days after the date a State receives notification of such action under subsection (a), the Administrator shall withhold additional payments to the State until the Administrator is satisfied that the State has taken the necessary corrective action.

(c) REALLOTMENT OF WITHHELD PAYMENTS.—If the Administrator is not satisfied that adequate corrective actions have been taken by the State within 12 months after the State is notified of such actions under subsection (a), the payments withheld from the State by the Administrator under subsection (b) shall be made available for reallotment in accordance with the most recent formula for allotment of funds under this title.

(33 U.S.C. 1385)

SEC. 606. AUDITS, REPORTS, AND FISCAL CONTROLS; INTENDED USE PLAN.

(a) FISCAL CONTROL AND AUDITING PROCEDURES.—Each State electing to establish a water pollution control revolving fund under this title shall establish fiscal controls and accounting procedures sufficient to assure proper accounting during appropriate accounting periods for—

(1) payments received by the fund;

(2) disbursements made by the fund; and

(3) fund balances at the beginning and end of the accounting period.

(b) ANNUAL FEDERAL AUDITS.—The Administrator shall, at least on an annual basis, conduct or require each State to have independently conducted reviews and audits as may be deemed necessary or appropriate by the Administrator to carry out the objectives of this section. Audits of the use of funds deposited in the water pollution revolving fund established by such State shall be conducted in accordance with the auditing procedures of the General Accounting Office, including chapter 75 of title 31, United States Code.

(c) INTENDED USE PLAN.—After providing for public comment and review, each State shall annually prepare a plan identifying the intended uses of the amounts available to its water pollution control revolving fund. Such intended use plan shall include, but not be limited to—

(1) a list of those projects for construction of publicly owned treatment works on the State's priority list developed pursuant to section 216 of this Act and a list of activities eligible for assistance under sections 319 and 320 of this Act;

(2) a description of the short- and long-term goals and objectives of its water pollution control revolving fund;

(3) information on the activities to be supported, including a description of project categories, discharge requirements under titles III and IV of this Act, terms of financial assistance, and communities served;

(4) assurances and specific proposals for meeting the requirements of paragraphs (3), (4), (5), and (6) of section 602(b) of this Act; and

(5) the criteria and method established for the distribution of funds.

(d) ANNUAL REPORT.—Beginning the first fiscal year after the receipt of payments under this title, the State shall provide an annual report to the Administrator describing how the State has met the goals and objectives for the previous fiscal year as identified in the plan prepared for the previous fiscal year pursuant to subsection (c), including identification of loan recipients, loan amounts, and loan terms and similar details on other forms of financial assistance provided from the water pollution control revolving fund.

(e) ANNUAL FEDERAL OVERSIGHT REVIEW.—The Administrator shall conduct an annual oversight review of each State plan prepared under subsection (c), each State report prepared under subsection (d), and other such materials as are considered necessary and appropriate in carrying out the purposes of this title. After reasonable notice by the Administrator to the State or the recipient of a loan from a water pollution control revolving fund, the State or loan recipient shall make available to the Administrator such records as the Administrator reasonably requires to review and determine compliance with this title.

(f) APPLICABILITY OF TITLE II PROVISIONS.—Except to the extent provided in this title, the provisions of title II shall not apply to grants under this title.

(33 ' 1386)

SEC. 607. AUTHORIZATION OF APPROPRIATIONS.

There is authorized to be appropriated to carry out the purposes of this title the following sums:

(1) $1,200,000,000 per fiscal year for each of fiscal year 1989 and 1990;

(2) $2,400,000,000 for fiscal year 1991;

(3) $1,800,000,000 for fiscal year 1992;

(4) $1,200,000,000 for fiscal year 1993; and

(5) $600,000,000 for fiscal year 1994.

(33 U.S.C. 1387)

any warm or cold water aquatic animal production facility as a concentrated aquatic animal production facility upon determining that it is a significant contributor of pollution to waters of the United States. In making this designation the Director shall consider the following factors:

(i) The location and quality of the receiving waters of the United States;

(ii) The holding, feeding, and production capacities of the facility;

(iii) The quantity and nature of the pollutants reaching waters of the United States; and

(iv) Other relevant factors.

(2) A permit application shall not be required from a concentrated aquatic animal production facility designated under this paragraph until the Director has conducted on-site inspection of the facility and has determined that the facility should and could be regulated under the permit program.

§122.25 Aquaculture projects (applicable to State NPDES programs, see §123.25).

(a) *Permit requirement.* Discharges into aquaculture projects, as defined in this section, are subject to the NPDES permit program through section 318 of CWA, and in accordance with 40 CFR part 125, subpart B.

(b) *Definitions.* (1) *Aquaculture project* means a defined managed water area which uses discharges of pollutants into that designated area for the maintenance or production of harvestable freshwater, estuarine, or marine plants or animals.

(2) *Designated project area* means the portions of the waters of the United States within which the permittee or permit applicant plans to confine the cultivated species, using a method or plan or operation (including, but not limited to, physical confinement) which, on the basis of reliable scientific evidence, is expected to ensure that specific individual organisms comprising an aquaculture crop will enjoy increased growth attributable to the discharge of pollutants, and be harvested within a defined geographic area.

§122.26 Storm water discharges (applicable to State NPDES programs, see §123.25).

(a) *Permit requirement.* (1) Prior to October 1, 1994, discharges composed entirely of storm water shall not be required to obtain a NPDES permit except:

(i) A discharge with respect to which a permit has been issued prior to February 4, 1987;

(ii) A discharge associated with industrial activity (see §122.26(a)(4));

(iii) A discharge from a large municipal separate storm sewer system;

(iv) A discharge from a medium municipal separate storm sewer system;

(v) A discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. This designation may include a discharge from any conveyance or system of conveyances used for collecting and conveying storm water runoff or a system of discharges from municipal separate storm sewers, except for those discharges from conveyances which do not require a permit under paragraph (a)(2) of this section or agricultural storm water runoff which is exempted from the definition of point source at §122.2.

The Director may designate discharges from municipal separate storm sewers on a system-wide or jurisdiction-wide basis. In making this determination the Director may consider the following factors:

(A) The location of the discharge with respect to waters of the United States as defined at 40 CFR 122.2.

(B) The size of the discharge;

(C) The quantity and nature of the pollutants discharged to waters of the United States; and

(D) Other relevant factors.

(2) The Director may not require a permit for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing or treatment operations or

transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(3) *Large and medium municipal separate storm sewer systems.* (i) Permits must be obtained for all discharges from large and medium municipal separate storm sewer systems.

(ii) The Director may either issue one system-wide permit covering all discharges from municipal separate storm sewers within a large or medium municipal storm sewer system or issue distinct permits for appropriate categories of discharges within a large or medium municipal separate storm sewer system including, but not limited to: all discharges owned or operated by the same municipality; located within the same jurisdiction; all discharges within a system that discharge to the same watershed; discharges within a system that are similar in nature; or for individual discharges from municipal separate storm sewers within the system.

(iii) The operator of a discharge from a municipal separate storm sewer which is part of a large or medium municipal separate storm sewer system must either:

(A) Participate in a permit application (to be a permittee or a co-permittee) with one or more other operators of discharges from the large or medium municipal storm sewer system which covers all, or a portion of all, discharges from the municipal separate storm sewer system;

(B) Submit a distinct permit application which only covers discharges from the municipal separate storm sewers for which the operator is responsible; or

(C) A regional authority may be responsible for submitting a permit application under the following guidelines:

(*1*) The regional authority together with co-applicants shall have authority over a storm water management program that is in existence, or shall be in existence at the time part 1 of the application is due;

(*2*) The permit applicant or co-applicants shall establish their ability to make a timely submission of part 1 and part 2 of the municipal application;

(*3*) Each of the operators of municipal separate storm sewers within the systems described in paragraphs (b)(4) (i), (ii), and (iii) or (b)(7) (i), (ii), and (iii) of this section, that are under the purview of the designated regional authority, shall comply with the application requirements of paragraph (d) of this section.

(iv) One permit application may be submitted for all or a portion of all municipal separate storm sewers within adjacent or interconnected large or medium municipal separate storm sewer systems. The Director may issue one system-wide permit covering all, or a portion of all municipal separate storm sewers in adjacent or interconnected large or medium municipal separate storm sewer systems.

(v) Permits for all or a portion of all discharges from large or medium municipal separate storm sewer systems that are issued on a system-wide, jurisdiction-wide, watershed or other basis may specify different conditions relating to different discharges covered by the permit, including different management programs for different drainage areas which contribute storm water to the system.

(vi) Co-permittees need only comply with permit conditions relating to discharges from the municipal separate storm sewers for which they are operators.

(4) *Discharges through large and medium municipal separate storm sewer systems.* In addition to meeting the requirements of paragraph (c) of this section, an operator of a storm water discharge associated with industrial activity which discharges through a large or medium municipal separate storm sewer system shall submit, to the operator of the municipal separate storm sewer system receiving the discharge no later than May 15, 1991, or 180 days prior to commencing such discharge:

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the name of the facility; a contact person and phone number; the location of the discharge; a description, including Standard Industrial Classification, which best reflects the principal products or services provided by each facility; and any existing NPDES permit number.

(5) *Other municipal separate storm sewers.* The Director may issue permits for municipal separate storm sewers that are designated under paragraph (a)(1)(v) of this section on a system-wide basis, jurisdiction-wide basis, watershed basis or other appropriate basis, or may issue permits for individual discharges.

(6) *Non-municipal separate storm sewers.* For storm water discharges associated with industrial activity from point sources which discharge through a non-municipal or non-publicly owned separate storm sewer system, the Director, in his discretion, may issue: a single NPDES permit, with each discharger a co-permittee to a permit issued to the operator of the portion of the system that discharges into waters of the United States; or, individual permits to each discharger of storm water associated with industrial activity through the non-municipal conveyance system.

(i) All storm water discharges associated with industrial activity that discharge through a storm water discharge system that is not a municipal separate storm sewer must be covered by an individual permit, or a permit issued to the operator of the portion of the system that discharges to waters of the United States, with each discharger to the non-municipal conveyance a co-permittee to that permit.

(ii) Where there is more than one operator of a single system of such conveyances, all operators of storm water discharges associated with industrial activity must submit applications.

(iii) Any permit covering more than one operator shall identify the effluent limitations, or other permit conditions, if any, that apply to each operator.

(7) *Combined sewer systems.* Conveyances that discharge storm water runoff combined with municipal sewage are point sources that must obtain NPDES permits in accordance with the procedures of §122.21 and are not subject to the provisions of this section.

(8) Whether a discharge from a municipal separate storm sewer is or is not subject to regulation under this section shall have no bearing on whether the owner or operator of the discharge is eligible for funding under title II, title III or title VI of the Clean Water Act. *See* 40 CFR part 35, subpart I, appendix A(b)H.2.j.

(9) On and after October 1, 1994, dischargers composed entirely of storm water, that are not otherwise already required by paragraph (a)(1) of this section to obtain a permit, shall be required to apply for and obtain a permit according to the application requirements in paragraph (g) of this section. The Director may not require a permit for discharges of storm water as provided in paragraph (a)(2) of this section or agricultural storm water runoff which is exempted from the definition of point source at §§122.2 and 122.3.

(b) *Definitions.* (1) *Co-permittee* means a permittee to a NPDES permit that is only responsible for permit conditions relating to the discharge for which it is operator.

(2) *Illicit discharge* means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

(3) *Incorporated place* means the District of Columbia, or a city, town, township, or village that is incorporated under the laws of the State in which it is located.

(4) *Large municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 250,000 or more as determined by the latest Decennial Census by the Bureau of Census (appendix F); or

(ii) Located in the counties listed in appendix H, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(4)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; and

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a large municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraph (b)(4) (i), (ii), (iii) of this section.

(5) *Major municipal separate storm sewer outfall* (or "major outfall") means a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for municipal separate storm sewers that receive storm water from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

(6) *Major outfall* means a major municipal separate storm sewer outfall.

(7) *Medium municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 100,000 or more but less than 250,000, as determined by the latest Decennial Census by the Bureau of Census (appendix G); or

(ii) Located in the counties listed in appendix I, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(7)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; or

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a medium municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (b)(7) (i), (ii), (iii) of this section.

(8) *Municipal separate storm sewer* means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains):

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(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

(9) *Outfall* means a *point source* as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the United States and are used to convey waters of the United States.

(10) *Overburden* means any material of any nature, consolidated or unconsolidated, that overlies a mineral deposit, excluding topsoil or similar naturally-occurring surface materials that are not disturbed by mining operations.

(11) *Runoff coefficient* means the fraction of total rainfall that will appear at a conveyance as runoff.

(12) *Significant materials* includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

(13) *Storm water* means storm water runoff, snow melt runoff, and surface runoff and drainage.

(14) *Storm water discharge associated with industrial activity* means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing,, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR part 122. For the categories of industries identified in paragraphs (b)(14) (i) through (x) of this section, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR part 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in paragraph (b)(14)(xi) of this section, the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the

drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (b)(14)(i)-(xi) of this section) include those facilities designated under the provisions of paragraph (a)(1)(v) of this section. The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection:

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) in paragraph (b)(14) of this section);

(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, 373;

(iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (b)(14) (i)-(vii) or (ix)-(xi) of this section are associated with industrial activity;

(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA;

(x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;

(xi) Facilities under Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories (ii)-(x));

(15) *Uncontrolled sanitary landfill* means a landfill or open dump, whether in operation or closed, that does not meet the requirements for runon or runoff controls established pursuant to subtitle D of the Solid Waste Disposal Act.

(c) *Application requirements for storm water discharges associated with industrial activity*—(1) *Individual application.* Dischargers of storm water associated with industrial activity are required to apply for an individual permit, apply for a permit through a group application, or seek coverage under a promulgated storm water general permit. Facilities that are required to obtain an individual permit, or any discharge of storm water which the Director is evaluating for designation (*see* 40 CFR 124.52(c)) under paragraph (a)(1)(v) of this section and is not a municipal separate storm sewer, and which is not part of a group application described under paragraph (c)(2) of this section, shall submit an NPDES application in accordance with the requirements of §122.21 as modified and supplemented by the provisions of the remainder of this paragraph. Applicants for discharges composed entirely of storm water shall submit Form 1 and Form 2F. Applicants for discharges composed of storm water and non-storm water shall submit Form 1, Form 2C, and Form 2F. Applicants for new sources or new discharges (as defined in §122.2 of this part) composed of storm water and non-storm water shall submit Form 1, Form 2D, and Form 2F.

(i) Except as provided in §122.26(c)(1)(ii)-(iv), the operator of a storm water discharge associated with industrial activity subject to this section shall provide:

(A) A site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) of the facility including: each of its drainage and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each past or present area used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied, each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility;

(B) An estimate of the area of impervious surfaces (including paved areas and building roofs) and the total area drained by each outfall (within a mile radius of the facility) and a narrative description of the following: Significant materials that in the three years prior to the submittal of this application have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of such materials; materials management practices employed, in the three years prior to the submittal of this application, to minimize contact by these materials with storm water runoff; materials loading and access areas; the location, manner and frequency in which pesticides, herbicides, soil conditioners and fertilizers are applied; the location and a description of existing structural and non-structural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the ultimate disposal of any solid or fluid wastes other than by discharge;

(C) A certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for

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the presence of non-storm water discharges which are not covered by a NPDES permit; tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. The certification shall include a description of the method used, the date of any testing, and the on-site drainage points that were directly observed during a test;

(D) Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility that have taken place within the three years prior to the submittal of this application;

(E) Quantitative data based on samples collected during storm events and collected in accordance with §122.21 of this part from all outfalls containing a storm water discharge associated with industrial activity for the following parameters:

(*1*) Any pollutant limited in an effluent guideline to which the facility is subject;

(*2*) Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit);

(*3*) Oil and grease, pH, BOD5, COD, TSS, total phosphorus, total Kjeldahl nitrogen, and nitrate plus nitrite nitrogen;

(*4*) Any information on the discharge required under paragraph §122.21(g)(7)(iii) and (iv) of this part;

(*5*) Flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, and the method of flow measurement or estimation; and

(*6*) The date and duration (in hours) of the storm event(s) sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event (in hours);

(F) Operators of a discharge which is composed entirely of storm water are exempt from the requirements of § 122.21 (g)(2), (g)(3), (g)(4), (g)(5), (g)(7)(i), (g)(7)(ii), and (g)(7)(v); and

(G) Operators of new sources or new discharges (as defined in §122.2 of this part) which are composed in part or entirely of storm water must include estimates for the pollutants or parameters listed in paragraph (c)(1)(i)(E) of this section instead of actual sampling data, along with the source of each estimate. Operators of new sources or new discharges composed in part or entirely of storm water must provide quantitative data for the parameters listed in paragraph (c)(1)(i)(E) of this section within two years after commencement of discharge, unless such data has already been reported under the monitoring requirements of the NPDES permit for the discharge. Operators of a new source or new discharge which is composed entirely of storm water are exempt from the requirements of §122.21 (k)(3)(ii), (k)(3)(iii), and (k)(5).

(ii) The operator of an existing or new storm water discharge that is associated with industrial activity solely under paragraph (b)(14)(x) of this section, is exempt from the requirements of § 122.21(g) and paragraph (c)(1)(i) of this section. Such operator shall provide a narrative description of:

(A) The location (including a map) and the nature of the construction activity;

(B) The total area of the site and the area of the site that is expected to undergo excavation during the life of the permit;

(C) Proposed measures, including best management practices, to control pollutants in storm water discharges during construction, including a brief description of applicable State and local erosion and sediment control requirements;

(D) Proposed measures to control pollutants in storm water discharges that will occur after construction operations have been completed, including a brief description of applicable State or local erosion and sediment control requirements;

(E) An estimate of the runoff coefficient of the site and the increase in impervious area after the construction addressed in the permit application is completed, the nature of fill material and existing data describing the soil or the quality of the discharge; and

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(F) The name of the receiving water.

(iii) The operator of an existing or new discharge composed entirely of storm water from an oil or gas exploration, production, processing, or treatment operation, or transmission facility is not required to submit a permit application in accordance with paragraph (c)(1)(i) of this section, unless the facility:

(A) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 117.21 or 40 CFR 302.6 at anytime since November 16, 1987; or

(B) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 110.6 at any time since November 16, 1987; or

(C) Contributes to a violation of a water quality standard.

(iv) The operator of an existing or new discharge composed entirely of storm water from a mining operation is not required to submit a permit application unless the discharge has come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(v) Applicants shall provide such other information the Director may reasonably require under §122.21(g)(13) of this part to determine whether to issue a permit and may require any facility subject to paragraph (c)(1)(ii) of this section to comply with paragraph (c)(1)(i) of this section.

(2) *Group application for discharges associated with industrial activity.* In lieu of individual applications or notice of intent to be covered by a general permit for storm water discharges associated with industrial activity, a group application may be filed by an entity representing a group of applicants (except facilities that have existing individual NPDES permits for storm water) that are part of the same subcategory (*see* 40 CFR subchapter N, part 405 to 471) or, where such grouping is inapplicable, are sufficiently similar as to be appropriate for general permit coverage under §122.28 of this part. The part 1 application shall be submitted to the Office of Water Enforcement and Permits, U.S. EPA, 401 M Street, SW., Washington, DC 20460 (EN-336) for approval. Once a part 1 application is approved, group applicants are to submit Part 2 of the group application to the Office of Water Enforcement and Permits. A group application shall consist of:

(i) *Part 1.* Part 1 of a group application shall:

(A) Identify the participants in the group application by name and location. Facilities participating in the group application shall be listed in nine subdivisions, based on the facility location relative to the nine precipitation zones indicated in appendix E to this part.

(B) Include a narrative description summarizing the industrial activities of participants of the group application and explaining why the participants, as a whole, are sufficiently similar to be a covered by a general permit:

(C) Include a list of significant materials stored exposed to precipitation by participants in the group application and materials management practices employed to diminish contact by these materials with precipitation and storm water runoff:

(D) For groups of more than 1,000 members, identify at least 100 dischargers participating in the group application from which quantitative data will be submitted. For groups of 100 or more members, identify a minimum of ten percent of the dischargers participating in the group application from which quantitative data will be submitted. For groups of between 21 and 99 members identify a minimum of ten dischargers participating in the group application from which quantitative data will be submitted. For groups of 4 to 20 members, identify a minimum of 50 percent of the dischargers participating in the group application from which quantitative data will be submitted. For groups with more than 10 members, either a minimum of two dischargers from each precipitation zone indicated in appendix E of this part in which ten or more members of the group are located, or one discharger from each precipitation zone indicated in appendix E of this part in which nine

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or fewer members of the group are located, must be identified to submit quantitative data. For groups of 4 to 10 members, at least one facility in each precipitation zone indicated in appendix E of this part in which members of the group are located must be identifed to submit quantitative data. A description of why the facilities selected to perform sampling and analysis are representative of the group as a whole in terms of the information provided in paragraphs (c)(1)(i)(B) and (c)(1)(i)(C) of this section, shall accompany this section. Different factors impacting the nature of the storm water discharges, such as the processes used and material management, shall be represented, to the extent feasible, in a manner roughly equivalent to their proportion in the group.

(ii) *Part 2.* Part 2 of a group application shall contain quantitative data (NPDES Form 2F), as modified by paragraph (c)(1) of this section, so that when part 1 and part 2 of the group application are taken together, a complete NPDES application (Form 1, Form 2C, and Form 2F) can be evaluated for each discharger identified in paragraph (c)(2)(i)(D) of this section.

(d) *Application requirements for large and medium municipal separate storm sewer discharges.* The operator of a discharge from a large or medium municipal separate storm sewer or a municipal separate storm sewer that is designated by the Director under paragraph (a)(1)(v) of this section, may submit a jurisdiction-wide or system-wide permit application. Where more than one public entity owns or operates a municipal separate storm sewer within a geographic area (including adjacent or interconnected municipal separate storm sewer systems), such operators may be a coapplicant to the same application. Permit applications for discharges from large and medium municipal storm sewers or municipal storm sewers designated under paragraph (a)(1)(v) of this section shall include:

(1) *Part 1.* Part 1 of the application shall consist of:

(i) *General information.* The applicants' name, address, telephone number of contact person, ownership status and status as a State or local government entity.

(ii) *Legal authority.* A description of existing legal authority to control discharges to the municipal separate storm sewer system. When existing legal authority is not sufficient to meet the criteria provided in paragraph (d)(2)(i) of this section, the description shall list additional authorities as will be necessary to meet the criteria and shall include a schedule and commitment to seek such additional authority that will be needed to meet the criteria.

(iii) *Source identification.* (A) A description of the historic use of ordinances, guidance or other controls which limited the discharge of non-storm water discharges to any Publicly Owned Treatment Works serving the same area as the municipal separate storm sewer system.

(B) A USGS 7.5 minute topographic map (or equivalent topographic map with a scale between 1:10,000 and 1:24,000 if cost effective) extending one mile beyond the service boundaries of the municipal storm sewer system covered by the permit application. The following information shall be provided:

(*1*) The location of known municipal storm sewer system outfalls discharging to waters of the United States;

(*2*) A description of the land use activities (e.g. divisions indicating undeveloped, residential, commercial, agricultural and industrial uses) accompanied with estimates of population densities and projected growth for a ten year period within the drainage area served by the separate storm sewer. For each land use type, an estimate of an average runoff coefficient shall be provided;

(*3*) The location and a description of the activities of the facility of each currently operating or closed municipal landfill or other treatment, storage or disposal facility for municipal waste;

(*4*) The location and the permit number of any known discharge to the municipal storm sewer that has been issued a NPDES permit;

(*5*) The location of major structural controls for storm water discharge (retention basins, detention basins, major infiltration devices, etc.); and

(*6*) The identification of publicly owned parks, recreational areas, and other open lands.

(iv) *Discharge characterization.* (A) Monthly mean rain and snow fall estimates (or summary of weather bureau data) and the monthly average number of storm events.

(B) Existing quantitative data describing the volume and quality of discharges from the municipal storm sewer, including a description of the outfalls sampled, sampling procedures and analytical methods used.

(C) A list of water bodies that receive discharges from the municipal separate storm sewer system, including downstream segments, lakes and estuaries, where pollutants from the system discharges may accumulate and cause water degradation and a brief description of known water quality impacts. At a minimum, the description of impacts shall include a description of whether the water bodies receiving such discharges have been:

(*1*) Assessed and reported in section 305(b) reports submitted by the State, the basis for the assessment (evaluated or monitored), a summary of designated use support and attainment of Clean Water Act (CWA) goals (fishable and swimmable waters), and causes of nonsupport of designated uses;

(*2*) Listed under section 304(l)(1)(A)(i), section 304(l)(1)(A)(ii), or section 304(l)(1)(B) of the CWA that is not expected to meet water quality standards or water quality goals;

(*3*) Listed in State Nonpoint Source Assessments required by section 319(a) of the CWA that, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain water quality standards due to storm sewers, construction, highway maintenance and runoff from municipal landfills and municipal sludge adding significant pollution (or contributing to a violation of water quality standards);

(*4*) Identified and classified according to eutrophic condition of publicly owned lakes listed in State reports required under section 314(a) of the CWA (include the following: A description of those publicly owned lakes for which uses are known to be impaired; a description of procedures, processes and methods to control the discharge of pollutants from municipal separate storm sewers into such lakes; and a description of methods and procedures to restore the quality of such lakes);

(*5*) Areas of concern of the Great Lakes identified by the International Joint Commission;

(*6*) Designated estuaries under the National Estuary Program under section 320 of the CWA;

(*7*) Recognized by the applicant as highly valued or sensitive waters;

(*8*) Defined by the State or U.S. Fish and Wildlife Services's National Wetlands Inventory as wetlands; and

(*9*) Found to have pollutants in bottom sediments, fish tissue or biosurvey data.

(D) *Field screening.* Results of a field screening analysis for illicit connections and illegal dumping for either selected field screening points or major outfalls covered in the permit application. At a minimum, a screening analysis shall include a narrative description, for either each field screening point or major outfall, of visual observations made during dry weather periods. If any flow is observed, two grab samples shall be collected during a 24 hour period with a minimum period of four hours between samples. For all such samples, a narrative description of the color, odor, turbidity, the presence of an oil sheen or surface scum as well as any other relevant observations regarding the potential presence of non-storm water discharges or illegal dumping shall be provided. In addition, a narrative description of the results of a field analysis using suitable methods to estimate pH, total chlorine, total copper, total phenol, and detergents (or surfactants) shall be provided along with a description of the flow rate. Where the field analysis does not involve analytical methods approved under 40 CFR part 136, the applicant shall provide a description of the method used including the name of the manufacturer of the test method along with the range and accuracy of the test. Field screening points shall be either major outfalls or other outfall points (or any other point of access such as manholes) randomly located throughout the storm sewer system by placing a grid over a drainage system

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map and identifying those cells of the grid which contain a segment of the storm sewer system or major outfall. The field screening points shall be established using the following guidelines and criteria:

(*1*) A grid system consisting of perpendicular north-south and east-west lines spaced ¼ mile apart shall be overlayed on a map of the municipal storm sewer system, creating a series of cells;

(*2*) All cells that contain a segment of the storm sewer system shall be identified; one field screening point shall be selected in each cell; major outfalls may be used as field screening points;

(*3*) Field screening points should be located downstream of any sources of suspected illegal or illicit activity;

(*4*) Field screening points shall be located to the degree practicable at the farthest manhole or other accessible location downstream in the system, within each cell; however, safety of personnel and accessibility of the location should be considered in making this determination;

(*5*) Hydrological conditions; total drainage area of the site; population density of the site; traffic density; age of the structures or buildings in the area; history of the area; and land use types;

(*6*) For medium municipal separate storm sewer systems, no more than 250 cells need to have identified field screening points; in large municipal separate storm sewer systems, no more than 500 cells need to have identified field screening points; cells established by the grid that contain no storm sewer segments will be eliminated from consideration; if fewer than 250 cells in medium municipal sewers are created, and fewer than 500 in large systems are created by the overlay on the municipal sewer map, then all those cells which contain a segment of the sewer system shall be subject to field screening (unless access to the separate storm sewer system is impossible); and

(*7*) Large or medium municipal separate storm sewer systems which are unable to utilize the procedures described in paragraphs (d)(1)(iv)(D) (*1*) through (*6*) of this section, because a sufficiently detailed map of the separate storm sewer systems is unavailable, shall field screen no more than 500 or 250 major outfalls respectively (or all major outfalls in the system, if less); in such circumstances, the applicant shall establish a grid system consisting of north-south and east-west lines spaced ¼ mile apart as an overlay to the boundaries of the municipal storm sewer system, thereby creating a series of cells; the applicant will then select major outfalls in as many cells as possible until at least 500 major outfalls (large municipalities) or 250 major outfalls (medium municipalities) are selected; a field screening analysis shall be undertaken at these major outfalls.

(E) *Characterization plan.* Information and a proposed program to meet the requirements of paragraph (d)(2)(iii) of this section. Such description shall include: the location of outfalls or field screening points appropriate for representative data collection under paragraph (d)(2)(iii)(A) of this section, a description of why the outfall or field screening point is representative, the seasons during which sampling is intended, a description of the sampling equipment. The proposed location of outfalls or field screening points for such sampling should reflect water quality concerns (*see* paragraph (d)(1)(iv)(C) of this section) to the extent practicable.

(v) *Management programs.* (A) A description of the existing management programs to control pollutants from the municipal separate storm sewer system. The description shall provide information on existing structural and source controls, including operation and maintenance measures for structural controls, that are currently being implemented. Such controls may include, but are not limited to: Procedures to control pollution resulting from construction activities; floodplain management controls; wetland protection measures; best management practices for new subdivisions; and emergency spill response programs. The description may address controls established under State law as well as local requirements.

(B) A description of the existing program to identify illicit connections to the municipal storm sewer system. The description should include inspection procedures and methods for detecting and preventing illicit discharges, and describe areas where this program has been implemented.

(vi) *Fiscal resources.* (A) A description of the financial resources currently available to the municipality to complete part 2 of the permit application. A description of the municipality's budget for existing storm water programs, including an overview of the municipality's financial resources and budget, including overall indebtedness and assets, and sources of funds for storm water programs.

(2) *Part 2.* Part 2 of the application shall consist of:

(i) *Adequate legal authority.* A demonstration that the applicant can operate pursuant to legal authority established by statute, ordinance or series of contracts which authorizes or enables the applicant at a minimum to:

(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;

(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer;

(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water;

(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;

(E) Require compliance with conditions in ordinances, permits, contracts or orders; and

(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

(ii) *Source identification.* The location of any major outfall that discharges to waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(*1*) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;

(iii) *Characterization data.* When "quantitative data" for a pollutant are required under paragraph (d)(a)(iii)(A)(*3*) of this paragraph, the applicant must collect a sample of effluent in accordance with 40 CFR 122.21(g)(7) and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method. The applicant must provide information characterizing the quality and quantity of discharges covered in the permit application, including:

(A) Quantitative data from representative outfalls designated by the Director (based on information received in part 1 of the application, the Director shall designate between five and ten outfalls or field screening points as representative of the commercial, residential and industrial land use activities of the drainage area contributing to the system or, where there are less than five outfalls covered in the application, the Director shall designate all outfalls) developed as follows:

(*1*) For each outfall or field screening point designated under this subparagraph, samples shall be collected of storm water discharges from three storm events occurring at least one month apart in accordance with the requirements at §122.21(g)(7) (the Director may allow exemptions to sampling three storm events when climatic conditions create good cause for such exemptions);

(*2*) A narrative description shall be provided of the date and duration of the storm event(s) sampled, rainfall estimates of the storm event which generated the sampled discharge and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event;

(*3*) For samples collected and described under paragraphs (d)(2)(iii)(A)(*1*) and (A)(*2*) of this section, quantitative data shall be provided for: the organic pollutants listed in Table II; the pollutants listed in Table III (toxic metals, cyanide, and total phenols) of appendix D of 40 CFR part 122, and for the following pollutants:

Total suspended solids (TSS)
Total dissolved solids (TDS)
COD
BOD_5
Oil and grease
Fecal coliform
Fecal streptococcus
pH
Total Kjeldahl nitrogen
Nitrate plus nitrite
Dissolved phosphorus
Total ammonia plus organic nitrogen
Total phosphorus

(*4*) Additional limited quantitative data required by the Director for determining permit conditions (the Director may require that quantitative data shall be provided for additional parameters, and may establish sampling conditions such as the location, season of sample collection, form of precipitation (snow melt, rainfall) and other parameters necessary to insure representativeness);

(B) Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under §122.21(c)(7)) for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

(C) A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(*1*) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section; and

(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.

(iv) *Proposed management program.* A proposed management program covers the duration of the permit. It shall include a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate. The program shall also include a description of staff and equipment available to implement the program. Separate proposed programs may be submitted by each coapplicant. Proposed programs may impose controls on a systemwide basis, a watershed basis, a jurisdiction basis, or on individual outfalls. Proposed programs will be considered by the Director when developing permit conditions to reduce pollutants in discharges to the maximum extent practicable. Proposed management programs shall describe priorities for implementing controls. Such programs shall be based on:

(A) A description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description shall include:

(*1*) A description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers;

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(*2*) A description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed. (Controls to reduce pollutants in discharges from municipal separate storm sewers containing construction site runoff are addressed in paragraph (d)(2)(iv)(D) of this section;

(*3*) A description of practices for operating and maintaining public streets, roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities;

(*4*) A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible;

(*5*) A description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges (this program can be coordinated with the program developed under paragraph (d)(2)(iv)(C) of this section); and

(*6*) A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

(B) A description of a program, including a schedule, to detect and remove (or require the discharger to the municipal separate storm sewer to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. The proposed program shall include:

(*1*) A description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; this program description shall address all types of illicit discharges, however the following category of non-storm water discharges or flows shall be addressed where such discharges are identified by the municipality as sources of pollutants to waters of the United States: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers, uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (program descriptions shall address discharges or flows from fire fighting only where such discharges or flows are identified as significant sources of pollutants to waters of the United States);

(*2*) A description of procedures to conduct on-going field screening activities during the life of the permit, including areas or locations that will be evaluated by such field screens;

(*3*) A description of procedures to be followed to investigate portions of the separate storm sewer system that, based on the results of the field screen, or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water (such procedures may include: sampling procedures for constituents such as fecal coliform, fecal streptococcus, surfactants (MBAS), residual chlorine, fluorides and potassium; testing with fluorometric dyes; or conducting in storm sewer inspections where safety and other considerations allow. Such description shall include the location of storm sewers that have been identified for such evaluation);

(*4*) A description of procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer;

(*5*) A description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers;

(*6*) A description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials; and

(*7*) A description of controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems where necessary;

(C) A description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system. The program shall:

(*1*) Identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;

(*2*) Describe a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of quantitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease, COD, pH, BOD_5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21(g)(7) (iii) and (iv).

(D) A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system, which shall include:

(*1*) A description of procedures for site planning which incorporate consideration of potential water quality impacts;

(*2*) A description of requirements for nonstructural and structural best management practices;

(*3*) A description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality; and

(*4*) A description of appropriate educational and training measures for construction site operators.

(v) *Assessment of controls.* Estimated reductions in loadings of pollutants from discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water.

(vi) *Fiscal analysis.* For each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2) (iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds.

(vii) Where more than one legal entity submits an application, the application shall contain a description of the roles and responsibilities of each legal entity and procedures to ensure effective coordination.

(viii) Where requirements under paragraph (d)(1)(iv)(E), (d)(2)(ii), (d)(2)(iii)(B) and (d)(2)(iv) of this section are not practicable or are not applicable, the Director may exclude any operator of a discharge from a municipal separate storm sewer which is designated under paragraph (a)(1)(v), (b)(4)(ii) or (b)(7)(ii) of this section from such requirements. The Director shall not exclude the operator of a discharge from a municipal separate storm sewer identified in appendix F, G, H or I of part 122, from any of the permit application requirements under this paragraph except where authorized under this section.

(e) *Application deadlines under paragraph (a)(1).* Any operator of a point source required to obtain a permit under paragraph (a)(1) of this section that does not have an effective NPDES permit covering its storm water outfalls shall submit an application in accordance with the following deadlines:

(1) *Individual applications.* (i) Except as provided in paragraph (e)(1)(ii) of this section, for any storm water discharge associated with industrial activity identified in paragraphs (b)(14) (i) through (xi) of this section, that is not part of a group application as described in paragraph (c)(2) of this section or which is not authorized by a storm water general permit, a permit application made pursuant to paragraph (C) of this section shall be submitted to the Director by October 1, 1992;

(ii) For any storm water discharge associated with industrial activity from a facility that is owned or operated by a municipality with a population of less than 100,000 other than an airport, powerplant, or uncontrolled sanitary landfill, permit application requirements are contained in paragraph (g) of this section.

(2) For any group application submitted in accordance with paragraph (c)(2) of this section:

(i) *Part 1.* (A) Except as provided in paragraph (e)(2)(i)(B) of this section, part 1 of the application shall be submitted to the Director, Office of Wastewater Enforcement and Compliance by September 30, 1991;

(B) Any municipality with a population of less than 250,000 shall not be required to submit a part 1 application before May 18, 1992.

(C) For any storm water discharge associated with industrial activity from a facility that is owned or operated by a municipality with a population of less than 100,000 other than an airport, powerplant, or uncontrolled sanitary landfill, permit applications requirements are reserved.

(ii) Based on information in the part 1 application, the Director will approve or deny the members in the group application within 60 days after receiving part 1 of the group application.

(iii) *Part 2.* (A) Except as provided in paragraph (e)(2)(iii)(B) of this section, part 2 of the application shall be submittted to the Director, Office of Wastewater Enforcement and Compliance by October 1, 1992;

(B) Any municipality with a population of less than 250,000 shall not be required to submit a part 1 application before May 17, 1993.

(C) For any storm water discharge associated with industrial activity from a facility that is owned or operated by a municipality with a population of less than 100,000 other than an airport, powerplant, or uncontrolled sanitary landfill, permit applications requirements are reserved.

(iv) *Rejected facilities.* (A) Except as provided in paragraph (e)(2)(iv)(B) of this section, facilities that are rejected as members of the group shall submit an individual application (or obtain coverage under an applicable general permit) no later than 12 months after the date of receipt of the notice of rejection or October 1, 1992, whichever comes first.

(B) Facilities that are owned or operated by a municipality and that are rejected as members of part 1 group application shall submit an individual application no later than 180 days after the date of receipt of the notice of rejection or October 1, 1992, whichever is later.

(v) A facility listed under paragraph (b)(14) (i)-(xi) of this section may add on to a group application submitted in accordance with paragraph (e)(2)(i) of this section at the discretion of the Office of Water Enforcement and Permits, and only upon a showing of good cause by the facility and the group applicant; the request for the addition of the facility shall be made no later than February 18, 1992; the addition of the facility shall not cause the percentage of the facilities that are required to submit quantitative data to be less than 10%, unless there are over 100 facilities in the group that are submitting quantitative data; approval to become part of group application must be obtained from the group or the trade association representing the individual facilities.

(3) For any discharge from a large municipal separate storm sewer system:

(i) Part 1 of the application shall be submitted to the Director by November 18, 1991;

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application;

(iii) Part 2 of the application shall be submitted to the Director by November 16, 1992.

(4) For any discharge from a medium municipal separate storm sewer system:

(i) Part 1 of the application shall be submitted to the Director by May 18, 1992.

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application.

(iii) Part 2 of the application shall be submitted to the Director by May 17, 1993.

(5) A permit application shall be submitted to the Director within 60 days of notice, unless permission for a later date is granted by the Director (*see* 40 CFR 124.52(c)), for:

(i) A storm water discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines that the discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States (see paragraph (a)(1)(v) of this section);

(ii) A storm water discharge subject to paragraph (c)(1)(v) of this section.

(6) Facilities with existing NPDES permits for storm water discharges associated with industrial activity shall maintain existing permits. Facilities with permits for storm water discharges associated with industrial activity which expire on or after May 18, 1992 shall submit a new application in accordance with the requirements of 40 CFR 122.21 and 40 CFR 122.26(c) (Form 1, Form 2F, and other applicable Forms) 180 days before the expiration of such permits.

(7) The Director shall issue or deny permits for discharges composed entirely of storm water under this section in accordance with the following schedule:

(i)(A) Except as provided in paragraph (e)(7)(i)(B) of this section, the Director shall issue or deny permits for storm water discharges associated with industrial activity no later than October 1, 1993, or, for new sources or existing sources which fail to submit a complete permit application by October 1, 1992, one year after receipt of a complete permit application;

(B) For any municipality with a population of less than 250,000 which submits a timely Part I group application under paragraph (e)(2)(i)(B) of this section, the Director shall issue or deny permits for storm water discharges associated with industrial activity no later than May 17, 1994, or, for any such municipality which fails to submit a complete Part II group permit application by May 17, 1993, one year after receipt of a complete permit application;

(ii) The Director shall issue or deny permits for large municipal separate storm sewer systems no later than November 16, 1993, or, for new sources or existing sources which fail to submit a complete permit application by November 16, 1992, one year after receipt of a complete permit application;

(iii) The Director shall issue or deny permits for medium municipal separate storm sewer systems no later than May 17, 1994, or, for new sources or existing sources which fail to submit a complete permit application by May 17, 1993, one year after receipt of a complete permit application.

(f) *Petitions.* (1) Any operator of a municipal separate storm sewer system may petition the Director to require a separate NPDES permit (or a permit issued under an approved NPDES State program) for any discharge into the

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municipal separate storm sewer system.

(2) Any person may petition the Director to require a NPDES permit for a discharge which is composed entirely of storm water which contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

(3) The owner or operator of a municipal separate storm sewer system may petition the Director to reduce the Census estimates of the population served by such separate system to account for storm water discharged to combined sewers as defined by 40 CFR 35.2005(b)(11) that is treated in a publicly owned treatment works. In municipalities in which combined sewers are operated, the Census estimates of population may be reduced proportional to the fraction, based on estimated lengths, of the length of combined sewers over the sum of the length of combined sewers and municipal separate storm sewers where an applicant has submitted the NPDES permit number associated with each discharge point and a map indicating areas served by combined sewers and the location of any combined sewer overflow discharge point.

(4) Any person may petition the Director for the designation of a large or medium municipal separate storm sewer system as defined by paragraphs (b)(4)(iv) or (b)(7)(iv) of this section.

(5) The Director shall make a final determination on any petition received under this section within 90 days after receiving the petition.

(g) *Application requirements for discharges composed entirely of storm water under Clean Water Act section 402(p)(6).* Any operator of a point source required to obtain a permit under paragraph (a)(9) of this section shall submit an application in accordance with the following requirements.

(1) *Application deadlines.* The operator shall submit an application in accordance with the following deadlines:

(i) A discharger which the Director determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States shall apply for a permit to the Director within 180 days of receipt of notice, unless permission for a later date is granted by the Director (*see* 40 CFR 124.52(c)); or

(ii) All other dischargers shall apply to the Director no later than August 7, 2001.

(2) *Application requirements.* The operator shall submit an application in accordance with the following requirements, unless otherwise modified by the Director:

(i) *Individual application for non-municipal discharges.* The requirements contained in paragraph (c)(1) of this section.

(ii) *Application requirements for municipal separate storm sewer discharges.* The requirements contained in paragraph (d) of this section.

(iii) *Notice of intent to be covered by a general permit issued by the Director.* The requirements contained in 40 CFR 122.28(b)(2).

[55 FR 48063, Nov. 16, 1990, as amended at 56 FR 12100, Mar. 21, 1991; 56 FR 56554, Nov. 5, 1991; 57 FR 11412, Apr. 2, 1992; 57 FR 60447, Dec. 18, 1992; 60 FR 17956, Apr. 7, 1995; 60 FR 19464, Apr. 18, 1995; 60 FR 40235, Aug. 7, 1995]

§ 122.27 Silvicultural activities (applicable to State NPDES programs, see § 123.25).

(a) *Permit requirement.* Silvicultural point sources, as defined in this section, as point sources subject to the NPDES permit program.

(b) *Definitions.* (1) *Silvicultural point source* means any discernible, confined and discrete conveyance related to rock crushing, gravel washing, log sorting, or log storage facilities which are operated in connection with silvicultural activities and from which pollutants are discharged into waters of the United States. The term does not include non-point source silvicultural activities such as nursery operations, site preparation, reforestation and subsequent cultural treatment, thinning, prescribed burning, pest and fire control, harvesting operations, surface drainage, or road construction and maintenance from which there is natural runoff. However, some of these activities (such as stream crossing for roads) may involve point source discharges of dredged or fill material which may require a CWA section 404 permit (See 33 CFR 209.120 and part 233).

(2) *Rock crushing and gravel washing facilities* means facilities which process crushed and broken stone, gravel, and riprap (See 40 CFR part 436, subpart B, including the effluent limitations guidelines).

(3) *Log sorting and log storage facilities* means facilities whose discharges result from the holding of unprocessed wood, for example, logs or roundwood with bark or after removal of bark held in self-contained bodies of water (mill ponds or log ponds) or stored on land where water is applied intentionally on the logs (wet decking). (See 40 CFR part 429, subpart I, including the effluent limitations guidelines).

§ 122.28 General permits (applicable to State NPDES programs, see § 123.25).

(a) *Coverage.* The Director may issue a general permit in accordance with the following:

(1) *Area.* The general permit shall be written to cover a category of discharges or sludge use or disposal practices or facilities described in the permit under paragraph (a)(2)(ii) of this section, except those covered by individual permits, within a geographic area. The area shall correspond to existing geographic or political boundaries, such as:

(i) Designated planning areas under sections 208 and 303 of CWA;

(ii) Sewer districts or sewer authorities;

(iii) City, county, or State political boundaries;

(iv) State highway systems;

(v) Standard metropolitan statistical areas as defined by the Office of Management and Budget;

(vi) Urbanized areas as designated by the Bureau of the Census according to criteria in 30 FR 15202 (May 1, 1974); or

(vii) Any other appropriate division or combination of boundaries.

(2) *Sources.* The general permit may be written to regulate, within the area described in paragraph (a)(1) of this section, either:

(i) Storm water point sources; or

(ii) A category of point sources other than storm water point sources, or a category of "treatment works treating domestic sewage," if the sources or "treatment works treating domestic sewage" all:

(A) Involve the same or substantially similar types of operations;

(B) Discharge the same types of wastes or engage in the same types of sludge use or disposal practices;

(C) Require the same effluent limitations, operating conditions, or standards for sewage sludge use or disposal;

(D) Require the same or similar monitoring; and

(E) In the opinion of the Director, are more appropriately controlled under a general permit than under individual permits.

(b) *Administration.* (1) *In general.* General permits may be issued, modified, revoked and reissued, or terminated in accordance with applicable requirements of part 124 or corresponding State regulations. Special procedures for issuance are found at §123.44 for States and § 124.58 for EPA.

(2) *Authorization to discharge, or authorization to engage in sludge use and disposal practices.* (i) Except as provided in paragraphs (b)(2)(v) and (b)(2)(vi) of this section, dischargers (or treatment works treating domestic sewage) seeking coverage under a general permit shall submit to the Director a written notice of intent to be covered by the general permit. A discharger (or treatment works treating domestic sewage) who fails to submit a notice of intent in accordance with the terms of the permit is not authorized to discharge, (or in the case of sludge disposal permit, to engage in a sludge use or disposal practice), under the terms of the general permit unless the general permit, in accordance with paragraph (b)(2)(v) of this section, contains a provision that a notice of intent is not required or the Director notifies a discharger (or treatment works treating domestic sewage) that it is covered by a general permit in accordance with paragraph (b)(2)(vi) of this section. A complete and timely, notice of intent (NOI), to be covered in accordance with general permit requirements, fulfills the requirements for permit applications for purposes of §§122.6, 122.21 and 122.26.

(ii) The contents of the notice of intent shall be specified in the general permit and shall require the submission of information necessary for adequate program implementation, including at a minimum, the legal name and address of the owner or operator, the facility name and address, type of facility or discharges, and the receiving stream(s). General permits for storm water discharges associated with industrial activity from inactive mining, inactive oil and gas operations, or inactive landfills occurring on Federal lands where an operator cannot be identified may contain alternative notice of intent requirements. All notices of intent shall be signed in accordance with § 122.22.

(iii) General permits shall specify the deadlines for submitting notices of intent to be covered and the date(s) when a discharger is authorized to discharge under the permit;

(iv) General permits shall specify whether a discharger (or treatment works treating domestic sewage) that has submitted a complete and timely notice of intent to be covered in accordance with the general permit and that is eligible for coverage under the permit, is authorized to discharge, (or in the case of a sludge disposal permit, to engage in a sludge use or disposal practice), in accordance with the permit either upon receipt of the notice of intent by the Director, after a waiting period specified in the general permit, on a date specified in the general permit, or upon receipt of notification of inclusion by the Director. Coverage may be terminated or revoked in accordance with paragraph (b)(3) of this section.

(v) Discharges other than discharges from publicly owned treatment works, combined sewer overflows, primary industrial facilities, and storm water discharges associated with industrial activity, may, at the discretion of the Director, be authorized to discharge under a general permit without submitting a notice of intent where the Director finds that a notice of intent requirement would be inappropriate. In making such a finding, the Director shall consider: the type of discharge; the expected nature of the discharge; the potential for toxic and conventional pollutants in the discharges; the expected volume of the discharges; other means of identifying discharges covered by the permit; and the estimated number of discharges to be covered by the permit. The Director shall provide in the public notice of the general permit the reasons for not requiring a notice of intent.

(vi) The Director may notify a discharger (or treatment works treating domestic sewage) that it is covered by a general permit, even if the discharger (or treatment works treating domestic sewage) has not submitted a notice of intent to be covered. A discharger (or treatment works treating domestic sewage) so notified may request an individual permit under paragraph (b)(3)(iii) of this section.

(3) *Requiring an individual permit.* (i) The Director may require any discharger authorized by a general permit to apply for and obtain an individual NPDES permit. Any interested person may petition the Director to take action under this paragraph. Cases where an individual NPDES permit may be required include the following:

(A) The discharger or "treatment works treating domestic sewage" is not in compliance with the conditions of the general NPDES permit;

(B) A change has occurred in the availability of demonstrated technology or practices for the control or abatement of pollutants applicable to the point source or treatment works treating domestic sewage;

(C) Effluent limitation guidelines are promulgated for point sources covered by the general NPDES permit;

(D) A Water Quality Management plan containing requirements applicable to such point sources is approved;

(E) Circumstances have changed since the time of the request to be covered so that the discharger is no longer appropriately controlled under the general permit, or either a temporary or permanent reduction or elimination of the authorized discharge is necessary;

(F) Standards for sewage sludge use or disposal have been promulgated for the sludge use and disposal practice covered by the general NPDES permit; or

(G) The discharge(s) is a significant contributor of pollutants. In making this determination, the Director may consider the following factors:

(*1*) The location of the discharge with respect to waters of the United States;

(*2*) The size of the discharge;

(*3*) The quantity and nature of the pollutants discharged to waters of the United States; and

(*4*) Other relevant factors;

(ii) *For EPA issued general permits only*, the Regional Administrator may require any owner or operator authorized by a general permit to apply for an individual NPDES permit as provided in paragraph (b)(3)(i) of this section, only if the owner or operator has been notified in writing that a permit application is required. This notice shall include a brief statement of the reasons for this decision, an application form, a statement setting a time for the owner or operator to file the application, and a statement that on the effective date of the individual NPDES permit the general permit as it applies to the individual permittee shall automatically terminate. The Director may grant additional time upon request of the applicant.

(iii) Any owner or operator authorized by a general permit may request to be excluded from the coverage of the general permit by applying for an individual permit. The owner or operator shall submit an application under § 122.21, with reasons supporting the request, to the Director no later than 90 days after the publication by EPA of the general permit in the FEDERAL REGISTER or the publication by a State in accordance with applicable State law. The request shall be processed under part 124 or applicable State procedures. The request shall be granted by issuing of any individual permit if the reasons cited by the owner or operator are adequate to support the request.

(iv) When an individual NPDES permit is issued to an owner or operator otherwise subject to a general NPDES permit, the applicability of the general permit to the individual NPDES permittee is automatically terminated on the effective date of the individual permit.

(v) A source excluded from a general permit solely because it already has an individual permit may request that the individual permit be revoked, and that it be covered by the general permit. Upon revocation of the individual permit, the general permit shall apply to the source.

(c) *Offshore oil and gas facilities* (Not applicable to State programs). (1) The Regional Administrator shall, except as provided below, issue general permits covering discharges from offshore oil and gas exploration and production facilities within the Region's jurisdiction. Where the offshore area includes areas, such as areas of biological concern, for which separate permit conditions are required, the Regional Administrator may issue separate general permits, individual permits, or both. The reason for separate general permits or individual permits shall be set forth in the appropriate fact sheets or statements of basis. Any statement of basis or fact sheet for a draft permit shall include the Regional Administrator's tentative determination as to whether the permit applies to "new sources," "new dischargers," or existing sources and the reasons for this determination, and the Regional Administrator's proposals as to areas of biological concern subject either to separate individual or general permits. For Federally leased lands, the general permit area should generally be no less extensive than the lease sale area defined by the Department of the Interior.

(2) Any interested person, including any prospective permittee, may petition the Regional Administrator to issue a general permit. Unless the Regional Administrator determines under paragraph (c)(1) of this section that no general permit is appropriate, he shall promptly provide a project decision schedule covering the issuance of the general permit or permits for any lease sale area for which the Department of the Interior has published a draft environmental impact statement. The project decision schedule shall meet the requirements of §124.3(g), and shall include a schedule providing for the issuance of the final general permit or permits not later than the date of the final notice of sale projected by the Department of the Interior or six months after the date of the request, whichever is later. The Regional Administrator may, at his discretion, issue a project decision schedule for offshore oil and gas facilities in the territorial seas.

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(3) Nothing in this paragraph (c) shall affect the authority of the Regional Administrator to require an individual permit under §122.28(b)(3)(i) (A) through (G).

(Clean Water Act (33 U.S.C. 1251*et seq.*), Safe Drinking Water Act (42 U.S.C. 300f*et seq.*), Clean Air Act (42 U.S.C. 7401 *et seq.*), Resource Conservation and Recovery Act (42 U.S.C. 6901 *et seq*))

[48 FR 14153, Apr. 1, 1983, as amended at 48 FR 39619, Sept. 1, 1983; 49 FR 38048, Sept. 26, 1984; 50 FR 6940, Feb. 19, 1985; 54 FR 18782, May 2, 1989; 55 FR 48072, Nov. 16, 1990; 57 FR 11412 and 11413, Apr. 2, 1992]

§ 122.29 New sources and new dischargers.

(a) *Definitions.* (1) *New source* and *new discharger* are defined in §122.2. [See Note 2.]

(2) *Source* means any building, structure, facility, or installation from which there is or may be a discharge of pollutants.

(3) *Existing source* means any source which is not a new source or a new discharger

(4) *Site* is defined in § 122.2;

(5) *Facilities or equipment* means buildings, structures, process or production equipment or machinery which form a permanent part of the new source and which will be used in its operation, if these facilities or equipment are of such value as to represent a substantial commitment to construct. It excludes facilities or equipment used in connection with feasibility, engineering, and design studies regarding the source or water pollution treatment for the source.

(b) *Criteria for new source determination.* (1) Except as otherwise provided in an applicable new source performance standard, a source is a "new source" if it meets the definition of "new source" in § 122.2, and

(i) It is constructed at a site at which no other source is located; or

(ii) It totally replaces the process or production equipment that causes the discharge of pollutants at an existing source; or

(iii) Its processes are substantially independent of an existing source at the same site. In determining whether these processes are substantially independent, the Director shall consider such factors as the extent to which the new facility is integrated with the existing plant; and the extent to which the new facility is engaged in the same general type of activity as the existing source..

(2) A source meeting the requirements of paragraphs (b)(1) (i), (ii), or (iii) of this section is a new source only if a new source performance standard is independently applicable to it. If there is no such independently applicable standard, the source is a new discharger. See § 122.2.

(3) Construction on a site at which an existing source is located results in a modification subject to §122.62 rather than a new source (or a new discharger) if the construction does not create a new building, structure, facility, or installation meeting the criteria of paragraph (b)(1) (ii) or (iii) of this section but otherwise alters, replaces, or adds to existing process or production equipment.

(4) Construction of a new source as defined under §122.2 has commenced if the owner or operator has:

(i) Begun, or caused to begin as part of a continuous on-site construction program:

(A) Any placement, assembly, or installation of facilities or equipment; or

(B) Significant site preparation work including clearing, excavation or removal of existing buildings, structures, or facilities which is necessary for the placement, assembly, or installation of new source facilities or equipment; or

(ii) Entered into a binding contractual obligation for the purchase of facilities or equipment which are intended to be used in its operation with a reasonable time. Options to purchase or contracts which can be terminated or modified without substantial loss, and contracts for feasibility engineering, and design studies do not constitute a contractual obligation under the paragraph.

(c) *Requirement for an environmental impact statement.* (1) The issuance of an NPDES permit to new source:

(i) By EPA may be a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969 (NEPA), 33 U.S.C. 4321 *et seq.* and is subject to the

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environmental review provisions of NEPA as set out in 40 CFR part 6, subpart F. EPA will determine whether an Environmental Impact Statement (EIS) is required under §122.21(k) (special provisions for applications from new sources) and 40 CFR part 6, subpart F;

(ii) By an NPDES approved State is not a Federal action and therefore does not require EPA to conduct an environmental review.

(2) An EIS prepared under this paragraph shall include a recommendation either to issue or deny the permit.

(i) If the recommendation is to deny the permit, the final EIS shall contain the reasons for the recommendation and list those measures, if any, which the applicant could take to cause the recommendation to be changed;

(ii) If the recommendation is to issue the permit, the final EIS shall recommend the actions, if any, which the permittee should take to prevent or minimize any adverse environmental impacts;

(3) The Regional Administrator, to the extent allowed by law, shall issue, condition (other than imposing effluent limitations), or deny the new source NPDES permit following a complete evaluation of any significant beneficial and adverse impacts of the proposed action and a review of the recommendations contained in the EIS or finding of no significant impact.

(d) *Effect of compliance with new source performance standards.* (The provisions of this paragraph do not apply to existing sources which modify their pollution control facilities or construct new pollution control facilities and achieve performance standards, but which are neither new sources or new dischargers or otherwise do not meet the requirements of this paragraph.)

(1) Except as provided in paragraph (d)(2) of this section, any new discharger, the construction of which commenced after October 18, 1972, or new source which meets the applicable promulgated new source performance standards before the commencement of discharge, may not be subject to any more stringent new source performance standards or to any more stringent technology-based standards under section 301(b)(2) of CWA for the soonest ending of the following periods:

(i) Ten years from the date that construction is completed;

(ii) Ten years from the date the source begins to discharge process or other nonconstruction related wastewater; or

(iii) The period of depreciation or amortization of the facility for the purposes of section 167 or 169 (or both) of the Internal Revenue Code of 1954.

(2) The protection from more stringent standards of performance afforded by paragraph (d)(1) of this section does not apply to:

(i) Additional or more stringent permit conditions which are not technology based; for example, conditions based on water quality standards, or toxic effluent standards or prohibitions under section 307(a) of CWA; or

(ii) Additional permit conditions in accordance with §125.3 controlling toxic pollutants or hazardous substances which are not controlled by new source performance standards. This includes permit conditions controlling pollutants other than those identified as toxic pollutants or hazardous substances when control of these pollutants has been specifically identified as the method to control the toxic pollutants or hazardous substances.

(3) When an NPDES permit issued to a source with a "protection period" under paragraph (d)(1) of this section will expire on or after the expiration of the protection period, that permit shall require the owner or operator of the source to comply with the requirements of section 301 and any other then applicable requirements of CWA immediately upon the expiration of the protection period. No additional period for achieving compliance with these requirements may be allowed except when necessary to achieve compliance with requirements promulgated less than 3 years before the expiration of the protection period.

(4) The owner or operator of a new source, a new discharger which commenced discharge after August 13, 1979, or a recommencing discharger shall install and have in operating condition, and shall "start-up" all pollution control equipment required to meet the

conditions of its permits before beginning to discharge. Within the shortest feasible time (not to exceed 90 days), the owner or operator must meet all permit conditions. The requirements of this paragraph do not apply if the owner or operator is issued a permit containing a compliance schedule under § 122.47(a)(2).

(5) After the effective date of new source performance standards, it shall be unlawful for any owner or operator of any new source to operate the source in violation of those standards applicable to the source.

[48 FR 14153, Apr. 1, 1983, as amended at 49 FR 38048, Sept. 26, 1984; 50 FR 4514, Jan. 31, 1985; 50 FR 6941, Feb. 19, 1985]

Subpart C—Permit Conditions

§ 122.41 Conditions applicable to all permits (applicable to State programs, see § 123.25).

The following conditions apply to all NPDES permits. Additional conditions applicable to NPDES permits are in § 122.42. All conditions applicable to NPDES permits shall be incorporated into the permits either expressly or by reference. If incorporated by reference, a specific citation to these regulations (or the corresponding approved State regulations) must be given in the permit.

(a) *Duty to comply.* The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

(1) The permittee shall comply with effluent standards or prohibitions established under section 307(a) of the Clean Water Act for toxic pollutants and with standards for sewage sludge use or disposal established under section 405(d) of the CWA within the time provided in the regulations that establish these standards or prohibitions or standards for sewage sludge use or disposal, even if the permit has not yet been modified to incorporate the requirement.

(2) The Clean Water Act provides that any person who violates section 301, 302, 306, 307, 308, 318 or 405 of the Act, or any permit condition or limitation implementing any such sections in a permit issued under section 402, or any requirement imposed in a pretreatment program approved under sections 402(a)(3) or 402(b)(8) of the Act, is subject to a civil penalty not to exceed $25,000 per day for each violation. The Clean Water Act provides that any person who *negligently* violates sections 301, 302, 306, 307, 308, 318, or 405 of the Act, or any condition or limitation implementing any of such sections in a permit issued under section 402 of the Act, or any requirement imposed in a pretreatment program approved under section 402(a)(3) or 402(b)(8) of the Act, is subject to criminal penalties of $2,500 to $25,000 per day of violation, or imprisonment of not more than 1 year, or both. In the case of a second or subsequent conviction for a negligent violation, a person shall be subject to criminal penalties of not more than $50,000 per day of violation, or by imprisonment of not more than 2 years, or both. Any person who *knowingly* violates such sections, or such conditions or limitations is subject to criminal penalties of $5,000 to $50,000 per day of violation, or imprisonment for not more than 3 years, or both. In the case of a second or subsequent conviction for a knowing violation, a person shall be subject to criminal penalties of not more than $100,000 per day of violation, or imprisonment of not more than 6 years, or both. Any person who knowingly violates section 301, 302, 303, 306, 307, 308, 318 or 405 of the Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of the Act, and who knows at that time that he thereby places another person in imminent danger of death or serious bodily injury, shall, upon conviction, be subject to a fine of not more than $250,000 or imprisonment of not more than 15 years, or both. In the case of a second or subsequent conviction for a knowing endangerment violation, a person shall be subject to a fine of not more than $500,000 or by imprisonment of not more than 30 years, or both. An organization, as defined in section 309(c)(3)(B)(iii) of the CWA, shall, upon conviction of violating the imminent

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danger provision, be subject to a fine of not more than $1,000,000 and can be fined up to $2,000,000 for second or subsequent convictions.

(3) Any person may be assessed an administrative penalty by the Administrator for violating section 301, 302, 306, 307, 308, 318 or 405 of this Act, or any permit condition or limitation implementing any of such sections in a permit issued under section 402 of this Act. Administrative penalties for Class I violations are not to exceed $10,000 per violation, with the maximum amount of any Class I penalty assessed not to exceed $25,000. Penalties for Class II violations are not to exceed $10,000 per day for each day during which the violation continues, with the maximum amount of any Class II penalty not to exceed $125,000.

(b) *Duty to reapply.* If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit.

(c) *Need to halt or reduce activity not a defense.* It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

(d) *Duty to mitigate.* The permittee shall take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

(e) *Proper operation and maintenance.* The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit.

(f) *Permit actions.* This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

(g) *Property rights.* This permit does not convey any property rights of any sort, or any exclusive privilege.

(h) *Duty to provide information.* The permittee shall furnish to the Director, within a reasonable time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish to the Director upon request, copies of records required to be kept by this permit.

(i) *Inspection and entry.* The permittee shall allow the Director, or an authorized representative (including an authorized contractor acting as a representative of the Administrator), upon presentation of credentials and other documents as may be required by law, to:

(1) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

(2) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

(3) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

(4) Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act, any substances or parameters at any location.

(j) *Monitoring and records.* (1) Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

(2) Except for records of monitoring information required by this permit related to the permittee's sewage sludge use and disposal activities, which shall be retained for a period of at least five

years (or longer as required by 40 CFR part 503), the permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. This period may be extended by request of the Director at any time.

(3) Records of monitoring information shall include:

(i) The date, exact place, and time of sampling or measurements;

(ii) The individual(s) who performed the sampling or measurements;

(iii) The date(s) analyses were performed;

(iv) The individual(s) who performed the analyses;

(v) The analytical techniques or methods used; and

(vi) The results of such analyses.

(4) Monitoring results must be conducted according to test procedures approved under 40 CFR part 136 or, in the case of sludge use or disposal, approved under 40 CFR part 136 unless otherwise specified in 40 CFR part 503, unless other test procedures have been specified in the permit.

(5) The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or both. If a conviction of a person is for a violation committed after a first conviction of such person under this paragraph, punishment is a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or both.

(k) *Signatory requirement.* (1) All applications, reports, or information submitted to the Director shall be signed and certified. (See § 122.22)

(2) The CWA provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

(l) *Reporting requirements.* (1) *Planned changes.* The permittee shall give notice to the Director as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when:

(i) The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source in §22.29(b); or

(ii) The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements under § 122.42(a)(1).

(iii) The alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan;

(2) *Anticipated noncompliance.* The permittee shall give advance notice to the Director of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

(3) *Transfers.* This permit is not transferable to any person except after notice to the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the Clean Water Act. (See §122.61; in some cases, modification or revocation and reissuance is mandatory.)

(4) *Monitoring reports.* Monitoring results shall be reported at the intervals specified elsewhere in this permit.

(i) Monitoring results must be reported on a Discharge Monitoring Report (DMR) or forms provided or specified by the Director for reporting results of monitoring of sludge use or disposal practices.

(ii) If the permittee monitors any pollutant more frequently than required by the permit using test procedures approved under 40 CFR part 136 or, in the case of sludge use or disposal, approved under 40 CFR part 136 unless otherwise specified in 40 CFR part 503, or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR or sludge reporting form specified by the Director.

(iii) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified by the Director in the permit.

(5) *Compliance schedules.* Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.

(6) *Twenty-four hour reporting.* (i) The permittee shall report any noncompliance which may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the permittee becames aware of the circumstances. A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

(ii) The following shall be included as information which must be reported within 24 hours under this paragraph.

(A) Any unanticipated bypass which exceeds any effluent limitation in the permit. (See § 122.41(g).

(B) Any upset which exceeds any effluent limitation in the permit.

(C) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Director in the permit to be reported within 24 hours. (See § 122.44(g).)

(iii) The Director may waive the written report on a case-by-case basis for reports under paragraph (l)(6)(ii) of this section if the oral report has been received within 24 hours.

(7) *Other noncompliance.* The permittee shall report all instances of noncompliance not reported under paragraphs (l) (4), (5), and (6) of this section, at the time monitoring reports are submitted. The reports shall contain the information listed in paragraph (l)(6) of this section.

(8) *Other information.* Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Director, it shall promptly submit such facts or information.

(m) *Bypass*—(1) *Definitions.* (i) *Bypass* means the intentional diversion of waste streams from any portion of a treatment facility.

(ii) *Severe property damage* means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

(2) *Bypass not exceeding limitations.* The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of paragraphs (m)(3) and (m)(4) of this section.

(3) *Notice*—(i) *Anticipated bypass.* If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten days before the date of the bypass.

(ii) *Unanticipated bypass.* The permittee shall submit notice of an unanticipated bypass as required in paragraph (l)(6) of this section (24-hour notice).

(4) *Prohibition of bypass.* (i) Bypass is prohibited, and the Director may take enforcement action against a permittee for bypass, unless:

(A) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

(B) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

(C) The permittee submitted notices as required under paragraph (m)(3) of this section.

(ii) The Director may approve an anticipated bypass, after considering its adverse effects, if the Director determines that it will meet the three conditions listed above in paragraph (m)(4)(i) of this section.

(n) *Upset*—(1) *Definition. Upset* means an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

(2) *Effect of an upset.* An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of paragraph (n)(3) of this section are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

(3) *Conditions necessary for a demonstration of upset.* A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

(i) An upset occurred and that the permittee can identify the cause(s) of the upset;

(ii) The permitted facility was at the time being properly operated; and

(iii) The permittee submitted notice of the upset as required in paragraph (l)(6)(ii)(B) of this section (24 hour notice).

(iv) The permittee complied with any remedial measures required under paragraph (d) of this section.

(4) *Burden of proof.* In any enforcement proceeding the permittee seeking to establish the occurrence of an upset has the burden of proof.

(Clean Water Act (33 U.S.C. 1251*et seq.*), Safe Drinking Water Act (42 U.S.C. 300f*et seq.*), Clean Air Act (42 U.S.C. 7401 *et seq.*), Resource Conservation and Recovery Act (42 U.S.C. 6901 *et seq*))

[48 FR 14153, Apr. 1, 1983, as amended at 48 FR 39620, Sept. 1, 1983; 49 FR 38049, Sept. 26, 1984; 50 FR 4514, Jan. 31, 1985; 50 FR 6940, Feb. 19, 1985; 54 FR 255, Jan. 4, 1989; 54 FR 18783, May 2, 1989]

§ 122.42 Additional conditions applicable to specified categories of NPDES permits (applicable to State NPDES programs, see §123.25).

The following conditions, in addition to those set forth in §122.41, apply to all NPDES permits within the categories specified below:

(a) *Existing manufacturing, commercial, mining, and silvicultural dischargers.* In addition to the reporting requirements under §122.41(l), all existing manufacturing, commercial, mining, and silvicultural dischargers must notify the Director as soon as they know or have reason to believe:

(1) That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

(i) One hundred micrograms per liter (100 μ g/l);

(ii) Two hundred micrograms per liter (200 μ g/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 μ g/l) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;

(iii) Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with § 122.21(g)(7); or

(iv) The level established by the Director in accordance with §122.44(f).

(2) That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

(i) Five hundred micrograms per liter (500 μ g/l);

(ii) One milligram per liter (1 mg/l) for antimony;

(iii) Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with § 122.21(g)(7).

(iv) The level established by the Director in accordance with §122.44(f).

(b) *Publicly owned treatment works.* All POTWs must provide adequate notice to the Director of the following:

(1) Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to section 301 or 306 of CWA if it were directly discharging those pollutants; and

(2) Any substantial change in the volume or character of pollutants being introduced into that POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(3) For purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

(c) *Municipal separate storm sewer systems.* The operator of a large or medium municipal separate storm sewer system or a municipal separate storm sewer that has been designated by the Director under §122.26(a)(1)(v) of this part must submit an annual report by the anniversary of the date of the issuance of the permit for such system. The report shall include:

(1) The status of implementing the components of the storm water management program that are established as permit conditions;

(2) Proposed changes to the storm water management programs that are established as permit condition. Such proposed changes shall be consistent with §122.26(d)(2)(iii) of this part; and

(3) Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under §122.26(d)(2)(iv) and (d)(2)(v) of this part;

(4) A summary of data, including monitoring data, that is accumulated throughout the reporting year;

(5) Annual expenditures and budget for year following each annual report;

(6) A summary describing the number and nature of enforcement actions, inspections, and public education programs;

(7) Identification of water quality improvements or degradation;

(d) *Storm water discharges.* The initial permits for discharges composed entirely of storm water issued pursuant to § 122.26(e)(7) of this part shall require compliance with the conditions of the permit as expeditiously as practicable, but in no event later than three years after the date of issuance of the permit.

[48 FR 14153, Apr. 1, 1983, as amended at 49 FR 38049, Sept. 26, 1984; 50 FR 4514, Jan. 31, 1985; 55 FR 48073, Nov. 16, 1990; 57 FR 60448, Dec. 18, 1992]

§ 122.43 Establishing permit conditions (applicable to State programs, see § 123.25).

(a) In addition to conditions required in all permits (§§122.41 and 122.42), the Director shall establish conditions, as required on a case-by-case basis, to provide for and assure compliance with all applicable requirements of CWA and regulations. These shall include conditions under §§122.46 (duration of permits), 122.47(a) (schedules of compliance), 122.48 (monitoring), and for EPA permits only 122.47(b) (alternates schedule of compliance) and 122.49 (considerations under Federal law).

(b)(1) For a State issued permit, an applicable requirement is a State statutory or regulatory requirement which

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takes effect prior to final administrative disposition of a permit. For a permit issued by EPA, an applicable requirement is a statutory or regulatory requirement (including any interim final regulation) which takes effect prior to the issuance of the permit (except as provided in §124.86(c) for NPDES permits being processed under subpart E or F of part 124). Section 124.14 (reopening of comment period) provides a means for reopening EPA permit proceedings at the discretion of the Director where new requirements become effective during the permitting process and are of sufficient magnitude to make additonal proceedings desirable. For State and EPA administered programs, an applicable requirement is also any requirement which takes effect prior to the modification or revocation and reissuance of a permit, to the extent allowed in § 122.62.

(2) New or reissued permits, and to the extent allowed under §122.62 modified or revoked and reissued permits, shall incorporate each of the applicable requirements referenced in §§122.44 and 122.45.

(c) *Incorporation.* All permit conditions shall be incorporated either expressly or by reference. If incorporated by reference, a specific citation to the applicable regulations or requirements must be given in the permit.

§ 122.44 Establishing limitations, standards, and other permit conditions (applicable to State NPDES programs, see § 123.25).

In addition to the conditions established under §122.43(a), each NPDES permit shall include conditions meeting the following requirements when applicable.

(a) *Technology-based effluent limitations and standards* based on effluent limitations and standards promulgated under section 301 of CWA or new source performance standards promulgated under section 306 of CWA, on case-by-case effluent limitations determined under section 402(a)(1) of CWA, or on a combination of the two, in accordance with § 125.3. For new sources or new dischargers, these technology based limitations and standards are subject to the provisions of §122.29(d) (protection period).

(b)(1) *Other effluent limitations and standards* under sections 301, 302, 303, 307, 318 and 405 of CWA. If any applicable toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is promulgated under section 307(a) of CWA for a toxic pollutant and that standard or prohibition is more stringent than any limitation on the pollutant in the permit, the Director shall institute proceedings under these regulations to modify or revoke and reissue the permit to conform to the toxic effluent standard or prohibition. See also § 122.41(a).

(2) *Standards for sewage sludge use or disposal* under section 405(d) of the CWA unless those standards have been included in a permit issued under the appropriate provisions of subtitle C of the Solid Waste Disposal Act, Part C of Safe Drinking Water Act, the Marine Protection, Research, and Sanctuaries Act of 1972, or the Clean Air Act, or under State permit programs approved by the Administrator. When there are no applicable standards for sewage sludge use or disposal, the permit may include requirements developed on a case-by-case basis to protect public health and the environment from any adverse effects which may occur from toxic pollutants in sewage sludge. If any applicable standard for sewage sludge use or disposal is promulgated under section 405(d) of the CWA and that standard is more stringent than any limitation on the pollutant or practice in the permit, the Director may initiate proceedings under these regulations to modify or revoke and reissue the permit to conform to the standard for sewage sludge use or disposal.

(c) *Reopener clause:* for any discharger within a primary industry category (see appendix A), requirements under section 307(a)(2) of CWA as follows:

(1) On or before June 30, 1981: (i) If applicable standards or limitations have not yet been promulgated, the permit shall include a condition stating that, if an applicable standard or limitation is promulgated under sections 301(b)(2) (C) and (D), 304(b)(2), and 307(a)(2) and that effluent standard or limitation is

more stringent than any effluent limitation in the permit or controls a pollutant not limited in the permit, the permit shall be promptly modified or revoked and reissued to conform to that effluent standard or limitation.

(ii) If applicable standards or limitations have been promulgated or approved, the permit shall include those standards or limitations. (If EPA approves existing effluent limitations or decides not to develop new effluent limitations, it will publish a notice in the FEDERAL REGISTER that the limitations are "approved" for the purpose of this regulation.)

(2) On or after the statutory deadline set forth in section 301(b)(2) (A), (C), and (E) of CWA, any permit issued shall include effluent limitations to meet the requirements of section 301(b)(2) (A), (C), (D), (E), (F), whether or not applicable effluent limitations guidelines have been promulgated or approved. These permits need not incorporate the clause required by paragraph (c)(1) of this section.

(3) The Director shall promptly modify or revoke and reissue any permit containing the clause required under paragraph (c)(1) of this section to incorporate an applicable effluent standard or limitation under sections 301(b)(2) (C) and (D), 304(b)(2) and 307(a)(2) which is promulgated or approved after the permit is issued if that effluent standard or limitation is more stringent than any effluent limitation in the permit, or controls a pollutant not limited in the permit.

(4) For any permit issued to a treatment works treating domestic sewage (including "sludge-only facilities"), the Director shall include a reopener clause to incorporate any applicable standard for sewage sludge use or disposal promulgated under section 405(d) of the CWA. The Director may promptly modify or revoke and reissue any permit containing the reopener clause required by this paragraph if the standard for sewage sludge use or disposal is more stringent than any requirements for sludge use or disposal in the permit, or controls a pollutant or practice not limited in the permit.

(d) *Water quality standards and State requirements:* any requirements in addition to or more stringent than promulgated effluent limitations guidelines or standards under sections 301, 304, 306, 307, 318 and 405 of CWA necessary to:

(1) Achieve water quality standards established under section 303 of the CWA, including State narrative criteria for water quality.

(i) Limitations must control all pollutants or pollutant parameters (either conventional, nonconventional, or toxic pollutants) which the Director determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard, including State narrative criteria for water quality.

(ii) When determining whether a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative or numeric criteria within a State water quality standard, the permitting authority shall use procedures which account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, the sensitivity of the species to toxicity testing (when evaluating whole effluent toxicity), and where appropriate, the dilution of the effluent in the receiving water.

(iii) When the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the allowable ambient concentration of a State numeric criteria within a State water quality standard for an individual pollutant, the permit must contain effluent limits for that pollutant.

(iv) When the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the numeric criterion for whole effluent toxicity, the permit must contain effluent limits for whole effluent toxicity.

(v) Except as provided in this subparagraph, when the permitting authority determines, using the procedures in paragraph (d)(1)(ii) of this section, toxicity testing data, or other information, that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative criterion within an applicable State water quality standard, the permit must contain effluent limits for whole effluent toxicity. Limits on whole effluent toxicity are not necessary where the permitting authority demonstrates in the fact sheet or statement of basis of the NPDES permit, using the procedures in paragraph (d)(1)(ii) of this section, that chemical-specific limits for the effluent are sufficient to attain and maintain applicable numeric and narrative State water quality standards.

(vi) Where a State has not established a water quality criterion for a specific chemical pollutant that is present in an effluent at a concentration that causes, has the reasonable potential to cause, or contributes to an excursion above a narrative criterion within an applicable State water quality standard, the permitting authority must establish effluent limits using one or more of the following options:

(A) Establish effluent limits using a calculated numeric water quality criterion for the pollutant which the permitting authority demonstrates will attain and maintain applicable narrative water quality criteria and will fully protect the designated use. Such a criterion may be derived using a proposed State criterion, or an explicit State policy or regulation interpreting its narrative water quality criterion, supplemented with other relevant information which may include: EPA's Water Quality Standards Handbook, October 1983, risk assessment data, exposure data, information about the pollutant from the Food and Drug Administration, and current EPA criteria documents; or

(B) Establish effluent limits on a case-by-case basis, using EPA's water quality criteria, published under section 304(a) of the CWA, supplemented where necessary by other relevant information; or

(C) Establish effluent limitations on an indicator parameter for the pollutant of concern, provided:

(*1*) The permit identifies which pollutants are intended to be controlled by the use of the effluent limitation;

(*2*) The fact sheet required by §24.56 sets forth the basis for the limit, including a finding that compliance with the effluent limit on the indicator parameter will result in controls on the pollutant of concern which are sufficient to attain and maintain applicable water quality standards;

(*3*) The permit requires all effluent and ambient monitoring necessary to show that during the term of the permit the limit on the indicator parameter continues to attain and maintain applicable water quality standards; and

(*4*) The permit contains a reopener clause allowing the permitting authority to modify or revoke and reissue the permit if the limits on the indicator parameter no longer attain and maintain applicable water quality standards.

(vii) When developing water quality-based effluent limits under this paragraph the permitting authority shall ensure that:

(A) The level of water quality to be achieved by limits on point sources established under this paragraph is derived from, and complies with all applicable water quality standards; and

(B) Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7.

(2) Attain or maintain a specified water quality through water quality related effluent limits established under section 302 of CWA;

(3) Conform to the conditions to a State certification under section 401 of the CWA that meets the requirements of §124.53 when EPA is the permitting authority. If a State certification is stayed by a court of competent jurisdiction or an appropriate State board or agency, EPA shall notify the State that the Agency will deem certification waived unless a finally effective

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State certification is received within sixty days from the date of the notice. If the State does not forward a finally effective certification within the sixty day period, EPA shall include conditions in the permit that may be necessary to meet EPA's obligation under section 301(b)(1)(C) of the CWA;

(4) Conform to applicable water quality requirements under section 401(a)(2) of CWA when the discharge affects a State other than the certifying State;

(5) Incorporate any more stringent limitations, treatment standards, or schedule of compliance requirements established under Federal or State law or regulations in accordance with section 301(b)(1)(C) of CWA;

(6) Ensure consistency with the requirements of a Water Quality Management plan approved by EPA under section 208(b) of CWA;

(7) Incorporate section 403(c) criteria under part 125, subpart M, for ocean discharges;

(8) Incorporate alternative effluent limitations or standards where warranted by "fundamentally different factors," under 40 CFR part 125, subpart D;

(9) Incorporate any other appropriate requirements, conditions, or limitations (other than effluent limitations) into a new source permit to the extent allowed by the National Environmental Policy Act, 42 U.S.C. 4321 *et seq.* and section 511 of the CWA, when EPA is the permit issuing authority. (See § 122.29(c)).

(e) *Technology-based controls for toxic pollutants.* Limitations established under paragraphs (a), (b), or (d) of this section, to control pollutants meeting the criteria listed in paragraph (e)(1) of this section. Limitations will be established in accordance with paragraph (e)(2) of this section. An explanation of the development of these limitations shall be included in the fact sheet under § 124.56(b)(1)(i).

(1) Limitations must control all toxic pollutants which the Director determines (based on information reported in a permit application under § 122.21(g)(7) or (10) or in a notification under § 122.42(a)(1) or on other information) are or may be discharged at a level greater than the level which can be achieved by the technology-based treatment requirements appropriate to the permittee under § 125.3(c); or

(2) The requirement that the limitations control the pollutants meeting the criteria of paragraph (e)(1) of this section will be satisfied by:

(i) Limitations on those pollutants; or

(ii) Limitations on other pollutants which, in the judgment of the Director, will provide treatment of the pollutants under paragraph (e)(1) of this section to the levels required by §25.3(c).

(f) *Notification level.* A "notification level" which exceeds the notification level of §122.42(a)(1)(i), (ii) or (iii), upon a petition from the permittee or on the Director's initiative. This new notification level may not exceed the level which can be achieved by the technology-based treatment requirements appropriate to the permittee under § 125.3(c)

(g) *Twenty-four hour reporting.* Pollutants for which the permittee must report violations of maximum daily discharge limitations under § 122.41(l)(6)(ii)(C) (24-hour reporting) shall be listed in the permit. This list shall include any toxic pollutant or hazardous substance, or any pollutant specifically identified as the method to control a toxic pollutant or hazardous substance.

(h) *Durations* for permits, as set forth in § 122.46.

(i) *Monitoring requirements.* In addition to §122.48, the following monitoring requirements:

(1) To assure compliance with permit limitations, requirements to monitor:

(i) The mass (or other measurement specified in the permit) for each pollutant limited in the permit;

(ii) The volume of effluent discharged from each outfall;

(iii) Other measurements as appropriate including pollutants in internal waste streams under §122.45(i); pollutants in intake water for net limitations under §122.45(f); frequency, rate of discharge, etc., for noncontinuous discharges under §122.45(e); pollutants subject to notification requirements under §122.42(a); and pollutants in sewage sludge or other monitoring as specified in 40 CFR part 503; or as determined to be necessary on a case-by-

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case basis pursuant to section 405(d)(4) of the CWA.

(iv) According to test procedures approved under 40 CFR part 136 for the analyses of pollutants having approved methods under that part, and according to a test procedure specified in the permit for pollutants with no approved methods.

(2) Except as provided in paragraphs (i)(4) and (i)(5) of this section, requirements to report monitoring results shall be established on a case-by-case basis with a frequency dependent on the nature and effect of the discharge, but in no case less than once a year. For sewage sludge use or disposal practices, requirements to monitor and report results shall be established on a case-by-case basis with a frequency dependent on the nature and effect of the sewage sludge use or disposal practice; minimally this shall be as specified in 40 CFR part 503 (where applicable), but in no case less than once a year.

(3) Requirements to report monitoring results for storm water discharges associated with industrial activity which are subject to an effluent limitation guideline shall be established on a case-by-case basis with a frequency dependent on the nature and effect of the discharge, but in no case less than once a year.

(4) Requirements to report monitoring results for storm water discharges associated with industrial activity (other than those addressed in paragraph (i)(3) of this section) shall be established on a case-by-case basis with a frequency dependent on the nature and effect of the discharge. At a minimum, a permit for such a discharge must require:

(i) The discharger to conduct an annual inspection of the facility site to identify areas contributing to a storm water discharge associated with industrial activity and evaluate whether measures to reduce pollutant loadings identified in a storm water pollution prevention plan are adequate and properly implemented in accordance with the terms of the permit or whether additional control measures are needed;

(ii) The discharger to maintain for a period of three years a record summarizing the results of the inspection and a certification that the facility is in compliance with the plan and the permit, and identifying any incidents of non-compliance;

(iii) Such report and certification be signed in accordance with §122.22; and

(iv) Permits for storm water discharges associated with industrial activity from inactive mining operations may, where annual inspections are impracticable, require certification once every three years by a Registered Professional Engineer that the facility is in compliance with the permit, or alternative requirements.

(5) Permits which do not require the submittal of monitoring result reports at least annually shall require that the permittee report all instances of noncompliance not reported under § 122.41(l) (1), (4), (5), and (6) at least annually.

(j) *Pretreatment program for POTWs.* Requirements for POTWs to:

(1) Identify, in terms of character and volume of pollutants, any significant indirect dischargers into the POTW subject to pretreatment standards under section 307(b) of CWA and 40 CFR part 403.

(2) Submit a local program when required by and in accordance with 40 CFR part 403 to assure compliance with pretreatment standards to the extent applicable under section 307(b). The local program shall be incorporated into the permit as described in 40 CFR part 403. The program shall require all indirect dischargers to the POTW to comply with the reporting requirements of 40 CFR part 403.

(3) For POTWs which are "sludge-only facilities," a requirement to develop a pretreatment program under 40 CFR part 403 when the Director determines that a pretreatment program is necessary to assure compliance with Section 405(d) of the CWA.

(k) *Best management practices* to control or abate the discharge of pollutants when:

(1) Authorized under section 304(e) of CWA for the control of toxic pollutants and hazardous substances from ancillary industrial activities;

(2) Numeric effluent limitations are infeasible, or

(3) The practices are reasonably necessary to achieve effluent limitations

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and standards or to carry out the purposes and intent of CWA.

(l) *Reissued permits.* (1) Except as provided in paragraph (l)(2) of this section when a permit is renewed or reissued, interim effluent limitations, standards or conditions must be at least as stringent as the final effluent limitations, standards, or conditions in the previous permit (unless the circumstances on which the previous permit was based have materially and substantially changed since the time the permit was issued and would constitute cause for permit modification or revocation and reissuance under §122.62.)

(2) In the case of effluent limitations established on the basis of Section 402(a)(1)(B) of the CWA, a permit may not be renewed, reissued, or modified on the basis of effluent guidelines promulgated under section 304(b) subsequent to the original issuance of such permit, to contain effluent limitations which are less stringent than the comparable effluent limitations in the previous permit.

(i) Exceptions—A permit with respect to which paragraph (l)(2) of this section applies may be renewed, reissued, or modified to contain a less stringent effluent limitation applicable to a pollutant, if—

(A) Material and substantial alterations or additions to the permitted facility occurred after permit issuance which justify the application of a less stringent effluent limitation;

(B)(*1*) Information is available which was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and which would have justified the application of a less stringent effluent limitation at the time of permit issuance; or

(*2*) The Administrator determines that technical mistakes or mistaken interpretations of law were made in issuing the permit under section 402(a)(1)(b);

(C) A less stringent effluent limitation is necessary because of events over which the permittee has no control and for which there is no reasonably available remedy;

(D) The permittee has received a permit modification under section 301(c), 301(g), 301(h), 301(i), 301(k), 301(n), or 316(a); or

(E) The permittee has installed the treatment facilities required to meet the effluent limitations in the previous permit and has properly operated and maintained the facilities but has nevertheless been unable to achieve the previous effluent limitations, in which case the limitations in the reviewed, reissued, or modified permit may reflect the level of pollutant control actually achieved (but shall not be less stringent than required by effluent guidelines in effect at the time of permit renewal, reissuance, or modification).

(ii) *Limitations.* In no event may a permit with respect to which paragraph (l)(2) of this section applies be renewed, reissued, or modified to contain an effluent limitation which is less stringent than required by effluent guidelines in effect at the time the permit is renewed, reissued, or modified. In no event may such a permit to discharge into waters be renewed, issued, or modified to contain a less stringent effluent limitation if the implementation of such limitation would result in a violation of a water quality standard under section 303 applicable to such waters.

(m) *Privately owned treatment works.* For a privately owned treatment works, any conditions expressly applicable to any user, as a limited co-permittee, that may be necessary in the permit issued to the treatment works to ensure compliance with applicable requirements under this part. Alternatively, the Director may issue separate permits to the treatment works and to its users, or may require a separate permit application from any user. The Director's decision to issue a permit with no conditions applicable to any user, to impose conditions on one or more users, to issue separate permits, or to require separate applications, and the basis for that decision, shall be stated in the fact sheet for the draft permit for the treatment works.

(n) *Grants.* Any conditions imposed in grants made by the Administrator to POTWs under sections 201 and 204 of CWA which are reasonably necessary for the achievement of effluent limitations under section 301 of CWA.

(o) *Sewage sludge.* Requirements under section 405 of CWA governing the

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disposal of sewage sludge from publicly owned treatment works or any other treatment works treating domestic sewage for any use for which regulations have been established, in accordance with any applicable regulations.

(p) *Coast Guard.* When a permit is issued to a facility that may operate at certain times as a means of transportation over water, a condition that the discharge shall comply with any applicable regulations promulgated by the Secretary of the department in which the Coast Guard is operating, that establish specifications for safe transportation, handling, carriage, and storage of pollutants.

(q) *Navigation.* Any conditions that the Secretary of the Army considers necessary to ensure that navigation and anchorage will not be substantially impaired, in accordance with §124.58.

(r) *Great Lakes.* When a permit is issued to a facility that discharges into the Great Lakes System (as defined in 40 CFR 132.2), conditions promulgated by the State, Tribe, or EPA pursuant to 40 CFR part 132.

[48 FR 14153, Apr. 1, 1983, as amended at 49 FR 31842, Aug. 8, 1984; 49 FR 38049, Sept. 26, 1984; 50 FR 6940, Feb. 19, 1985; 50 FR 7912, Feb. 27, 1985; 54 FR 256, Jan. 4, 1989; 54 FR 18783, May 2, 1989; 54 FR 23895, June 2, 1989; 57 FR 11413, Apr. 2, 1992; 57 FR 33049, July 24, 1992; 60 FR 15386, Mar. 23, 1995]

§ 122.45 Calculating NPDES permit conditions (applicable to State NPDES programs, see §123.25).

(a) *Outfalls and discharge points.* All permit effluent limitations, standards and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided under §122.44(k) (BMPs where limitations are infeasible) and paragraph (i) of this section (limitations on internal waste streams).

(b) *Production-based limitations.* (1) In the case of POTWs, permit effluent limitations, standards, or prohibitions shall be calculated based on design flow.

(2)(i) Except in the case of POTWs or as provided in paragraph (b)(2)(ii) of this section, calculation of any permit limitations, standards, or prohibitions which are based on production (or other measure of operation) shall be based not upon the designed production capacity but rather upon a reasonable measure of actual production of the facility. For new sources or new dischargers, actual production shall be estimated using projected production. The time period of the measure of production shall correspond to the time period of the calculated permit limitations; for example, monthly production shall be used to calculate average monthly discharge limitations.

(ii)(A)(*1*) The Director may include a condition establishing alternate permit limitations, standards, or prohibitions based upon anticipated increased (not to exceed maximum production capability) or decreased production levels.

(*2*) *For the automotive manufacturing industry* only, the Regional Administrator shall, and the State Director may establish a condition under paragraph (b)(2)(ii)(A)(*1*) of this section if the applicant satisfactorily demonstrates to the Director at the time the application is submitted that its actual production, as indicated in paragraph (b)(2)(i) of this section, is substantially below maximum production capability and that there is a reasonable potential for an increase above actual production during the duration of the permit.

(B) If the Director establishes permit conditions under paragraph (b)(2)(ii)(A) of this section:

(*1*) The permit shall require the permittee to notify the Director at least two business days prior to a month in which the permittee expects to operate at a level higher than the lowest production level identified in the permit. The notice shall specify the anticipated level and the period during which the permittee expects to operate at the alternate level. If the notice covers more than one month, the notice shall specify the reasons for the anticipated production level increase. New notice of discharge at alternate levels is required to cover a period or production level not covered by prior notice or, if during two consecutive months otherwise covered by a notice, the production level at the permitted facility does not in fact meet the higher level designated in the notice.

(*2*) The permittee shall comply with the limitations, standards, or prohibitions that correspond to the lowest

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federal register

Friday
November 16, 1990

Part II

Environmental Protection Agency

40 CFR Parts 122, 123, and 124
National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges; Final Rule

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 122, 123, and 124

[FRL-3834-7]

RIN 2040-AA79

National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: Today's final rule begins to implement section 402(p) of the Clean Water Act (CWA) (added by section 405 of the Water Quality Act of 1987 (WQA)), which requires the Environmental Protection Agency (EPA) to establish regulations setting forth National Pollutant Discharge Elimination System (NPDES) permit application requirements for: storm water discharges associated with industrial activity; discharges from a municipal separate storm sewer system serving a population of 250,000 or more; and discharges from municipal separate storm sewer systems serving a population of 100,000 or more, but less than 250,000.

Today's rule also clarifies the requirements of section 401 of the WQA, which amended CWA section 402(1)(2) to provide that NPDES permits shall not be required for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing, or treatment operations or transmission facilities, composed entirely of flows which are from conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with, or do not come into contact with, any overburden, raw material, intermediate product, finished product, byproduct, or waste product located on the site of such operations. This rule sets forth NPDES permit application requirements addressing storm water discharges associated with industrial activity and storm water discharges from large and medium municipal separate storm sewer systems.

DATES: This final rule becomes effective December 17, 1990. In accordance with 40 CFR 23.2, this rule shall be considered final for purposes of judicial review on November 30, 1990, at 1 p.m. eastern daylight time. The public record is located at EPA Headquarters, EPA Public Information Reference Unit, room 2402, 401 M Street SW., Washington DC 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: For further information on the rule contact: Thomas J. Seaton, Kevin Weiss, or Michael Mitchell Office of Water Enforcement and Permits (EN-336), United States Environmental Protection Agency, 401 M Street SW., Washington, DC 20460, (202) 475-9518.

SUPPLEMENTARY INFORMATION:

SUPPLEMENTARY INFORMATION:

I. Background and Water Quality Concerns

The 1972 amendments to the Federal Water Pollution Control Act (referred to as the Clean Water Act or CWA), prohibit the discharge of any pollutant to navigable waters from a point source unless the discharge is authorized by an NPDES permit. Efforts to improve water quality under the NPDES program traditionally and primarily focused on reducing pollutants in discharges of industrial process wastewater and municipal sewage. This program emphasis developed for a number of reasons. At the onset of the program in 1972, many sources of industrial process wastewater and municipal sewage were not adequately controlled and represented pressing environmental problems. In addition, sewage outfalls and industrial process discharges were easily identified as responsible for poor, often drastically degraded, water quality conditions. However, as pollution control measures were initially

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developed for these discharges, it became evident that more diffuse sources (occurring over a wide area) of water pollution, such as agricultural and urban runoff were also major causes of water quality problems. Some diffuse sources of water pollution, such as agricultural storm water discharges and irrigation return flows, are statutorily exempted from the NPDES program.

Since enactment of the 1972 amendments to the CWA, considering the rise of economic activity and population, significant progress in controlling water pollution has been made, particularly with regard to industrial process wastewater and municipal sewage. Expenditures by EPA, the States, and local governments to construct and upgrade sewage treatment facilities have substantially increased the population served by higher levels of treatment. Backlogs of expired permits for industrial process wastewater discharges have been reduced. Continued improvements are expected for these discharges as the NPDES program continues to place increasing emphasis on water quality-based pollution controls, especially for toxic pollutants.

Although assessments of water quality are difficult to perform and verify, several national assessments of water quality are available. For the purpose of these assessments, urban runoff was considered to be a diffuse source or nonpoint source pollution. From a legal standpoint, however, most urban runoff is discharged through conveyances such as separate storm sewers or other conveyances which are point sources under the CWA. These discharges are subject to the NPDES program. The "National Water Quality Inventory, 1988 Report to Congress" provides a general assessment of water quality based on biennial reports submitted by the States under section 305(b) of the CWA. In preparing the section 305(b) Reports, the States were asked to indicate the fraction of the States' waters that were assessed, as well as the fraction of the States' waters that were fully supporting, partly supporting, or not supporting designated uses. The Report indicates that of the rivers, lakes, and estuaries that were assessed by States (approximately one-fifth of stream miles, one-third of lake acres and one-half of estuarine waters), roughly 70% to 75% are supporting the uses for which they are designated. For waters with use impairments, States were asked to determine impacts due to diffuse sources (agricultural and urban runoff and other sources), municipal sewage, industrial process wastewaters, combined sewer overflows, and natural and other sources, then combine impacts to arrive at estimates of the relative percentage of State waters affected by each source. In this manner, the relative importance of the various sources of pollution that are causing use impairments was assessed and weighted national averages were calculated. Based on 37 States that provided information on sources of pollution, industrial process wastewaters were cited as the cause of nonsupport for 7.5% of rivers and streams, 10% of lakes, and 6% of estuaries. Municipal sewage was the cause of nonsupport for 13% of rivers and streams, 5% lakes, 48% estuaries, 41% of the Great Lake shoreline, and 11% of coastal waters. The Assessment concluded that pollution from diffuse sources, such as runoff from agricultural, urban areas, construction sites, land disposal and resource extraction, is cited by the States as the leading cause of water quality impairment. These sources appear to be increasingly important contributors of use impairment as discharges of industrial process wastewaters and municipal sewage plants come under increased control and as intensified data collection efforts provide additional information. Some examples of diffuse sources cited as causing use impairment are: for rivers and streams, 9% from separate storm sewers, 6% from construction and 13% from resource extraction; for lakes, 28% from separate storm sewers and 26% from land disposal; for the Great Lakes shoreline, 10% from separate storm sewers, 34% from resource extraction, and 82% from land disposal; for estuaries, 28% from separate storm sewers and 27% from land disposal; and for coastal areas, 20% from separate storm sewers and 29% from land disposal.

The States conducted a more comprehensive study of diffuse pollution sources under the sponsorship of the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) and EPA. The study resulted in the report "America's Clean Water—The States' Nonpoint Source Assessment, 1985" which indicated that 38 States reported urban runoff as a major cause of beneficial use impairment. In addition, 21 States reported construction site runoff as a major cause of use impairment.

To provide a better understanding of the nature of urban runoff from commercial and residential areas, from 1978 through 1983, EPA provided funding and guidance to the Nationwide Urban Runoff Program (NURP). The NURP included 28 projects across the Nation conducted separately at the local level but centrally reviewed, coordinated, and guided.

One focus of the NURP was to characterize the water quality of discharges from separate storm sewers which drain residential, commercial, and light industrial (industrial parks) sites. The majority of samples collected in the study were analyzed for eight conventional pollutants and three metals. Data collected under the NURP indicated that on an annual loading basis, suspended solids in discharges from separate storm sewers draining runoff from residential, commercial and light industrial areas are around an order of magnitude greater than solids in discharges from municipal secondary sewage treatment plants. In addition, the study indicated that annual loadings of chemical oxygen demand (COD) are comparable in magnitude to effluent from secondary sewage treatment plants. When analyzing annual loadings associated with urban runoff, it is important to recognize that discharges of urban runoff are highly intermittent, and that the short-term loadings associated with individual events will be high and may have shockloading effects on receiving water, such as low dissolved oxygen levels. NURP data also showed that fecal coliform counts in urban runoff are typically in the tens to hundreds of thousands per 100 ml of runoff during warm weather conditions, although the study suggested that fecal coliform may not be the most appropriate indicator organism for identifying potential health risks in storm water runoff. Although NURP did not evaluate oil and grease, other studies have demonstrated that urban runoff is an extremely important source of oil pollution to receiving waters, with hydrocarbon levels in urban runoff typically being reported at a range of 2 to 15 mg/l. These hydrocarbons tend to accumulate in bottom sediments where they may persist for long periods of time and exert adverse impacts on benthic organisms.

A portion of the NURP study involved monitoring 120 priority pollutants in storm water discharges from lands used for residential, commercial and light industrial activities. Seventy-seven priority pollutants were detected in samples of storm water discharges from residential, commercial and light industrial lands taken during the NURP study, including 14 inorganic and 63 organic pollutants. Table A-1 shows the priority pollutants which were detected in at least ten percent of the discharge samples which were sampled for priority pollutants.

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TABLE A-1.— PRIORITY POLLUTANTS DETECTED IN AT LEAST 10% OF NURP SAMPLES

[In percent]

	Frequency of detection
Metals and inorganics:	
Antimony	13
Arsenic	52
Beryllium	12
Cadmium	48
Chromium	58
Copper	91
Cyanides	23
Lead	94
Nickel	43
Selenium	11
Zinc	94
Pesticides:	
Alpha-hexachlorocyclohexane	20
Alpha-endosulfan	19
Chlordane	17
Lindane	15
Halogenated aliphatics:	
Methane, dichloro-	11
Phenols and cresols:	
Phenol	14
Phenol, pentachloro-	19
Phenol, 4-nitro	10
Phthalate esters:	
Phthalate, bis(2-ethylhexyl)	22
Polycyclic aromatic hydrocarbons.	
Chrysene	10
Fluoranthene	16
Phenanthrene	12
Pyrene	15

The NURP data also showed a significant number of these samples exceeded various EPA freshwater water quality criteria.

The NURP study provides insight on what can be considered background levels of pollutants for urban runoff, as the study focused primarily on monitoring runoff from residential, commercial and light industrial areas. However, NURP concluded that the quality of urban runoff can be adversely impacted by several sources of pollutants that were not directly evaluated in the study and are generally not reflected in the NURP data, including illicit connections, construction site runoff, industrial site runoff and illegal dumping.

Other studies have shown that many storm sewers contain illicit discharges of non-storm water and that large amounts of wastes, particularly used oils, are improperly disposed in storm sewers. Removal of these discharges present opportunities for dramatic improvements in the quality of storm water discharges. Storm water discharges from industrial facilities may contain toxics and conventional pollutants when material management practices allow exposure to storm water, in addition to wastes from illicit connections and improperly disposed wastes.

In some municipalities, illicit connections of sanitary, commercial and industrial discharges to storm sewer systems have had a significant impact on the water quality of receiving waters. Although the NURP study did not emphasize the identification of illicit connections to storm sewers (other than to assure that monitoring sites used in the study were free from sanitary sewage contamination), the study concluded that illicit connections can result in high bacterial counts and dangers to public health. The study also noted that removing such discharges presented opportunities for dramatic improvements in the quality of urban storm water discharges.

Studies have shown that illicit connections to storm sewers can create severe, wide-spread contamination problems. For example, the Huron River Pollution Abatement Program inspected 660 businesses, homes and other buildings located in Washtenaw County, Michigan and identified 14% of the buildings as having improper storm drain connections. Illicit discharges were detected at a higher rate of 60% for automobile related businesses, including service stations, automobile dealerships, car washes, body shops and light industrial facilities. While some of the problems discovered in this study were the result of improper plumbing or illegal connections, a majority were approved connections at the time they were built.

Intensive construction activities may result in severe localized impacts on water quality because of high unit loads of pollutants, primarily sediments. Construction sites can also generate other pollutants such as phosphorus and nitrogen from fertilizer, pesticides, petroleum products, construction chemicals and solid wastes. These materials can be toxic to aquatic organisms and degrade water for drinking and water-contact recreation. Sediment loadings rates from construction sites are typically 10 to 20 times that of agricultural lands, with runoff rates as high as 100 times that of agricultural lands, and typically 1,000 to 2,000 times that of forest lands. Even a small amount of construction may have a significant negative impact on water quality in localized areas. Over a short period of time, construction sites can contribute more sediment to streams than was previously deposited over several decades.

II. Water Quality Act of 1987

The WQA contains three provisions which specifically address storm water discharges. The central WQA provision governing storm water discharges is section 405, which adds section 402(p) to the CWA. Section 402(p)(1) provides that EPA or NPDES States cannot require a permit for certain storm water discharges until October 1, 1992, except for storm water discharges listed under section 402(p)(2). Section 402(p)(2) lists five types of storm water discharges which are required to obtain a permit prior to October 1, 1992:

(A) A discharge with respect to which a permit has been issued prior to February 4, 1987;

(B) A discharge associated with industrial activity;

(C) A discharge from a municipal separate storm sewer system serving a population of 250,000 or more;

(D) A discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000; or

(E) A discharge for which the Administrator or the State, as the case may be, determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States.

Section 402(p)(4)(A) requires EPA to promulgate final regulations governing storm water permit application requirements for storm water discharges associated with industrial activity and discharges from large municipal separate storm sewer systems (systems serving a population of 250,000 or more), "no later than two years" after the date of enactment (*i.e.*, no later than February 4, 1989). Section 402(p)(4)(B) also requires EPA to promulgate final regulations governing storm water permit application requirements for discharges from medium municipal separate storm sewer systems (systems serving a population of 100,000 or more but less than 250,000) "no later than four years" after enactment (*i.e.*, no later than February 4, 1991).

In addition, section 402(p)(4) provides that permit applications for storm water discharges associated with industrial activity and discharges from large municipal separate storm sewer systems "shall be filed no later than three years" after the date of enactment of the WQA (*i.e.*, no later than February 4, 1990). Permit applications for discharges from medium municipal systems must be filed "no later than five years" after enactment (*i.e.*, no later than February 4, 1992).

The WQA clarified and amended the requirements for permits for storm water discharges in the new CWA section 402(p)(3). The Act clarified that permits for discharges associated with industrial activity must meet all of the applicable provisions of section 402 and section [illegible]

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including technology and water quality based standards. However, the new Act makes significant changes to the permit standards for discharges from municipal storm sewers. Section 402(p)(3)(B) provides that permits for such discharges:

(i) May be issued on a system- or jurisdiction-wide basis;
(ii) Shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers; and
(iii) Shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

These changes are discussed in more detail later in today's rule.

The EPA, in consultation with the States, is required to conduct two studies on storm water discharges that are in the class of discharges for which EPA and NPDES States cannot require permits prior to October 1, 1992. The first study will identify those storm water discharges or classes of storm water discharges for which permits are not required prior to October 1, 1992, and determine, to the maximum extent practicable, the nature and extent of pollutants in such discharges. The second study is for the purpose of establishing procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality. Based on the two studies the EPA, in consultation with State and local officials, is required to issue regulations no later than October 1, 1992, which designate additional storm water discharges to be regulated to protect water quality and establish a comprehensive program to regulate such designated sources. This program must, at a minimum, (A) Establish priorities, (B) establish requirements for State storm water management programs, and (C) establish expeditious deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements, as appropriate.

Section 401 of the WQA amends section 402(1)(2) of the CWA to provide that the EPA shall not require a permit for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing, or treatment operations or transmission facilities if the storm water discharge is not contaminated by contact with, or does not come into contact with any overburden, raw material, intermediate product, finished product, byproduct or waste product located on the site of such operations.

Section 503 of the WQA amends section 502(14) of the CWA to exclude agricultural storm water discharges from the definition of point source.

III. Remand of 1984 Regulations

On December 4, 1987, the United States Court of Appeals for the District of Columbia Circuit vacated 40 CFR 122.26, (as promulgated on September 26, 1984, 49 FR 37998, September 26, 1984), and remanded the regulations to EPA for further rulemaking (*NRDC* v. *EPA*, No. 80–1607). EPA had requested the remand because of significant changes made by the storm water provisions of the WQA. The effect of the decision was to invalidate the storm water discharge regulations then found at § 122.26.

Storm water discharges which had been issued an NPDES permit prior to February 4, 1987, were not affected by the Court remand or the February 12, 1988, rule implementing the court order (53 FR 4157). (*See* section 402(p)(2)(A) of the CWA.) Similarly, the remand did not affect the authority of EPA or an NPDES State to require a permit for any storm water discharge (except an agricultural storm water discharge) designated under section 402(p)(2)(E) of the CWA. The notice of the remand clarified that such designated discharges meet the regulatory definition of point source found at 40 CFR 122.2 and that EPA or an NPDES State can rely on the statutory authority and require the filing of an application (Form 1 and Form 2C) for an NPDES permit with respect to such discharges on a case-by-case basis.

IV. Codification Rule and Case-by-Case Designations

Codification Rule

On January 4, 1989, (54 FR 255), EPA published a final rule which codified numerous provisions of the WQA into EPA regulations. The codification rule included several provisions dealing with storm water discharges. The codification rule promulgated the language found at section 402(p) (1) and (2) of the amended Clean Water Act at 40 CFR 122.26(a)(1). In addition, the codification rule promulgated the language of Section 503 of the WQA which exempted agricultural storm water discharges from the definition of point source at 40 CFR 122.2; and section 401 of the WQA addressing uncontaminated storm water discharges from mining or oil and gas operations at 40 CFR 122.26(a)(2).

EPA also codified the statutory authority of section 402(p)(2)(E) of the CWA for the Administrator or the State Director, as the case may be, to designate storm water discharges for a permit on a case-by-case basis at 40 CFR 122.26(a)(1)(v).

Case by Case Designations

Section 402(p)(2)(E) of the CWA authorizes case-by-case designations of storm water discharges for immediate permitting if the Administrator or the State Director determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

In determining that a storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States for the purpose of a designation under section 402(p)(2)(E), the legislative history for the provision provides that "EPA or the State should use any available water quality or sampling data to determine whether the latter two criteria (contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States) are met, and should require additional sampling as necessary to determine whether or not these criteria are met." Conference Report, *Cong. Rec.* S16443 (daily ed. October 16, 1986). In accordance with this legislative history, today's rule promulgates permit application requirements for certain storm water discharges, including discharges designated on a case-by-case basis. EPA will consider a number of factors when determining whether a storm water discharge is a significant contributor of pollution to the waters of the United States. These factors include: the location of the discharge with respect to waters of the United States; the size of the discharge; the quantity and nature of the pollutants reaching waters of the United States; and any other relevant factors. Today's rule incorporates these factors at 40 CFR 122.26(a)(1)(v).

Under today's rule, case-by-case designations are made under regulatory procedures found at 40 CFR 124.52. The procedures at 40 CFR 124.52 require that whenever the Director decides that an individual permit is required, the Director shall notify the discharger in writing that the discharge requires a permit and the reasons for the decision. In addition, an application form is sent with the notice. Section 124.52 provides a 60 day period from the date of notice for submitting a permit application. Although this 60 day period may be appropriate for many designated storm water discharges, site specific factors may dictate that the Director provide additional time for submitting a permit application. For example, due to the complexities associated with designation of a municipal separate storm sewer system for a system- or jurisdiction-wide permit, the Director may provide the applicant with additional time to submit relevant information or may require that information be submitted in several phases.

V. Consent Decree of October 20, 1989

On April 20, 1989, EPA was served notice of intent to sue by Kathy Williams *et al.* because of the Agency's failure to promulgate final storm regulations on February 4, 1989, pursuant to Section 402(p)(4) of the CWA. A suit was filed by the same party on July 20, 1989, alleging the same cause of action, to wit: the Agency's failure to promulgate regulations under section 402(p)(4) of the CWA. On October 20, 1989, EPA entered into a consent decree with Kathy Williams *et al.* wherein the Federal District Court, District of Oregon, Southern Division, decreed that the Agency promulgate final regulations for storm water discharges identified in sections 402(p)(2) (B) and (C) of the CWA no later than July 20, 1990. *Kathy Williams et al.*, v. *William K. Reilly, Administrator, et al.*, No. 89-6265-E (D-Ore.) In July 1990, the consent degree was amended to provide for a promulgation date of October 31. Today's rule is promulgated in compliance with the terms of the consent decree as amended.

VI. Today's Final Rule and Response to Comments

A. Overview

Section 405 of the WQA alters the regulatory approach to control pollutants in storm water discharges by adopting a phased and tiered approach. The new provision phases in permit application requirements, permit issuance deadlines and compliance with permit conditions for different categories of storm water discharges. The approach is tiered in that storm water discharges associated with industrial activity must comply with sections 301 and 402 of the CWA (requiring control of the discharge of pollutants that utilize the Best Available Technology (BAT) and the Best Conventional Pollutant Control Technology (BCT) and where necessary, water quality-based controls), but permits for discharges from municipal separate storm sewer systems must require controls to reduce the discharge of pollutants to the maximum extent practicable, and where necessary water quality-based controls, and must include a requirement to effectively prohibit non-storm water discharges into the storm sewers. Furthermore, EPA in consultation with State and local officials must develop a comprehensive program to designate and regulate other storm water discharges to protect water quality.

This final regulation establishes requirements for the storm water permit application process. It also sets forth the required components of municipal storm water quality management plans, as well as a preliminary permitting strategy for industrial activities. In implementing these regulations, EPA and the States will strive to achieve environmental results in a cost effective manner by placing high priority on pollution prevention activities, and by targeting activities based on reducing risk from particularly harmful pollutants and/or from discharges to high value waters. EPA and the States will also work with applicants to avoid cross media transfers of storm water contaminants, especially through injection to shallow wells in the Class V Underground Injection Control Program.

In addition, EPA recognizes that problems associated with storm water, combined sewer overflows (CSOs) and infiltration and inflow (I&I) are all inter-related even though they are treated somewhat differently under the law. EPA believes that it is important to begin linking these programs and activities and, because of the potential cost to local governments, to investigate the use of innovative, non-traditional approaches to reducing or preventing contamination of storm water.

The application process for developing municipal storm water management plans provides an ideal opportunity between steps 1 and 2 for considering the full range of nontraditional, preventive approaches, including municipalities, public awareness/education programs, use of vegetation and/or land conservancy practices, alternative paving materials, creative ways to eliminate I&I and illegal hook-ups, and potentials for water reuse. EPA has already announced its plans to present an award for the best creative, cost effective approaches to storm water and CSOs beginning in 1991.

This rulemaking establishes permit application requirements for classes of storm water discharges that were specifically identified in section 402(p)(2). These priority storm water discharges include storm water discharges associated with industrial activity and discharges from a municipal separate storm sewer serving a population of 100,000 or more.

This rulemaking was developed after careful consideration of 450 sets of comments, comprising over 3200 pages, that were received from a variety of industries, trade associations, municipalities, State and Federal Agencies, environmental groups, and private citizens. These comments were received during a 90-day comment period which extended from December 7, 1988, to March 7, 1989. EPA received several requests for an extension of the comment period from 30-days up to 90-days. Many arguments were advanced for an extension including: the extent and complexity of the proposal, the existence of other concurrent EPA proposals, and the need for technical evaluations of the proposal. EPA considered these comments as they were received, but declined to extend the comment period beyond 90 days. The standard comment period on proposals normally range from 30 to 60 days. In light of the statutory deadline of February 4, 1989, additional time for the comment period beyond what was already a substantially lengthened comment period would have been inappropriate. The number and extent of the comments received on this proposal indicated that interested parties had substantially adequate time to review and comment on the regulation. Furthermore, the public was invited to attend six public meetings in Washington DC, Chicago, Dallas, Oakland, Jacksonville, and Boston to present questions and comments. EPA is convinced that substantial and adequate public participation was sought and received by the Agency.

Numerous commenters have also requested that the rule be reproposed due to the extent of the proposal and the number of options and issues upon which the Agency requested comments. EPA has decided against a reproposal. The December 7, 1988, notice of proposed rulemaking was extremely detailed and thoroughly identified major issues in such a manner as to allow the public clear opportunities to comment. The comments that were received were extensive, and many provided valuable information and ideas that have been incorporated into the regulation. Accordingly, the Agency is confident it has produced a workable and rational approach to the initial regulation of storm water discharges and a regulation that reflects the experience and knowledge of the public as provided in the comments, and which was [illegible] developed in accordance with the

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procedural requirements of the Administrative Procedures Act (APA). EPA believes that while the number of issues raised by the proposal was extensive, the number of detailed comments indicates that the public was able to understand the issues in order to comment adequately. Thus, a reproposal is unnecessary.

B. Definition of Storm Water

The December 7, 1988, notice requested comment on defining storm water as storm water runoff, surface runoff, street wash waters related to street cleaning or maintenance, infiltration (other than infiltration contaminated by seepage from sanitary sewers or by other discharges) and drainage related to storm events or snow melt. This definition is consistent with the regulatory definition of "storm sewer" at 40 CFR 35.2005(b)(47) which is used in the context of grants for construction of treatment works. This definition aids in distinguishing separate storm water sewers from sanitary sewers, combined sewers, process discharge outfalls and non-storm water, non-process discharge outfalls.

The definition of "storm water" has an important bearing on the NPDES permitting scheme under the CWA. The following discusses the interrelationship of NPDES permitting requirements for storm water discharges addressed by this rule and NPDES permitting requirements for other non-storm water discharges which may be discharged via the storm sewer as a storm water discharge. Today's rule addresses permit application requirements for storm water discharges associated with industrial activity and for discharges from municipal separate storm sewer systems serving a population of 100,000 or more. Storm water discharges associated with industrial activity are to be covered by permits which contain technology-based controls based on BAT/BCT considerations or water quality-based controls, if necessary. A permit for storm water discharges from an industrial facility may also cover other non-storm water discharges from the facility. Today's rule establishes individual (Form 1 and Form 2F) and group application requirements for storm water discharges associated with industrial activity. In addition, EPA or authorized NPDES States with authorized general permit programs may issue general permits which establish alternative application or notification requirements for storm water discharges covered by the general permit(s). Where a storm water discharge associated with industrial activity is mixed with a non-storm water discharge, both discharges must be covered by an NPDES permit (this can be in the same permit or with multiple permits). Permit application requirements for these "combination" discharges are discussed later in today's notice.

Today's rule also addresses permit application requirements for discharges from municipal separate storm sewer systems serving a population of 100,000 or more. Under today's rule, appropriate municipal owners or operators of these systems must obtain NPDES permits for discharges from these systems. These permits are to establish controls to the maximum extent practicable (MEP), effectively prohibit non-storm water discharges to the municipal separate storm sewer system and, where necessary, contain applicable water quality-based controls. Where non-storm water discharges or storm water discharges associated with industrial activity discharge through a municipal separate storm sewer system (including systems serving a population of 100,000 or more as well as other systems), which ultimately discharges to a waters of the United States, such discharges through a municipal storm sewer need to be covered by an NPDES permit that is independent of the permit issued for discharges from the municipal separate storm sewer system. Today's rule defines the term "illicit discharge" to describe any discharge through a municipal separate storm sewer that is not composed entirely of storm water and that is not covered by an NPDES permit. Such illicit discharges are not authorized under the CWA. Section 402(p)(3)(B) of the CWA requires that permits for discharges from municipal separate storm sewers require the municipality to "effectively prohibit" non-storm water discharges from the municipal separate storm sewer. As discussed in more detail below, today's rule begins to implement the "effective prohibition" by requiring municipal operators of municipal separate storm sewer systems serving a population of 100,000 or more to submit a description of a program to detect and control certain non-storm water discharges to their municipal system. Ultimately, such non-storm water discharges through a municipal separate storm sewer must either be removed from the system or become subject to an NPDES permit (other than the permit for the discharge from the municipal separate storm sewer). For reasons discussed in more detail below, in general, municipalities will not be held responsible for prohibiting some specific components of discharges or flows listed below through their municipal separate storm sewer system, even though such components may be considered non-storm water discharges, unless such discharges are specifically identified on a case-by-case basis as needing to be addressed. However, operators of such non-storm water discharges need to obtain NPDES permits for these discharges under the present framework of the CWA (rather than the municipal operator of the municipal separate storm sewer system). (Note that section 516 of the Water Quality Act of 1987 requires EPA to conduct a study of de minimis discharges of pollutants to waters of the United States and to determine the most effective and appropriate methods of regulating any such discharges.)

EPA received numerous comments on the proposed regulatory definition of storm water, many of which proposed exclusions or additions to the definition. Several commenters suggested that the definition should include or not include detention and retention reservoir releases, water line flushing, fire hydrant flushing, runoff from fire fighting, swimming pool drainage and discharge, landscape irrigation, diverted stream flows, uncontaminated pumped ground water, rising ground waters, discharges from potable water sources, uncontaminated waters from cooling towers, foundation drains, non-contact cooling water (such as HVAC or heating, ventilation and air conditioning condensation water that POTWs require to be discharged to separate storm sewers rather than sanitary sewers), irrigation water, springs, roof drains, water from crawl space pumps, footing drains, lawn watering, individual car washing, flows from riparian habitats and wetlands. Most of these comments were made with regard to the concern that these were commonly occurring discharges which did not pose significant environmental problems. It was also noted that, unless these flows are classified as storm water, permits would be required for these discharges.

In response to the comments which requested EPA to define the term "storm water" broadly to include a number of classes of discharges which are not in any way related to precipitation events, EPA believes that this rulemaking is not an appropriate forum for addressing the appropriate regulation under the NPDES program of such non-storm water discharges, even though some classes of non-storm water discharges may typically contain only minimal amounts of pollutants. Congress did not intend that the term storm water be used to describe any discharge that has a de minimis amount of pollutants, nor did it intend for section 402(p) to be used to provide a moratorium from permitting other non-storm water discharges. Consequently, the final definition of storm water has not been expanded from what was proposed. However, as discussed in more detail later in today's notice, municipal operators of municipal separate storm sewer systems will generally not be held responsible for "effectively prohibiting" limited classes of these discharges through their municipal separate storm sewer systems.

The proposed rule included infiltration in the definition of storm water. In this context one commenter suggested that the term infiltration be defined. Infiltration is defined at 40 CFR 35.2005(b)(20) as water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections or manholes. Infiltration does not include, and is distinguished from, inflow. Another commenter urged that ground water infiltration not be classified as storm water because the chemical characteristics and contaminants of ground water will differ from surface storm water because of a longer contact period with materials in the soil and because ground water quality will not reflect current practices at the site. In today's rule, the definition of storm water excludes infiltration since pollutants in these flows will depend on a large number of factors, including interactions with soil and past land use practices at a given site. Further infiltration flows can be contaminated by sources that are not related to precipitation events, such as seepage from sanitary sewers. Accordingly the final regulatory language does not include infiltration in the definition of storm water. Such flows may be subject to appropriate permit conditions in industrial permits. As discussed in more detail below, municipal management programs must address infiltration where identified as a source of pollutants to waters of the United States.

One commenter questioned the status of discharges from detention and retention basins used to collect storm water. This regulation covers discharges of storm water associated with industrial activity and discharges from municipal separate storm sewer systems serving a population of 100,000 or more into waters of the United States. Therefore, discharges from basins that are part of a conveyance system for a storm water discharge associated with industrial activity or part of a municipal separate storm sewer system serving a population of 100,000 or more are covered by this regulation. Flows which are channeled into basins and which do not discharge into waters of the United States are not addressed by today's rule.

Several commenters requested that the term illicit connection be replaced with a term that does not connote illegal discharges or activity, because many discharges of non-storm water to municipal separate storm sewer systems occurred prior to the establishment of the NPDES program and in accordance with local or State requirements at the time of the connection. EPA disagrees that there should be a change in this terminology. The fact that these connections were at one time legal does not confer such status now. The CWA prohibits the point source discharge of non-storm water not subject to an NPDES permit through municipal separate storm sewers to waters of the United States. Thus, classifying such discharges as illicit properly identifies such discharges as being illegal.

A commenter wanted clarification of the terms "other discharges" and "drainage" that are used in the definition of "storm water." As noted above, today's rule clarifies that infiltration is not considered storm water. Thus the portion of the definition of storm water that refers to "other discharges" has also been removed. However, the term drainage has been retained. "Drainage" does not take on any meaning other than the flow of runoff into a conveyance, as the word is commonly understood.

One commenter stated that irrigation flows combined with storm water discharges should be excluded from consideration in the storm water program. The Agency would note that irrigation return flows are excluded from regulation under the NPDES program. Section 402(l)(1) states that the Administrator or the State shall not require permits for discharges composed entirely of return flows from irrigated agriculture. The legislative history of the 1977 Clean Water Act, which enacted this language, states that the word "entirely" was intended to limit the exception to only those flows which do not contain additional discharges from activities unrelated to crop production. Congressional Record Vol. 123 (1977), pg. 4360, Senate Report No. 95–370. Accordingly, a storm water discharge component, from an industrial facility for example, included in such "joint" discharges may be regulated pursuant to an NPDES permit either at the point at which the storm water flow enters or joins the irrigation flow, or where the combined flow enters waters of the United States or a municipal separate storm sewer.

Some commenters expressed concern about including street wash waters as storm water. One commenter argued including street wash waters in the definition of storm water should not be construed to eliminate the need for management practices relating to construction activities where sediment may simply wash into storm drains. EPA agrees with these points and the concerns that storm sewers may receive material that pose environmental problems if street wash waters are included in the definition. Accordingly, such discharges are no longer in the definition as proposed, and must be addressed by municipal management programs as part of the prohibition on non-storm water discharges through municipal separate storm sewer systems.

Several commenters requested that the terms discharge and point source, in the context of permits for storm water discharge, be clarified. Several commenters stated that the EPA should clarify that storm water discharge does not include "sheet flow" off of an industrial facility. EPA interprets this as request for clarification on the status of the terms "point source" and "discharge" under these regulations. In response, this rulemaking only covers storm water discharges from point sources. A point source is defined at 40 CFR 122.2 as "any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff." EPA agrees with one commenter that this definition is adequate for defining what discharges of storm water are covered by this rulemaking. EPA notes that this definition would encompass municipal separate storm sewers. In view of this comprehensive definition of point source, EPA need clarify in this rulemaking only that a storm water discharge subject to NPDES regulation does not include storm water that enters the waters of the United States via means other than a "point source." As further discussed below, storm water from an industrial facility which enters and is subsequently discharged through a municipal separate storm sewer is a "discharge associated with industrial

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activity" which must be covered by an individual or general permit pursuant to today's rule.

EPA would also note that individual facilities have the burden of determining whether a permit application should be submitted to address a point source discharge. Those unsure of the classification of storm water flow from a facility, should file permit applications addressing the flow, or prior to submitting the application consult permitting authorities for clarification.

One commenter stated that "point source" for this rulemaking should be defined, for the purposes of achieving better water quality, as those areas where "discharges leave the municipal [separate storm sewer] system." EPA notes in response that "point source" as currently defined will address such discharges, while keeping the definition of discharge and point source within the framework of the NPDES program, and without adding potentially confusing and ambiguous additional definitions to the regulation. If this comment is asserting that the term point source should not include discharges from sources through the municipal system, EPA disagrees. As discussed in detail below, discharges through municipal separate storm sewer systems which are not connected to an operable treatment works are discharges subject to NPDES permit requirements at (40 CFR 122.3(c)), and may properly be deemed point sources.

One industry argued that the definition of "point source" should be modified for storm water discharges so as to exclude discharges from land that is not artificially graded and which has a propensity to form channels where precipitation runs off. EPA intends to embrace the broadest possible definition of point source consistent with the legislative intent of the CWA and court interpretations to include any identifiable conveyance from which pollutants might enter the waters of the United States. In most court cases interpreting the term "point source", the term has been interpreted broadly. For example, the holding in *Sierra Club* v. *Abston Construction Co., Inc.*, 620 F.2d 41 (5th Cir. 1980) indicates that changing the surface of land or establishing grading patterns on land will result in a point source where the runoff from the site is ultimately discharged to waters of the United States:

> Simple erosion over the material surface, resulting in the discharge of water and other materials into navigable waters, does not constitute a point source discharge, absent some effort to *change the surface*, to *direct* the water flow or otherwise impede its progress * * * Gravity flow, resulting in a discharge into a navigable body of water, may be part of a point source discharge if the [discharger] at least initially collected or channeled the water and other materials. A point source of pollution may also be present where [dischargers] design spoil piles from discarded overburden such that, during periods of precipitation, erosion of spoil pile walls results in discharges into a navigable body of water by means of ditches, gullies and similar conveyances, even if the [dischargers] have done nothing beyond the mere collection of rock and other materials * * * Nothing in the Act relieves [dischargers] from liability simply because the operators did not actually construct those conveyances, so long as they are reasonably likely to be the means by which pollutants are ultimately deposited into a navigable body of water. Conveyances of pollution formed either as a result of natural erosion or by material means, and which constitute a component of a * * * drainage system, may fit the statutory definition and thereby subject the operators to liability under the Act." 620 F.2d at 45 (emphasis added).

Under this approach, point source discharges of storm water result from structures which increase the imperviousness of the ground which acts to collect runoff, with runoff being conveyed along the resulting drainage or grading patterns.

The entire thrust of today's regulation is to control pollutants that enter receiving water from storm water conveyances. It is these conveyances that will carry the largest volume of water and higher levels of pollutants. The storm water permit application process and permit conditions will address circumstances and discharges peculiar to individual facilities.

One industry commented that the definition of waters of the State under some State NPDES programs included municipal storm sewer systems. The commenter was concerned that certain industrial facilities discharging through municipal storm sewers in these states would be required to obtain an NPDES permit, despite EPA's proposal not to require permits from such facilities generally. In response, EPA notes that section 510 of the CWA, approved States are able to have stricter requirements in their NPDES program. In approved NPDES States, the definition of waters of the State controls with regard to what constitutes a discharge to a water body. However, EPA believes that this will have little impact, since, as discussed below, all industrial dischargers, including those discharging through municipal separate storm sewer systems, will be subject to general or individual NPDES permits, regardless of any additional State requirements.

One municipality commented that neither the term "point source" nor "discharge" should be used in conjunction with industrial releases into urban storm water systems because that gives the impression that such systems are navigable waters. EPA disagrees that any confusion should result from the use of these terms in this context. In this rulemaking, EPA always addresses such discharges as "discharges through municipal separate storm sewer systems" as opposed to "discharges to waters of the United States." Nonetheless, such industrial discharges through municipal storm sewer systems are subject to the requirements of today's rule, as discussed elsewhere.

One commenter desired clarification with regard to what constituted an outfall, and if an outfall could be a pipe that connected two storm water conveyances. This rulemaking defines outfall as a point of discharge into the waters of the United States, and not a conveyance which connects to Sections of municipal separate storm sewer. In response to another comment, this rulemaking only addresses discharges to waters of United States, consequently discharges to ground waters are not covered by this rulemaking (unless there is a hydrological connection between the ground water and a nearby surface water body. *See, e.g., Exxon Corp.* v. *Train*, 554 F.2d 1310, 1312 n.1 (5th Cir. 1977); *McClellan Ecological Seepage Situation* v. *Weinberger*, 707 F.Supp. 1182, 1195–96 (E.D. Cal. 1988)).

In the WQA and other places, the term "storm water" is presented as a single word. Numerous comments were received by EPA as to the appropriate spelling. Many of these comments recommended that two words for storm water is appropriate. EPA has decided to use an approach consistent with the Government Printing Office's approved form where storm water appears as two words.

C. Responsibility for Storm Water Discharges Associated With Industrial Activity Through Municipal Separate Storm Sewers

The December 7, 1988, notice of proposed rulemaking requested comments on the appropriate permitting scheme for storm water discharges, associated with industrial activity through municipal separate storm sewers. EPA proposed a permitting scheme that would define the requirement to obtain coverage under an NPDES permit for a storm water discharge associated with industrial activity through a municipal separate storm sewer in terms of the classification of the municipal separate storm sewer. EPA proposed holding municipal operators of large or medium

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municipal separate storm sewer systems primarily responsible for applying for and obtaining an NPDES permit covering system discharges as well as storm water discharges (including storm water discharges associated with industrial activity) through the system. Under the proposed approach, operators of storm water discharges associated with industrial activity which discharge through a large or medium municipal separate storm sewer system would generally not be required to obtain permit coverage for their discharge (unless designated as a significant contributor of pollution pursuant to section 402(p)(2)(E)) provided the municipality was notified of: The name, location and type of facility and a certification that the discharge has been tested (if feasible) for non-storm water (including the results of any testing). The notification procedure also required the operator of the storm water discharge associated with industrial activity to determine that: The discharge is composed entirely of storm water; the discharge does not contain hazardous substances in excess of reporting quantities; and the facility is in compliance with applicable provisions of the NPDES permit issued to the municipality for storm water.

In the proposal, EPA also requested comments on whether a decision on regulatory requirements for storm water discharges associated with industrial activity through other municipal separate storm sewer systems (generally those serving a population of less than 100,000) should be postponed until completion of two studies of storm water discharges required under section 402(p)(5) of the CWA.

EPA favored these approaches because they appeared to reduce the potential administrative burden associated with preparing and processing the thousands of permit applications associated with the rulemaking and provide EPA additional flexibility in developing permitting requirements for storm water discharges associated with industrial activity. EPA also expressed its belief, based upon an analysis of ordinances controlling construction site runoff in place in certain cities, that municipalities generally possessed legal authority sufficient to control contributions of industrial storm water pollutants to their separate storm sewers to the degree necessary to implement the proposed rule. EPA commented that municipal controls on industrial sources implemented to comply with an NPDES permit issued to the municipality would likely result in a level of storm water pollution control very similar to that put directly on the industrial source through its own NPDES permit. This was to be accomplished by requiring municipal permitees, to the maximum extent practicable, to require industrial facilities in the municipality to develop and implement storm water controls based on a consideration of the same or similar factors as those used to make BAT/BCT determinations. (*See* 40 CFR 125.3 (d)(2) and (d)(3)).

The great majority of commenters on the December 7, 1988, notice addressed this aspect of the proposal. Based on consideration of the comments received on the notice, EPA has decided that it is appropriate to revise the approach in its proposed rule to require direct permit coverage for all storm water discharges associated with industrial activity, including those that discharge through municipal separate storm sewers. In response to this decision, EPA has continued to analyze the appropriate manner to respond to the large number of storm water discharges subject to this rulemaking. The development of EPA's policy regarding permitting these discharges is discussed in more detail in the section VI.D of today's preamble.

EPA notes that the status of discharges associated with industrial activity which pass through a municipal separate storm sewer system under section 402(p) raises difficult legal and policy questions. EPA believes that treating these discharges under permits separate from those issued to the municipality will most fully address both the legal and policy concerns raised in public comment.

Certain commenters supported EPA's proposal. Some commenters claimed that EPA lacked any authority to permit industrial discharges which were not discharged immediately to waters of the U.S. Other commenters agreed with EPA's statements in the proposal that its approach would result in a more manageable administrative burden for EPA and the NPDES states. However, numerous comments also were received which provided various arguments in support of revising the proposed approach. These comments addressed several areas including the definition of discharge under the CWA, the requirements and associated statutory time frames of section 402(p), as well as the resource and enforcement constraints of municipalities. EPA is persuaded by these comments and has modified its approach accordingly. The key comments on this issue are discussed below.

EPA disagrees with commenters who suggested that EPA lacks authority to permit separately industrial discharges through municipal sewers. The CWA prohibits the discharge of a pollutant except pursuant to an NPDES permit. Section 502(12)(A) of the CWA defines the "discharge of a pollutant" as "any addition of any pollutant to navigable waters from any point source." [3] There is no qualification in the statutory language regarding the source of the pollutants being discharged. Thus, pollutants from a remote location which are discharged through a point source conveyance controlled by a different entity (such as a municipal storm sewer) are nonetheless discharges for which a permit is required.

EPA's regulatory definition of the term "discharge" reflects this broad construction. EPA defines the term to include

> additions of pollutants into waters of the United States from: surface runoff which is collected or channelled by man; *discharges through pipes, sewers, or other conveyances owned by a State, municipality, or other person which does not lead to a treatment works;* and discharges through pipes, sewers, or other conveyances, leading into privately owned treatment works.

40 CFR § 122.2 (1989) (emphasis added). The only exception to this general rule is the one contemplated by section 307(b) of the CWA, *i.e.*, the introduction of pollutants into publicly-owned treatment works. EPA treats these as "indirect discharges," subject not to NPDES requirements, but to pretreatment standards under section 307(b).

In light of its construction of the term discharge, EPA has consistently maintained that a person who sends pollutants from a remote location through a point source into a water of the U.S. may be held liable for the unpermitted discharge of that pollutant. Thus, EPA asserts the authority to require a permit either from the operator of the point source conveyance, (such as a municipal storm sewer or a privately-owned treatment works), or from any person causing pollutants to be present in that conveyance and discharged through the point source, or both. *See Decision of the General Counsel (of EPA) No. 43* ("In re Friendswood Development Co.") (June 11, 1976) (operator of privately owned treatment work and dischargers to it are both subject to NPDES permit requirements). *See also*, 40 CFR 122.3(g), 122.44(m).

[3] Indeed, the DC Circuit has held, in the storm water context, that EPA may not exempt any point source discharges of pollutants from the requirement to obtain an NPDES permit. *NRDC v. Costle*, 568 F.2d 1369, 1377 (DC Cir. 1977).

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(NPDES permit writer has discretion to permit contributors to a privately owned treatment works as direct dischargers). In other words, where pollutants are added by one person to a conveyance owned/operated by another person, and that conveyance discharges those pollutants through a point source, EPA may permit either person or both to ensure that the discharge is properly controlled. Pollutants from industrial sites discharged through a storm sewer to a point source are appropriately treated in this fashion.

Furthermore, EPA believes that storm water from an industrial plant which is discharged through a municipal storm sewer is a "discharge associated with industrial activity." Today's rule, as in the proposal, defines discharges associated with industrial activity solely in terms of the origin of the storm water runoff. There is no distinction for how the storm water reaches the waters of the U.S. In other words, pollutants in storm water from an industrial plant which are discharged are "associated with industrial activity," regardless of whether the industrial facility operates the conveyance discharging the storm water (or whether the storm water is ultimately discharged through a municipal storm sewer). Indeed, there is no distinction in the "industrial" nature of these two types of discharges. The pollutants of concern in an industrial storm water discharge are present when the storm water leaves the facility, either through an industrial or municipal storm water conveyance. EPA has no data to suggest that the pollutants in industrial storm water entering a municipal storm sewer are any different than those in storm water discharged immediately to a water of the U.S. Thus, industrial storm water in a municipal sewer is properly classified as "associated with industrial activity." Although EPA proposed not to cover these discharges by separate permit, the Agency believes that it is clearly not precluded from doing so.

Many comments also supported the proposed approach, noting that holding municipalities primarily responsible for obtaining a permit which covers industrial storm water discharges through municipal systems would reduce the administrative burden associated with preparing and processing thousands of permit applications—permit applications that would be submitted if each industrial discharger through a large or medium municipal separate storm sewer system had to apply individually (or as part of a group application).

EPA appreciates these concerns. Yet EPA also recognizes that there are also significant problems with putting the burden of controlling these sources on the municipalities (except for designated discharges) which must be balanced with the concerns about the permit application burden on industries. The industrial permitting strategy discussed in section VI.D below attempts to achieve this balance.

EPA also does not believe that the administrative burden will be nearly as significant as originally thought, for several reasons. First, as discussed in section VI.F.2 below and in response to significant public comment, EPA has significantly narrowed the scope of the definition of "associated with industrial activity" to focus in on those facilities which are most commonly considered "industrial" and thought to have the potential for the highest levels of pollutants in their storm water discharges. EPA believes this is a more appropriate way to ensure a manageable scope for the industrial storm water program in light of the statutory language of section 402(p), since it does not attempt to arbitrarily distinguish industrial facilities on the basis of the ownership of the conveyance through which a facility discharges its storm water. Second, EPA's industrial permitting strategy discussed in section VI.D is designed around aggressive use of general permits to cover the vast majority of industrial sources. These general permits will require industrial facilities to develop storm water control plans and practices similar to those that would have been required by the municipality. Yet, general permits will eliminate the need for thousands of individual or group permit applications, greatly reducing the burden on both industry EPA/States. Finally, even under the proposal, EPA believes that a large number of industrial dischargers would have been appropriate for designation for individual permitting under section 402(p)(2)(E), with the attendant individual application requirements. Today's approach will actually decrease the overall burden on these facilities; rather than filing an individual permit application upon designation, these facilities will generally be covered by a general permit.

By contrast, several commenters asserted that not only does EPA have the authority to cover these discharges by separate permit, it is required to by the language of section 402(p). As discussed above, storm water from an industrial plant which passes through a municipal storm sewer to a point source and is discharged to waters of the U.S. is a "discharge associated with industrial activity." Therefore, it is subject to the appropriate requirements of section 402(p). The operator of the discharge (or the industrial facility where the storm water originates) must apply for a permit within three years of the 1987 amendments (*i.e.*, Feb. 4, 1990);[8] EPA must issue a permit by one year later (Feb. 4, 1991); and the permit must require compliance within three years of permit issuance. That permit must ensure that the discharge is in compliance with all appropriate provisions of sections 301 and 402. Commenters asserted that EPA's proposal would violate these two requirements of the law. First, the statute requires all industrial storm water discharges to obtain a permit in the first round of permitting (*i.e.*, February 4, 1990). However, Congress established a different framework to address discharges from small municipal separate storm sewer systems. Section 402(p) requires EPA to complete two studies of storm water discharges, and based on those studies, promulgate additional regulations, including requirements for state storm water management programs by October 1, 1992. EPA is prohibited from issuing permits for storm water discharges from small municipal systems until October 1, 1992 unless the discharge is designated under section 402(p)(2)(E). Thus, industrial storm water discharges from these systems would not be covered by a permit until later than contemplated by statute. Second, permits for municipal storm sewer systems require controls on storm water discharges "to the maximum extent practicable," as opposed to the BAT/BCT requirements of section 301(b)(2). Yet, all industrial storm water discharges must comply with section 301(b)(2). Thus, covering industrial storm water under a municipal storm water permit will not ensure the legally-required level of control of industrial storm water discharges.

In addition to comments on the requirements of section 402(p), EPA received several comments questioning whether EPA's proposal to cover industrial pollutants in municipal separate storm sewers solely in the permit issued to the municipality would ensure adequate control of these pollutants due to both inadequate [illegible]

[8] It should be noted that EPA did not [illegible] the required storm water regulations by February [illegible] 1989, as contemplated by section [illegible]. As discussed below, today's rule generally requires industrial storm water dischargers to file a permit application [illegible] year.

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resources and enforcement. Some municipalities stated that the burdens of this responsibility would be too great with regard to source identification and general administration of the program. These commenters claimed they lacked the necessary technical and regulatory expertise to regulate such sources. Commenters also noted that additional resources to control these sources would be difficult to obtain given the restrictions on local taxation in many states and the fact that EPA will not be providing funding to local governments to implement their storm water programs.

Municipalities also expressed concerns regarding enforcement of EPA's proposed approach. Some municipalities remarked that they did not have appropriate legal authority to address these discharges. Several commenters also stated that requiring municipalities to be responsible for addressing storm water discharges associated with industrial activity through their municipal system would result in unequal treatment of industries nationwide because of different municipal requirements and enforcement procedures. Several municipal entities expressed concern with regard to their responsibility and liability for pollutants discharged to their municipal storm sewer system, and further asserted that it was unfair to require municipalities to bear the full cost of controlling such pollutants. Other municipalities suggested that overall municipal storm water control would be impaired, since municipalities would spend a disproportionate amount of resources trying to control industrial discharges through their sewers, rather than addressing other storm water problems. In a related vein, certain commenters suggested that, where industrial storm water was a significant problem in a municipal sewer, EPA's proposed approach would hamper enforcement at the federal/state level, since all enforcement measures could be directed only at the municipality, rather than at the most direct source of that problem.

In response to all of these concerns, EPA has decided to require storm water discharges associated with industrial activity which discharge through municipal separate storm sewers to obtain separate individual or general NPDES permits. EPA believes that this change will adequately address all of the key concerns raised by commenters.

The Agency was particularly influenced by concerns that many municipalities lacked the authority under state law to address industrial storm water practices. EPA had assumed that since several cities regulate construction site activities, that they could regulate other industrial operations in a similar manner. Several commenters suggested otherwise. In light of these concerns, EPA agrees with certain commenters that municipal controls on industrial facilities, in lieu of federal control, might not comply with section 402(p)(3)(A) for those facilities.[3] This calls into question whether EPA's proposed approach would have reasonably implemented Congressional intent to address industrial storm water early and stringently in the permitting process.

EPA also agrees with those commenters who argued that municipal controls on industrial storm water sources were not directly analogous to the pretreatment program under section 307(b), as EPA suggested in the preamble to the proposal. The authority of cities to control the type and volume of industrial pollutants into a POTW is generally unquestioned under the laws of most states, since sewage and industrial waste treatment is a service provided by the municipality. Thus, EPA has greater confidence that cities can and will adopt effective pretreatment programs. By contrast, many cities are limited in the types of controls they can impose on flows into storm sewers; cities are more often limited to regulations on quantity of industrial flows to prevent flooding the system. So too, the pretreatment program allows for federal enforcement of local pretreatment requirements. Enforcement against direct dischargers (including dischargers through municipal storm sewers) is possible only when the municipal requirements are contained in an NPDES permit.

Although today's rule will require industrial discharges through municipal storm sewers to be covered by separate permit, EPA still believes that municipal operators of large and medium municipal systems have an important role in source identification and the development of pollutant controls for industries that discharge storm water through municipal separate storm sewer systems is appropriate. Under the CWA, large and medium municipalities are responsible for reducing pollutants in discharges from municipal separate storm sewers to the maximum extent practicable. Because storm water from industrial facilities may be a major contributor of pollutants to municipal separate storm sewer systems, municipalities are obligated to develop controls for storm water discharges associated with industrial activity through their system in their storm water management program. (*See* section VI.H.7. of today's preamble.) The CWA provides that permits for municipal separate storm sewers shall require municipalities to reduce pollutants to the maximum extent practicable. Permits issued to municipalities for discharges from municipal separate storm sewers will reflect terms, specified controls, and programs that achieve that goal. As with all NPDES permits, responsibility and liability is determined by the discharger's compliance with the terms of the permit. A municipality's responsibility for industrial storm water discharged through their system is governed by the terms of the permit issued. If an industrial source discharges storm water through a municipal separate storm sewer in violation of requirements incorporated into a permit for the industrial facility's discharge, that industrial operator of the discharge may be subject to an enforcement action instituted by the Director of the NPDES program.

Today's rule also requires operators of storm water discharges associated with industrial activity through large and medium municipal systems to provide municipal entities of the name, location, and type of facility that is discharging to the municipal system. This information will provide municipalities with a base of information from which management plans can be devised and implemented. This requirement is in addition to any requirements contained in the industrial facility's permit. As in the proposal, the notification process will assist cities in development of their industrial control programs.

EPA intends for the NPDES program, through requirements in permits for storm water discharges associated with industrial activity, to work in concert with municipalities in the industrial component of their storm water management program efforts. EPA believes that permitting of municipal storm sewer systems and the industrial discharges through them will act in a complementary manner to fully control the pollutants in those sewer systems. This will fully implement the intent of

[3] EPA notes that the legal issue raised by commenters regarding whether industrial storm water would be controlled to BAT if covered by a municipal permit at the MEP level is primarily a theoretical issue. As explained above, the proposal assumed that cities would establish controls on industry very similar to those established in an NPDES permit using best professional judgment. EPA's key concern, rather, is whether cities can, in fact, establish such controls. Thus, today's final rule should not appreciably change the requirements to be imposed on industrial sources, only how those requirements are enforced.

Congress to control industrial as well as large and medium municipal storm water discharges as expeditiously and effectively as possible. This approach will also address the concerns of municipalities that they lack sufficient authority and resources to control all industrial contributions to their storm sewers and will be liable for discharges outside of their control.

The permit application requirements for large and medium municipal separate storm sewer systems, discussed in more detail later in today's preamble, address the responsibilities of the municipal operators of these systems to identify and control pollutants in storm water discharges associated with industrial activity. Permit applications for large and medium municipal separate storm sewer systems are to identify the location of facilities which discharge storm water associated with industrial activity to the municipal system (*see* section VI.H.7. of the preamble). In addition, municipal applicants will provide a description of a proposed management program to reduce, to the maximum extent practicable, pollutants from storm water discharges associated with industrial activity which discharge to the municipal system (*see* section VI.H.7.c of this preamble). EPA notes that each municipal program will be tailored to the conditions in that city. Differences in regional weather patterns, hydrology, water quality standards, and storm sewer systems themselves dictate that storm water management practices will vary to some degree in each municipality. Accordingly, similar industrial storm water discharges may be treated differently in terms of the requirements imposed by the municipality, depending on the municipal program. Nonetheless, any individual or general permit issued to the industrial facility must comply with section 402(p)(3)(A) of the CWA.

EPA intends to provide assistance and guidance to municipalities and permitting authorities for developing storm water management programs that achieve permit requirements. EPA intends to issue a guidance document addressing municipal permit applications in the near term.

Controls developed in management plans for municipal system permits may take a variety of forms. Where necessary, municipal permittees can pursue local remedies to develop measures to reduce pollutants or halt storm water discharges with high levels of pollutants through municipal storm sewer systems. Some local entities have already implemented ordinances or laws that are designed to reduce the discharge of pollutants to municipal separate storm sewers, while other municipalities have developed a variety of techniques to control pollutants in storm water. Alternatively, where appropriate, municipal permittees may develop end-of-pipe controls to control pollutants in these discharges such as regional wet detention ponds or diverting flow to publicly owned treatment works. Finally, municipal applicants may bring individual storm water discharges, which cannot be adequately controlled by the municipal permittees or general permit coverage, to the attention of the permitting authority. Then, at the Director's discretion, appropriate additional controls can be required in the permit for the facility generating the targeted storm water discharge.

One commenter suggested that municipal operators of municipal separate storm sewers should have control over all storm water discharges from a facility that discharges both through the municipal system and to waters of the United States. In response, under this regulatory and statutory scheme, industries that discharge storm water directly into the waters of the United States, through municipal separate storm sewer systems, or both are required to obtain permit coverage for their discharges. However, municipalities are not precluded from exercising control over such facilities through their own municipal authorities.

It is important to note that EPA has established effluent guideline limitations for storm water discharges for nine subcategories of industrial dischargers (Cement Manufacturing (40 CFR part 411), Feedlots (40 CFR part 412), Fertilizer Manufacturing (40 CFR part 418), Petroleum Refining (40 CFR part 419), Phosphate Manufacturing (40 CFR part 422), Steam Electric (40 CFR part 423), Coal Mining (40 CFR part 434), Ore Mining and Dressing (40 CFR part 440) and Asphalt (40 CFR part 441)). Most of the existing facilities in these subcategories already have individual permits for their storm water discharges. Under today's rule, facilities with existing NPDES permits for storm water discharges through a municipal storm sewer will be required to maintain these permits and apply for an individual permit, under § 122.26(c), when existing permits expire. EPA received numerous comments supporting this decision because requiring facilities that have existing permits to comply with today's requirements immediately would be inefficient and not serve improved water quality.

Sections 402(p) (1) and (2) of the CWA provide that discharges from municipal separate storm sewer systems serving a population of less than 100,000 are not required to obtain a permit prior to October 1, 1992, unless designated on a case-by-case basis under section 402(p)(2)(E). However, as discussed above, storm water discharges associated with industrial activity through such municipal systems are not excluded. Thus, under today's rule, all storm water discharges associated with industrial activity that discharge through municipal separate storm sewer systems are required to obtain NPDES permit coverage, including those which discharge through systems serving populations less than 100,000. EPA believes requiring permits will address the legal concerns raised by commenters regarding these sources. In addition, it will allow for control of these significant sources of pollution while EPA continues to study under section 402(p)(6) whether to require the development of municipal storm water management plans in these municipalities. If these municipalities do ultimately obtain NPDES permits for their municipal separate storm sewer systems, early permitting of the industrial contributions may aid those cities in their storm water management efforts.

In the December 7, 1988, proposal, EPA recognized that storm water discharges associated with industrial activity from Federal facilities through municipal separate storm sewer systems may pose unique legal and administrative situations. EPA received numerous comments on this issue, with most of these comments coming from cities and counties. The comments reflected a general concern with respect to a municipality's ability to control Federal storm water discharges through municipal separate storm sewer systems. Most municipalities stated that they do not have the legal authority to adequately enforce against problem storm water discharges from Federal facilities and that these facilities should be required to obtain separate storm water permits. Some commenters stated that they have no Constitutional authority to regulate Federal facilities or establish regulation for such facilities. Some commenters indicated that Federal facilities could not be inspected, monitored, or subjected to enforcement for national security and other jurisdictional reasons. Some commenters argued that without clearly stated legal authority for the municipality, such discharges should be required to obtain permits. One

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municipality pointed out that Federal facilities within city limits are exempted from their Erosion and Sediment Control Act and that permits for these facilities should be required.

Under today's rule, Federal facilities which discharge storm water associated with industrial activity through municipal separate storm sewer systems will be required to obtain NPDES permit coverage under Federal or State law. EPA believes this will cure the legal authority problems at the local level raised by the commenters. EPA notes that this requirement is consistent with section 313(a) of the CWA.

D. Preliminary Permitting Strategy for Storm Water Discharges Associated With Industrial Activity

Many of the comments received on the December 7, 1988, proposal focused on the difficulties that EPA Regions and authorized NPDES States, with their finite resources, will have in implementing an effective permitting program for the large number of storm water discharges associated with industrial activity. Many commenters noted that problems with implementing permit programs are caused not only by the large number of industrial facilities subject to the program, but by the difficulties associated with identifying appropriate technologies for controlling storm water at various sites and the differences in the nature and extent of storm water discharges from different types of industrial facilities.

EPA recognizes these concerns; and based on a consideration of comments from authorized NPDES States, municipalities, industrial facilities and environmental groups on the permitting framework and permit application requirements for storm water discharges associated with industrial activity, EPA is in the process of developing a preliminary strategy for permitting storm water discharges associated with industrial activity. In developing this strategy, EPA recognizes that the CWA provides flexibility in the manner in which NPDES permits are issued.[4] EPA intends to use this flexibility in designing a workable and reasonable permitting system. In accordance with these considerations, EPA intends to publish in the near future a discussion of its preliminary permitting strategy for implementing the NPDES storm water program.

The preliminary strategy is intended to establish a framework for developing permitting priorities, and includes a four tier set of priorities for issuing permits to be implemented over time:

- *Tier I—baseline permitting:* One or more general permits will be developed to initially cover the majority of storm water discharges associated with industrial activity;
- *Tier II—watershed permitting:* Facilities within watersheds shown to be adversely impacted by storm water discharges associated with industrial activity will be targeted for permitting.
- *Tier III—industry specific permitting:* Specific industry categories will be targeted for individual or industry-specific permits; and
- *Tier IV—facility specific permitting:* A variety of factors will be used to target specific facilities for individual permits.

Tier I—Baseline Permitting

EPA intends to issue general permits that initially cover the majority of storm water discharges associated with industrial activity in States without authorized NPDES programs. These permits will also serve as models for States with authorized NPDES programs.

The consolidation of many sources under one permit will greatly reduce the otherwise overwhelming administrative burden associated with permitting storm water discharges associated with industrial activity. This approach has a number of additional advantages, including:

- Requirements will be established for discharges covered by the permit;
- Facilities whose discharges are covered by the permit will have an opportunity for substantial compliance with the CWA;
- The public, including municipal operators of municipal separate storm sewers which may receive storm water discharges associated with industrial activity, will have access under section 308(b) of the CWA to monitoring data and certain other information developed by the permittee;
- EPA will have the opportunity to begin to collect and review data on storm water discharges from priority industries, thereby supporting the development of subsequent permitting activities;
- Applicable requirements of municipal storm water management programs established in permits for discharges from municipal separate storm sewer systems will be enforceable directly against non-complying industrial facilities that generate the discharges;
- The public will be given an opportunity to comment on permitting activities;
- The baseline permits will provide a basis for bringing selected enforcement actions by eliminating many issues which might otherwise arise in an enforcement proceeding; and
- Finally, the baseline permits will provide a focus for public comment on the development of subsequent phases of the permitting strategy for storm water discharges, including the development of priorities for State storm water management programs developed under section 402(p)(6) of the CWA.

Initially, the coverage of the baseline permits will be broad, but the coverage is intended to shrink as other permits are issued for storm water discharges associated with industrial activities pursuant to Tier II through IV activities.

2. Tier II—Watershed Permitting

Facilities within watersheds shown to be adversely impacted by storm water discharges associated with industrial activity will be targeted for individual and general permitting. This process can be initiated by identifying receiving waters (or segments of receiving waters) where storm water discharges associated with industrial activity have been identified as a source of use impairment or are suspected to be contributing to use impairment.

3. Tier III—Industry Specific Permitting

Specific industry categories will be targeted for individual or industry-specific general permits. These permits will allow permitting authorities to focus attention and resources on industry categories of particular concern and/or industry categories where tailored requirements are appropriate. EPA will work with the States to coordinate the development of model permits for selected classes of industrial storm water discharges. EPA is also working to identify priority industrial categories in the two reports to Congress required under section 402(p)(5) of the CWA. In addition, group applications that are received can be used to develop model permits for the appropriate industries.

[4] The courts in *NRDC v. Train*, 396 F.Supp. 1393 (D.D.C. 1975) *aff'd. NRDC v. Costle*, 568 F.2d 1369 (DC Cir. 1977), have acknowledged the administrative burden placed on the Agency by requiring individual permits for a large number of storm water discharges. These courts have recognized EPA's discretion to use certain administrative devices, such as area permits or general permits to help manage its workload. In addition, the courts have recognized flexibility in the type of permit conditions that are established, including requirements for best management practices.

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4. Tier IV—Facility Specific Permitting

Individual permits will be appropriate for some storm water discharges in addition to those identified under Tier II and III activities. Individual permits should be issued where warranted by: the pollution potential of the discharge; the need for individual control mechanisms; and in cases where reduced administrative burdens exist. For example, individual NPDES permits for facilities with process discharges should be expanded during the normal process of permit reissuance to cover storm water discharges from the facility.

5. Relationship of Strategy to Permit Applications Requirements

The preliminary long-term permitting strategy described above identifies several permit schemes that EPA anticipates will be used in addressing storm water discharges associated with industrial activity. One issue that arises with this strategy is determining the appropriate information needed to develop and issue permits for these discharges. The NPDES regulatory scheme provides three major options for obtaining permit coverage for storm water discharges associated with industrial activity: (1) Individual permit applications; (2) group applications; and (3) case-by-case requirements developed for general permit coverage.

a. *Individual permit application requirements.* Today's notice establishes requirements for individual permit applications for storm water discharges associated with industrial activity. These application requirements are applicable for all storm water discharges associated with industrial activity, except where the operator of the discharge is participating in a group application or a general permit is issued to cover the discharge and the general permit provides alternative means to obtain permit coverage. Information in individual applications is intended to be used in developing the site-specific conditions generally associated with individual permits.

Individual permit applications are expected to play an important role in all tiers of the Strategy, even where general permits are used. Although general permits may provide for notification requirements that operate in lieu of the requirement to submit individual permit applications, the individual permit applications may be needed under several circumstances. Examples include: where a general permit requires the submission of a permit application as the notice of intent to be covered by the permit; where the owner or operator authorized by a general permit requests to be excluded from the coverage of the general permit by applying for a permit (*see* 40 CFR 122.28(b)(2)(iii) for EPA issued general permits); and where the Director requires an owner or operator authorized by a general permit to apply for an individual permit (*see* 40 CFR 122.28(b)(2)(ii) for EPA issued general permits).

b. *Group applications.* Today's rule also promulgates requirements for group applications for storm water discharges associated with industrial activity. These applications provide participants of groups with sufficiently similar storm water discharges an alternative mechanism for applying for permit coverage.

The group application requirements are primarily intended to provide information for developing industry specific general permits. (Group applications can also be used to issue individual permits in authorized NPDES States without general permit authority or where otherwise appropriate). As such, group application requirements correlate well with the Tier III permitting activities identified in the long-term permitting Strategy.

c. *Case-by-case requirements.* 40 CFR 122.21(a) excludes persons covered by general permits from requirements to submit individual permit applications. Further, the general permit regulations at 40 CFR 122.28 do not address the issue of how a potential permittee is to apply to be covered under a general permit. Rather, conditions for notification of intent (NOI) to be covered by the general permit are established in the permits on a case-by-case basis, and operate in lieu of permit application requirements. Requirements for submitting NOIs to be covered by a general permit can range from full applications (this would be Form 1 and Form 2F for most discharges composed entirely of storm water discharges associated with industrial activity), to no notice. EPA recommends that the NOI requirements established in a general permit for storm water discharges associated with industrial activity be commensurate with the needs of the permit writer in establishing the permit and the permit program. The baseline general permit described in Tier I is intended to support the development of controls for storm water discharges associated with industrial activity that can be supported by the limited resources of the permitting Agency. In this regard, the burdens of receiving and reviewing NOI's from the large number of facilities covered by the permit should also be considered when developing NOI requirements. In addition, NOI requirements should be developed in conjunction with permit conditions establishing reporting requirements during the term of the permit.

NOI requirements in general permits can establish a mechanism which can be used to establish a clear accounting of the number of permittees covered by the general permit, the nature of operations at the facility generating the discharge, their identity and location. The NOI can be used as an initial screening tool to determine discharges where individual permits are appropriate. Also, the NOI can be used to identify classes of discharges appropriate for more specific general permits, as well as provide information needed to notify such dischargers of the issuance of a more specific general permit. In addition, the NOI can provide for the identification of the permittee to provide a basis for enforcement and compliance monitoring strategies. EPA will further address this issue in the context of specific general permits it plans to issue in the near future.

Today's rule requires that individual permit applications for storm water discharges associated with industrial activity be submitted within one year from the date of publication of this notice. EPA is considering issuing general permits for the majority of storm water discharges associated with industrial activity in those States and territories that do not have authorized State NPDES programs (MA, ME, NH, FL, LA, TX, OK, NM, SD, AZ, AK, ID, District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands) before that date to enable industrial dischargers of storm water to ascertain whether they are eligible for coverage under a general permit (and subject to any alternative notification requirements established by the general permit in lieu of the individual permit application requirements of today's rule) or whether they must submit an individual permit application (or participate in a group application) before the regulatory deadlines for submitting these applications passes. Storm water application deadlines are discussed in further detail below.

E. Storm Water Discharge Sampling

Storm water discharges are intermittent by their nature, and pollutant concentrations in storm water discharges will be highly variable. Not only will variability arise between storm events, but the flow and pollutant

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concentrations of such discharges will vary with time during an event. This variability raises two technical problems: how best to characterize the discharge associated with a single storm event; and how best to characterize the variability between discharges of different events that may be caused by seasonal changes and changes in material management practices, for example.

Prior to today's rulemaking, 40 CFR 122.21(g)(7) required that applicants for NPDES permits submit quantitative data based on one grab sample taken every hour of the discharge for the first four hours of discharge. EPA has modified this requirement such that, instead of collecting and analyzing four grab samples individually, applicants for permits addressing storm water discharges associated with industrial activity will provide data as indicators of two sets of conditions: data collected during the first 30 minutes of discharge and flow-weighted average storm event concentrations. Large and medium municipalities will provide data on flow-weighted average storm event concentrations only.

Data describing pollutants in a grab sample taken during the first few minutes of the discharge can often be used as a screen for non-storm water discharges to separate storm sewers because such pollutants may be flushed out of the system during the initial portion of the discharge. In addition, data from the first few minutes of a discharge are useful because much of the traditional structural technology used to control storm water discharges, including detention and retention devices, may only provide controls for the first portion of the discharge, with relatively little or no control for the remainder of the discharge. Data from the first portion of the discharge will give an indication of the potential usefulness of these techniques to reduce pollutants in storm water discharges. Also, such discharges may be primarily responsible for pollutant shocks to the ecosystem in receiving waters.

Studies such as NURP have shown that flow-weighted average concentrations of storm water discharges are useful for estimating pollutant loads and for evaluating certain concentration-based water quality impacts. The use of flow-weighted composite samples are also consistent with comments raised by various industry representatives during previous Agency rulemakings that continuous monitoring of discharges from storm events is necessary to adequately characterize such discharges.

EPA requested comment on the feasibility of the proposed modification of sampling procedures at § 122.21(g)(7) and the ability to characterize pollutants in storm water discharges with an average concentration from the first portion of the discharge compared to collecting and separately analyzing four grab samples. It was proposed that an event composite sample be collected, as well as a grab sample collected during the first 20 minutes of runoff. Comments were solicited as to whether or not this sampling method would provide better definition of the storm load for runoff characterization than would the requirement to collect and separately analyze four grab samples.

Many commenters questioned the ability to obtain a 20 minute sample in the absence of automatic samplers. Some believed that pollutants measured by such a sample can be accounted for in the event composite sample. Others argued that this is an unwarranted sampling effort if municipal storm water management plans are to be geared to achieving annual pollutant load reductions. Many commenters advised that problems accessing sampling stations and mobilizing sampling crews, particularly after working hours, made sampling during the first 20 minutes impractical. These comments were made particularly with respect to municipalities, where the geographical areas could encompass several hundred square miles. Several alternatives were suggested including: the collection of a sample in the first hour, and representative grab sampling in the next three hours, one per hour; or perform time proportioned sampling for up to four hours.

Because of the logistical problems associated with collecting samples during the first few minutes of discharge from municipal systems, EPA will only require such sampling from industrial facilities. Municipal systems will be spread out over many square miles with sampling locations potentially several miles from public works departments or other responsible government agencies. Reaching such locations in order to obtain samples during the first few minutes of a storm event may prove impossible. For essentially the same reasons, the requirement has been modified to encompass the first 30 minutes of the discharge, instead of 20 minutes, for industrial discharges. The rule also clarifies that the sample should be taken during the first 30 minutes or as soon thereafter as practicable. Where appropriate, characterization of this portion of the discharge from selected outfalls or sampling points may be a condition to permits issued to municipalities. With regard to protocols for the collection of sample aliquots for flow-weighted composite samples, § 122.21(g)(7) provides that municipal applicants may collect flow-weighted composite samples using different protocols with respect to the time duration between the collection of sample aliquots, subject to the approval of the Director or Regional Administrator. In other words, the period may be extended from 15 minutes to 20 or 25 minutes between sample aliquots, or decreased from 15 to 10 or 5 minutes.

Other comments raised issues that apply both to the impact of runoff characterization and the first discharge representation. These primarily pertained to regions that have well defined wet and dry seasons. Comments questioned whether or not it is fair to assume that the initial storm or two of a wet season, which will have very high pollutant concentrations, are actually representative of the runoff concentrations for the area.

In response, EPA believes that it is important to represent the first part of the discharge either separately or as a part of the event composite samples. This loading is made up primarily of the mass of unattached fine particulates and readily soluble surface load that accumulates between storms. This load washes off of the basin's directly connected paved surfaces when the runoff velocities reach the level required for entrainment of the particulate load into the surface flow. It should be noted that for very fine particulates and solubles, this can occur very soon after the storm begins and much sooner than the peak flow. The first few minutes of discharge represents a shock load to the receiving water, in terms of concentration of pollutants, because for many constituents the highest concentrations of the event will occur during this initial period. Due to the need to properly quantify this load, it is not necessary to represent the first discharge from the upper reaches of the outfall's tributary area. In runoff characterization basins, the assumption is that the land use in the basin is homogeneous, or nearly so, and that the first discharge from the lower reaches for all intents and purposes is representative of the entire basin. If a sample is taken during the first 30 minutes of the runoff, it will be composed primarily of first discharge. If the sample is taken at the outfall an hour into the event, it may contain

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discharge from the remote portions of the basin. It will not be representative of the discharge because it will also contain later washoff from the lower reaches of the basin, resulting in a low estimation of the first discharge load of most constituents. Conversely, larger suspended particulates that normally are not present in first discharge due to inadequate velocities will appear in this later sampling scenario because of the influence of higher runoff rates in the lower basin. Many commonly used management practices are designed based on their ability to treat a volume of water defined by the first discharge phenomenon. It is important to characterize the first discharge load because most management practices effectively treat only, or primarily, this load.

It should be noted that first discharge runoff is sometimes contaminated by non-storm water related pollutants. In many urban catchments, contaminants that result from illicit connections and illegal dumping may be stored in the system until "flushed" during the initial storm period. This does not negate the need for information on the characteristic first discharge load, but does indicate that the first phase field screen results for illicit connections should be used to help define those outfalls where this problem might exist.

Several methods can be used to develop an event average concentration. Either automatic or manual sampling techniques can be used that sample the entire hydrograph, or at least the first four hours of it, that will result in several discrete samples and associated flow rates that represent the various flow regimes of an event. These procedures have the potential for providing either an event average concentration, an event mean concentration, or discrete definition of the washoff process. Automatic sampling procedures are also available that collect a single composite sample, either on a time-proportioned or flow proportioned basis.

When discrete samples are collected, an event average composite sample can be produced by the manual composite of the discrete samples in equal volumes. Laboratory analysis of time-proportioned composite samples will directly yield the event average concentration. Mathematical averaging of discrete sample analysis results will yield an event average concentration.

When discrete samples are collected, a flow-weighted composite sample can be produced based on the discharge record. This is done by manually flow proportioning the volumes of the individual samples. Laboratory analysis of flow weighted composite samples will directly yield an event mean concentration. Mathematical integration of the change in concentrations and mass flux of the discharge for discrete sample data can produce an event mean concentration. This procedure was used during the NURP program.

EPA wishes to emphasize that the reason for sampling the type of storm event identified in § 122.21(g)(7) is to provide information that represents local conditions that will be used to create sound storm water management plans. Based on the method to be used to generate system-wide estimates of pollutant loads, either method, discrete or event average concentrations, may be preferable to the other. If simulation models will be used to generate loading estimates, analysis of discrete samples will be more valuable so that calibration of water quality and hydrology may be performed. On the other hand, simple estimation methods based on event average or event mean concentrations may not justify the additional cost of discrete sample analysis.

EPA believes that the first discharge loading should be represented in the permit application from industrial facilities and, if appropriate, permitting authorities may require the same in the discharge characterization component of permits issued to municipalities. The first discharge load should also be represented as part of an event composite sample. This requirement will assist industries in the development of effective storm water management plans.

EPA requested comments on the appropriateness of the proposed rules and of proposed amendments to the rules regarding discharge sampling. Comments were received which addressed the appropriateness of imposing uniform national guidelines. Several commenters are concerned that uniform national guidelines may not be appropriate due to the geographic variations in meteorology, topography, and pollutant sources. While some assert that a uniform guideline will provide consistency of the sample results, others prefer a program based on regional or State guidelines that more specifically address their situation.

Several commenters, addressing industrial permit application requirements, preferred that the owner/operator be allowed to set an individual sampling protocol with approval of the permit writer. Some commenters were concerned that one event may not be sufficient to characterize runoff from a basin as this may result in gross over-estimation or underestimation of the pollutant loads. Others indicated confusion with regard to sampling procedures, lab analysis procedures, and the purpose of the program.

In response, today's regulations establish certain minimum requirements. Municipalities and industries may vary from these requirements to the extent that their implementation is at least as stringent as outlined in today's rule. EPA views today's rule as a means to provide assurance [illegible] the quality of the data collected. [illegible] this end, it is important that the [illegible] level of sampling required [illegible] defined.

In response to E[illegible] posal that the first discharge be [illegible] in "representative" [illegible] mpling, several commenters [illegible] their concerns known [illegible] possible equipment necess[illegible] meet this requirement. Seve[illegible] mmenters are concerned that in [illegible] o get a first discharge sample, [illegible] atic sampling equipment will be [illegible] red. Concerns re[illegible] d to the ne[illegible] his equipment s[illegible] ed in the c[illegible] its frequently; [illegible] advised tha[illegible] equipment is e[illegible] sive and th[illegible] demand on [illegible] equipment [illegible] ill be too large for [illegible] turers to meet. [illegible] ar be leased. [illegible] maintained that not [illegible] it is available to [illegible] in many [illegible]

[illegible] or requiring the [illegible] ment to satisfy [illegible] A [illegible] the long run [illegible] to have [illegible] is [illegible] ation of [illegible] goals [illegible] ent is [illegible] sample [illegible] attended [illegible] performed, [illegible] ement will be requir[illegible]

EPA rea[illegible] at equ[illegible] availability [illegible] However, [illegible] recommenda[illegible] relative to th[illegible] bility of equipment. If automatic [illegible] g equipment is not available, ma[illegible] mpling is an appropriate al[illegible] ative.

F. Storm Water Discharges Associated With Industrial Activity

1. Permit Applicability

a. *Storm water discharges associated with industrial activity in states of the United States.* Under today's rule dischargers of storm water associated

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with industrial activity are required to apply for an NPDES permit. Permits are to be applied for in one of three ways depending on the type of facility: Through the individual permit application process; through the group application process; or through a notice of intent to be covered by general permit.

Storm water discharges associated with the industrial activities identified under § 122.26(b)(14) of today's rule may avail themselves of general permits that EPA intends to propose and promulgate in the near future. The general permit will be available to be promulgated in each non-NPDES State, following State certification, and as a model for use by NPDES States with general permit authority. It is envisioned that these general permits will provide baseline storm water management practices. For certain categories of industries, specific management practices will be prescribed in addition to the baseline management practices. As information on specific types of industrial activities is developed, other, more industry-specific general permits will be developed.

Today's rule requires facilities with existing NPDES permits for storm water discharges to apply for individual permits under the individual permit application requirements found at 122.26(c) 180 days before their current permit expires. Facilities not eligible for coverage under a general permit are required to file an individual or group permit application in accordance with today's rule. The general permits to be proposed and promulgated will indicate what facilities are eligible for coverage by the general permit.

b. *Storm water discharges through municipal storm sewers.* As discussed above, many operators of storm water discharges associated with industrial activity are not required to apply for an individual permit or participate in a group application under § 122.26(c) of today's rule if covered by a general permit. Under the December 7, 1988, proposal, dischargers through large and medium municipal separate storm sewer systems were not required, as a general rule, to apply for an individual permit or as a group applicant. Today's rule is a departure from that proposal. Today's rule requires all dischargers through municipal separate storm sewer systems to apply for an individual permit, apply as part of a group application, or seek coverage under a promulgated general permit for storm water discharges associated with industrial activity.

Municipal operators of large and medium municipal separate storm sewer systems are responsible for obtaining system-wide or area permits for their system's discharges. These permits are expected to require that controls be placed on storm water discharges associated with industrial activity which discharge through the municipal system. It is anticipated that general or individual permits covering industrial storm water dischargers to these municipal separate storm sewer systems will require industries to comply with the terms of the permit issued to the municipality, as well other terms specific to the permittee.

c. *Storm water discharges through non-municipal storm sewers.* Under today's rulemaking all operators of storm water discharges associated with industrial activity that discharge into a privately or Federally owned storm water conveyance (a storm water conveyance that is not a municipal separate storm sewer) will be required to be covered by an NPDES permit (*e.g.* an individual permit, general permit, or as a co-permittee to a permit issued to the operator of the portion of the system that directly discharges to waters of the United States). This is a departure from the "either/or" approach that EPA requested comments on in the December 7, 1988, notice. The "either/or" approach would have allowed either the system discharges to be covered by a permit issued to the owner/operator of the system segment that discharged to waters of the United States, or by an individual permit issued to each contributor to the non-municipal conveyance.

EPA requested comments on the advantages and disadvantages of retaining the "either/or" approach for non-municipal storm sewers. An abundance of comment was received by EPA on this particular part of the program. A number of industrial commenters and a smaller number of municipalities favored retaining the "either/or" approach as proposed, while most municipal entities, one industry, and one trade association favored requiring permits for each discharger.

Two commenters stated that private owners of conveyances may not have the legal authority to implement controls on discharges through their system and would not want to be held responsible for such controls. EPA agrees that this is a potential problem. Therefore, today's rule will require permit coverage for each storm water discharge associated with industrial activity.

One commenter supported the concept of requiring all the facilities that discharge to a non-municipal conveyance to be co-permittees. EPA agrees that this type of permitting scheme, along with other permit schemes such as area or general permits, is appropriate for discharges from non-municipal sewers, as long as each storm water discharge through the system is associated with industrial activity and thus currently subject to NPDES permit coverage.

One State agency commented that in the interest of uniformity, all industries that discharge to non-municipal conveyances should be required to conform to the application requirements. One industry stated that the rules must provide a way for the last discharger before the waters of the U.S. to require permits for facilities discharging into the upper portions of the system. EPA agrees with these comments. Today's rule provides that each discharger may be covered under individual permits, as co-permittees to a single permit, or by general permit rather than holding the last discharger to the waters of the United States solely responsible.

In response to one commenter, the term "non-municipal" has been clarified to explain that the term refers to non-publicly owned or Federally-owned storm sewer systems.

Some commenters supporting the approach as proposed, noted that industrial storm water dischargers into such systems can take advantage of the group application process. EPA agrees that in appropriate circumstances, such as when industrial facilities discharging storm water to the same system are sufficiently similar, group applications can be used for discharges to non-municipal conveyances. However, EPA believes that it would be inappropriate to approve group applications for those facilities whose only similarity is that they discharge storm water into the same private conveyance system. The efficacy of the group application procedures is predicated on the similarity of operations and other factors. The fact that several industries discharge storm water to the same non-municipal sewer system alone may not make these discharges sufficiently similar for group application approval.

One commenter suggested that EPA has not established any deadlines for submission of permit applications for storm water discharges associated with industrial activity through non-municipal separate storm sewer systems. EPA wants to clarify that industrial storm water dischargers into privately owned or Federally owned storm water conveyances are required to apply for permits in the same time frame as individual or group applicants (or as otherwise provided for in [illegible] general permit).

One commenter stated that the operator of the conveyance that accepts discharges into its system has control and police power over those that discharge into the system by virtue of the ability to restrict discharges into the system. This commenter stated that these facilities should be the entity required to obtain the permit in all cases. Assuming that this statement is true in all respects, the larger problem is that one's theoretical ability to restrict discharges is not necessarily tied to the reality of enforcing those restrictions or even detecting problem discharges when they exist. In a similar vein one commenter urged that a private operator will not be in any worse a position than a municipal entity to determine who is the source of pollution up-stream. EPA agrees that from a hydrological standpoint this may be true. However, from the standpoint of detection resources, police powers, enforcement remedies, and other facets of municipal power that may be brought to bear upon problem dischargers, private systems are in a far more precarious position with respect to controlling discharges from other private sources.

In light of the comments received, EPA has decided that the either/or approach as proposed is inappropriate. Operators of non-municipal systems will generally be in a poorer position to gain knowledge of pollutants in storm water discharges and to impose controls on storm water discharges from other facilities than will municipal system operators. In addition, best management practices and other site-specific controls are often most appropriate for reducing pollutants in storm water discharges associated with industrial activity and can often only be effectively addressed in a regulatory scheme that holds each industrial facility operator directly responsible. The either/or approach as proposed is not conducive to establishing these types of practices unless each discharger is discharging under a permit. Also, some non-municipal operators of storm water conveyances, which receive storm water runoff from industrial facilities, may not be generating storm water discharges associated with industrial activity themselves and, therefore, they would otherwise not need to obtain a permit prior to October 1, 1992, unless specifically designated under section 402(p)(2)(E). Accordingly, EPA disagrees with comments that dischargers to non-municipal conveyances should have the flexibility to be covered by their permit or covered by the permit issued to the operator of the outfall to waters to the United States.

2. Scope of "Associated with Industrial Activity"

The September 26, 1984, final regulation divided those discharges that met the regulatory definition of storm water point source into two groups. The term Group I storm water discharges was defined in an attempt to identify those storm water discharges which had a higher potential to contribute significantly to environmental impacts. Group I included those discharges that contained storm water drained from an industrial plant or plant associated areas. Other storm water discharges (such as those from parking lots and administrative buildings) located on lands used for industrial activity were classified as Group II discharges. The regulations defined the term "plant associated areas" by listing several examples of areas that would be associated with industrial activities. However, the resulting definition led to confusion among the regulated community regarding the distinctions between the Group I and Group II classifications.

In amending the CWA in 1987, Congress did not explicitly adopt EPA's regulatory classification of Group I and Group II discharges. Rather, Congress required EPA to address "storm water discharges associated with industrial activity" in the first round of storm water permitting. In light of the adoption of the term "associated with industrial activity" in the CWA, and the ongoing confusion surrounding the previous regulatory definition, EPA has eliminated the regulatory terms "Group I storm water discharge" and "Group II storm water discharge" pursuant to the December 7, 1987, Court remand and has not revived it. In addition, today's notice promulgates a definition of the term "storm water discharge associated with industrial activity" at § 122.26(b)(14) and clarified the scope of the term.

In describing the scope of the term "associated with industrial activity", several members of Congress explained in the legislative history that the term applied if a discharge was "directly related to manufacturing, processing or raw materials storage areas at an industrial plant." (Vol. 132 Cong. Rec. H10932, H10936 (daily ed. October 15, 1986); Vol. 133 Cong. Rec. H176 (daily ed. January 8, 1987)). Several commenters cited this language in arguing for a more expansive or less expansive definition of "associated with industrial activity." EPA believes that the legislative history supports the decision to exclude from the definition of industrial activity, at § 122.26(b)(14) of today's rule, those facilities that are generally classified under the Office of Management and Budget Standard Industrial Classifications (SIC) as wholesale, retail, service, or commercial activities.

Two commenters recommended that all commercial enterprises should be required to obtain a permit under this regulation. Another commenter recommended that all the facilities listed in the December 7, 1988, proposal, including those listed in paragraphs (xi) through (xvi) on page 49432 of the December 7, 1988, proposal, should be included. EPA disagrees since the intent of Congress was to establish a phased and tiered approach to storm water permits, and that only those facilities having discharges associated with industrial activity should be included initially. The studies to be conducted pursuant to section 402(p)(5) will examine sources of pollutants associated with commercial, retail, and other light business activity. If appropriate, additional regulations addressing these sources can be developed under section 402(p)(6) of the CWA. As further discussed below, EPA believes that the facilities identified in paragraphs (xi) through (xvi) are more properly characterized as commercial or retail facilities, rather than indutrial facilities.

Today's rule clarifies the regulatory definition of "associated with industrial activity" by adopting the language used in the legislative history and supplementing it with a description of various types of areas that are directly related to an industrial process (e.g. industrial plant yards, immediate access roads and rail lines, drainage ponds, material handling sites, sites used for the application or disposal of process waters, sites used for the storage and maintenance of material handling equipment, and known sites that are presently or have been used in the past for residual treatment, storage or disposal). The agency has also incorporated some of the suggestions offered by the public in comments.

Three commenters suggested that the permit application should focus only on storm water with the potential to come into contact with industrial-related pollutant sources, rather than focusing on how plant areas are utilized. These commenters suggested that facilities that are wholly enclosed or have their operations entirely protected from the elements should not be subject to permit requirements under today's rule. EPA agrees that these comments have merit with regard to certain types of facilities. Today's rule defines the term "storm water discharge associated with

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industrial activity" to include storm water discharges from facilities identified in today's rule at 40 CFR 122.21(b)(14)(xi) (facilities classified as Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221–25) only if:

areas where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery at these facilities are exposed to storm water. Such areas include: material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment; storage or disposal; shipping and receiving areas; manufacturing buildings; material storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.

The critical distinction between the facilities identified at 40 CFR 122.26(b)(14)(xi) and the facilities identified at 40 CFR 122.26(b)(14)(i)–(x) is that the former are not classified as having "storm water discharges associated with industrial activity" unless certain materials or activities are exposed to storm water. Storm water discharges from the latter set of facilities are considered to be "associated with industrial activity" regardless of the actual exposure of these same materials or activities to storm water.

EPA believes this distinction is appropriate because, when considered as a class, most of the activity at the facilities in § 122.26(b)(14)(xi) is undertaken in buildings; emissions from stacks will be minimal or non-existent; the use of unhoused manufacturing and heavy industrial equipment will be minimal; outside material storage, disposal or handling generally will not be a part of the manufacturing process; and generating significant dust or particulates would be atypical. As such, these industries are more akin or comparable to businesses, such as retail, commercial, or service industries, which Congress did not contemplate regulating before October 1, 1992, and storm water discharges from these facilities are not "associated with industrial activity." Thus, these industries will be required to obtain a permit under today's rule only when the manufacturing processes undertaken at such facilities would result in storm water contact with industrial materials associated with the facility.

Industrial categories in § 122.26(b)(14)(xi) all tend to engage in production activities in the manner described in the paragraph above. Facilities under SIC 20 process foods including meats, dairy food, fruit, and flour. Facilities classified under SIC 21 make cigarettes, cigars, chewing tobacco and related products. Under SIC 22, facilities produce yarn, etc., and/or dye and finish fabrics. Facilities under SIC 23 are in the business of producing clothing by cutting and sewing purchased woven or knitted textile products. Facilities under SIC 2434 and 25 are establishments engaged in furniture making. SIC 265 and 267 address facilities that manufacture paper board products. Facilities under SIC 27 perform services such as bookbinding, plate making, and printing. Facilities under SIC 283 manufacture pharmaceuticals and facilities under 285 manufacture paints, varnishes, lacquers, enamels, and allied products. Under SIC 30 establishments manufacture products from plastics and rubber. Those facilities under SIC 31 (except 311), 323, 34 (except 3441), 35, 36, and 37 (except 373) manufacture industrial and commercial metal products, machinery, equipment, computers, electrical equipment, and transportation equipment, and glass products made of purchased glass. Facilities under SIC 38 manufacture scientific and electrical instruments and optical equipment. Those under SIC 39 manufacture a variety of items such as jewelry, silverware, musical instruments, dolls, toys, and athletic goods. SIC 4221–25 are warehousing and storage activities.

In contrast, the facilities identified by SIC 24 (except and 2434), 26 (except 265 and 267), 28 (except 283 and 285), 29, 311, 32 (except 323), 33, 3441, 373 when taken as a group, are expected to have one or many of the following activities, processes occurring on-site: storing raw materials, intermediate products, final products, by-products, waste products, or chemicals outside; smelting; refining; producing significant emissions from stacks or air exhaust systems; loading or unloading chemical or hazardous substances; the use of unhoused manufacturing and heavy industrial equipment; and generating significant dust or particulates. Accordingly, these are classes of facilities which can be viewed as generating storm water discharges associated with industrial activity requiring a permit. Establishments identified under SIC 24 (except 2434) are engaged in operating sawmills, planing mills and other mills engaged in producing lumber and wood basic materials. SIC 26 facilities are paper mills. Under SIC 28, facilities produce basic chemical products by predominantly chemical processes. SIC 29 describes facilities that are engaged in the petroleum industry. Under SIC 311, facilities are engaged in tanning, currying, and finishing hides and skins. Such processes use chemicals such as sulfuric acid and sodium dichromate, and detergents, and a variety of raw and intermediate materials. SIC 32 manufacture glass, clay, stone and concrete products form raw materials in the form quarried and mined stone, clay, and sand. SIC 33 identifies facilities that smelt, refine ferrous and nonferrous metals from ore, pig or scrap, and manufacturing related products. SIC 3441 identifies facilities manufacturing fabricated structural metal. Facilities under SIC 373 engage in ship building and repairing. The permit application requirements for storm water discharges from facilities in these categories are unchanged from the proposal.

Today's rule clarifies that the requirement to apply for a permit applies to storm water discharges from plant areas that are no longer used for industrial activities (if significant materials remain and are exposed to storm water) as well as areas that are currently being used for industrial activities. EPA would also clarify that all discharges from these areas including those that discharge through municipal separate storm sewers are addressed by this rulemaking.

One commenter questioned the use of the word "or" instead of the word "and" to describe storm water "which is located at an industrial plant 'or' directly related to manufacturing, processing, or raw material storage areas at an industrial plant." The comment expressed the concern that discharges from areas not located at an industrial plant would be subject to permitting by this language and questioned whether this was EPA's intent. EPA agrees that this is a potential source of confusion and has modified this language to reflect the conjunctive instead of the alternative. This change has been made to provide consistency in the rule whereby some areas at industrial plants, such as administrative parking lots which do not have storm water discharges commingled with discharges from manufacturing areas, are not included under this rulemaking.

Two commenters wanted clarification of the term "or process water," in the definition of discharge associated with industrial activity at § 122.26(b)(14). This rulemaking replaces this term with the term "process waste water" which is defined at 40 CFR part 401.

One commenter took issue with the decision to include drainage ponds, refuse sites, sites for residual treatment, storage, or disposal, as areas associated with industrial activity, because it was the commenter's view that such areas are unconnected with industrial activity. EPA disagrees with this comment. If refuse and other sites are used in conjunction with manufacturing or the by-products of manufacturing they are clearly associated with industrial activity. As noted above, Congress intended to include discharges directly related to manufacturing and processing at industrial plants. EPA is convinced that wastes, refuse, and residuals are the direct result or consequence of manufacturing and processing and, when located or stored at the plant that produces them, are directly related to manufacturing and processing at that plant. Storm water drainage from such areas, especially those areas exposed to the elements (*e.g.* rainfall) has a high potential for containing pollutants from materials that were used in the manufacturing process at that facility. One commenter supported the inclusion of these areas since many toxins degrade very slowly and the mere passage of time will not eliminate their effects. EPA agrees and finalizes this part of the definition as proposed. One commenter requested clarification of the term "residual" as used in this context. Residual can generally be defined to include material that is remaining subsequent to completion of an industrial process. One commenter noted that the current owner of a facility may not know what areas or sites at a facility were used in this manner in the past. EPA has clarified the definition of discharge associated with industrial activity to include areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. The Agency believes that the current owner will be in a position to establish these facts.

One commenter suggested including material shipping and receiving areas, waste storage and processing areas, manufacturing buildings, storage areas for raw materials, supplies, intermediates, and finished products, and material handling facilities as additional areas "associated with industrial activity." EPA agrees that this would add clarification to the definition, and has incorporated these areas into the definition at § 122.26(b)(14).

One commenter stated that the language "point source located at an industrial plant" would include outfalls located at the facility that are not owned or operated by the facility, but which are municipal storm sewers on easements granted to a municipality for the conveyance of storm water. EPA agrees that if the industry does not operate the point source then that facility is not required to obtain a permit for that discharge. A point source is a conveyance that discharges pollutants into the waters of the United States. If a facility does not operate that point source, then it would be the responsibility of the municipality to cover it under a permit issued to them. However, if contaminated storm water associated with industrial activity were introduced into that conveyance by that facility, the facility would be subject to permit application requirements as is all industrial storm water discharged through municipal sewers.

EPA disagrees with several comments that road drainage or railroad drainage within a facility should not be covered by the definition. Access roads and rail lines (even those not used for loading and unloading) are areas that are likely to accumulate extraneous material from raw materials, intermediate products and finished products that are used or transported within, or to and from, the facility. These areas will also be repositories for pollutants such as oil and grease from machinery or vehicles using these areas. As such they are related to the industrial activity at facilities. However, the language describing these areas of industrial activity has been clarified to include those access roads and rail lines that are "used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility." For the same reasons haul roads (roads dedicated to transportation of industrial products at facilities) and similar extensions are required to be addressed in permit applications. Two industries stated that haul roads and similar extensions should be covered by permits by rule. EPA is not considering the use of a permit by rule mechanism under this regulation, however this issue will be addressed in the section 402(p)(5) reports to Congress and in general permits to be proposed and promulgated in the near future. EPA would note however that facilities with similar operations and storm water concerns that desire to limit administrative burdens associated with permit applications and obtaining permits may want to avail themselves of the group application and/or general permits.

In response to comments, EPA would also like to clarify that it intends the language "immediate access roads" (including haul roads) to refer to roads which are exclusively or primarily dedicated for use by the industrial facility. EPA does not expect facilities to submit permit applications for discharges from public access roads such as state, county, or federal roads such as highways or BLM roads which happen to be used by the facility. Also, some access roads are used to transport bulk samples of raw materials or products (such as prospecting samples from potential mines) in small-scale prior to industrial production. EPA does not intend to require permit applications for access roads to operations which are not yet industrial activities.

EPA does agree with comments made by several industries that undeveloped areas, or areas that do not encompass those described above, should generally not be addressed in the permit application, or a storm water permit, as long as the storm water discharge from these areas is segregated from the storm water discharge associated with the industrial activity at the facility.

Numerous commenters stated that maintenance facilities, if covered, should not be included in the definition. EPA disagrees with this comment. Maintenance facilities will invariably have points of access and egress, and frequently will have outside areas where parts are stored or disposed of. Such areas are locations where oil, grease, solvents and other materials associated with maintenance activities will accumulate. In response to one commenter, such areas are only regulated in the context of those facilities enumerated in the definition at § 122.26(b)(14), and not similar areas of retail or commercial facilities.

Another commenter requested that "storage areas" be more clearly defined. EPA disagrees that this term needs further clarification in the context of this section of the rule. However, in response to one comment, tank farms at industrial facilities are included. Tank farms are in existence to store products and materials created or used by the facility. Accordingly they are directly related to manufacturing processes.

Regarding storage areas, one commenter stated that the regulations should emphasize that only facilities that are not totally enclosed are required to submit permit applications. EPA does not agree with this interpretation since use of the generic term storage area indicates no exceptions for certain physical characteristics. Thus discharges from enclosed storage areas are also covered by today's rule (except as discussed above). EPA also disagrees with one

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comment asserting that small outside storage areas of finished products at industrial facilities should be excluded under the definition of associated with industrial activity. EPA believes that such areas are areas associated with industrial activity which Congress intended to be regulated under the CWA. As noted above, the legislative history refers to storage areas, without reference to whether they are covered or uncovered, or of a certain size.

The same language, in the legislative history cited above, was careful to state that the term "associated with industrial activity" does not include storm water "discharges associated with parking lots and administrative and employee buildings." To accommodate legislative intent, segregated storm water discharges from these areas will not be required to obtain a permit prior to October 1, 1992. Many commenters stated that this was an appropriate method in which to limit the scope of "associated with industrial activity." However, if a storm water discharge from a parking lot at an industrial facility is mixed with a storm water discharge "associated with industrial activity," the combined discharge is subject to permit application requirements for storm water discharges associated with industrial activity. EPA disagrees with some commenters who urged that office buildings and administrative parking lots should be covered if they are located at the plant site. EPA agrees with one commenter that inclusion of storm water discharge from these areas would be overstepping Congressional intent unless such are commingled with storm water discharges from the plant site. Several commenters requested that language be incorporated into the rule which establishes that storm water discharges from parking lots and administrative areas not be included in the definition of associated with industrial activity. EPA agrees and has retained language used in the proposal which addresses this distinction.

Storm water discharges from parking lots and administrative buildings along with other discharges from industrial lands that do not meet the regulatory definition of "associated with industrial activity" and that are segregated from such discharges may be required to obtain an NPDES permit prior to October 1, 1992, under certain conditions. For example, large parking facilities, due to their impervious nature may generate large amounts of runoff which may contain significant amounts of oil and grease and heavy metals which may have adverse impacts on receiving waters. The Administrator or NPDES State has the authority under section 402(p)(2)(E) of the amended CWA to require a permit prior to October 1, 1992, by designating storm water discharges such as those from parking lots that are significant contributors of pollutants or contribute to a water quality standard violation. EPA will address storm water discharges from lands used for industrial activity which do not meet the regulatory definition of "associated with industrial activity" in the section 402(p)(5) study to determine the appropriate manner to regulate such discharges.

Several commenters requested clarification that the definition does not include sheet flow or discharged storm water from upstream adjacent facilities that enters the land or comingles with discharge from a facility submitting a permit application. EPA wishes to clarify that operators of facilities are generally responsible for its discharge in its entirety regardless of the initial source of discharge. However, where an upstream source can be identified and permitted, the liability of a downstream facility for other storm water entering that facility may be minimized. Facilities in such circumstances may be required to develop management practices or other run-on/run-off controls, which segregates or otherwise prevents outside runoff from comingling with its storm water discharge. Some commenters expressed concern about other pollutants which may arrive on a facility's premises from rainfall. This comment was made in reference to runoff with a high or low pH. If an applicant has reason to believe that pollutants in its storm water discharge are from such sources, then that needs to be addressed in the permit application and brought to the attention of the permitting authority, which can draft appropriate permit conditions to reflect these circumstances.

EPA requested comments on clarifying the types of facilities that involve industrial activities and generate storm water. EPA preferred basing the clarification, in part, on the use of Standard Industrial Classification (SIC) codes, which have been suggested in comments to prior storm water rulemakings because they are commonly used and accepted and would provide definitions of facilities involved in industrial activity. Several commenters supported the use by EPA of Standard Industrial Classifications for the same reasons identified by EPA as a generally used and understood form of classification. It was also noted that using such a classification would allow targeting for special notification and educational mailings. Three municipalities and three State authorities commented that SICs were appropriate and endorsed their use as a sound basis for determining which industries are covered.

One municipality questioned how SIC classifications will be assigned to particular industries. SICs have descriptions of the type of industrial activity that is engaged in by facilities. Industries will need to assess for themselves whether they are covered by a listed SIC and submit an application accordingly. Another commenter questioned if Federal facilities that do not have an SIC code identification are required to file a permit application. Federal facilities will be required to submit a permit application if they are engaged in an industrial activity that is described under § 122.26(b)(14). The definition of industrial activity incorporates language that requires Federal facilities to submit permit applications in such circumstances. The language has been further clarified to include State and municipal facilities.

EPA requested comments on the scope of the definition (types of facilities addressed) as well as the clarity of regulation. EPA identified the following types of facilities in the proposed regulation as those facilities that would be required to obtain permits for storm water discharges associated with industrial activity:

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are also identified under category (xi) of this paragraph). One commenter (a municipality) agreed with EPA that these industries should be addressed in this rulemaking. No other comments were received on this category. EPA agrees with this comment since these facilities are those that Congress has required EPA to examine and regulate under the CWA with respect to process water discharges. The industries in these categories have generally been identified by EPA as the most significant dischargers of process wastewaters in the country. As such, these facilities are likely to have storm water discharges associated with industrial activity for which permit applications should be required.

One commenter stated that because oil and gas producers are subject to [illegible] effluent guidelines, EPA is disregarding the intent of Congress to exclude [illegible]

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facilities pursuant to section 402(1). EPA disagrees with this comment. EPA is not prohibited from requiring permit applications from industries with storm water discharge associated with industrial activity. EPA is prohibited only from requiring a permit for oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water that is not contaminated by contact with or has not come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations such discharges. In keeping with this requirement, EPA is requiring permit applications from oil and gas exploration, production, processing, or treatment operations, or transmission facilities that fall into a class of dischargers as described in § 122.26(c)(iii).

(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283 and 285), 29, 311, 32 (except 323), 33, 3411, 373 and *(xi). Facilities classified as Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221–25.* One large municipality and one industry agreed with EPA that facilities covered by these SICs should be covered by this rulemaking. Many commenters, however, took exception to including all or some of these industries. However as noted elsewhere these facilities are appropriate for permit applications.

One commenter stated that within certain SICs industries, such as textile manufacturers use few chemicals and that there is little chance of pollutants in their storm water discharge. EPA agrees that some industries in this category are less likely than others to have storm water discharges that pose significant risks to receiving water quality. However, there are many other activities that are undertaken at these facilities that may result in polluted storm water. Further, the CWA is clear in its mandate to require permit applications for discharges associated with industrial activity. Excluding any of the facilities under these categories, except where the facility manufacturing plant more closely resembles a commercial or retail outlet would be contrary to Congressional intent.

One State questioned the inclusion of facilities identified in SIC codes 20–39 because of their temporary and transient nature or ownership. Agency disagrees that simply because a facility may transfer ownership that storm water quality concerns should be ignored. If constant ownership was a condition precedent to applying for and obtaining a permit, few if any facilities would be subject to this rulemaking.

One State estimated that the proposed definition would lead to permits for 18,000 facilities in its State. Consequently this commenter recommended that the facilities under SIC 20–39 should be limited to those facilities that have to report under section 313 of title III, Superfund Amendments and Reauthorization Act. However, as noted by another commenter, limiting permit requirements to these facilities would be contrary to Congressional intent. While use of chemicals at a facility may be a source of pollution in storm water discharges, other every day activities at an industrial site and associated pollutants such as oil and grease, also contribute to the discharge of pollutants that are to be addressed by the CWA and these regulations. While the number of permit applications may number in the thousands, EPA intends for group applications and general permits to be employed to reduce the administrative burdens as greatly as possible.

Two commenters felt the permit applications should be limited to all entities under SIC 20–39. EPA disagrees that all the industrial activities that need to be addressed fall within these SICs. Discharges from facilities under paragraphs (i) through (xi) such as POTWs, transportation facilities, and hazardous waste facilities, are of an industrial nature and clearly were intended to be addressed before October 1, 1992.

Two commenters stated that SIC 241 should be excluded in that logging is a transitory operation which may occur on a site for only 2–3 weeks once in a 20–30 year period. It was perceived that delays in obtaining permits for such operations could create problems in harvest schedule and mill demand. This commenter stated that runoff from such operations should be controlled by BMPs in effect for such industries and that such a permit would not be practical and would be cost prohibitive.

EPA agrees with the commenter that this provision needs clarification. The existing regulations at 40 CFR 122.27 currently define the scope of the NPDES program with regard to silvicultural activities. 40 CFR 122.27(b)(1) defines the term "silvicultural point source" to mean any discrete conveyance related to rock crushing, gravel washing, log sorting, or log storage facilities which are operated in connection with silvicultural activities and from which pollutants are discharged into waters of the United States. Section 122.27(b)(1) also excludes certain sources. The definition of discharge associated with industrial activity does not include activities or facilities that are currently exempt from permitting under NPDES. EPA does not intend to change the scope of 40 CFR 122.27 in this rulemaking. Accordingly, the definition of "storm water discharge associated with industrial activity" does not include sources that may be included under SIC 24, but which are excluded under 40 CFR 122.27. Further, EPA intends to examine the scope of the NPDES silvicultural regulations at 40 CFR 122.27 as it relates to storm water discharges in the course of two studies of storm water discharges required under section 402(p)(5) of the CWA.

In response to one comment, EPA intends that the list of applicable SICs will define and identify what industrial facilities are required to apply. Facilities that warehouse finished products under the same code at a different facility from the site of manufacturing are not required to file a permit application, unless otherwise covered by this rulemaking.

(iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990 and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations. Several commenters urged that Congress intended to require permits or permit applications only for the manufacturing sector of the oil and gas industry (or those activities that [illegible] designated in SIC 20 through 39). EPA disagrees with this argument. The fact that Congress used the language cited above and not the appropriate the SIC [illegible] definition explicitly does not indicate [illegible] that a broader definition or less [illegible] exclusive definition was contemplated. According to these comments, [illegible] water discharges from oil and gas [illegible]

exploration and production facilities would be exempt from regulation. However, EPA is convinced that a facility that is engaged in finding and extracting crude oil and natural gas from subsurface formations, separating the oil and gas from formation water, and preparing that crude oil for transportation to a refinery for manufacturing and processing into refined products, will have discharges directly relating to the processing or raw material storage at an industrial plant and are therefore discharges associated with industrial activity.

For further clarification EPA is intending to focus only on those facilities that are in SIC 10–14. Furthermore, in response to several comments, this rulemaking will require permit applications for storm water discharges from currently inactive petroleum related facilities within SIC codes 10–14, if discharges from such facilities meet the requirements as described in section VI.F.7.a. and § 122.26(c)(1)(iii). Inactive facilities will have storm water associated with industrial activity irrespective of whether the activity is ongoing. Congress drew no distinction between active and inactive facilities in the statute or in the legislative history.

(iv) Hazardous waste treatment, storage, or disposal facilities that are operating under interim status or a permit under Subtitle C of the Resource, Conservation and Recovery Act. One commenter believed that all RCRA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) facilities should be specifically identified using SIC codes for further clarification. EPA considers this to be unnecessarily redundant, since the RCRA/CERCLA identification is sufficient.

Several industries asserted that storm water discharge from landfills, dumps, and land application sites, properly closed or otherwise subject to corrective or remedial actions under RCRA, should not be included in the definition. One commenter noted that the runoff from these areas is like runoff from undeveloped areas. One commenter also concluded that landfills, dumps, and land application sites should also be excluded if they are properly maintained under RCRA.

One commenter also rejected the idea of requiring permits from all active and inactive landfills and open dumps that have received any industrial wastes, and subtitle C facilities. This commenter felt that these facilities were already adequately covered under RCRA.

Two industry commenters felt that it would be redundant to have hazardous waste facilities regulated by RCRA and the NPDES storm water program. One felt this was especially so if there are current pretreatment standards.

The Agency disagrees that all activities that may contribute to storm water discharges at RCRA subtitle C facilities are being fully controlled and that requiring NPDES permits for storm water discharges at RCRA subtitle C facilities is redundant. First, the vast majority of permitted hazardous waste management facilities are industrial facilities involved in the manufacture or processing of products for distribution in commerce. Their hazardous waste management activities are incidental to the production-related activities. While RCRA subtitle C regulations impose controls in storm water runoff from hazardous waste management units and require cleanup of releases of hazardous wastes, they generally do not control non-systematic spills or process. These releases, from the process itself or the storage of raw materials or finished products are a potential source of storm water contamination. In addition, RCRA subtitle C (except via corrective action authority) does not address management of "non hazardous" industrial wastes, which nevertheless could also potentially contaminate storm water runoff.

Second, at commercial hazardous waste management facilities, the RCRA subtitle C permitting requirements and management standards do not control all releases of potentially toxic materials. For example, some permitted commercial treatment facilities may store and use chemicals in the treatment of RCRA hazardous wastes. Releases of these treatment chemicals from storage areas are a potential source of storm water contamination.

Finally, many RCRA subtitle C facilities have inactive Solid Waste Management Units (SWMU's) on the facility property. These SWMU's may contain areas on the land surface that are contaminated with hazardous constituents. RCRA requires that hazardous waste management facilities must investigate these areas of potential contamination, and then perform corrective action to remediate any SWMU's that are of concern. However, the corrective action process at these facilities will not be completed for a number of years due to the complexity of the cleanup decisions, and due to the fact that many hazardous waste management facilities do not yet have RCRA permits. Until corrective action has been completed at all such subtitle C facilities, SWMU's are a potential source of storm water contamination that should be addressed under the NPDES program. Finally, under section 1004(27) of RCRA, all point source discharges, including those at RCRA regulated facilities, are to be regulated by the NPDES program. Thus, there is no concern of regulatory overlap, and to the extent that the storm water regulations are effectively implemented, it will help address these units in a way that alleviates the need for expensive corrective action in the future.

(v) Landfills, land application sites, and open dumps that receive or have received industrial wastes and that are subject to regulation under subtitle D of RCRA. EPA received numerous comments supporting the regulation of municipal landfills which receive industrial waste and are subject to regulation under subtitle D of RCRA. EPA agrees with these comments. These industries have significant potential for storm water discharges that can adversely affect receiving water.

Two States argued that landfills should be addressed under the non-point source program. EPA disagrees that the non-point source program is sufficient for addressing these facilities. Further, addressing a class of facilities under the non-point source program does not exempt storm water discharges from these facilities from regulation under NPDES. The CWA requires EPA to promulgate regulations for controlling point source discharges of storm water from industrial facilities. Point sources from landfills consisting of storm water are such discharges requiring an NPDES permit. Several commenters argued that these discharges are adequately addressed by RCRA and that regulating them under this storm water rule would be redundant. However, as discussed above, RCRA expressly does not regulate point source discharges subject to NPDES permits. Given the nature of these facilities and of the material stored or disposed, EPA believes storm water permits are necessary. Similarly EPA rejects the comment that storm water discharges from these facilities are already adequately regulated by State authority. Congress has mandated that storm water discharges associated with industrial activity have an NPDES permit.

One commenter wanted EPA to define by size what landfills are covered. In response, it is the intent of these regulations to require permit applications from all landfills that receive industrial waste. Storm water discharges from such facilities are addressed because of the nature of the material with which the storm water comes in contact. The size of facility will not dictate what type of waste is exposed to the elements.

One commenter requested that the definition of industrial wastes be clarified. For the purpose of this rule, industrial waste consists of materials delivered to the landfill for disposal and whose origin is any of the facilities described under § 122.26(b)(14) of this regulation.

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093. One commenter suggested that the recycling of materials such as paper, glass, plastics, etc., should not be classified as an industrial activity. EPA disagrees that such facilities should be excluded on that basis. These facilities may be considered industrial, as are facilities that manufacture such products absent recycling.

Other facilities exhibit traits that indicate industrial activity. In junkyards, the condition of materials and junked vehicles and the activities occurring on the yard frequently result in significant losses of fluids, which are sources of toxic metals, oil and grease and polychlorinated aromatic hydrocarbons. Weathering of plated and non-plated metal surfaces may result in contributions of toxic metals to storm water. Clearly such facilities cannot be classified as commercial or retail.

One municipality felt that "significant recycling" should be defined or clarified. EPA agrees that the proposed language is ambiguous. It has been clarified to require permit applications from facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093. These SIC codes describe facilities engaged in dismantling, breaking up, sorting, and wholesale distribution of motor vehicles and parts and a variety of other materials. The Agency believes these SIC codes clarify the term significant recycling.

One municipality stated that regulation of these facilities under NPDES would be duplicative if they are publicly owned facilities. One State expressed the view that automobile junkyards, salvage yards could not legitimately be considered industrial activity. As noted above, EPA disagrees with these comments. Facilities that are actively engaged in the storage and recycling of products including metals, oil, rubber, and synthetics are in the business of storing and recycling materials associated with or once used in industrial activity. These activities are not commercial or retail because they are engaged in the dismantling of motors for distribution in wholesale or retail, and the assembling, breaking up, sorting, and wholesale distribution of scrap and waste materials, which EPA views as industrial activity. Further, being a publicly owned facility does not confer non-industrial status.

(vii) Steam electric power generating facilities, including coal handling sites, and onsite and offsite ancillary transformer storage areas. Most of the comments were against requiring permit applications for onsite and offsite ancillary transformer facilities. One commenter stated that these transformers did not leak in storage and if there were leakage problems in handling transformers, such leaks were subject to Federal and State spill clean-up procedures. The same commenter suggested that if EPA required applications from such facilities that it exclude those that have regular inspections, management practices in place, or those that store 50 transformers at any one time.

EPA agrees that such facilities should not be covered by today's rule. As one commenter noted, the Toxic Substances Control Act (TSCA) addresses pollutants associated with transformers that may enter receiving water through storm water discharges. EPA has examined regulations under TSCA and agrees that regulation of storm water discharges from these facilities should be the subject of the studies being performed under section 402(p)(5), rather than regulations established by today's rule. Under TSCA, transformers are required to be stored in a manner that prevents rain water from reaching the stored PCBs or PCB items. 40 CFR 761.65(b)(1)(i). EPA considers transformer storage to be more akin to retail or other light commercial activities, where items are inventoried in buildings for prolonged periods for use or sale at some point in the future, and where there is no ongoing manufacturing or other industrial activity within the structure.

One commenter stated that this category of industries should be loosened so that all steam electric facilities are addressed—oil fired and nuclear. EPA believes that the language as proposed broadly defines the type of industrial activity addressed without specifying each mode of steam electric production. One commenter noted that the EPA has no authority under the CWA (*Train* v. *CPIR, Inc.*, 426 U.S. 1 (1976)) to regulate the discharge of source, special nuclear and by-product materials which are regulated under the Atomic Energy Act. EPA agrees permit applications may not address those aspects of such facilities, however the facility in its entirety may not necessarily be exempt. A permit application will be appropriate for discharges from non-exempt categories.

(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221–25), 43, 44, 45, and 5171 which have vehicle maintenance shops, material handling facilities, equipment cleaning operations or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, or which are identified in another subcategory of facilities under EPA's definition of storm water discharges associated with industrial activity. One commenter requested clarification of the terms "vehicle maintenance." Vehicle maintenance refers to the rehabilitation, mechanical repairing, painting, fueling, and lubricating of instrumentalities of transportation located at the described facilities. EPA is declining to write this definition into the regulation however since "vehicle maintenance" should not cause confusion as a descriptive term. One commenter wanted railroad tracks where rail cars are set aside for minor repairs excluded from regulation. In response, if the activity involves any of the above activities then a permit application is required. Train yards where repairs are undertaken are associated with industrial activity. Train yards generally have trains which, in and of themselves, can be classified as heavy industrial equipment. Trains, concentrated in train yards, are diesel fueled, lubricated, and repaired in volumes that connote industrial activity, rather than retail or commercial activity.

One commenter argued that if gasoline stations are not considered for permitting, then all transportation facilities should be exempt. EPA disagrees with the thrust of this comment. Transportation facilities such as bus depots, train yards, taxi stations, and airports are generally larger than individual repair shops, and generally engage in heavier more expansive forms of industrial activity. In keeping with Congressional intent to cover all industrial facilities, permit applications from such facilities are appropriate. In contrast, EPA views gas stations as retail commercial facilities not covered

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by this regulation. It should be noted that SIC classifies gas stations as retail.

(ix) POTW lands used for land application treatment technology/ sludge disposal, handling or processing areas, and chemical handling and storage areas. One commenter wanted more clarification of the term POTW lands. Another commenter requested clarification of the terms sludge disposal, sludge handling areas, and sludge processing areas. One State recommended that a broader term than POTW should be used. EPA notes that on May 2, 1989, it promulgated NPDES Sewage Sludge Permit Regulations; State Sludge Management Program Requirements at 40 CFR part 501. This regulation identified those facilities that are subject to section 405(f) of the CWA as "treatment works treating domestic sewage."

In response to the above comments, EPA has decided to use this language to define what facilities are required to apply for a storm water permit. Under this rulemaking "treatment works treating domestic sewage," or any other sewage sludge or wastewater treatment device or system used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge, with a design flow of 1.0 mgd or more, or facilities required to have an approved pretreatment program under 40 CFR part 403, will be required to apply for a storm water permit. However, permit applications will not be required to address land where sludge is beneficially reused such as farm lands and home gardens or lands used for sludge management that are not physically located within the confines (offsite facility) of the facility or where sludge is beneficially reused in compliance with section 405 of the Clean Water Act (proposed rules were published on February 6, 1989, at 54 FR 5746). EPA believes that such activity is not "industrial" since it is agricultural or domestic application (non-industrial) unconnected to the facility generating the material.

EPA received many comments on the necessity and appropriateness of requiring permit applications for storm water discharges from POTW lands. It was anticipated by numerous commenters that the above cited sludge regulations would adequately address storm water discharges from lands where sludge is applied. However, the sewage sludge regulations do not directly address NPDES permit requirements for storm water discharges from POTW lands and related areas to the extent required by today's rulemaking; the regulations cover only permits for use or disposal of sludge. Also, the regulations proposed on February 4, 1989, cover primarily the technical standards for the composition of sewage sludge which is to be used or disposed. They do not include detailed permitting requirements for discharges of storm water from lands where sludge has been applied to the land. To that extent, EPA is not persuaded by these commenters that POTWs and POTW lands should be excluded from these storm water permit application requirements.

Two commenters noted that some States already regulate sludge use or disposal activities substantially and that EPA should refrain from further regulation. EPA disagrees that this is a basis for excluding facilities from Federal requirements. Notwithstanding regulations in existence under State law, EPA is required by the CWA to promulgate regulations for permit application for storm water associated with industrial activity. Under the NPDES program, States are able to promulgate more rigorous requirements. However a minimum level of control is required under Federal law. One commenter also indicated that a State's sludge land application sites must follow a well defined plan to ensure there is no sludge related runoff. Notwithstanding that a State may require storm water controls for sludge land applications, as noted above, EPA is required to promulgate regulations requiring permit applications from appropriate facilities. EPA views facilities such as waste treatment plants that engage in on-site sludge composting, storage of chemicals such as ferric chloride, alum, polymers, and chlorine, and which may experience spills and bubbleovers are suitable candidates for storm water permits. Facilities using such materials are not characteristic of commercial or retail activities. Use and storage of chemicals and the production of material such as sludge, with attendant heavy metals and organics, is activity that is industrial in nature. The size and scope of activities at the facility will determine the extent to which such activities are undertaken and such materials used and produced at the facility. Accordingly, EPA believes limiting the facilities covered under this category to those of 1.0 mgd and those covered under the industrial pretreatment program is appropriate.

To the extent that permit applicants are already required to employ certain management practices regarding storm water, these may be incorporated into permits and permit conditions issued by Federal and State permitting authorities. EPA has selected facilities identified under 40 CFR part 501 (*i.e.* those with a design flow of 1.0 mgd or more or those required to have an approved pretreatment program) since these facilities will have largest contribution of industrial process discharges. Sludge from such facilities will contain higher concentrations of heavy metal and organic pollutants.

One commenter stated that sludge disposal is a public activity that should be addressed in a public facility's storm water management program under a municipal storm water management program. EPA disagrees. Industrial facilities, whether publicly owned or not, are required to apply for and obtain permits when they are designated as industrial activity.

Another comment stated that a permit should not be required for facilities that collect all runoff on site and treat it at the same POTW. EPA believes that a permit application should be required from such facilities. However, the above practice can be incorporated as a permit condition for such a facility. One commenter stated storm water from sludge and chemical handling areas can be routed through the headworks of the POTW. The agency agrees that this may be an appropriate management practice for POTWs as long as other NPDES regulatory requirements are fulfilled with regard to POTWs.

(x) Construction activities, including clearing, grading and excavation activities except operations that result in the disturbance of less than five acre total land area which are not part of a larger common plan of development or sale. EPA addresses whether these facilities should be covered by today's rule in section VI.F.8.

The December 7, 1988, proposal also requested comments on including the following other categories of discharges in the definition of industrial activities: (xii) Automotive repair shops classified as Standard Industrial Classification 751 or 753; (xiii) Gasoline service stations classified as Standard Industrial Code 5541; (xiv) Lands other than POTW lands (offsite facilities) used for sludge management; (xv) Lumber and building materials retail facilities classified as Standard Industrial Classification 5211; (xvi) Landfills, land application sites, and open dumps that do not receive industrial wastes and that are subject to regulation under subtitle D of RCRA; (xvii) Facilities classified as Standard Industrial Classification 46 (pipelines, except natural gas) and 492 (gas production and distribution); (xviii) Major electrical powerline corridors;

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EPA received numerous comments on whether to require permit applications for these particular facilities. The December 7, 1988, proposal reflected EPA's intent not to require permits for these facilities, but rather to address these facilities in the two studies required by CWA sections 402(p)(5) and (6). After reviewing the comments on this issue, EPA believes that these facilities should be addressed under these sections of the CWA. Most of these facilities are classified as light commercial and retail business establishments, agricultural facilities where residential or domestic waste is received, or land use activities where there is no manufacturing. It should be noted that although EPA is not requiring the facilities identified as categories (xii) to (xviii), in the December 7, 1988, proposal to apply for a permit application under this rulemaking, such facilities may be designated under section 402(p)(2)(E) of the CWA.

Three commenters recommended that EPA clarify that non-exempt Department of Energy and Department of Defense facilities should be covered by the storm water regulation. The regulation clearly states that Federal Facilities that are engaged in industrial activity (*i.e.* those activities in § 122.26(b)(14)(i)–(xi)) are required to submit permit applications. Those applying for permits covering Federal facilities should consult the Standard Industrial Classifications for further clarification.

One commenter questioned how EPA intended to regulate municipal facilities engaged in industrial activities. Municipal facilities that are engaged in the type of industrial activity described above and which discharge into waters of the United States or municipal separate storm sewer systems are required to apply for permits. These facilities will be covered in the same manner as other industrial facilities. The fact that they are municipally owned does not in any way exclude them from needing permit applications under this rulemaking.

One commenter suggested exempting those facilities that have total annual sales less than five million dollars or occupy less than five acres of land. Another commenter thought that all minor permittees should be exempt. EPA believes that the quality of storm water and the extent to which discharges impact receiving water is not necessarily related to the size of the facility or the dollar value of its business. What is important in this regard, is the extent to which steps are taken at facilities to curb the quantity and type of material that may pollute storm water discharges from these facilities. Therefore EPA has not excluded facilities from permitting on such a basis. This same commenter stated that the proposed rules should not address facilities with multiple functions (industrial and retail). EPA disagrees. If a facility engages in activity that is defined in paragraphs (i) through (xi) above, it is required to apply for a permit regardless of the fact that it also has a retail element. Such facilities need only submit a permit application for the industrial portion of the facility (as long as storm water from the non-industrial portion is segregated, as discussed above). This commenter also felt that more studies needed to be undertaken to determine the best way to regulate industries. EPA agrees that storm water problems need further study and for that reason EPA has devoted substantial manpower and resources to complete comprehensive studies under section 402(p)(5), while also addressing industrial sources that need immediate attention under this rulemaking.

One commenter requested that EPA give examples of storm water discharges from each of the facilities that have been designated for submitting permit applications. Agency believes that this is unnecessary and impractical since every facility, regardless of the type of industry, will have different terrain, hydrology, weather patterns, management practices and control techniques. However, EPA intends to issue guidance on filing permit applications for storm water discharges from industrial facilities which details how an industry goes about filing an industrial permit and dealing with storm water discharges.

Today's rulemaking for storm water discharges associated with industrial activity at § 122.26(c)(1)(i) includes special conditions for storm water discharges originating from mining operations, oil or gas operations (§ 122.26(c)(1)(iii)), and from the construction operations listed above (§ 122.26(c)(1)(ii)). These requirements are discussed in more detail in section VI.F.7 and section VI.F.9 of today's notice.

3. Individual Application Requirements

Today's rule establishes individual and group permit application requirements for storm water discharges associated with industrial activity. These requirements will address facilities precluded from coverage under the general permits to be proposed and promulgated by EPA in the near future. EPA considers it necessary to obtain the information required in individual permit applications from certain facilities because of the nature of their industrial activity and because of existing institutional mechanisms for issuing and tracking NPDES permits. Furthermore, some States will not have general permitting authority. Facilities located in such States will be required to submit individual applications or participate in a group application. The following response to comments received on these requirements pertains to these facilities.

Under the September 26, 1984, regulation operators of Group I storm water discharges were required to submit NPDES Form 1 and Form 2C permit applications. In response to post-regulation comments received on that rule, EPA proposed new permit application requirements (March 7, 1985, (50 FR 9362) and August 12, 1985, (50 FR 32548)) which would have decreased the analytical sampling requirements of the Form 2C and provided procedures for group applications. Passage of the WQA in 1987 gave the EPA additional time to consider the appropriate permit application requirements for storm water discharges. On December 7, 1988, application requirements were proposed and numerous comments were received. Based upon these comments, modifications and refinements have been made to the industrial storm water permit application.

Some commenters expressed the view that the permit application requirements are too burdensome, require too much paperwork, are of dubious utility, and focus too greatly on the collection of quantitative data. EPA disagrees. In comparison to prior approaches for permitting storm water discharges and other existing permitting programs, EPA has streamlined the permit application process, limited the quantitative data requirements, and required narrative information that will be used to determine permit conditions that relate to the quality of storm water discharge. To the extent that EPA needs non-quantitative information to develop appropriate permit conditions, EPA disagrees with the view of some commenters that the information required is excessive. In response to comments on earlier rulemakings and a comment received on the December 7, 1988, proposal (stressing that the emphasis should be on site management, rather than monitoring, sampling, and reporting) EPA has shifted the emphasis of the permit application requirements for storm water discharges associated with industrial activity from the existing requirements for collection of quantitative data (sampling data) in Form 2C towards collection of less quantitative data supplemented by additional information needed for evaluation of the nature of the storm water discharges.

The permit application requirements proposed for storm water discharges reduce the amount of quantitative data required in the permit application and exempt discharges which contain entirely storm water (*i.e.* contain no other discharge that, without the storm water component, would require an NPDES permit), from certain reporting requirements of Form 2C. The proposed modifications also would exempt applicants for discharges which contain entirely storm water from several non-quantitative information collection provisions currently required in the Form 2C. The proposed modifications would rely more on descriptive information for assessing impacts of the storm water discharge. One commenter proposed that information that the applicant has submitted for other permits be incorporated by reference into the storm water permit application. EPA disagrees that incorporation by reference is appropriate. The permitting authority will need to have this information readily available for evaluating permit application and permit conditions. Furthermore, EPA feels that the applicant is in the best position to provide the information and verify its accuracy. However, if the applicant has such information and it accurately reflects current circumstances, then the applicant can rely on the information for meeting the information requirements of the application. Another commenter suggested that EPA should only require the information in § 122.26(c)(1) (A) and (B) (*i.e.*, the requirement for a topographic map indicating drainage areas and estimate of impervious areas and material management practices). As explained in greater detail below, EPA is convinced that some quantitative data and the other narrative requirements are necessary for developing appropriate permit conditions.

Form 2F addressing permit applications for storm water discharges associated with industrial activity is included in today's final rule. A complete permit application for discharges composed entirely of storm water, will be comprised of Form 2F and Form 1. Operators of discharges which are composed of both storm water and non-storm water will submit, where required, a Form 1, an entire Form 2C (or Form 2D) and Form 2F when applying. In this case, the applicant will provide quantitative data describing the discharge during a storm event in Form 2F and quantitative data describing the discharge during non-storm events in Form 2C. Non-quantitative information reported in the Form 2C will not have to be reported again in the Form 2F.

Under today's rule, Form 2F for storm water discharges associated with industrial activity would not require the submittal of all of the quantitative information required in Form 2C, but would require that quantitative data be submitted for:

- Any pollutant limited in an effluent guideline for an industrial applicant's subcategory;
- Any pollutant listed in the facility's NPDES permit for its process wastewater;
- Oil and grease, TSS, COD, pH, BOD5, total phosphorus, total Kjeldahl nitrogen; nitrate plus nitrite nitrogen; and
- Any information on the discharge required under 40 CFR 122.21(g)(7) (iii) and (iv).

In order to characterize the discharge(s) sampled, applicants need to submit information regarding the storm event(s) that generated the sampled discharge, including the date(s) the sample was taken, flow measurements or estimates of the duration of the storm event(s) sampled, rainfall measurements or estimates from the storm event(s) which generated the sampled runoff, and the duration between the storm event sampled and the end of the previous storm event. Information regarding the storm event(s) sampled is necessary to evaluate whether the discharge(s) sampled was generally representative of other discharges expected to occur during storm events and to characterize the amount and nature of runoff discharges from the site.

One commenter stated that the quantitative information should be limited to those pollutants that are expected to be known to the applicant. EPA believes this would be inappropriate since there will be no way of determining initially whether these pollutants are present despite the expectations of the applicant. Once the data is provided, permits can be drafted which address specific pollutants. This rulemaking requires that the applicant test for oil and grease, COD, pH, BOD5, TSS, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen and total phosphorus. Oil and grease and TSS are a common component of storm water and can have serious impacts on receiving waters. Oxygen demand (COD and BOD5) will help the permitting authority evaluate the oxygen depletion potential of the discharge. BOD5 is the most commonly used indicator of potential oxygen demand. COD is considered a more inclusive indicator of oxygen demand, especially where metals interfere with the BOD5 test. The pH will provide the permitting authority with important information on the potential availability of metals to the receiving flora, fauna and sediment. Total Kjeldahl nitrogen, nitrate plus nitrite nitrogen and total phosphorus are measures of nutrients which can impact water quality. Because this data is useful in developing appropriate permit conditions, EPA disagrees with the argument made by one commenter that quantitative data requirements should be a permit condition and not part of the application process.

In the proposed rule, the Agency used total nitrogen as a parameter. This has been changed to total Kjeldahl nitrogen and nitrate plus nitrite nitrogen for clarity.

Today's rule defines sampling at industrial sites in terms of sampling for those parameters that have effluent limits in existing NPDES permits, as well as for any other conventional or nonconventional parameter that might be expected to be found at the outfall. Comments on the appropriateness of the defined parameters were solicited by the proposal. Numerous commenters maintained that either the parameter list be made industry specific, or that pollutant categories not detected in the initial screen be exempted from further testing. Some suggested that only conventional pollutants, inorganics, and metals be sampled unless reason for others is found.

In terms of specific water quality parameters, it was recommended that surfactants not be tested for unless foam is visible. One commenter also suggested that fecal coliform sampling is inappropriate for industrial permits applications. One commenter favored testing for TOC instead of VOC. In response, VOC has been eliminated from the list of parameters because it will not yield specific usable data. VOC is not specifically required in any sampling in today's rule, except where priority pollutant scans are required.

Some recommended that procedures be modified to facilitate quicker, less expensive lab analyses. Concern was also raised that industry might be required to collect its own rainfall data if there is no nearby observation station. Some commenters stated that EPA should not allow automatic sampling for either biological or oil and grease sampling due to the potential for contamination in sampling equipment.

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In response, EPA believes that the sampling requirements for industry in today's rule are reasonable and not burdensome. These requirements address parameters that have effluent limits in existing NPDES permits, as well as for any other conventional or nonconventional parameter that might be expected to be found at the applicants outfall. Under this procedure both industry-specific and site-specific contaminants are already identified in the existing permit. Whether all these parameters need to be made a part of any discharge characterization plans, under the terms of the permit, will be a case-by-case determination for the permitting authority. EPA maintains that the test for surfactants (if in effluent guidelines or in the facility's NPDES permit for process water) is justifiable even when a foam is not obvious at the outfall. The presence of detergents in storm water may be indicated by foam, but the absence of foam does not indicate that detergents are not present.

EPA requested comments on fecal coliform as a parameter. Fecal coliform was included on the list as an indicator of the presence of sanitary sewage. In large concentrations, fecal coliform may be an effective indicator of sanitary sewage as opposed to other animal wastes. EPA believes that sanitary cross connections will also be found at industrial facilities. Furthermore, the test for fecal coliform is an inexpensive test and its inclusion or exclusion should make little impact financially on the individual application costs. Sampling for volatile organic carbon shall be accomplished when required, as it is an appropriate indicator of industrial solvents and organic wastes.

In response to comments, EPA acknowledges that there are certain pollutants that are capable of leaving residues in automatic sampling devices that will potentially contaminate subsequent samples. In these cases, such as for biological monitoring, if such a problem is perceived to exist and it is expected that the contaminant will render the subsequent samples unusable, manual grab samples may be needed. This would include grab samples for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform, and fecal streptococcus. EPA is not disallowing the use of automatic sampling because of possible contamination, as this type of sampling may be the best method for obtaining the necessary samples from a selected storm events.

In addition to the conventional pollutants listed above, this final rule requires applicants, when appropriate, to sample other pollutants based on a consideration of site-specific factors. These parameters account for pollutants associated with materials used for production and maintenance, finished products, waste products and non-process materials such as fertilizers and pesticides that may be present at a facility. Applicants must sample for any pollutant limited in an effluent guideline applicable to the facility or limited in the facility's NPDES permit. These pollutants will generally be associated with the facility's manufacturing process or wastes. Other process and non-process related pollutants, will be addressed by complying with the requirements of 40 CFR 122.21(g)(7) (iii) and (iv).

Section 122.21(g)(7)(iii) requires applicants to indicate whether they know or have reason to believe that any pollutant listed in Table IV (conventional and nonconventional pollutants) of appendix D to 40 CFR part 122 is discharged. If such a pollutant is either directly limited or indirectly limited by the terms of the applicant's existing NPDES permit through limitations on an indicator parameter, the applicant must report quantitative data. For pollutants that are not contained in an effluent limitations guideline, the applicant must either report quantitative data or describe the reasons the pollutant is expected to be discharged. With regard to pollutants listed in Table II (organic pollutants) or Table III (metals, cyanide and total phenol) of appendix D, the applicant must indicate whether they know or have reason to believe such pollutants are discharged from each outfall and, if they are discharged in amounts greater than 10 parts per billion (ppb), the applicant must report quantitative data. An applicant qualifying as a small business under 40 CFR 122.21(g)(8), (*e.g.*, coal mines with a probable total annual production of less than 100,000 tons per year or, for all other applicants, gross total annual sales averaging less than $100,000 per year (in second quarter 1980 dollars)), is not required to analyze for pollutants listed in Table II of appendix D (the organic toxic pollutants).

Section 122.21(g)(7)(iv) requires applicants to indicate whether they know or have reason to believe that any pollutant in Table V of appendix D to 40 CFR part 122 (certain hazardous substances) is discharged. For every pollutant expected to be discharged, the applicant must briefly describe the reasons the pollutant is expected to be discharged and report any existing quantitative data it has for the pollutant.

When collecting data for permit applications, applicants may make use of 40 CFR 122.21(g)(7), which provides that "when an applicant has two or more outfalls with substantially identical effluents, the Director may allow the applicant to test only one outfall and report that the quantitative data also applies to the substantially identical outfalls." Where the facility has availed itself of this provision, an explanation of why the untested outfalls are "substantially identical" to tested outfalls must be provided in the application. Where the amount of flow associated with the outfalls with substantially identical effluent differs, measurements or estimates of the total flow of each of the outfalls must be provided. Several commenters stated that the time and expense associated with sampling and analysis would be saved if the applicant was able to pick substantially identical outfalls without prior approval of the permitting authority. EPA disagrees that this would be an appropriate devolution of authority to the permit applicant. The permitting authority needs to ensure that these outfalls have been grouped according to appropriate criteria (for example do the outfalls serve similar drainage areas at the facility). Furthermore, EPA is not requiring that the permit applicant engage in sampling to demonstrate that the outfalls are indeed substantially identical, because that would of course defeat the purpose of § 122.21(g)(7). The procedure for establishing identical outfalls is not that onerous and provides a means for industry to save substantially on time and resources for sampling.

EPA proposed and requested comment on a requirement that the facility must sample a storm event that is typical for the area in terms of duration and severity The storm event must be greater than 0.1 inches and must be at least 96 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. In general, variance of the parameters (such as the duration of the event and the total rainfall of the event) should not exceed 50 percent from the parameters of the average rainfall event in that area. EPA also requested comments on addresaing snow melt events under this definition.

Commenters stated that median or average rainfall is not an acceptable approach; the minimum depth and duration of rainfall must be specified; the allowable 50% variation is questionable; the total depth of the storm is irrelevant; and the storm should be viewed based on the average intensity of the storm. One commenter

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suggested that using the median rainfall event would be a better approach than the average rainfall event.

Others insisted that "representative" or typical storms do not exist in semi-arid climates and that representative rainfall must be site-specific (regional) and seasonal. Several commenters contended that the requirement for 96 dry hours between events is not acceptable, with 48 and 72 hours identified as possible alternatives.

One commenter believed that a typical standard design storm, such as the 1-year, 24-hour, or 10-year, 1-hour, would be preferable. Another commenter felt that the storm event should be based on the rainfall required to generate a minimum discharge level. One commenter questioned whether the storm is to be sampled at all sites simultaneously.

To clarify its decision on what storm event should be sampled, EPA notes that its selection of the storm event considers both regional and seasonal variation of precipitation. This is evidenced in the rule with regard to sites in the municipal application (three events sampled), and in the requirements for industrial group applications (a minimum of two applicants, or one applicant in groups of less than 10, to be represented in each precipitation zone (*see* section VI.F.4 below).

The definition of a 0.1 inch minimum was determined by NURP and other studies to be the minimum rainfall depth capable of producing the rainfall/runoff characteristics necessary to generate a sufficient volume of runoff for meaningful sample analysis. EPA believes by requiring the average storm to be used as the basis for sampling that depth, duration, and therefore average rainfall intensity are being regionally defined. The Agency has also added the option of using the median rainfall event instead of the average. The potential for monitoring events that may not meet this specification should be minimized by allowing the proposed 50 percent variation in rainfall depth and/or duration from event statistics. However, the 50 percent variation need only be met when possible. Further, there is flexibility in the rule where the Director may allow or establish site specific requirements such as the minimum duration between the previous measurable storm event and the storm event sampled, the amount of precipitation from the storm event to be sampled, and the form of precipitation sampled (snowmelt or rainfall). If data is obtained from a rain event that does not meet the criteria above, the Director has the discretion to accept the data as valid.

The December 7, 1988, proposal called for a 96-hour period between events of measurable rainfall, here defined as 0.1 inch, which provided a four day minimum for the accumulation of pollutants on the surface of the outfalls' tributary areas. The key word in the definition is "measurable", which means that the 96-hour period did not necessarily have to be dry, only that no cleansing rainfall (*i.e.* 0.1 inch rain event) has occurred. However, after reviewing comments on this issue EPA has decided to change the period to 72 hours. Many commenters indicated that 96 hours is too restrictive and that securing a sample under such circumstances would be unnecessarily difficult. EPA agrees that the quality or representativeness of the sample would not be adversely affected by this change.

EPA does not agree with comments that the requirement of a particular "design" storm would be appropriate. Many commenters have expressed concern that they might sample an event not meeting the requirements for industrial group applications as defined. Because there is no way to know with sufficient certainty beforehand that an upcoming event will approximate a one-year, twenty-four hour storm, many events would be unnecessarily sampled before this event is realized.

EPA does not intend that a municipality or industry be required to sample all required outfalls for a single storm. This would represent a unmanageable investment in equipment and manpower. In some areas, it may be necessary to sample multiple sites for a single event due to the irregularity of rainfall, but not all sites.

EPA described parameters for selecting storm events for sampling of municipal and industrial outfalls in the December 7, 1988, proposal. EPA has received several comments regarding the problems that rainfall measurement in general presents. A recurring comment relative to reporting rainfall, and in verifying that the storm itself is representative, deals with the spatial distribution of rainfall. The rainfall measured at an airport does not always represent rainfall at the site, particularly in summer months when thunderstorms are prevalent. One commenter stated that it would be easier to base the selected storm on either a minimum discharge, or on a discharge duration other than on the total precipitation, because these parameters are easily measured at the site and are not dependent on the airport gauges receiving the same rainfall as the site. A few commenters questioned how to determine typical storm characteristics. One commenter advised that NOAA rainfall reporting stations provide data that represent only daily rainfall totals, not storm event data. One commenter pointed out that the time frame of the sampling requirement does not consider that a particular region may be in the midst of a multi-year drought cycle, and that what little rainfall occurs may have uncharacteristically high levels of pollutants.

The type of rain event sampled is an important parameter in any attempt to characterize system-wide loads based on the sampling results. Rainfall gauges that report only event total depth will provide the information necessary to characterize most events, provided that a reasonable estimate of the event duration can be made. If simulation models are to be used in estimating system-wide loads, rainfall measurement based on time and depth of rainfall will be needed. If the recording stations are not believed to accurately reflect this distribution, then the data will need to be collected by the applicant at a location central to the tributary area of the outfall.

The rainfall data collected by NOAA are in most cases available in the form of hourly rainfall depths. This information can be analyzed to develop characteristic storm depths and durations. In some cases, this information has already been analyzed for many long term reporting stations by various municipalities, states, and universities. The results of these investigations should be available to the applicants.

EPA realizes that prolonged rainless periods occur for both semi-arid areas and areas experiencing droughts and that the first storm after a prolonged dry period may well not be representative of "normal" runoff conditions. In order for the appropriate system-wide characterization of loads to be made, data must be collected. With regard to the municipal permit application, today's rule states that runoff characterization data will be collected during three events at from five to ten sites. The rule gives the Director the flexibility of modifying these requirements.

EPA has defined the parameters for selecting the storm event to be sampled such that at the discretion of the Director, seasonal, including winter, sampling might be required. EPA has received several comments regarding the problems that snowmelt sampling may present. Several commenters are

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opposed to monitoring of snowmelt events. The reasons cited include equipment problems and the unreasonableness of expecting this sampling, because of temperatures and the time required for personnel to be waiting for events. A few comments addressed the issues of snow pack depth, ambient temperature, and solar radiation levels, and that the snow pack may filter suspended solids or refreeze such that final melting is uncharacteristically over-polluted relative to normal conditions. Another commenter contended that it is impossible to manage the melting process and therefore unreasonable to expect controls to be implemented relative to snowmelt. In essence, it is contended that there is no first discharge unless the snow pack depth is low and melts quickly.

A few commenters favor monitoring snowmelt, for precisely the same reason that most oppose it: that the runoff from snowmelt is the most polluted runoff generated in some areas on an annual basis. Where this is the case, sampling snowmelt should be undertaken in order to accurately assess impacts to receiving streams. EPA is confident that in areas where automated sampling cannot be relied upon, grab sampling can probably be performed because the nature of the snowmelt process tends to make the timing of samples less of a problem when compared to typical rainfall events. EPA disagrees that management practices, either at industrial facilities or with regard to municipalities, cannot address snowmelt. Some areas may need to reassess their salt application procedures. In addition retention and detention devices may address snowmelt, as well as erosion controls at construction sites. Thus, obtaining samples of snowmelt is appropriate to allow development of such permit conditions.

Today's rule also modifies the Form 2C requirements by exempting applicants from the requirements at § 122.21(g)(2) (line drawings), (g)(4) (intermittent flows), (g)(7) (i), (ii), and (v) (various sampling requirements to characterize discharges) if the discharge covered by the application is composed entirely of storm water. Permit applications for discharges containing storm water associated with industrial activity would require applicants to provide other non-quantitative information which will aid permit writers to identify which storm water discharges are associated with industrial activity and to characterize the nature of the discharge.

Numerous comments were received regarding the requirement to submit a topographic map and site drainage map. Many of these comments offered alternatives to EPA's proposal. Two commenters suggested that a simple sketch of the site would be sufficient. Two commenters stated that one or the other should be adequate. One commenter believed that the drainage map was a good idea, but that the topographic map should be optional. Several commenters submitted that a topographic map was sufficient and that only SPCC plans or SARA submittals should supplement that. Another commenter argued that information relating to the location of the nearest surface water or drinking wells would be sufficient. Other commenters believed that a drainage map alone would indicate all relevant site specific information. Numerous commenters expressed concern that the drainage area map would be too detailed and that one which depicts the general direction of flow should be sufficient. Clarification was requested on whether the final rule would require the location of any drinking water wells. One commenter stated that a U.S.G.S. 7.5 quadrangle map will not illustrate drainage systems in all cases, and that therefore the requirement should be optional.

Several commenters agreed with EPA's proposal. One commenter maintained that drainage maps should be required from developments greater than three acres and from all individual applicants. Several commenters agreed with EPA's proposal that both maps should be provided, with arrows indicating site drainage and entering and leaving points. It was advised that drainage maps are useful in locating sources of storm water contamination, and it is useful to identify areas and activities which require source controls or remedial action. One commenter recommended that the map should extend far enough offsite to demonstrate how the privately owned system connects to the publicly owned system.

After considering the merits of all the comments and the reasons supporting EPA's proposal, EPA is convinced that a topographic map and a site drainage map are necessary components of the industrial application. Existing permit application regulations at 40 CFR 122.21(f)(7) require all permit applicants to submit as part of Form 1 a topographic map extending one mile beyond the property boundaries of the source depicting: the facility and each intake and discharge structure; each hazardous waste treatment, storage, or disposal facility; each well where fluids from the facility are injected underground; and those wells, springs, other surface water bodies, and drinking water wells listed in the map area in public records or otherwise known to the applicant within one-quarter mile of the facility property boundary. (See 47 FR 15304, April 8, 1982.) However, as indicated by the comments the information provided under § 122.21(f)(7) is generally not sufficient by itself for evaluating the nature of storm water discharges associated with industrial activity.

As stated in comments, a drainage map can provide more important site specific information for evaluating the nature of the storm water discharge in comparison to existing requirements, which require a larger map with only general information. The volume of storm water discharge and the pollutants associated with it will depend on the configuration and activities occurring at the industrial site. One commenter suggested that it would be appropriate to submit an aerial photograph of the site with all the topographic and drainage information superimposed on the photograph. EPA agrees that this may be an appropriate method of providing this information. EPA is not requiring a specific format for submitting this information.

EPA is also requiring that a narrative description be submitted to accompany the drainage map. The narrative will provide a description of on-site features including: existing structures (buildings which cover materials and other material covers; dikes; diversion ditches, etc.) and non-structural controls (employee training, visual inspections, preventive maintenance, and housekeeping measures) that are used to prevent or minimize the potential for release of toxic and hazardous pollutants; a description of significant materials that are currently or in the past have been treated, stored or disposed outside; and the method of treatment, storage or disposal used. The narrative will also include: a description of activities at materials loading and unloading areas; the location, manner and frequency in which pesticides, herbicides, soil conditioners and fertilizers are applied; a description of the soil; and a description of the areas which are predominately responsible for first flush runoff. This requirement is unchanged from the proposal.

Some commenters believed that information on pesticides, herbicides, and fertilizers and similar products is irrelevant, incidental to the facility's production activities, and should not be

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addressed by this rulemaking. EPA disagrees. As these materials are applied outside and hence subject to storm events, they are significant sources of pollutants in storm water discharges whether applied in residential or industrial settings. By providing this information in the permit application the permit writer will be able to determine whether such activity is associated with industrial activity and the subject of appropriate permit conditions. Nominal or incidental application of these materials at industrial facilities and non-detects in sampling of storm water discharges for the permit application will result, in most cases, in these materials not being addressed specifically in storm water permits.

Today's rule also requires that permit applicants for storm water discharges associated with industrial activity certify that all of the outfalls covered in the permit application have been tested or evaluated for non-storm water discharges which are not covered by an NPDES permit. (The applicant need not test for nonstorm water if the certification of the plant storm water discharges can be evaluated through the use of schematics or other adequate method). Section 405 of the WQA added section 402(p)(3)(B)(ii) to the CWA to require that permits for municipal separate storm sewers effectively prohibit non-storm water discharges to the storm sewer system. As discussed in part VI.F.7.b of today's preamble, untreated non-storm water discharges to storm sewers can create severe, wide-spread contamination problems and removing such discharges presents opportunities for dramatic improvements in the quality of such discharges. Although section 402(p)(3)(B)(ii) specifically addresses municipal separate storm sewers, EPA believes that illicit non-storm water discharges are as likely to be mixed with storm water at a facility that discharges directly to the waters of the United States as it is at a facility that discharges to a municipal storm sewer. Accordingly, EPA feels that it is appropriate to consider potential non-storm water discharges in permit applications for storm water discharges associated with industrial activity. The certification requirement would not apply to outfalls where storm water is intentionally mixed with process waste water streams which are already identified in and covered by a permit.

This rulemaking requires applicants for individual permits to submit known information regarding the history of significant spills at the facility. Several commenters indicated that the extent to which this information is required should be modified. One commenter stated that the requirement should be limited to those spills that resulted in a complaint or enforcement action. EPA disagrees. EPA believes that significant spills at a facility should generally include releases of oil or hazardous substances in excess of reportable quantities under section 311 of the Clean Water Act (*see* 40 CFR 110.10 and 40 CFR 117.21) or section 102 of CERCLA (*see* 40 CFR 302.4). Such a requirement is consistent with these regulations and the perception that such spills are significant enough to mandate the reporting of their occurrence. Some commenters stated that industries have already submitted this information in other contexts and should not be required to have to do it again. For the same reason another commenter felt that submittal of this information represents a waste of manpower and resources. EPA disagrees that requiring this information is unduly burdensome. If this information has already been provided for another purpose it follows that it is readily available to the industrial applicant. Thus, the burden of providing this information cannot be considered undue. Furthermore, the permit authority will need to have this available in order to determine which drainage areas are likely to generate storm water discharges associated with industrial activity, evaluate pollutants of concern, and develop appropriate permit conditions. However, to keep this information requirement within reasonable limits and limited to information already available to individual facilities, EPA has declined to expand the reporting requirements to spills of other materials, such as food as one commenter has suggested. However, EPA has decided to add raw materials used in food processing or production to the list of significant materials. Materials such as these may find their way into storm water discharges in such quantities that serious water quality impacts occur. These materials may find there way into storm water from transportation vehicles carrying materials into the facility, loading docks, processing areas, storage areas, and disposal sites.

One commenter urged that any information requested should be limited to a period of three years, which is the general NPDES records retention requirement under 40 CFR 122.21(p) and 40 CFR 112.7(d)(8). EPA agrees with this comment and has limited historical information requirements to the 3 years prior to the date the application is submitted. In this manner this regulation will be consistent with records keeping practices under the NPDES and Oil Spill Prevention programs, except sludge programs.

The December 7, 1988, proposal required the applicant to submit a description of each past or present area used for outdoor storage or disposal of significant materials. One commenter felt that the definition of significant material was too imprecise. EPA disagrees that the language should be made more precise by delineating every conceivable material that may add pollutants to storm water. Rather the definition is broad, to encourage permit applicants to list those materials that have the potential to cause water quality impacts. Stating what materials are addressed in meticulous detail may result in potentially harmful materials remaining unconsidered in permits. However, EPA has decided to add "fertilizers, pesticides, and raw materials used in the production or processing of food" to the definition in response to the comment of one State authority that such materials need to be accounted for due to their potential danger to storm water discharge quality. This same commenter recommended that "hazardous chemicals" should be added. EPA agrees, and will delineate those chemicals as "hazardous substances" which are designated under section 101(14) of CERCLA. Further clarification has been added by requiring the listing of any chemical the facility is required to report pursuant to section 313 of title III of SARA.

Another commenter felt that EPA should not require information of past storage of significant materials. EPA agrees that this proposed requirement is overbroad and has limited the time frame to those materials that were stored in areas 3 years or fewer from the date of the permit application. The 3-year limit is consistent with other Agency reporting requirements as discussed above.

One commenter questioned EPA's proposal not to provide for a waiver from the requirement to submit quantitative data if the applicant can demonstrate that it is unnecessary for permit issuance. Another commenter said that a waiver is inappropriate. EPA believes relevant quantitative data are essential to the process, but in this rulemaking the number of pollutants that must be sampled and analyzed is reduced compared to previous regulations. The proposed requirements for quantitative data are limited to pollutants that are appropriate for given site-specific operations, thereby making a waiver unnecessary.

Although the concept of a waiver is attractive because of the perceived potential reduction in burdens for applicants, EPA believes that because the storm water discharge testing requirements have already been streamlined, a waiver would not in practice provide significant reductions in burden for either applicants or permit issuing authorities. Requirements to provide and verify data demonstrating that a waiver is appropriate for a storm water discharge may prove to be more of a burden to the applicant and the permitting authorities. Establishing such a waiver procedure would be administratively complex and time-consuming for both EPA and the applicants, without any justifiable benefit. Therefore, this rulemaking does not include a waiver provision.

In response to one commenter, EPA wishes to emphasize that if a facility has zero storm water discharge because it is discharging to a detention pond only, a permit application is not required. Only those discharges to the waters of the United States or municipal systems need submit notifications, individual or group permit applications, or notices of intent where applicable. However, if the detention pond overflows or the discharger anticipates that it may overflow, then a permit application should be submitted.

Two commenters agreed with EPA's proposed requirement to have a description of past and present material management practices and controls. EPA believes that this is important information directly relating to the quality of storm water that can be expected at a particular facility and this requirement is retained in today's rule. However, as with other historical information requirements, EPA is limiting past practices to those that occurred within three years of the date that the application is submitted. One commenter argued that past practices should not be considered unless there is evidence that past practices cause current storm water quality problems. EPA anticipates that the information submitted by the applicant will be used to make this determination and that appropriate permit conditions can be developed accordingly.

One commenter requested clarification on the certification requirement that the data and information in the application is true and complete to the best of the certifying officer's knowledge. This is a fundamental and integral part of all NPDES permit applications. It essentially requires the signatory to assure the permit writer, based upon his or her personal knowledge, that the information has been submitted without a negligent, reckless, or purposeful misrepresentation. EPA intends to interpret this requirement in the same manner for storm water applications as other applications.

4. Group Applications

Today's final rule provides some industries with the option of participating in a group application, in lieu of submitting individual permits. There are several reasons for the group application. First, the group application procedure provides adequate information for issuing permits for certain classes of storm water discharges associated with industrial activity. Second, numerous commenters supported the concept of the group application as a way to reduce the costs and administrative burdens associated with storm water permit applications. Third, group applications will reduce the burden on the regulated community by requiring the submission of quantitative data from only selected members of the group. Fourth, the group application process will reduce the burden on the permit issuing authority by consolidating information for reviewing permit applications and for developing general permits suited to certain industrial groups. Where general permits are not appropriate or cannot be issued, a group application can be used to develop model individual permits, which can significantly reduce the burden of preparing individual permits.

As noted above in today's preamble, EPA intends to promulgate a general permit that will cover many types of industrial activity. Industrial dischargers eligible for such permits will generally be required to seek coverage by submittal of a notice of intent. Facilities that are ineligible for coverage under the general permit will be required to submit an individual permit application or submit a group application. The group application process promulgated today will serve as an important component to implement Tier III of EPA's industrial storm water permitting strategy discussed above. The general permit which EPA intends to promulgate in the near future shall set forth what types of facilities are eligible for coverage.

Some commenters criticized the group application procedure as an abdication of EPA's responsibility to effectively deal with pollutants in storm water discharges. One commenter stated that every facility subject to these regulations should be required to submit quantitative data. In response EPA believes, as do numerous commenters, that the group application procedure is a legitimate and effective way of dealing with a large volume of currently uncontrolled discharges. The only difference between the group application procedure and issuing individual permits based on individual applications is that the quantitative data requirements from individual facilities will be less if certain procedures are followed. EPA is convinced that marked improvements in the process of issuing permits will be achieved when these procedures are followed. Where the storm water discharge from a particular facility is identified as posing a special environmental risk, it can be required to submit individual applications and therefore separate quantitative data. It should also be noted that submittal of a group application does not exempt a facility from submitting quantitative data on its storm water discharge during the term of the permit.

The final rule refines and clarifies some of the requirements of the group application approach set forth in the December 7, 1988 proposal. Several commenters requested that EPA add a provision which would allow a facility that becomes subject to the regulations to "add on" to a group application after that group application has already been submitted. One commenter indicated that some trade associations are prohibited from engaging in an activity which would not apply to all its members, and that an "add on" provision was needed in the event such a prohibition was invoked. Another commenter noted that where a group is particularly large, for example one that consists of several thousand members, that it would be a logistical feat to ensure that all facilities eligible as members of the group are properly identified and listed on the application within the 120 day deadline for submitting part 1A of the application.

EPA believes that a group applicant should have a limited ability to add facilities to the group after part 1A has been submitted and that a provision which allows a group or group representative an unbridled ability to "add on" is impractical for a number of reasons. First, 10% of the facilities must submit quantitative data. Adding facilities after the group has been formed and approved would change the number of facilities that have to submit quantitative data on behalf of the group. This would result in an [illegible] administrative burden on the reviewing authority, which is in the position of having to organize the quantitative data and determine the [illegible] of group members (and those that are required to submit quantitative data) within 2 months of receiving part 1 of the group application. Further, during the permit application process permitting authorities will be developing permit conditions for an identified and pre-determined group of facilities. Allowing potentially significant numbers of permit applicants to suddenly inject themselves into a group application could unnecessarily hamper or disrupt the timely development of general and model permits. In addition, if a facility were "added on" the number of facilities having to submit quantitative data may drop below 10%. Thus the facility desiring to "add on" may be put in the position of having to submit the quantitative data themselves, which would clearly defeat the purpose of being a part of the group application.

Nevertheless, EPA has added a provision to 122.26(e) which enables facilities to add on to a group application at the discretion of the EPA's Office of Water Enforcement and Permits, and upon a showing of good cause by the group applicant. For the reasons noted above, EPA anticipates this provision will be invoked only in limited cases where good cause is shown. Facilities not properly identified in the group application, and which cannot meet the good cause test will be required to submit individual permit applications. EPA will advise such facilities within 30 days of receiving the request as to whether the facility may add on.

However, the "add on" facility must meet the following requirements: The application for the additional facility is made within 15 months of the final rule; and the addition of the facility does not reduce the percentage of the facilities that are required to submit quantitative data to below 10% unless there are over 100 facilities that are submitting quantitative data. Approval to become part of a group application is obtained from the group or the trade association and is certified by a representative of the group; approval for adding on to a group is obtained from the Office of Water Enforcement and Permits.

Several commenters stated that the application requirements for groups are so burdensome that the advantages of the process are undermined. These concerns are addressed in greater detail below. Among the requirements which commenters objected are the requirements to list every group member's company by name and address. EPA is convinced that a condition precedent to approving a group application is at least identifying the members of the group. Without such information it would be impossible to determine if all the facilities are sufficiently similar. EPA disagrees that industries will be dissuaded from using the group application process because the advantages of the process are undermined. Although commenters perceived many burdens associated with individual permit applications, by far the most significant burden identified by the comments is the requirement for obtaining and submitting quantitative data. The group application significantly reduces this burden by requiring only10% of the facilities to submit quantitative data if the number in the group is over 100. If the number in the group is over 1000, then only 100 of the facilities need submit quantitative information. If group applicants develop cost sharing procedures to reduce the financial and administrative burdens of submitting quantitative data, it is evident that utilizing the group application could save industries as much as 90% on the most economically burdensome aspect of the application.

Several commenters perceived that the group application procedure did not offer them significant savings because under the proposal their particular industry would only be required to test for COD, BOD5, pH, TSS, oil and grease, nitrogen, and phosphorous. These commenters stated that sampling for these pollutants is not particularly expensive. EPA believes that even if a group is required only to submit minimal quantitative data on particular pollutants, substantial savings can accrue to a particular industry if the group has many members. This is particularly true when the number of outfalls to be sampled, the information on storm events, and flow measurements are factored into the cost analysis. An additional benefit for members of the group as well as for permit issuing agencies is that the process of developing a permit, including drafting and responding to public comments on the permit, is consolidated by the group application process. Accordingly, it is less resource intensive for the group to work with permit issuance authorities to develop well founded permit conditions.

One commenter raised a concern about the situation where one of the facilities that is designated for submitting quantitative data drops out of the group. If this happened, then another facility would have to submit quantitative data. In response, EPA notes that one approach would be for the group to have one or two more facilities submit quantitative data than needed to avoid problems from such a departure or to account for new additions to the group. Certainly this issue goes directly to the facility selection process which is a critical component of the group application; the facilities need to be carefully selected and reviewed by the group to prevent such difficulties.

Several comments indicated a confusion over what facilities are eligible to take advantage of the group application procedure. Any industry or facility that is required to submit a storm water permit application under these regulations is eligible to participate in a group application. However, whether a facility can obtain a storm water permit under a group application procedure will depend upon whether that facility is a member of the same effluent guideline subcategory, or is sufficiently similar to other members of the group to be appropriate for a general permit or individual permit issued pursuant to the group application. Accordingly, group applications are not limited to national trade associations. The agency believes that the language in § 122.26(c)(2) adequately addresses these concerns. The process does not prohibit a particular company with multiple facilities from filing a group application as long as those facilities are sufficiently similar.

One commenter expressed concern that a single company would not be able to take advantage of the group application benefits unless the company had more than ten facilities. Under such circumstances the company would have to become integrated with a larger group of facilities owned by other companies in order to take advantage of the benefits afforded by the group application procedure. In response, the Agency is providing for a group application of between four and ten members, however at least half the facilities must submit data. One commenter stated that the number of facilities required to submit quantitative data should be determined on a case by case basis. EPA believes that 10 percent for groups with over ten members will be easiest to implement for both industry and EPA, and will ensure that adequate representative quantitative data are obtained so that meaningful determinations of facility similarity can be made and appropriate permit conditions in general or model permits can be developed.

Another commenter suggested that one facility with a multitude of [illegible] water discharge points [illegible] use the group permit [illegible] reduce the amount of [illegible] that it is required to submit. This is an accurate observation but only to the extent that the facility combines with several other facilities to form a group, in which case only 10% of the facilities need submit quantitative data. The group application procedure in today's rule is designed for use by multiple facilities only. However, if an individual facility has 10 outfalls with ten substantially identical effluents the discharger may petition the Director to sample only one of the outfalls, with that data applying to the remaining outfalls. See § 122.21(g)(7). Thus, existing authority already allows for a "group-like" process for sampling a subset of storm water outfalls at a single facility.

Concern was expressed that the spill reporting requirement from each facility in part 1B would preclude any group from demonstrating that the facilities sampled are "representative," because the incidence of past spills is very site-specific. EPA notes that since it has dropped the part 1B requirements for other reasons discussed below, this comment is now moot.

Numerous commenters noted that if a facility is part of a group application and is subsequently rejected as a group applicant, such an entity would not have a full year to submit an individual permit application. EPA agrees that this is a significant concern. Accordingly, those facilities that apply as a member of a group application will be afforded a full year from the time they are notified of their rejection as a member of the group to file an individual application. EPA notes that it intends to act on group application requests within 60 days of receipt; thus this approach will only provide facilities that are rejected from a group application a short extension of the deadline for other individual applications.

One commenter complained that the cost of defending a group's choice of representative facilities may exceed the cost of submitting an individual permit application, thereby reducing the incentive to apply as group. The agency anticipates that the selection process will be one open to negotiation between the affected parties and one that will end in a mutually satisfactory group of facilities. It is the intent of EPA to reduce the costs of submitting a permit application as much as possible, while providing adequate information to support permitting activities.

Another commenter argued that the use of model permits will create a disincentive for participating in a group because model permits may be used by the permit issuing authority to issue individual permits for discharges from similar facilities that did not participate in the group application. EPA does not agree. The benefit of applying as a group applicant is to take advantage of reduced representative quantitative data requirements. This incentive will exist regardless of whether or how model permits are used. Further, technology transfer can occur during the development of permits based on individual applications as well as those based on group applications.

One commenter suggested moving some of the facility specific information requirements of part 1 of the group application to part 2 of the group application in order to provide more incentive to apply as a group. EPA has considered this and believes such a change would be inappropriate. Part 1 information will be used to make an informed decision about whether individual facilities are appropriate as group members and appropriate for submitting representative quantitative data. Furthermore, information burdens from providing site specific factors in part 1 is relatively minimal, and the information requirements in the proposed part 1B application have been eliminated.

One commenter suggested that trade associations develop model permits since they have the most knowledge about the characteristics of the industries they represent. As noted above, EPA expects that the industries and trade associations will have input, through the permit application process, as to how permit conditions for storm water discharges are developed. While the applicant can submit proposed permit conditions with any type of application, EPA however cannot delegate the drafting of model permits to the permittees. EPA is developing and publishing guidance in conjunction with this rulemaking for developing permit conditions.

One commenter suggested that new dischargers should be able to take advantage of general permits developed pursuant to group applications. As with other general permits, EPA anticipates that such discharges will be able to fall within the scope of a general permit based on a group application where appropriate.

One commenter stated that the group application does not benefit municipalities since there is no requirement for industrial discharges through municipal sewers to apply for a permit. As noted in a previous discussion, industrial discharges through municipal sewers must be covered by an NPDES permit. Such facilities may avail themselves of the group application procedure. Also, municipalities are not precluded from developing a group application procedure under their management plan for industries that discharge into their municipal systems in order to streamline developing controls for such industries.

One industry wanted clarification [illegible] facilities located within a municipality would be eligible to participate in a group application. All industrial activities required to submit an individual permit are entitled to submit as part of group application, except those with existing NPDES permits covering storm water. Those facilities that discharge through a municipal separate storm sewer systems required to submit an individual application (because they do not fall within a general permit) are not precluded from using the group application procedure if appropriate.

Other municipalities expressed confusion over the industrial group application concept. The following responds to these comments. First, municipalities are not eligible for participation in a group application because the group application process is designed for industrial activities. Sampling requirements for municipal permit applications are already limited to a small subset of the outfalls from the system, as discussed below. Furthermore, permits for municipal separate storm sewer systems will be issued on a system-wide or jurisdiction-wide basis, rather than individually for each outfall. Thus, today's regulation already incorporates a "grouplike" permit application process for municipalities. Furthermore, it is highly unlikely that various municipal storm sewer systems would be "substantially similar" enough to justify group treatment in the same way as industrial facilities. In response to another comment, this regulation does not directly give the municipality enforcement power over members of an industrial group who may be discharging through its system. Only the permitting authority and private citizens and organizations (including the municipality acting in such a capacity) will have enforcement power over members of the group once permits are issued to those members.

One commenter believed that the States with authorized NPDES programs rather than EPA should establish permit terms for permits based on group applications. In response to this [illegible] comment, EPA wishes to clarify [illegible] in the group application process [illegible] applications will be submitted to [illegible] headquarters where they will be reviewed and [illegible]

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summaries of the group application will be distributed to authorized NPDES States. EPA wishes to emphasize that NPDES States are not bound by draft model permits developed by EPA. States may adopt model permits for use in their particular area, making adjustments for local water quality standards and other regional characteristics. Where general permit coverage is believed to be inappropriate, facilities may be required to apply for individual permits. One commenter objected to the group application procedure because it is not consistent with existing Federal permitting procedures, which will lead to confusion in the regulated community. The agency disagrees with this assessment. The group application is a departure from established NPDES program procedures. However, the comments, when viewed in their entirety, reflect widespread support from the regulated community for a group application procedure. Further, the comments reflect that those affected by this rulemaking understand the components of the group application and the procedures under which permits will be obtained pursuant to the group application.

One commenter expressed concern regarding how BAT limits for groups of similar industries will be developed. Technology based limits will be developed based on the information received from the group applicants. If the group applicants possess similar characteristics in terms of their discharge, BAT/BCT limitations and controls will be developed accordingly for those members of the group. If the discharge characteristics are not similar then applying industries are not appropriate for the group.

One commenter has suggested that the proposed group application is too complex with regard to the part 1A, part 1B, and part 2 group application requirements and that EPA should repropose these provisions. As discussed below, EPA has simplified the industrial group application requirements by eliminating the part 1B application. Thus, reproposal is unnecessary.

One commenter criticized the group application concept as not achieving any type of reduction in administrative burden for NPDES States. EPA disagrees with this assessment. If industries take advantage of the group application procedure, EPA will have an opportunity to review information describing a large number of dischargers in an organized manner. EPA will perform much of the initial review and analysis of the group application, and provide NPDES States with summaries of the applications thereby reducing the burden on the States. Furthermore, the procedure encourages a potentially large number of facilities to be covered by a general permit, which will clearly reduce the administrative burden of issuing individual permits.

The final rule establishes a regulatory procedure whereby a representative entity, such as a trade association, may submit a group application to the Office of Water Enforcement and Permits (OWEP) at EPA headquarters, in which quantitative data from certain representative members of a group of industrial facilities is supplied. Information received in the group application will be used by EPA headquarters to develop models for individual permits or general permits. These model permits are not issued permits, but rather they will be used by EPA Regions and the NPDES States to issue individual or general permits for participating facilities in the State. In developing such permits, the Region or NPDES State will, where necessary, adapt the model permits to take into account the hydrological conditions and receiving water quality in their area. One commenter expressed the view that having this procedure managed by EPA headquarters would cause delays and it should be delegated to the States and Regions. EPA disagrees that delay will ensue using this procedure. Furthermore, consistency in development of model and general permits can be achieved if application review is coordinated at EPA headquarters.

a. Facilities Covered. Under this rule the group application is submitted for only the facilities specifically listed in the application and not necessarily for an entire industry. The facilities in the group application selected to do sampling must be representative of the group, not necessarily of the industry.

Facilities that are sufficiently similar to those covered in a general permit (issued pursuant to a group application) that commence discharging after the general permit has been issued, must refer to the provisions of that general permit to determine if they are eligible for coverage. Facilities that have already been issued an individual permit for storm water discharges will not be eligible for participation in a group application. Several commenters believed that this restriction is inequitable since they have experienced the administrative burden of submitting a permit application. EPA disagrees. Industries that have already obtained a permit for storm water discharges have developed a storm water management program, engaged in the collection of quantitative data, and possess familiarity and experience with submitting storm water permit applications. The Agency sees no point to instituting an entirely new permit application process for facilities that have storm water permits issued individually. It makes little sense for these industries to be involved with submitting another permit application before their current permit expires.

As noted above, once a general permit has been issued to a group of dischargers, a new facility may request that they be covered by the general permit. The permitting authority can then examine the request in light of the general permit applicability requirements and determine whether the facility is suitable or not.

b. Scope of Group Applications. Numerous comments were received on how facilities should be evaluated as members of a group application. Several commenters stated that effluent limitation guideline subcategories are not relevant to pollutants found in storm water, but rather to the facility's everyday activities, and therefore similarity should be based on each facility's discharge or the similarity of pollutants expected to be found in a facility's discharge. Other commenters felt that similarity of operations at facilities should be the criteria. Others, believed that an examination of the facility's impact on storm water quality should be the applied criteria. Other commenters suggested that EPA provide more guidance as to how broadly groups can be defined and that a failure to do so would discourage facilities from going to the trouble and expense of entering into the group application process. Some commenters were concerned that facilities would be rejected as a group because of variations in processes and process wastewater characteristics.

EPA does not agree that effluent limitation guideline subcategories are inappropriate as a method for determining group applications. EPA guideline subcategories are functional classifications, breaking down facilities into groups, for purposes of setting effluent limitations guidelines. The use of EPA subcategories will save time for both applicants and permitting authorities in determining whether a [illegible] particular group is appropriate for a [illegible] group application. Furthermore, EPA believes that this method of [illegible] provides adequate guidance for [illegible] determining what facilities are [illegible] together. Establishing [illegible] extent to which a facility's [illegible]

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affects storm water quality would not provide applicants with sufficient guidance as to the appropriateness of individual industries for group applications and would not provide information needed to draft appropriate model permit conditions for potentially different types of industries, industrial processes, and material management practices.

However, EPA recognizes that the subcategory designations may not always be available or an effective methodology for grouping applicants. Also, there are situations where processes that are subject to different subcategories are combined. EPA agrees that the group application option should be flexible enough to allow groups to be created where subcategories are too rigid or otherwise inappropriate for developing group applications or where facilities are integrated or overlap into other subcategories. For these reasons, this rulemaking does not limit the submission to EPA subcategories alone, but rather allows groups to be formed where facilities are similar enough to be appropriate for general permit coverage.

In determining whether a group is appropriate for general permit coverage, EPA intends that the group applicant use the factors set forth in 40 CFR 122.28(a)(2)(ii), the current regulations governing general permits, as a guide. If facilities all involve the same or similar types of operations, discharge the same types of wastes, have the same effluent limitation and same or similar monitoring requirements, where applicable, they would probably be appropriate for a group application. To that extent, facilities that attempt to form groups where the constituent makeup of its process wastewater is dissimilar may run the risk of not being accepted for purposes of a group application.

Some commenters expressed the view that categories formed using general permit factors are too broad or that the language is too vague. One commenter expressed the view that the standard is too subjective and that permit writers will be evaluating the similarity of discharge too subjectively, while other commenters felt that the criteria should be broad and flexible. Other commenters stated that the effluent guideline subcategory or general permit coverage factors are not related to storm water discharges, because much of the criteria are based upon what is occurring inside the plant, rather than activities outside of the plant. EPA believes that these criteria are reasonable for defining the scope of a group application. EPA disagrees that the procedure, which is adequate for the issuance of general permits, is inadequate for the development of a group application. EPA believes that the activities inside a facility will generally correspond to activities outside of the plant that are exposed to storm events, including stack emissions, material storage, and waste products. Furthermore, if facilities are able to demonstrate their storm water discharge has similar characteristics, that is one element in the analysis needed for establishing that the group is appropriate. EPA disagrees that the criteria are too vague. If facilities are concerned that general permit criteria is insufficient guidance, then subcategories under 40 CFR subchapter N should be used. EPA believes that the program will function best if flexibility for creating groups is maintained.

If a NPDES approved State feels that a tighter grouping of applicants is appropriate individual permit applications can be requested from those permit applicants. One commenter indicated that it was not clear whether the group application procedure could be used for all NPDES requirements. EPA would clarify that the group application is designed only to cover storm water discharges from the industrial facilities identified in § 122.26(b)(14).

As noted above, EPA wishes to clarify that facilities with existing individual NPDES permits for storm water are not eligible to participate in the group application process. From an administrative standpoint EPA is not prepared to create an entirely different mechanism for permitting industries which already have such permits.

c. Group Application Requirements. The group application, as proposed, included the following requirements in three separate parts. Part 1A of a group application included: (A) Identification of the participants in the group application by name and location; (B) a narrative description summarizing the industrial activities of participants; (C) a list of significant materials stored outside by participants; and (D) identification of 10 percent of the dischargers participating in the group application for submitting quantitative data. A proposed part 1B of the group application included the following information from each participant in the group application: (A) A site map showing topography (or indicating the outline of drainage areas served by the outfall(s) and related information; (B) an estimate of the area of impervious surfaces (including paved areas and building roofs) and the total area drained by each outfall and a narrative description of significant materials; (C) a certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested for the presence of non-storm water discharges; (D) existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility; (E) a narrative description of industrial activities at the facility that are different from or that are in addition to the activities described under part 1A; and (F) a list of all constituents that are addressed in a NPDES permit issued to the facility for any of non-storm water discharge. Part 2 of a group application required quantitative data from 10 percent of the facilities identified.

Some commenters felt that spill histories, drainage maps, material management practices, and information on significant materials stored outside are too burdensome or meaningless for evaluating similarity of discharges among group applicants. Several commenters stated that such requirements where the group may consist of several thousand facilities were impractical and would not assist EPA in developing model permits. Many commenters insisted that the requirements imposed in part 1B would effectively discourage use of the group application procedure. EPA agrees in large part with these comments. After reevaluating the components of part 1B, and the entire rationale for instituting the group application procedure, EPA has decided to excise part 1B from the requirements, and rely on part 1A and part 2 for developing appropriate permit condition. Where appropriate, EPA may require facilities to submit the information, formerly in part 1B, during the term of the permit. In other cases, EPA will establish which facilities must submit individual permit applications where more site specific permits are appropriate.

Under the revised part 1 and part 2, EPA will receive information pertaining to the types of industrial activity engaged in by the group, materials used by the facilities, and representative quantitative data. EPA can use such information to develop management practices that address pollutants in storm water discharges from such facilities. For most facilities, general good housekeeping or management practices will eliminate pollutants in storm water. Such requirements can be further refined by determining the nature of a group's industrial activity and by obtaining information on material used at the facility and representative quantitative data from

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percentage of the facilities. Thus, EPA is confident that model permits and general permits can be developed from the information to be submitted under part 1 and part 2.

One commenter felt that more guidance on what makes a facility representative for sampling as part of a group is needed. In response, the Agency believes the rule as currently drafted provides adequate notice.

Another commenter asked how much sampling needed to be done and how much monitoring will transpire over the life of the permit for members of a group. This will vary from permit to permit and will be determined in permit proceedings. This rulemaking only covers the quantitative data that is to be submitted in the context of the group permit application.

One commenter indicated that because of the amount of diversity in the operations of a particular industry, obtaining a sample that could be considered representative would be extremely difficult. EPA recognizes that obtaining representative quantitative data through the group application process will prove to be difficult; however, EPA has sought to minimize these perceived problems. Under the group application concept, industries must be sufficiently similar to qualify. Industries which have significantly different operations from the rest of the group that affects the quality of their storm water discharge may be required to obtain an individual permit. Use of the nine precipitation zones will enable the data in the permit application to be more easily analyzed and patterns observed on the basis of hydrology and other regional factors. How EPA will evaluate the representativeness of the sample is discussed below.

Several commenters asked why the precipitation zone of group members is relevant to the application. The need to identify precipitation zones arises because the amount of rainfall is likely to have a significant impact on the quality of the receiving water. According to an EPA study (Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality; Office of Water, Nonpoint Source Branch, Sept. 1986) the United States can be divided into nine general precipitation zones. These zones are characterized by differences in precipitation volume, precipitation intensity, precipitation duration, and precipitation intervals. Industrial facilities that seek general permits via the group application option may show significantly different loading rates as a result of these regional precipitation differences. As an example, precipitation in Seattle, Washington, located in Zone 7, approaches the mean annual storm intensity of .024 inches/hour with a mean annual storm duration of 20 hours for that Zone. In contrast, precipitation in Atlanta, Georgia, located in Zone 3 approaches the mean annual storm intensity of .102 inches/hour and a mean storm duration of 6.2 hours for that Zone. Atlanta, receives on the average four times more precipitation per hour with storms lasting one-third as long. As a result of these differences, if identical facilities within a group application were situated in each of these areas, their storm water discharges would likely exhibit different pollutant characteristics. Accordingly, data should be submitted from facilities in each zone.

One commenter felt that the EPA should abandon or modify its rainfall zone concept, because storm water quality will depend more on what materials are used at the facility than rainfall. EPA disagrees. Because storm water loading rates may differ significantly as a result of regional precipitation differences, it is necessary that for each precipitation zone containing representatives of a group application, the group must provide samples from some of those representatives. In comments to previous rulemakings it was argued that the amount of rainfall will affect the degree of impact a storm water discharge may have on the receiving stream.

One commenter stated that the precipitation zones illustrated in appendix E of the proposed rulemaking do not adequately reflect regional differences in precipitation and that in some cases the zones cut through cities where there are concentrations of industries without differences in their precipitation patterns. The rainfall zone map is a general guide to determining what areas of the country need to be addressed when determining representative rainfall events and quantitative data. When dealing with rainfall on a national scale, it is near impossible to make generalized statements with a great deal of accuracy. In the case of rainfall zones, rainfall patterns may be similar for facilities in close proximity to each other but none the less in different rainfall zones. In response, EPA has created these zones to reflect regional rainfall patterns as accurately as possible. Because of the variable nature of rainfall such circumstances are sure to arise. However, in order to obtain a degree of representativeness EPA is convinced that the use of these rainfall zones as described is appropriate for the submittal of group applications and the quantitative data therein.

The second and third requirements of part 1 of the group application instruct the applicant to describe the industrial activity (processes) and the significant materials used by the group. For the significant materials listed, the applicant is to discuss the materials management practices employed by members of the group. For example, the applicant should identify whether such materials are commonly covered, contained, or enclosed, and whether storm water runoff from materials storage areas is collected in settling ponds prior to discharge or diverted away from such areas to minimize the likelihood of contamination. Also, the approximate percentage of facilities in the group with no practices in place to minimize materials stored outside is to be identified.

EPA considers that the processes and materials used at a particular facility may have a bearing on the quality of the storm water. Thus, if there are different processes and materials used by members of the group, the application must identify those facilities utilizing the different processes and materials, with an explanation as to why these facilities should still be considered similar.

One commenter felt that a facility should be able to describe in its permit application the possibility of individual materials entering receiving waters. EPA supports the applicant adding site specific information which will assist the permit writer making an informed decision about the nature of the facility, the quality of its storm water discharge, and appropriate permit conditions.

The fourth element of part 1 of the group application is a commitment to submit quantitative data from ten percent of the facilities listed. EPA proposed that there must be a minimum of ten and a maximum of one hundred facilities within a group that submit data. Comments reflected some dissatisfaction with this requirement. Some commenters asserted that ten percent was too high a number and would discourage group applications, while one commenter suggested a lesser percentage would be appropriate where the group can certify that facilities are representative. One commenter suggested that EPA have the discretion to allow for a smaller percentage. Several commenters argued that EPA should be satisfied with fewer than ten percent because EPA [illegible] data from less than ten percent of the plants in a subcategory when promulgating effluent guidelines and that EPA should rely on data collection goals

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with affected groups as was done in the 1985 storm water proposal. Other commenters pointed out that an anomalous situation could arise where the group was small and facilities were scattered throughout the precipitation zones. For example, if a group consisted of 20 members where a minimum of ten facilities had to submit samples, and two or more members were in each precipitation zone; a total of 18 facilities (90% of the group) would have to submit quantitative data. EPA believes that there must be a sufficient number of facilities submitting data for any patterns and trends to be detectable. However, in light of these comments EPA has decided to modify the language in § 122.26(c) to allow 1 discharger in each precipitation zone to submit quantitative data where 10 or fewer of the group members are located in a particular precipitation zone. EPA believes, however, that one hundred facilities would in most cases be sufficient to characterize the nature of the runoff and thus 100 should remain the maximum. If the data are insufficient, EPA has the authority to request more sampling under section 308 of the CWA.

One commenter suggested that the ten facility cutoff was unreasonable, and that instead of cutting off the group at ten, allow a smaller number in the group and allow the facilities to sample ten percent of their outfalls instead. EPA agrees, in part, and will allow groups of between four and ten to submit a group application. However, the ten percent rule would not be effective in such cases. Therefore, at least half the facilities in a group of four to ten will be required to provide quantitative data from at least one outfall, with each precipitation zone represented by at least one facility.

For any group application, in addition to selecting a sufficient number of facilities from each precipitation zone, facilities selected to do the sampling should be representative of the group as a whole in terms of those characteristics identifying the group which were described in the narrative, i.e., number and range of facilities, types of processes used, and any other relevant factors. If there is some variation in the processes used by the group (40 percent of the group of food processors are canners and 60 percent are canners and freezers, for example), the different processes are to be represented. Also, samples are to be provided from facilities utilizing the materials management practices identified, including those facilities which use no materials management practices. The representation of these different factors, to the extent feasible, is to be roughly equivalent to their proportion in the group.

EPA wishes to emphasize that the provision that ten percent of the facilities need to submit quantitative data only applies to the permit application process. The general or individual permit itself may require quantitative data from each facility.

Submittal of Part 2 of the Group Application. As with part 1, part 2 of the Group Application would be submitted to the Office of Water Enforcement and Permits, in Washington, DC. If the information is incomplete, or simply is found to be an inadequate basis for establishing model permit limits, EPA has the authority under section 308 of the Clean Water Act to require that more information be submitted, which may include sampling from facilities that were part of the group application but did not provide data with the initial submission. If the group application is used by a Region or NPDES State to issue a general permit, the general permit should specify procedures for additional coverage under the permit.

If a part 2 is unacceptable or insufficient, EPA has the option to request additional information or to require that the facilities that participated in the group application submit complete individual applications (e.g. facilities that have submitted Form 1 with the group application may be required to submit Form 2F, or facilities which have submitted complete Form 1 and Form 2F information in the group application generally would not have to submit additional information).

Once the group applications are reviewed and accepted, EPA will use the information to establish draft permit terms and conditions for models for individual and general permits. NPDES approved States and EPA regional offices will continue to be the permit-issuing authority for storm water discharges. The NPDES approved States accepting the group application approach and the EPA Regions may then take the model permits and adapt them for their particular area, making adjustments for local water quality standards and other localized characteristics, and making determinations as to the need for an individual storm water permit where general permit coverage is felt to be inappropriate. Permits would be proposed by the Region or NPDES approved State in accordance with current regulations for public comment before becoming final. In NPDES States without general permit [illegible] where an individual permit is deemed appropriate, the model permit can serve as the basis for issuing an individual permit.

The group application is an NPDES permit application just like any other and, as such, would be handled [illegible] normal permitting procedures, subject to the regulatory provisions applicable to permit issuance. Incomplete or otherwise inadequate submissions would be handled in the same manner as any other inadequate permit application. The permit issuing authority would retain the right to require submission of Form 1, Form 2C and Form 2F from any individual discharger it designates.

Some commenters offered other procedures for developing a group application procedure; however, these were frequently entirely different approaches or so novel that a reproposal would be required. One commenter suggested that those industries that are identified as being likely to pollute should be required to submit quantitative data. Numerous commenters contended that a generic approach for meeting the required information requirements for group applications would allow EPA to develop adequate general permits. EPA does not view these approaches as appropriate.

5. Group Application: Applicability in NPDES States

Many commenters expressed concern about how the group application procedure will work within the framework of an NPDES approved State. The relationship between EPA and the States that are authorized to administer the NPDES program, including implementation of the storm water program, is a complicated aspect of this rulemaking. Approved States (there are 38 States and one territory so approved) must have requirements that are at least as stringent as the Federal program [illegible] may be more stringent if they choose. Authority to issue general permits [illegible] optional with NPDES States.

EPA has determined that [illegible] of the facilities must provide quantitative data in the permit application as noted above. Furthermore, these applications [illegible] submitted to EPA headquarters. Consequently States, [illegible] approved or not, are not [illegible] reject or modify this [illegible] States may determine [illegible] sampling to be done [illegible] conditions. If they choose [illegible] general permits they may [illegible] authority in their NPDES [illegible] upon approval of the program by EPA, may then issue general permits. Within the context of the NPDES provisions of the CWA, if States do not have general permitting authority, then general permits are not available in those States.

In response to one comment, EPA does not have authority to issue general or individual permits to facilities in NPDES approved states. Today's rule provides a means for affected industries to be covered by general permits developed via the group application procedure as well as from general permits developed independently of the group application process. Accordingly, today's rule anticipates that most NPDES States will seek general permit issuance authority to implement the storm water program in the most efficient and economical way. Without general permit issuance authority NPDES States will be required to issue individual permits covering storm water discharges to potentially thousands of industrial facilities.

One commenter recommended that States with approved NPDES programs should be involved in determining what industries are representative for submitting quantitative data. EPA recognizes that States will have an interest in this determination and may possess insight as to the appropriateness of using some facilities. However, EPA may be managing hundreds of group applications and approving or disapproving them as expeditiously as possible. EPA believes that involving the States in this already administratively complex and time consuming undertaking would be counterproductive. In any event, NPDES approved States are not bound by the determinations of EPA as to the appropriateness of groups or the issuance of permits based on model permits or individual permits. However, States will be encouraged to use model permits that are developed by EPA. EPA will endeavor to design general and model permits that are effective while also adaptable to the concerns of different States. Again, States are able to develop more stringent standards where they deem it to be appropriate. There are currently seventeen States that have authority to issue general permits: Arkansas, Colorado, Illinois, Kentucky, Minnesota, Missouri, Montana, New Jersey, North Dakota, Oregon, Rhode Island, Utah, Washington, West Virginia and Wisconsin. As suggested in the comments, EPA is encouraging more States to develop general permit issuing authority in order to facilitate the permitting process.

One commenter advised that the rules should state that a NPDES approved State may accept a group application or require additional information. EPA has decided not to explicitly state this in the rule. However, this comment does raise some points that need to be addressed. Because the group application option is a modification of existing NPDES permit application requirements, the State is free to adopt this option, but is not required to. If the State chooses to adopt the group application and it does not have general permit authority, the group application can be used to issue individual permits. If an approved NPDES State chooses to not issue permits based on the group application, facilities that discharge storm water associated with industrial activity that are located in that State must submit individual applications to the State permitting authority. Before submitting a group application, facilities should ascertain from the State permitting authority whether that State intends to issue permits based upon a group application approved by EPA for the purpose of developing general permits. For facilities that discharge storm water associated with industrial activity which are named in a group application, the Director may require an individual facility to submit an individual application where he or she determines that general permit coverage would be inappropriate for the particular facility.

One commenter stressed that EPA should streamline the procedure for States desiring to obtain general permit coverage. EPA has, over the last year, streamlined this procedure and encourages States to take advantage of this procedure. EPA recommends that States consider obtaining general permit authority as a means to efficiently issue permits for storm water discharges. These States should contact the Office of Water Enforcement and Permits at EPA Headquarters as soon as possible.

6. Group Application: Procedural Concerns

One commenter claimed that the proposed group application process and procedures violated federal law. This commenter claimed that EPA was abrogating its responsibility by allowing a trade association to design a data collection plan in lieu of completing an NPDES application form designed by EPA, thus violating the Federal Advisory Committee Act. The commenter stated that EPA would be improperly influenced by special interests if trade associations were able to design their own storm water data gathering plans. The commenter further asserted that any decisions by EPA on the content of specific group applications would be rulemakings and thus subject to the provisions of the Administrative Procedure Act.

EPA disagrees with the comment that the group application violates the Federal Advisory Committee Act (FACA). FACA governs only those groups that are established or "utilized" by an agency for the purpose of obtaining "advice" or "recommendations." The group application option does not solicit or involve any "advice" or "recommendations." It simply allows submission of data by certain members of a group in accordance with specific regulatory criteria for determining which facilities are "representative" of a group. As such, the group application is merely a submission in accordance and in compliance with specific regulatory requirements and does not contain discretionary uncircumscribed "advice" or "recommendations" as to which facilities are representative of a group.

Thus, the determination of which facilities should submit testing data in accordance with regulatory criteria is little different from many other regulatory requirements where an applicant must submit information in accordance with certain criteria. For example, under 40 CFR 122.21 all outfalls must be tested except where two or more have "substantially identical" effluents. Similarly, quantitative data for certain pollutants are to be provided where the applicant knows or "has reason to believe" such pollutants are discharged. Both of these provisions allow the applicant to exercise discretion in making certain judgments but such action is circumscribed by regulatory standards. EPA further has authority to require these facilities to submit individual applications. In none of these instances are "recommendations" or "advice" involved. EPA also notes that it is questionable whether, in providing for group applications, it is "soliciting" advice or recommendations from groups or that such groups are being "utilized" by EPA as a "preferred source" of advice. See 48 FR 19324 (April 28, 1983). Furthermore, this data collection effort may be supplemented by EPA if, after review of the data, EPA determines additional data is necessary for permit issuance. Other information gathering may act as a check on the group applications received.

EPA also does not agree with the commenter's claim that the group application scheme represents an impermissible delegation of the Administrator's function in violation of the CWA regarding data gathering. The Administrator has the broadest discretion in determining what information is needed for permit development as well as the manner in which such information will be collected. The CWA does not require every discharger required to obtain a permit to file an application. Nor does the CWA require that the Administrator obtain data on which a permit is to be based through a formal application process (see 40 CFR 122.21). For years "applications" have not been required from dischargers covered by general permits. EPA currently obtains much information beyond that provided in applications pursuant to section 308 of the CWA. This is especially true with respect to general permit and effluent limitations guidelines development. The group application option is simply another means of data gathering. The Administrator may always collect more data should he determine it necessary upon review of a groups' data submission. And, he may obtain such additional data by whatever means permissible under the Statute that he deems appropriate. Thus, it can hardly be said that by this initial data gathering effort the Administrator has delegated his data gathering responsibilities. In addition, since groups are required to select "representative" facilities, etc., in accordance with specific regulatory requirements established by the Administrator and because EPA will scrutinize part 1 of the group applications and either accept or reject the group as appropriate for a group application, no impermissible delegation has occurred. EPA will make an independent determination of the acceptability of a group application in view of the information required to be submitted by the group applicant, other information available to EPA (such as information on industrial subcategories obtained in developing effluent limitations guidelines as well as individual storm water applications received as a result of today's rule) and any further information EPA may request to supplement part 1 pursuant to section 308 of the CWA. Moreover, any concerns that a general permit may be based upon biased data can be dealt with in the public permit issuance process.

Finally, EPA also does not agree that the group application option violates the Administrative Procedures Act. Again, the group application scheme is simply a data gathering device. EPA could very well have determined to gather data informally via specific requests pursuant to section 308 of the CWA. In fact, general permit and effluent limitations guideline development proceed along these lines. It would make little sense if the latter informal data gathering process were somehow illegal simply because it is set forth in a rule that allows applicants some relief upon certain showings. In this respect, several of EPA's existing regulations similarly allow an applicant to be relieved from certain data submission requirements upon appropriate demonstrations. For example, testing for certain pollutants and or certain outfalls may be waived under certain circumstances. Most importantly, the operative action of concern that impacts on the public is individual or general permit issuance based upon data obtained. As previously stated, ample opportunity for public participation is provided in the permit issuance proceeding.

7. Permit Applicability and Applications for Oil and Gas and Mining Operations

Oil, gas and mining facilities are among those industrial sites that are likely to discharge storm water runoff that is contaminated by process wastes, toxic pollutants, hazardous substances, or oil and grease. Such contamination can include disturbed soils and process wastes containing heavy metals or suspended or dissolved solids, salts, surfactants, or solvents used or produced in oil and gas operations. Because they have the potential for serious water quality impacts, Congress recognized, throughout the development of the storm water provisions of the Water Quality Act of 1987, the need to control storm water discharges from oil, gas, and mining operations, as well as those associated with other industrial activities.

However, Congress also recognized that there are numerous situations in the mining and oil and gas industries where storm water is channeled around plants and operations through a series of ditches and other structural devices in order to prevent pollution of the storm water by harmful contaminants. From the standpoint of resource drain on both EPA as the permitting agency and potential permit applicants, the conclusion was that operators that use good management practices and make expenditures to prevent contamination must not be burdened with the requirement to obtain a permit. Hence, section 402(1)(2) creates a statutory exemption from storm water permitting requirements for uncontaminated runoff from these facilities.

To implement section 402(1)(2), EPA intends to require permits for contaminated storm water discharges from oil, gas and mining operations. Storm water discharges that are not contaminated by contact with any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations will not be required to obtain a storm water discharge permit.

The regulated discharge associated with industrial activity is the discharge from any conveyance used for collecting and conveying storm water located at an industrial plant or directly related to manufacturing, processing or raw materials storage areas at an industrial plant. Industrial plants include facilities classified as Standard Industrial Classifications (SIC) 10 through 14 (the mining industry), including oil and gas exploration, production, processing, and treatment operations, as well as transmission facilities. See 40 CFR 122.26(b)(14)(iii). This also includes plant areas that are no longer used for such activities, as well as areas that are currently being used for industrial processes.

a. Oil and Gas Operations. In determining whether storm water discharges from oil and gas facilities are "contaminated", the legislative history reflects that the EPA should consider whether oil, grease, or hazardous materials are present in storm water runoff from the sites described above in excess of reportable quantities (RQs) under section 311 of the Clean Water Act or section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). [Vol. 132 Cong. Rec. H10574 (daily ed. October 15, 1986) Conference Report].

Many of the comments received by EPA regarding this exemption focused on the concern that EPA's test for requiring a permit is and would subject an unnecessarily large number of oil and gas facilities to permit application requirements. Specific comments made in support of this concern are addressed below.

A primary issue raised by commenters centered on how to determine when a storm water discharge from an oil or gas facility is "contaminated", and therefore subject to the permitting program under section 402 of the CWA. Many of the comments received from industry representatives objected to the Agency's intent, as expressed in the proposal, to use past discharges as a trigger for submitting permit applications.

The proposed rule provided that notification requirements for releases in excess of RQs established under the CWA and CERCLA would have to basis for triggering the submittal of permit applications for storm water discharges from oil and gas facilities. As described in the proposal, oil and gas operations that have been required to notify authorities of the release of either oil or a hazardous substance via a storm water route would be required to submit a permit application. In other words, any facility required to provide notification of the release of an RQ of oil or a hazardous substance in storm water in the past would be required to apply for a storm water permit under the current rule. In addition, any facility required to provide notification regarding a release occurring from the effective date of today's rule forward would be required to apply for a storm water permit.

Commenters maintained that the use of historical discharges to require permit applications is inconsistent with the language and intent of section 402(1)(2) of the CWA, and relevant legislative history, both of which focus on present contamination. Requiring storm water permits based solely on the occurrence of past contaminated discharges, even where no present contamination is evident, would go beyond the statutory requirement that EPA not issue a permit absent a finding present contamination. Commenters also noted that the proposal did not take into account the fact that past problems leading to such releases may have been corrected, and that requiring an NPDES permit may no longer be necessary. The result of such a requirement, commenters maintained, would be an excessive number of unnecessary permit applications being submitted, at significant cost and minimal benefit to both regulated facilities and regulating authorities.

Commenters also indicated that using the release of reportable quantities of oil, grease or hazardous substances as a permit trigger would identify discharges of an isolated nature, rather than the continuous discharges, which should be the focus of the NPDES permit program under section 402. Such an approach, commenters maintained, is inconsistent with existing regulations under section 311 of the CWA, and would result in permit applications from facilities that are more appropriately regulated under section 311.

Despite these criticisms, many commenters recognized that the Agency is left with the task of determining when discharges from oil and gas facilities are contaminated, in order to regulate them under section 402(1)(2). It was suggested by numerous commenters that the EPA adopt an approach similar to that used under section 311 of the CWA for Spill Prevention Control and Countermeasure (SPCC) Plans. Under SPCC, facilities that are likely to discharge oil into waters of the United States are required to maintain a SPCC plan. In the event the facility has a spill of 1,000 gallons or 2 or more reportable quantities of oil in a 12 month period, the facility is required to submit its SPCC plan to the Agency. The triggering events proposed by the commenters for storm water permits for oil and gas operations are six reportable sheens or discharges of hazardous substances (other than oil) in excess of section 311 or section 102 reportable quantities via a storm water point source route over any thirty-six month period. It was suggested that if this threshold is reached, an operator would then file a permit application (or join a group application) based upon the presumption that its current storm water discharges are contaminated.

In response to these comments, the Agency believes that past releases that are reportable quantities can be a valid indicator of the potential for present contamination of discharges. The legislative history as cited above supports this conclusion. EPA would note that the existence of a RQ release would serve only as a triggering mechanism for a permit application. Under the proposed rule, evidence of past contamination would merely require submission of a permit application and would not be used as conclusive evidence of current contamination. The determination as to whether a permit would be actually required due to current contaminated discharge would be made by the permitting authority after reviewing the permit application. The fact of a past RQ release does not necessarily imply a conclusive finding of contamination, only that sufficient potential for contamination exists to warrant a permit application or the collection of other further information. Today's rule does not change the proposed approach in this respect. Thus, EPA does not believe that today's rule exceeds the authority of section 402(1)(2).

EPA believes that there is no legal impediment to using past RQ discharges as a trigger for requiring a storm water permit application. EPA notes that, as mentioned above, even those commenters who objected to the proposed test on legal authority grounds merely offered an alternate test that requires more releases to have occurred within a shorter period of time before a permit application is required.

Therefore, the only disagreement that remains is over what constitutes a reasonable test that will identify facilities with the potential for storm water contamination. EPA notes that neither the statute nor the legislative history provides any guidance on this question. Furthermore, EPA disagrees with the commenters who suggested that 6 releases in the past 3 years or 2 releases in the past year are necessarily more valid measures of the potential for current contamination than EPA's proposed test. There is no statistical or other basis for preferring one test to the other. However, EPA does agree with those commenters that suggest that a single release in the distant past may not accurately reflect current conditions and the current potential for contamination.

EPA has therefore amended today's rule to provide that only oil and gas facilities which have had a release of an RQ of oil or hazardous substances in storm water in the past three years will be required to submit a permit application. EPA believes that limiting the permit trigger to events of the past three years will address commenters' concerns regarding the use of "stale history" in determining whether an application is required. EPA notes that the three year cutoff is consistent with the requirement for industrial facilities to report significant leaks or spills at the facility in their storm water permit applications. See 40 CFR 122.26(c)(1)(i)(D).

Commenters asserted that EPA and the States must have some reasonable basis for concluding that a storm water discharge is contaminated before requiring permit applications or permits. Commenters believed that § 122.26(c)(1)(iii)(B) as proposed implied that the Agency's authority in this respect is unrestricted. In response, EPA may collect such data by whatever appropriate means the statute allows, in order to obtain information that a permit is required. Usually, the most practical tool for doing so is the permit application itself. However, if necessary to supplement the information made available to the Agency, EPA has broad authority to obtain information necessary to determine whether or not a permit is required, under section 308 of the Clean Water Act. Given the plain language of the CWA and the Congressional intent as manifested in the legislative history, the Agency is convinced that the approach described above is appropriate. Yet, as further discussed below, EPA has also deleted as redundant § 122.26(c)(1)(iii)(B).

Regarding the types of facilities included in the storm water regulation, a number of commenters suggested that the Agency has misconstrued the meaning of facilities "associated with

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industrial activity", and has proposed an overly broad definition of such facilities in the oil and gas industry. Specifically, commenters suggested that only the manufacturing sector of the oil and gas industry should be subject to storm water permit application requirements, and that exploration and production activities, gas stations, terminals, and bulk plants should all be exempted from storm water permitting requirements. Commenters maintain that this broad interpretation would subject many oil and gas facilities to the storm water permit requirements, when these were not intended by Congress to be so regulated. As a second point related to this issue, some commenters felt that transmission facilities were not intended to be regulated under the storm water provisions, and should be exempted from permit requirements. This would be consistent, it was argued, with legislative history which concluded that transmission facilities do not significantly contribute to the contamination of water.

The Agency disagrees that these facilities do not fall under the storm water permitting requirements as envisioned by Congress. SIC 13, which is relied upon by EPA to identify these oil and gas operations, describes oil and gas extraction industries as including facilities related to crude oil and natural gas, natural gas liquids, drilling oil and gas wells, oil and gas exploration and field services. Moreover, legislative history as it applies to industrial activities, and thus to oil and gas (mining) operations, expressly includes exploration, production, processing, transmission, and treatment operations within the purview of storm water permitting requirements and exemptions. EPA's intent is for storm water permit requirements (and the exemption at hand) to apply to the activities listed above (exploration, production, processing, treatment, and transmission) as they relate to the categories listed in SIC 13.

Commenters requested clarification from the Agency that storm water discharges from oil and gas facilities require a permit or the filing of a permit application only when they are contaminated at the point of discharge into waters of the United States. Commenters noted that large amounts of potentially contaminated stormwater may not enter waters of the United States, or may enter at a point once the discharge is no longer "contaminated". In these cases, it should be clear that no permit or permit application is required.

EPA agrees that oil and gas exploration, production, processing, or treatment operations or transmission facilities must only obtain a storm water permit when a discharge to waters of the U.S. (including those discharges through municipal separate storm sewers) is contaminated. A permit application will be required when any discharge in the past three years or henceforth meets the test discussed above.

Under the proposed rule, the Agency stated at § 122.26(c)(1)(iii)(B) that the Director may require on a case-by-case basis the operator of an existing or new storm water discharge from an oil or gas exploration, production, processing, or treatment operation, or transmission facility to submit an individual permit application. The Agency has removed this section since CWA section 402(1)(2), as codified in 122.26(c)(1)(iii)(A), adequately addresses every situation where a permit should be required for these facilities.

b. Use of Reportable Quantities to Determine if a Storm Water Discharge from an Oil or Gas Operation is Contaminated. Section 311(b)(5) of the CWA requires reporting of certain discharges of oil or a hazardous substance into waters of the United States (see 44 FR 50766 (August 29, 1979)). Section 304(b)(4) of the Act requires that notification levels for oil and hazardous substances be set at quantities which may be harmful to the public health or welfare of the United States, including but not limited to fish, shellfish, wildlife, and public or private property, shorelines and beaches. Facilities which discharge oil or a hazardous substance in quantities equal to or in excess of an RQ, with certain exceptions, are required to notify the National Response Center (NRC).

Section 102 of CERCLA extended the reporting requirement for releases equal to or exceeding an RQ of a hazardous substance by adding chemicals to the list of hazardous substances, and by extending the reporting requirement (with certain exceptions) to any releases to the environment, not just those to waters of the United States.

Pursuant to section 311 of the CWA, EPA determined reportable quantities for discharges by correlating aquatic animal toxicity ranges with 5 reporting quantities, i.e., 1-, 10-, 100-, 1000-, and 5000- pounds per 24 hour period levels. Reportable quantity adjustments made under CERCLA rely on a different methodology. The strategy for adjusting reportable quantities begins with an evaluation of the intrinsic physical, chemical, and toxicological properties of each designated hazardous substance. The intrinsic properties examined, called "primary criteria," are aquatic toxicity, mammalian toxicity (oral, dermal, and inhalation), ignitability, reactivity, and chronic toxicity. In addition, substances that were identified as potential carcinogens have been evaluated for their relative activity as potential carcinogens. Each intrinsic property is ranked on a five-tier scale, associating a specific range of values on each scale with a particular reportable quantity value. After the primary criteria reportable quantities are assigned, the hazardous substances are further evaluated for their susceptibility to certain extrinsic degradation processes (secondary criteria). Secondary criteria consider whether a substance degrades relatively rapidly to a less harmful compound, and can be used to raise the primary criteria reportable quantity one level.

Also pursuant to section 311, EPA has developed a reportable quantity for oil and associated reporting requirements at 40 CFR part 110. These requirements, known as the oil sheen regulation, define the RQ for oil to be the amount of oil that violates applicable water quality standards or causes a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or causes a sludge or emulsion to be deposited.

Reportable quantities developed under the CWA and CERCLA were not developed as effluent guideline limitations which establish allowable limits for pollutant discharges to surface waters. Rather, a major purpose of the notification requirements is to alert government officials to releases of hazardous substances that may require rapid response to protect public health, welfare, and the environment. Notification based on reportable quantities serves as a trigger for informing the government of a release so that the need for response can be evaluated and any necessary response undertaken in a timely fashion. The reportable quantities do not themselves represent any determination that releases of a particular quantity are actually harmful to public health, welfare, or the environment.

EPA requested comment on the use of RQs for determining contamination [illegible] discharges from oil and gas facilities. As noted above numerous commenters [illegible] supported the concept of using [illegible] reportable quantities under certain circumstances. Comments on [illegible] measurement of oil sheens for the purpose of triggering a permit [illegible] application were divided. [illegible] commented that it is much [illegible] because the amount of oil creating a [illegible]

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sheen may be a relatively small amount. Others viewed the test as a quick, easy, practical method that has been effective in the past.

In relying on the reporting requirements associated with releases in excess of RQs for oil or hazardous substances to trigger the submittal of permit applications for oil and gas operations, the Agency believes that the use of the reporting requirements for oil will be particularly useful. The Agency believes that the release of oil to a storm water discharge in amounts that cause an oil sheen is a good indicator of the potential for water quality impacts from storm water releases from oil and gas operations. In addition, given the extremely high number of such operations (the Agency estimates that there are over 750,000 oil wells alone in the United States), relying on the oil sheen test to determine if storm water discharges from such sites are "contaminated" will be a far easier test for operators to determine whether to file a storm water permit application than a test based on sampling. The detection of a sheen does not require sophisticated instrumentation since a sheen is easily perceived by visual observation. EPA agrees with those comments calling the oil sheen test an appropriate measure for triggering a storm water permit application. In adopting this approach, EPA recognizes, as pointed out by many commenters that an oil sheen can be created with a relatively small amount of oil.

One commenter suggested that contamination must be caused by contact with on-site material before being subject to permit application requirements. The Agency agrees with this comment. Those facilities that have had releases in excess of reportable quantities will generally have contamination from contact with on-site material as described in the CWA. Thus, use of the RQ test is an appropriate trigger. As discussed above, determination of whether contamination is present to warrant issuance of a permit will be made in the context of the permit proceeding.

One commenter believed that the use of RQs is inappropriate because "the statute intended to exempt only oil and gas runoff that is not contaminated at all." The Agency wishes to clarify that reportable quantities are being used to determine what facilities need to file permit applications and to describe what is meant by the term "contaminated." The Director may require a permit for any discharges of storm water runoff contaminated by contact with any overburden, raw material, intermediate product, finished product, by product or waste product at the site of such operations. The use of RQs is solely a mechanism for identifying the facilities most likely to need a storm water permit consistent with the legislative history of section 402(l)(2).

c. Mining Operations. The December 7, 1988 proposal would establish background levels as the standard used to define when a storm water discharge from a mining operation is contaminated. When a storm water discharge from a mining site was found to contain pollutants at levels that exceed background levels, the owner or operator of the site was required to submit a permit application for that operation. The proposal was founded upon language in the legislative history stating that the determination of whether storm water is contaminated by contact with overburden, raw material, intermediate product, finished product, byproduct, or waste products "shall take into consideration whether these materials are present in such stormwater runoff . . . above natural background levels". (Vol. 132 Cong. Rec. H10574 (daily ed. Oct. 15, 1986) Conference Report).

Comments received on this component of the rule suggested that background levels of pollutants would be very difficult to calculate due to the complex topography frequently encountered in alpine mining regions. For example, if a mine is located in a mountain valley surrounded on all sides by hills, the site will have innumerable slopes feeding flow towards it. Under such circumstances, determining how the background level is set would prove impractical. Commenters indicated that it is very difficult to measure or determine background levels at sites where mining has occurred for prolonged periods. In many instances, data on original background levels may not be available due to long-term site activity. As a result, any background level established will vary based on the type and level of previous activity. In addition, mining sites typically have background levels that are naturally distinct from the surrounding areas. This is due to the geologic characteristics that makes them valuable as mining sites to begin with. This also makes it difficult to establish accurate background levels.

Because of these concerns EPA has decided to drop the use of background levels as a measure for determining whether a permit application is required. Accordingly, a permit application will be required when discharges of storm water runoff from mining operations come into contact with any overburden, raw material, intermediate product, finished product, byproduct, or waste product located on the site. Similar to the RQ test for oil and gas operations, EPA intends to use the "contact" test solely as a permit application trigger. The determination of whether a mining operation's runoff is contaminated will be made in the context of the permit issuance proceedings.

If the owner or operator determines that no storm water runoff comes into contact with overburden, raw material, intermediate product, finished product, byproduct, or waste products, then there is no obligation to file a permit application. This framework is consistent with the statutory provisions of section 402(l)(2) and is intended to encourage each mining site to adopt the best possible management controls to prevent such contact.

Several commenters stated that EPA's use of total pollutant loadings for determining permit applicability is not consistent with the general framework of the NPDES program. Their concern is that such evaluation criteria depart from how the NPDES program has been administered in the past, based on concentration limits. In addition, commenters requested that EPA clarify that information on mass loading will be used for determining the need for a permit only. Since the analysis of natural background levels as a basis for a permit application has been dropped from this rulemaking, these issues are moot.

Commenters noted that the proposed rule did not specify what impact this rulemaking has on the storm water exemptions in 40 CFR 440.131. The commenters recommended not changing any of these provisions. Some commenters indicated that mining facilities that have NPDES permits should not be subject to additional permitting under the storm water rule. EPA does not intend that today's rule have any effect on the conditional exemptions in 40 CFR 440.131. Where a facility has an overflow or excess discharge of process-related effluent due to stormwater runoff, the conditional exemptions in 40 CFR 440.131 remain available.

Several commenters note that the term overburden, as used in the context of the proposed storm water rule, is not defined and recommended that this term should be defined to delineate the [illegible] of the regulation. EPA agrees that the term overburden should be defined [illegible] help properly define the scope [illegible] water rule. In today's rule, the [illegible]

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overburden has been clarified to mean any material of any nature overlying a mineral deposit that is removed to gain access to that deposit, excluding topsoil or similar naturally-occurring surface materials that are not disturbed by mining operations. This definition is patterned after the overburden definition in SMCRA, and is designed to exclude undisturbed lands from permit coverage as industrial activity. However, the definition provided in this regulation may be revised at a later date, to achieve consistency with the promulgation of RCRA Subtitle D mining waste regulations in the future.

Numerous commenters raised issues pertaining to the inclusion of inactive mining areas as subject to the stormwater rule. Some commenters indicated that including inactive mine operations in the rule would create an unreasonable hardship on the industry. EPA has included inactive mining areas in today's rule because some mining sites represent a significant source of contaminated stormwater runoff. EPA has clarified that inactive mining sites are those that are no longer being actively mined, but which have an identifiable owner/operator. The rule also clarifies that active and inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities required for the sole purpose of maintaining the mining claim are undertaken. The Agency would clarify that claims on land where there has been past extraction, beneficiation, or processing of mining materials, but there is currently no active mining are considered inactive sites. However, in such cases the exclusion discussed above for uncontaminated discharges will still apply.

EPA's definition of active and inactive mining operations also excludes those areas which have been reclaimed under SMCRA or, for non-coal mining operations, under similar applicable State or Federal laws. EPA believes that, as a general matter, areas which have undergone reclamation pursuant to such laws have concluded all industrial activity in such a way as to minimize contact with overburden, mine products, etc. EPA and NPDES States, of course, retain the authority to designate particular reclaimed areas for permit coverage under section 402(p)(2)(E).

The proposed rule had included an exemption for areas which have been reclaimed under SMCRA, although the language of the proposed rule inadvertently identified the wrong universe of coal mining areas. The final rule language has been revised to clarify that areas which have been reclaimed under SMCRA (and thus are no longer subject to 40 CFR part 434 subpart E) are not subject to today's rule. Today's rule thus is consistent with the coal mining effluent guideline in its treatment of areas reclaimed under SMCRA.

In response to comments, EPA has also expanded this concept to exclude from coverage as industrial activity non-coal mines which are released from similar State or Federal reclamation requirements on or after the effective date of this rule. EPA believes it is appropriate, however, to require permit coverage for contaminated runoff from inactive non-coal mines which may have been subject to reclamation regulations, but which have been released from those requirements prior to today's rule. EPA does not have sufficient evidence to suggest that each State's previous reclamation rules and/or Federal requirements, if applicable, were necessarily effective in controlling future storm water contamination.

8. Application Requirements for Construction Activities

As discussed above, EPA has included storm water discharges from activities involving construction operations that result in the disturbance of five acres total land in the regulatory definition of storm water discharges associated with industrial activity.

This is a departure from the proposed rule which required permit applications for discharges from activities involving construction operations that result in the disturbance of less than one acre total land area and (which are not part of a larger common plan of development or sale; or operations that are for single family residential projects, including duplexes, triplexes, or quadruplexes, that result in the disturbance of less than five acre total land areas and which are not part of a larger common plan of development or sale). The reasons for this change are noted below.

Many commenters representing municipalities, States, and industry requested that clearing, grading, and excavation activities not be included in the definition of storm water discharges associated with industrial activity. It was suggested that EPA delay including construction activities until after the studies mandated in section 402(p)(5) of the CWA are completed. Other commenters felt that NPDES permits are not appropriate for construction discharges due to their short term, intermediate and seasonal nature. Another commenter felt that only the construction activities on the sites of the industrial facilities identified in the other subsections of the definition of "associated with industrial activity" should be included.

EPA believes that storm water permits are appropriate for the construction industry for several reasons. Construction activity at a high level of intensity is comparable to other activity that is traditionally viewed as industrial, such as natural resource extraction. Construction that disturbs large tracts of land will involve the use of heavy equipment such as bulldozers, cranes, and dump trucks. Construction activity frequently employs dynamite and/or other equipment to eliminate trees, bedrock, rockwork, and to fill or level land. Such activities also engage in the installation of haul roads, drainage systems, and holding ponds that are typical of the industrial activity identified in § 122.26(b)(14)(i-x). EPA cannot reasonably place such activity in the same category as light commercial or retail business.

Further, the runoff generated while construction activities are occurring has potential for serious water quality impacts and reflects an activity that is industrial in nature. Where construction activities are intensive, the localized impacts of water quality may be severe because of high unit loads of pollutants, primarily sediments. Construction sites can also generate other pollutants such as phosphorus, nitrogen and nutrients from fertilizer, pesticides, petroleum products, construction chemicals and solid wastes. These materials can be toxic to aquatic organisms and degrade water for drinking and water-contact recreation. Sediment runoff rates from construction sites are typically 10 to 20 times that of agricultural lands, with runoff rates as high as 100 times that of agricultural lands, and 1,000 to 2,000 times that of forest lands. Even small construction sites may have a significant negative impact on water quality in localized areas. Over a short period of time, construction sites can contribute more sediment to streams than was previously deposited over several decades.

EPA is convinced that because of the impacts of construction discharges that are directly to waters of the United States, such discharges should be addressed by permits issued by Federal or NPDES State permitting authorities. It is evident from numerous studies and reports submitted under section [illegible] of the CWA that discharges from construction sites continue to be a [illegible] source of water quality problems and water quality standard violations [illegible]

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Accordingly EPA is compelled to address these source under these regulations and thereby regulate these sources under a nationally consistent program with an appropriate level of enforcement and oversight.

Techniques to prevent or control pollutants in storm water discharges from construction are well developed and understood. A primary control technique is good site planning. A combination of nonstructural and structural best management practices are typically used on construction sites. Relatively inexpensive nonstructural vegetative controls, such as seeding and mulching, are effective control techniques. In some cases, more expensive structural controls may be necessary, such as detention basins or diversions. The most efficient controls result when a comprehensive storm water management system is in place. Another reason that EPA has decided to address this class of discharges is that it is part of the Agency's recent emphasis on pollution prevention. Studies such as NURP indicate that it is much more cost effective to develop measures to prevent or reduce pollutants in storm water during new development than it is to correct there problems later on. Many of these prevention and control practices, which can take the form of grading patterns as well as other controls, generally remain in place after the construction activities are completed.

a. Permit Application Requirements. In today's rulemaking, EPA has set forth distinct permit application requirements for these construction activities, at § 122.26(c)(1)(ii), to be used where general permits to be developed and promulgated by EPA are inapplicable. Such facilities will be required to provide a map indicating the site's location and the name of the receiving water and a narrative description of:

- The nature of the construction activity;
- The total area of the site and the area of the site that is expected to undergo excavation during the life of the permit;
- Proposed measures, including best management practices, to control pollutants in storm water discharges during construction, including a description of applicable Federal requirements and State or local erosion and sediment control requirements;
- Proposed measures to control pollutants in storm water discharges that will occur after construction operations have been completed, including a description of applicable State or local requirements, and
- An estimate of the runoff coefficient (fraction of total rainfall that will appear as runoff) of the site and the increase in impervious area after the construction addressed in the permit application is completed, a description of the nature of fill material and existing data describing the soil or the quality of the discharge.

Permit application requirements for construction activities do not include the submission of quantitative data. EPA believes that the changing nature of construction activities at a site to be covered by the permit application requirements generally would not be adequately described by quantitative data. The comments received by EPA support this determination. One State commented that a program they instituted has been based on quantitative data for the past 10 years and has proven to be very awkward, even unworkable.

Twenty commenters responded to the issue of appropriate construction site application deadlines including: Three towns (<100,000 population); one medium municipality; one large municipality; one agency associated with a large municipality; three agencies associated counties; three agencies associated with States; two industries; five industrial associations; and one private organization representing industry. The commenters primarily focused on actual deadlines and permitting authority response time.

Applicants for permits to discharge storm water into the waters of the United States from a construction site would normally be required to submit permits in the same time frame as new sources and new discharges. This rulemaking requires permit applications from such sources to be submitted at least 180 days prior to the date on which the discharge is to commence. Four commenters agreed with the application deadline of 180 days prior to commencement of discharge. Three commenters felt it would be difficult to apply 180 days prior to when the discharge was to begin. Three commenters recommended shortening the time period to 90 days. Numerous other commenters were concerned over delays during the permitting authority's review of the permit application. The commenters requested that a maximum response time be set in the regulation. Suggested maximum response times were 90 and 30 days.

In response to these comments, EPA has changed the application deadline for construction permits from at least 180 days prior to discharge to at least 90 days prior to the date when construction is to commence. This change reflects EPA's recognition of the nature of construction operations in that developers/builders may not be aware of projects 180 days before they are scheduled to begin.

Numerous commenters expressed concern over who should be responsible for applying for the permit. Two commenters felt the owner should be responsible so that construction bid documents can include the storm water management requirements and to avoid confusion among multiple subcontractors. One commenter thought that either the owner/developer, or general contractor should be responsible. Another commenter suggested that the designer should obtain the permit which would allow all necessary erosion controls to be part of the project plan. Several commenters requested that the responsibility simply be more clearly defined.

In response to these comments, EPA would clarify that the operator will generally be responsible for submitting the permit application. Under existing regulations at § 122.21(b), when a facility is owned by one person but operated by another, then it is the duty of the operator to apply for the permit. Due to the temporary nature of construction activities, EPA believes that the operator is the most appropriate person to be responsible for both short and long term best management practices included on the site. EPA considers the term "operator" to include a general contractor, who would generally be familiar enough with the site to prepare the application or to ensure that the site would be in compliance with the permit requirements. General contractors, in many cases, will often be on site coordinating the operation among his/her staff and any subcontractors. Furthermore, the operator/general contractor would be much more familiar with construction site operations than the owner and should be involved in the site planning from its initial stages. The application requirements in today's rule are designed to provide flexibility in developing controls to reduce pollutants in storm water discharges from construction sites. A significant aspect to this is the role of State and local authorities in control of construction storm water discharges. Sixty-three commenters addressed the question of what the role of State and local authorities should be. Most of these commenters supported local government control of construction discharges and that qualified State programs should satisfy Federal requirements.

Many commenters representing municipalities, States, and industry, felt that local government should have full control over construction storm water

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discharges, either under existing programs or those required by their municipal permit. EPA agrees with these comments as far as discharges through municipal storm sewers are concerned. EPA is requiring municipalities that are required to submit municipal permit applications under this regulation to describe their program for controlling storm water discharges from construction activities into their separate storm sewers. It is envisioned that municipalities will have primary responsibility over these discharges through NPDES municipal storm water permits. However, EPA also plans to cover such discharges under general permits to be promulgated in the near future.

In response to several comments that the regulation should provide flexibility for qualified State programs to satisfy Federal requirements, the application requirements recognize that many States have implemented erosion and sediment control programs. The permit application requires a brief description of these programs. This is intended to ensure consistency between NPDES permit requirements and other State controls. Permit applicants will be in the best position to pass on this site-specific information to the permitting authority. States or Federal NPDES authorities will have the ability to exercise authority over these discharges as will other State and local authorities responsible for construction. EPA envisions NPDES permitting efforts will be coordinated with any existing programs.

The proposed rule requested comments on appropriate measures to reduce pollutants in construction site runoff. Numerous commenters representing municipalities, States, and industry responded. Some commenters recommended specific best management practices (BMPs) whereas others suggested ways in which the measures should be incorporated into the program. One commenter suggested that EPA establish design and performance standards for appropriate BMPs. One State commenter recommended requiring a schedule or sequence for use of BMPs. A municipality suggested developing guidance on erosion control at construction sites and disseminating the guidance to educate contractors and construction workers in proper erosion control techniques. The Agency is continuing to review these recommendations for the purposes of permit development and issuance.

Another commenter suggested that further research be done to determine the effectiveness of particular BMPs in reducing pollutants in construction site runoff. EPA agrees that more research and studies can be undertaken to develop methodologies for more effective storm water controls and will continue to lookat these concerns pursuant to section 402(p)(5) studies. However, EPA is convinced that enough information, technology, and proven BMP's are available to address these discharges in this regulation.

Specific BMPs suggested by the commenters include: wheel washing; locked exit roadways, street cleaning methods which exclude sheet washing; clearing and grading codes; construction standards; riparian corridors; solids retention basins; soil erosion barriers; selected excavation; adequate collection systems; vegetate disturbed areas; proper application of fertilizers; proper equipment storage; use of straw bales and filter fabrics; and use of diversions to reduce effective length of slopes. EPA is continuing to evaluate these suggestions for developing appropriate permit conditions for construction activity.

b. Administrative Burdens. Many commenters representing municipalities, States, and industry commented on the administrative burdens of individually permitting each construction site discharging to waters of the United States. The extensive use of general permits for storm water discharges from construction activities that are subject to NPDES requirements is anticipated to minimize administrative delays associated with permit issuance. Many commenters strongly endorsed extensive use of general permits. In addition the Agency will provide as much assistance as possible for developing appropriate permit conditions.

Many commenters responded to the use of acreage limits in determining which construction sites are required to submit a permit application, including several cities, counties and States. Some commenters generally supported the use of an acre limit. Many commenters suggested increasing the acreage limit. Several suggested using a five acre limit for both residential and nonresidential development. Others suggested greater acreage as the cutoff. Two commenters concurred with the proposed limit of one acre/five acres and one commenter suggested lowering the residential limit to one acre.

Other factors were suggested as a means to create a cutoff for requiring permit applications. Several commenters suggested exempting construction that would be completed with a certain time frame, such as construction of less than 12 months. EPA believes that this is inappropriate because some construction can be intensive and expansive, but nonetheless take place over a short period of time, such as a [illegible] parking lot. One commenter suggested basing the limit on the quantity of [illegible] moved, i.e., cubic yards. In response, this approach would not be particularly helpful since removal of soil will not necessarily relate to the amount of land surface disturbed and exposed to the elements. Another commenter suggested that where there is single family detached housing construction that should trigger applications as well as the proposed acreage limit. This would not be appropriate since EPA is attempting to focus only on those construction activities that resemble industrial activity. After considering these and similar comments EPA has limited the definition of "storm water discharge associated with industrial activity" by exempting from the definition those construction operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale. In considering the appropriate scope of the definition of storm water discharge associated with industrial activity as it relates to construction activities, EPA recognized that a wide variety of factors can affect the water quality impacts associated with construction site runoff, including the quality of receiving waters, the size of the area disturbed, soil conditions, seasonal rainfall patterns, the slope of area disturbed, and the intensity of construction activities. These factors will be considered by the permit writer when issuing the permit. However, as noted above, EPA views such site-specific factors to be too difficult to define in a regulatory framework that is national in scope. For example, attempting to adjust permit application triggers based upon a myriad of regional rainfall patterns is not a practical solution. However, permit conditions adjusted for specific geographical areas may be appropriate.

Under the December 7, 1988, proposal, the definition of industrial activity [illegible] exempted construction operations that resulted in the disturbance of less than one acre total land area which was not part of a larger common plan of development or sale; or operations for single family residential projects, including duplexes, triplexes, and quadraplexes, that result in the disturbance of less than five [illegible] land areas which were not part of a larger common plan of development or sale. EPA [illegible] family residential development [illegible]

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other commercial development because other commercial development is more likely to occur in more densely developed areas. Also, it was reasoned that other commercial development provides a more complete opportunity to develop controls that remain in place after the construction activity is completed, since continued maintenance after the permit has expired, is more feasible.

However, EPA has decided to depart from the proposal and use an unqualified five acre area in today's final rule. This limit has been selected, in part, because of administrative concerns. EPA recognizes that State and local sediment and erosion controls may address construction activities disturbing less five acres for residential development; the five acre limit in today's rule is not intended to supersede more stringent State or local sediment and erosion controls. In light of the comments, EPA is convinced that the acreage limit is appropriate for identifying sites that are amount to industrial activity. Several comments suggested higher acreage limits without giving a supporting rationale except administrative concerns. Several commenters agreed that the five acre limit is suitable, but again without specifying why they agreed. EPA is convinced, however, that the acreage limits as finalized in today's rule reflect an earth disturbance and/or removal effort that is industrial in magnitude. Disturbances on large tracts of land will employ more heavy machinery and industrial equipment for removing vegetation and bedrock.

For construction facilities that are not included in the definition of storm water discharge associated with industrial activity, EPA will consider the appropriate procedures and methods to reduce pollutants in construction site runoff under the studies authorized by section 402(p)(5) of the CWA. EPA will also consider under section 402(p)(5) appropriate procedures and methods during post-construction for maintaining structural controls developed pursuant to NPDES permits issued for storm water discharges associated with industrial activity from construction sites.

Numerous commenters requested clarification as to whether permits for storm water discharges from construction activities at an industrial facility are required. EPA is requiring permits for all storm water discharges from construction activities where the land disturbed meets the requirements established in § 122.26(b)(14)(x) and which discharge into waters of the United States. The location of the construction activity or the ultimate land use at the site does not factor into the analysis.

G. Municipal Separate Storm Sewer Systems

1. Municipal Separate Storm Sewers

Today's rule defines "municipal separate storm sewer" at § 122.26(b)(8) to include any conveyance or system of conveyances that is owned or operated by a State or local government entity and is designed for collecting and conveying storm water which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2. It is important to note that today's permit application requirements for discharges from municipal separate storm sewer systems serving a population of 100,000 or more do not apply to discharges from combined sewers (systems designed as both a sanitary sewer and a storm sewer). For purposes of calculating whether a municipal separate storm sewer system meets the large or medium population criteria, a municipality may petition to have the population served by a combined sewer deducted from the total population. Section 122.26(f) of today's rule describes this procedure.

EPA requested comments on whether different language for the definition of municipal separate storm sewer would clarify responsibility under the NPDES permit system. Comments were also requested on whether the definition needed to be clarified by explicitly stating that municipal streets and roads with drainage systems (curb and gutter, ditches, etc.) are part of the municipal storm sewer system, and that the owners or operators of such roads are responsible for such discharges. Numerous comments were received by EPA on this issue. Some commenters questioned whether road culverts and road ditches were municipal separate storm sewers, while others specifically recommended that further clarifying language should be added so that owners and operators of roads and streets understand that they are covered by this regulation. In light of these comments, EPA has clarified that municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains that discharge into the waters of the United States are municipal separate storm sewers. One commenter asked if "other wastes" in the proposed definition of municipal separate storm sewer (40 CFR 122.26(b)(8)(i)) included storm water. In response, EPA has added "storm water" to this definition in order to clarify that the rule addresses such systems.

EPA requested comments on whether legal classifications such as "storm sewers that are not private (e.g. public, district or joint district sewers)" would provide a clearer definition of municipal separate storm sewer than an owner or operator criterion, especially for the purpose of determining responsibility under the NPDES program. Most commenters agreed that the owner/operator concept, and the additional language noted above, is sufficient for this purpose. EPA also requested comments on to what extent the owner/operator concept should apply to municipal governments with land-use authority over lands which contribute storm water runoff to the municipal storm sewer system, and how the responsibility should be clarified. In response to comments on this point, EPA has addressed these concerns in the context of clarifying what municipal entities are responsible for applying for a permit covering storm water discharges from municipal systems in section VI.H. below.

One commenter expressed a desire for clarification as to whether conveyances that were once used for the conveyance of storm water, but are no longer used in that manner, are covered by the definition. EPA emphasizes that this rulemaking only addresses conveyances that are part of a separate storm sewer system that discharges storm water into waters of the United States.

One commenter stated that if EPA intends to regulate roadside collection systems then EPA must repropose since these were not considered by the public. EPA disagrees with this comment since one of the options specifically addressed the inclusion of roadside drainage systems and roads in the definition of municipal separate storm sewer system. In addition, the public recognized the issue in comments on the proposal. EPA would note that several commenters specifically endorsed EPA's inclusion of these conveyances.

2. Effective Prohibition on Non-Storm Water Discharges

Section 402(p)(3)(B)(ii) of the amended CWA requires that permits for discharges from municipal storm sewers shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers. Based on the legislative history of section [illegible] of the WQA, EPA does not interpret the effective prohibition on non-storm water discharges to municipal separate storm sewers to apply to discharges that are not composed entirely of storm water, as long as such discharge has been issued a separate NPDES permit. Rather,

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an "effective prohibition" would require separate NPDES permits for non-storm water discharges to municipal storm sewers. In many cases in the past, applicants for NPDES permits for process wastewaters and other non-storm water discharges have been granted approval to discharge into municipal separate storm sewers, provided that the permit conditions for the discharge are met at the point where the discharge enters into the separate storm sewer. Permits for such discharges must meet applicable technology-based and water-quality based requirements of Sections 402 and 301 of the CWA. If the permit for a non-storm water discharge to a municipal separate storm sewer contains water-quality based limitations, then such limitations should generally be based on meeting applicable water quality standards at the boundary of a State established mixing zone (for States with mixing zones) located in the receiving waters of the United States.

All options will be considered when an applicant applies for a NPDES permit for a non-storm water discharge to a municipal separate storm sewer. In some cases, permits will be denied for discharges to storm sewers that are causing water quality problems in receiving waters. However, not all discharges present such problems; and in these cases EPA or State permit writers may allow such discharges to municipal separate storm sewers within appropriate permit limits.

Today's rule has two permit application requirements that are designed to begin implementation of the effective prohibition. The first requirement discussed in VI.H.6.a., below, addresses a screening analysis which is intended to provide sufficient information to develop priorities for a program to detect and remove illicit discharges. The second provision, discussed in VI.H.7.b., requires municipal applicants to develop a recommended site-specific management plan to detect and remove illicit discharges (or ensure they are covered by an NPDES permit) and to control improper disposal to municipal separate storm sewer systems.

Several commenters suggested that either the definition of "storm water" should include some additional classes of nonprecipitation sources, or that municipalities should not be held responsible for "effectively prohibiting" some classes of nonstorm water discharges into their municipal storm sewers. The various types of discharges addressed by these comments include: detention and retention reservoir releases, water line flushing, fire hydrant flushing, runoff from fire fighting, swimming pool drainage and discharge, landscape irrigation, diverted stream flows, uncontaminated pumped ground water, rising ground water; discharges from potable water sources, uncontaminated waters from cooling towers, foundation drains, non-contact cooling water (such as heating, ventilation, air conditioning (HVAC) water that POTWs require to be discharged to separate storm sewers rather than sanitary sewers), irrigation water, springs, roofdrains, water from crawl space pumps, footing drains, lawn watering, individual car washing, flows from riparian habitats and wetlands. Most of these comments were made with regard to the concern that these were commonly occurring discharges which did not pose significant environmental problems.

EPA disagrees that the above described flows will not pose, in every case, significant environmental problems. At the same time, it is unlikely Congress intended to require municipalities to effectively prohibit individual car washing or discharges resulting from efforts to extinguish a building fire and other seemingly innocent flows that are characteristic of human existence in urban environments and which discharge to municipal separate storm sewers. It should be noted that the legislative history is essentially silent on this point. Accordingly, EPA is clarifying that section 402(p)(3)(B) of the CWA (which requires permits for municipal separate storm sewers to 'effectively' prohibit non-storm water discharges) does not require permits for municipalities to prohibit certain discharges or flows of nonstorm water to waters of the United States through municipal separate storm sewers in all cases. Accordingly, § 122.26(d)(2)(iv)(B)(1) states that the proposed management program shall include: "A description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; the program description shall address the following categories of non-storm water discharges or flows only where such discharges are identified by the municipality as sources of pollutants to waters of the United States: Water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers, uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash waters. Program descriptions shall address discharges from fire fighting only where such discharges or flows are identified as significant sources of pollutants to waters of the United States."

However, the Director may include permit conditions that either require municipalities to prohibit or otherwise control any of these types of discharges where appropriate. In the case of fire fighting it is not the intention of these rules to prohibit in any circumstances the protection of life and public or private property through the use of water or other fire retardants that flow into separate storm sewers. However, there may be instances where specified management practices are appropriate where these flows do occur (controlled blazes are one example).

Conveyances which continue to accept other "non-storm water" discharges (e.g. discharges without an NPDES permit) with the exceptions noted above do not meet the definition of municipal separate storm sewer and are not subject to section 402(p)(3)(B) of the CWA unless the non-storm water discharges are issued separate NPDES permits. Instead, conveyances which continue to accept non-storm water discharges which have not been issued separate NPDES permits are subject to sections 301 and 402 of the CWA. For example, combined sewers which convey storm water and sanitary sewage are not separate storm sewers and must comply with permit application requirements at 40 CFR 122.21 as well as other regulatory criteria for combined sewers.

3. Site-Specific Storm Water Quality Management Programs for Municipal Systems

Section 402(p)(3)(iii) of the CWA mandates that permits for discharges from municipal separate storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable (MEP), including management practices, control techniques and systems, design and engineering methods, and such other provisions as the Director determines appropriate for the control of such pollutants. [illegible]

When enacting this provision, Congress was aware of the [illegible] regulating discharges from [illegible]

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separate storm sewers solely through traditional end-of-pipe treatment and intended for EPA and NPDES States to develop permit requirements that were much broader in nature than requirements which are traditionally found in NPDES permits for industrial process discharges or POTWs. The legislative history indicates, municipal storm sewer system "permits will not necessarily be like industrial discharge permits. Often, an end-of-the-pipe treatment technology is not appropriate for this type of discharge." [Vol. 132 Cong. Rec. S16425 (daily ed. Oct. 16, 1986)].

A shift towards comprehensive storm water quality management programs to reduce the discharge of pollutants from municipal separate storm sewer systems is appropriate for a number of reasons. First, discharges from municipal storm sewers are highly intermittent, and are usually characterized by very high flows occurring over relatively short time intervals. For this reason, municipal storm sewer systems are usually designed with an extremely high number of outfalls within a given municipality to reduce potential flooding. Traditional end-of-pipe controls are limited by the materials management problems that arise with high volume, intermittent flows occurring at a large number of outfalls. Second, the nature and extent of pollutants in discharges from municipal systems will depend on the activities occurring on the lands which contribute runoff to the system. Municipal separate storm sewers tend to discharge runoff drained from lands used for a wide variety of activities. Given the material management problems associated with end-of-pipe controls, management programs that are directed at pollutant sources are often more practical than relying solely on end-of-pipe controls.

In past rulemakings, much of the criticism of the concept of subjecting discharges from municipal separate storm sewers to the NPDES permit program focused on the perception that the rigid regulatory program applied to industrial process waters and effluents from publicly owned treatment works was not appropriate for the site-specific nature of the sources which are responsible for the discharge of pollutants from municipal storm sewers.

The water quality impacts of discharges from municipal separate storm sewer systems depend on a wide range of factors including: The magnitude and duration of rainfall events, the time period between events, soil conditions, the fraction of land that is impervious to rainfall, land use activities, the presence of illicit connections, and the ratio of the storm water discharge to receiving water flow. In enacting section 405 of the WQA, Congress recognized that permit requirements for municipal separate storm sewer systems should be developed in a flexible manner to allow site-specific permit conditions to reflect the wide range of impacts that can be associated with these discharges. The legislative history accompanying the provision explained that "[p]ermits for discharges from municipal separate stormwater systems * * * must include a requirement to effectively prohibit non-stormwater discharges into storm sewers and controls to reduce the discharge of pollutants to the maximum extent practicable, * * * These controls may be different in different permits. All types of controls listed in subsection [(p)(3)(C)] are not required to be incorporated into each permit" [Vol. 132 Cong. Rec. H10576 (daily ed. October 15, 1986) Conference Report]. Consistent with the intent of Congress, this rule sets out permit application requirements that are sufficiently flexible to allow the development of site-specific permit conditions.

Several commenters agreed with this approach. One municipality recommended that there be as much flexibility as possible so that the permitting authority can work with each municipality in developing meaningful long-term goals with plans for improving storm water quality. This commenter noted that too many specific regulations that apply nationwide do not take into consideration the climatic and governmental differences within the States. EPA agrees that as much flexibility as possible should be incorporated into the program. However, flexibility should not be built into the program to such an extent that all municipalities do not face essentially the same responsibilities and commitment for achieving the goals of the CWA. EPA believes that these final regulations build in substantial flexibility in designing programs that meet particular needs, without abandoning a nationally consistent structure designed to create storm water control programs.

4. Large and Medium Municipal Storm Sewer Systems

During the 1987 reauthorization of the CWA, Congress established a framework for EPA to implement a permit program for municipal separate storm sewers and establishing phased deadlines for its implementation. The amended CWA establishes priorities for EPA to develop permit application requirements and issue permits for discharges from three classes of municipal separate storm sewer systems. The CWA requires that NPDES permits be issued for discharges from large municipal separate storm sewer systems (systems serving a population of more than 250,000) by no later than February 4, 1991. Permits for discharges from medium municipal separate storm sewer systems (systems serving a population of more than 100,000, but less than 250,000) must be issued by February 4, 1992. After October 1, 1992, the requirements of sections 301 and 402 of the CWA are restored for all other discharges from municipal separate storm sewers.

The priorities established in the Act are based on the size of the population served by the system. Municipal operators of these systems are generally thought to be more capable of initiating storm water programs and discharges from municipal separate storm sewers serving larger populations are thought to present a higher potential for contributing to adverse water quality impacts. NURP and other studies have verified that the event mean concentration of pollutants in urban runoff from residential and commercial areas remains relatively constant from one area to another, indicating that pollutant loads from urban runoff strongly depend on the total area and imperviousness of developed land, which in turn is related to population.

The term "municipal separate storm sewer system" is not defined by the Act. By not defining the term, Congress intended to provide EPA discretion to define the scope of municipal systems consistent with the objectives of developing site-specific management programs in NPDES permits. EPA considered two key issues in defining the scope of municipal separate storm sewer system: (1) What is a reasonable definition of the term "system," and (2) how to determine the number of people "served" by a storm sewer system. EPA found these two issues to be intertwined. Different approaches to defining the scope of a system allowed for greater or lesser certainty in determining the population served by the system.

In the December 7, 1988, proposal, EPA described seven options for defining "municipal separate storm sewer system." In developing these options the EPA considered:

- The inter-jurisdictional [illegible] associated with municipal [illegible]
- The fact that many municipal storm water management programs [illegible] traditionally focused on water [illegible]

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concerns, and have not evaluated water quality impacts of system discharges or developed measures to reduce pollutants in such discharges;

• The advantages of developing system-wide storm water management programs for municipal systems;

• The geographic basis necessary for planning of comprehensive management programs to reduce pollutants in discharges from municipal separate storm sewers to the maximum extent practicable:

• The geographic basis necessary to provide flexibility to target controls on areas where water quality impacts associated with discharges from municipal systems are the greatest and to provide an opportunity to develop cost effective controls;

• The need to establish a reasonable number of permits for municipal systems during the initial phases of program development that will provide an adequate basis for a storm water quality management program for over 13,000 municipalities after the October 1, 1992 general prohibition on storm water permits expires; and

• Congressional intent to allow the development of jurisdiction-wide, comprehensive storm water management programs with priorities given to the most heavily populated areas of the country.

a. Overview of Proposed Options and Comments. The December 7, 1988, proposal requested comment on seven options for defining large and medium municipal separate storm sewer system. With the addition of a watershed-based approach suggested by certain commenters, eight options or approaches were addressed by the over 200 commenters on this issue: Option 1—systems owned or operated by incorporated places augmented by integrated discharges; Option 2—systems owned or operated by incorporated places augmented with significant other municipal discharges; Option 3—systems owned or operated by counties; Option 4—systems owned and operated by States or State departments of transportation; Option 5—systems within the boundaries of an incorporated place; Option 6—systems within the boundaries of counties; Option 7—systems in census designated urbanized areas; and Option 8—systems defined by watershed boundaries.

Generally, these options can be classified into two categories. The first category of options, Options 1, 2 and 3, define municipal systems in terms of the municipal entity which owns or operates storm sewers within municipal boundaries of the requisite population. The second category of options would define municipal systems on a geographic basis. Under Options 4, 5, 6, 7 and 8 all municipal separate storm sewers within the specified geographic area would be part of the municipal system, regardless of which municipal entity owns or operates the storm sewer. EPA did not propose to define the scope of a municipal separate storm sewer system in engineering terms because of practical problems determining the boundaries of and the populations served by "systems" defined in such a manner. In addition an engineering approach based on physical interconnections of storm sewer pipes by itself does not provide a rational basis for developing a storm water program to improve water quality where a large number of individual storm water catchments are found within a municipality.

In the December 7, 1988, proposal, EPA favored those options that relied primarily on the municipal entity which owns or operates or otherwise has jurisdiction over storm sewers. These options were preferred because it was anticipated that the administrative complexities of developing the permit programs would be reduced by decreasing the number of affected municipal entities. However, most commenters were not satisfied that such an approach would reduce administrative burdens or complexities.

The diversity of arguments and rationales offered in comments justifying the selection of particular option, or combinations thereof, were generally a function of geographic, climatic, and institutional differences around the country. As such, there was little substantive agreement with how this program should be implemented as far as defining large and medium municipal separate storm sewer systems. Of all the options, Option 1 generally received the most favorable comment. However, the overwhelming majority of comments suggested different options or other alternatives. Having reviewed the comments at length, EPA is convinced that the definition of municipal separate storm sewers should possess elements of several of the options enumerated above and a mechanism that enables States or EPA Regions to define a system that best suits their various political and geographical conditions.

The following comments were the most pervasive, and represent those issues and concerns of greatest importance to the public: (1) The approach chosen initially must be realistic and achievable administratively; (2) the definition must be flexible enough to accommodate development of the program on a watershed basis, and incorporate elements of existing programs and frameworks and regional differences in climate, geography, and political institutions; (3) permittees must have legal authority and control over land use; (4) discharges from State highways identified as a significant source of runoff and pollutants, should be included in the program and combined in some manner with one or more of the other options; (5) the definition should address how the inclusion of interrelated discharges into the municipal separate storm sewer system are timed, decided upon, dealt with, etc.; (6) any approach must address the major sources of pollutants; (7) development of co-permittee management plans must be coordinated or developed on a regional basis and in the same time frame—fragmented or balkanized programs must be avoided; (8) municipalities should be regulated as equitably as possible; (9) flood control districts should be addressed as a system or part of a system; (10) the definition must conform to the legal requirements of the Clean Water Act; and (11) the definition should limit the number of co-permittees as much as possible.

b. Definition of large and medium municipal separate storm sewer system. A combination of the options outlined in the 1988 proposal would address most of these concerns, while achieving a realistic and environmentally beneficial storm water program. Accordingly, EPA has adopted the following definition of large and medium municipal separate storm sewer systems. Large and medium separate storm sewer systems are municipal separate storm sewers that:

(i) Are located in an incorporated place with a population of 100,000 or more or 250,000 or more as determined by the latest Decennial Census by the Bureau of Census (see appendices F and G of part 122 for a list of these places based on the 1980 Census);

(ii) Are located within counties having areas that are designated as urbanized areas by latest decennial Bureau of Census estimates and where the population of such areas exceeds 100,000; after the population in the incorporated places, townships or towns within such counties is excluded (see appendices H and I for a listing of [illegible] counties based on the 1980 [illegible] (incorporated places, towns and townships within these counties [illegible] excluded from permit application requirements unless they fall [illegible] paragraph (i) or are designated [illegible] paragraph (iii)); or (iii) are own[illegible]

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operated by a municipality other than those described in paragraph (i) or (ii) that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraphs (i) or (ii). In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in subparagraph (i);

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; or

(E) Other relevant factors.

(iv) The Director may, upon petition, designate as a system, any municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (i), (ii), and (iii).

Under today's rule at § 122.26(a)(3)(iii) the regional authority shall be responsible for submitting a permit application under the following guidelines: The regional authority together with co-applicants shall have authority over a storm water management program that is in existence, or shall be in existence at the time part 1 of the application is due; the permit applicant or co-applicants shall establish their ability to make a timely submission of part 1 and part 2 of the municipal application; each of the operators of municipal separate storm systems described in paragraphs 122.26(b)(4) (i), (ii), and (iii) and (7)(i), (ii), and (iii), that are under the purview of the designated regional authority, shall comply with the application requirements of § 122.26(d).

As noted above, the finalized definition of large and medium municipal separate storm sewer system is combination of the approaches as proposed. (In the following discussion "paragraph (i)" refers to §§ 122.26 (b)(4)(i) and (b)(7)(i); "paragraph (ii)" refers to §§ 122.26(b)(4)(ii) and (b)(7)(ii); "paragraph (iii)" refers to §§ 122.26 (b)(4)(iii) and (b)(7)(iii); and "paragraph (iv)" refers to §§ 122.26 (b)(4)(iv) and (b)(7)(iv)). Paragraph (i) originates from proposed Option 5 (boundaries of incorporated places); paragraph (ii) originates from Option 6 (boundaries of counties) and Option 7 (urbanized areas); paragraph (iii) originates from Options 1 and 5; and paragraph (iv) is an outgrowth of comments on all options, especially Option 4 (State owned systems/State highways) and Option 8 (watersheds).

This definition creates a system by virtue of the fact that storm sewers within defined geographical and political areas, and the owner/operators of separate storm sewers in those areas, are addressed or required to obtain permits. Although within these systems, different segments and discharges of storm water conveyances may be owned or operated by different public entities, EPA is convinced by comments that discharges from such conveyances are interrelated to such an extent that all of these conveyances may be properly considered a "system." These comments are identified and discussed in greater detail below.

c. Response to comments. Many commenters urged that the approach taken must be administratively achievable. Option 5 of the proposal (boundaries of incorporated places), which can be equated to paragraphs (i) and (iii) above, was identified by several commenters as the most workable of all the options. Many commenters stated that Option 1 (systems owned or operated by incorporated places) was inappropriate because of special districts and other owners of systems within the incorporated area; and although EPA proposed a designation provision for interrelated discharges in Option 1, commenters advised that it would be impossible to identify these systems, account for their discharges, and exclude or include them in a timely manner if Option 1 was selected (Option 1 only addresses those systems owned or operated by the incorporated place). The final rule would obviate these concerns, since all the publicly owned sewers within the boundaries of the municipality will be required to be covered by a permit.

Other commenters noted that cities sometimes have storm water conveyances owned or operated by numerous entities. One municipality commented that these problems could be more easily resolved using a unified permit/district wide approach, which the final approach outlined above can accomplish. One county stated that Option 1 of the proposal would result in a permanent balkanization of stormwater programs and that a regional approach focusing on the entire system should be established. Another municipality recommended that all the systems of conveyances within the incorporated city boundaries be issued a permit. In rejecting Option 1 of the proposal, one municipality stated that program inefficiencies would result from implementing a piecemeal program in a contiguous urban environment with different owners and operators. One State conveyed similar concerns. Using a geographical approach, as described in paragraph (i) of the final definition, will best address all of these concerns.

One commenter criticized proposed Option 1 as being contrary to the legal requirements of the WQA, and a further example of EPA's continuing attempt to minimize the scope of a national storm water program. It was noted that the legislative history regarding requirements for large and medium municipal separate storm sewer systems in section 402(p) of the CWA generally does not reference incorporated cities or towns. As a result, the commenter recommended that the term "municipal" in municipal separate storm sewer system refer to separate storm sewers operated by municipal entities meeting the definition of "municipality" in section 502 of the CWA and that the scope of the term "municipal separate storm sewer system" be defined as broadly as possible. This approach would result in defining large and medium municipal separate storm sewer systems to include all municipal separate storm sewers within the 410 counties with a population of 100,000 or more. EPA has adopted the commenter's recommendation to extend the scope of the program to the extent that today's rule covers all municipal separate storm sewers within certain areas rather than only those operated by an incorporated place. EPA disagrees however that it must define the term "system" to include sewers within any municipal boundary of sufficient population with reference to section 502(4). By not providing explicit definitions, section 402(p)(3)(B) of the CWA gives EPA discretion to define how municipal separate storm sewer systems are defined. There is no indication in the language of the CWA or the legislative history that Congress intended that the scope of "municipality" and the scope of "municipal separate storm sewer system" to be identical, particularly since the latter term is not defined in the statute. Furthermore, for the reasons discussed elsewhere in this section, EPA believes that today's definition is a [illegible] reasonable accommodation of the many conflicting concerns surrounding the proper way to delineate the extent of [illegible]

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municipal separate storm sewer system serving over 100,000 people.

Several commenters concluded that EPA should be flexible enough to allow the permitting authority broad discretion to establish system wide permits, with flood control districts and/or counties acting as co-permittees with the various incorporated cities within the district boundaries. Commenters expressed concern that Option 1 would not allow for such flexibility.

Arguments that were advanced by commenters in support of proposed Option 1 are equally applicable to paragraph (i), above. Like proposed Option 1, the approach outlined above targets major cities. However, it also has the advantage of addressing municipal separate storm sewer systems which may be interrelated to those owned by the city, a benefit recognized by one municipality that endorsed the selection of proposed Option 5. This will also give the permitting authority more discretion to establish co-permittee relationships.

Paragraph (ii) of the final definition also uses a geographical approach to the definition of municipal storm sewer systems to include municipal storm sewers within urbanized counties. Thus, it closely resembles Option 7 of the proposal. The counties identified in paragraph (ii) have, based on the 1980 Census, a population of 100,000 or more in urbanized,[5] unincorporated portions of the county. In the unincorporated areas of these counties (or in the 20 States where the Census recognizes minor civil divisions, unincorporated county areas outside of towns or townships), the county is the primary local government entity. In these cases, the county performs many of the same functions as incorporated cities with a population of 100,000, and is generally expected to have the necessary legal and land use authority in these areas to begin to implement storm water management programs. Due to the urbanized nature of their population, discharges from the municipal separate storm sewers in these counties will have many similarities to discharges from municipal systems in incorporated cities with a population of 100,000 or more. Addressing these counties in this fashion will not adversely affect small municipalities (incorporated places, towns and townships) within the county, as municipal separate storm sewers that are located in the small incorporated places, townships or towns within these counties are not automatically included as part of the system.

EPA has focused on the unincorporated areas because permit applications cannot be required from systems that serve a population less than 100,000, unless designated. EPA received the comment that if the sewers in incorporated places within such counties were included as part of the system for that county, there would be the potential for systems serving a population less than 100,000 to be improperly subject to permit requirements. EPA agrees with the comment, except that EPA reserves the authority to designate sewers in small incorporated places as part of the system subject to permitting, pursuant to paragraph (iii) of the final definition. Incorporated areas within the identified counties will be required to file permit applications if the population served by the municipal separate storm sewer system is 100,000 or more.

As one commenter noted, the counties addressed by the definition will generally be areas of high growth with a growing tax base that can finance a storm water management program. Numerous counties affected by paragraph (ii) commented on the proposal. Several of these indicated a preference for the county government as the permittee. Others indicated that their county had the ability to perform the functions of the permit applicant and permittee. One county brought to EPA's attention that the county had laid plans for a storm water utility scheduled to be in operation in 1989. Several of the counties supported the use of watersheds, or flexible regional approaches, as the basis for the definition of municipal separate storm sewer systems. The modified definition should satisfy these concerns.

EPA recognizes that some of the counties addressed by today's rule have, in addition to areas with high unincorporated urbanized populations, areas that are essentially rural or uninhabited and may not be the subject of planned development. While permits issued for these municipal systems will cover municipal system discharges in unincorporated portions of the county, it is the intent of EPA that management plans and other components of the programs focus on the urbanized and developing areas of the county. Undeveloped lands of the county are not expected to have many, if any, municipal separate storm sewers.

Paragraphs (i) and (ii) above will help resolve the problems associated with permittees not having adequate land use controls, the legal authority to implement controls, and the ownership of the conveyances. This factor was mentioned by numerous commenters [illegible] the proposed options, especially [illegible] governments. Under paragraphs (i) and (ii), all publicly owned separate storm sewers within the appropriate municipal boundaries will be defined as part of the municipal system. In many cases, a number of municipal operators of these storm sewers will be responsible for discharges from these systems. Since a number of co-permittees may be addressed in the permits for these discharges, problems associated with the ability to control pollutants that are contributed from interrelated discharges will be minimized. State highways or flood control districts, which may have no land use authority in incorporated cities, will be co-permittees with the city which does possess land use authority. EPA envisions that permit conditions for these systems will be written to establish duties that are commensurate with the legal authorities of a co-permittee. For example, under a permit, a flood control district may be responsible for the maintenance of drainage channels that they have jurisdiction over, while a city is responsible for implementing a sediment and erosion ordinance for construction sites which relates to discharges to the drainage channel. Confusion over ownership of conveyances or systems, at least for the purposes of determining whether they require a permit, will be minimized since all conveyances will be covered. Similarly, under paragraph (ii), the affected counties are expected to have the necessary legal and land use authority to implement programs and controls in unincorporated, urbanized areas because the county government is the primary political or governing entity in these geographical areas.

Many commenters from all levels of State and local government expressed concern about controlling pollutants from State highways. Paragraphs (i) and (ii) will result in discharges from [illegible] separate storm sewers serving State highways and other highways [illegible] storm sewers that are located within incorporated places with the [illegible] appropriate population or highways [illegible] unincorporated portions of [illegible] counties being included as [illegible] large or medium municipal separate storm sewer system, since all [illegible] separate storm sewers within the boundaries of these political [illegible] included. Paragraph (iii) [illegible]

[5] The Bureau of Census defines urbanized areas to provide a description of high-density development. Urbanized areas are comprised of a central city (or cities) with a surrounding closely settled area. The population of the entire urbanized area must be greater than 50,000 persons, and the closely settled area outside of the city, the urban fringe, must generally have a population density greater than 1,000 persons per square mile (just over 1.5 persons per acre) to be included.

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the submission of a permit application for storm sewers operated as part of an entire State highway system. Paragraph (iv) would allow an entire system in a geographical region under the purview of a State agency (such as a State Department of Transportation) to be designated, where all the permit application requirements and requirements established under § 122.26(a)(iii)(C) can be met.

Paragraphs (i) and (ii) can effectively deal with many of the major sources of pollutants. One municipality noted that Option 5 (paragraph (i)) would require all systems in the incorporated boundaries to obtain permits and institute control measures, rather than just the few owned or operated by incorporated cities. Another municipality noted that this approach could deal with many of the regional variations in sources of pollution. Many commenters, including environmental groups, believed that proposed Option 3 (systems owned or operated by counties), Option 6 (systems within the boundaries of counties), and Option 7 (system in urbanized areas) were good approaches because more sources of pollution would be addressed. It was also maintained that Options 3, 6 and 7 could incorporate watershed planning which, in the view of some commenters, is the only effective way to address pollutants in storm water.

Commenters noted that addressing counties and urbanized areas would focus attention on developing areas which would otherwise be left out in the initial phases of permitting. One commenter noted that most new development in large urbanized areas occurs outside of core cities (incorporated cities with a population of 100,000 or more). Newly developing areas provide opportunities for installing pollutant controls cost effectively. EPA agrees with these comments and notes that paragraph (ii) addresses a significant number of counties with highly developed or developing areas.

However, EPA is convinced that addressing all counties or urbanized areas in the initial phases of the storm water program is ill-advised. Commenters noted that some counties have inappropriate or nonexistent governmental structures, and that a program that addressed all counties in the country with a population of 100,000 or more would be unmanageable, because too many municipal entities nationwide would be involved in the program initially. Commenters advised that defining municipal storm sewer systems solely in terms of the boundaries of census urbanized areas (Option 7) would result in systems which did not correspond to jurisdictions that are in a position to implement a storm water programs. Thus, EPA has modified Option 7 and combined it with Option 6 to create paragraph (ii) above.

Paragraph (iii) incorporates a designation authority such that municipalities that own or operate discharges from separate storm sewers systems other than those described in paragraph (i) or (ii) may be designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the other discharges of the designated storm sewer and the discharges from the large or medium municipal separate storm sewers. In making this determination the physical interconnections between the municipal separate storm sewers, the location of discharges from the designated municipal separate storm sewer relative to discharges from large or medium municipal separate storm sewers, the quantity and nature of pollutants discharged to waters of the United States, the nature of the receiving waters, or other relevant factors may be considered.

Comments indicated that the designation authority as proposed and described above should be retained. One State noted that this approach gives the most flexibility in making the case-by-case designations, while also delineating in sufficient detail what criteria are used to make the determination. This commenter was concerned about being able to regulate many of the interrelated discharges from counties surrounding incorporated cities.

Paragraph (iv) of the final definition allows the permitting authority, upon petition, to designate as a medium or large municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (i), (ii), (iii).

Paragraph (iv) was added to the final definitions to respond to a variety of concerns of commenters. One of the prime concerns of commenters was that the definition of large and medium municipal separate storm sewer systems must be flexible enough to accommodate: Programs on a watershed basis, existing storm water programs and frameworks and regional differences in climate, geography, and political institutions. Some States were particularly expressive regarding this concern. One State maintained that an inflexible program could totally disrupt ongoing State efforts. Other commenters urged that the regulation encourage the establishment of regional storm water authorities or other mechanisms that can deal with storm water quality on a watershed basis. One State proposed defining the municipal separate storm sewer system to include all municipal separate storm sewers within a core incorporated place of 100,000 or more, and all surrounding incorporated places within the State defined watershed. One of the State water districts advised that the regulations should be flexible enough to allow regional water quality boards to apply the regulations geographically. One national association expressed concern that existing institutional arrangements for flood control and drainage would be ignored, while another warned against fostering a proliferation of inconsistent patchwork programs based on arbitrary definitions and jurisdictions which bear no relationship to water quality.

EPA is convinced that the mechanism described in paragraph (iv) provides a means whereby the mechanisms and concepts identified above can be utilized or created in appropriate circumstances. In addition, § 122.26(f)(4) provides a means for State or local government agencies to petition the Director for the designation of regional authorities responsible for a portion of the storm water program. For example, some States or counties may currently or in the near future have regional storm water management authorities that have the ability to apply for permits under today's rule and carry out the terms of the permit. Some of these authorities may encompass within their jurisdiction large or medium municipal separate storm sewer systems as defined in today's rule. EPA wishes to encourage such entities to assume the role as permittee under today's rule. That is the purpose of paragraph (iv). Such authorities may petition the Director to assume such a role.

Many commenters expressed the view that municipal management plans must be coordinated or developed among co-permittees on a regional basis and in the same timeframe. Paragraphs (i), (iii) and (iv) would bring in all appropriate municipal entities with jurisdiction over a specified geographical area in the same timeframe. Several commenters, including one State, noted proposed Option 1 would lead to fragmented, ill-coordinated programs. Paragraphs (i), (iii), and (iv) do not suffer this drawback to the same extent since all the municipal separate storm sewers are addressed within the incorporated place, instead of only those owned or operated by the incorporated place.

Equal treatment of municipalities within a watershed or other specified area was a major subject of comment. Many commenters urged that a degree of fairness could be achieved by requiring permit applications, and the concomitant expenditure of municipal dollars and resources, from all municipalities within an entire urban area that contributes to storm water pollution, rather than from a discrete system within an arbitrary political boundary. Paragraph (i), especially when coupled with paragraphs (ii), (iii), and (iv), can best accomplish a more equitable approach, because all owners and operators of municipal separate storm sewers within a system have responsibilities. In addition, some of the areas outside the incorporated city limits which are engaged in expansive urban or suburban development will be brought into the program. Paragraph (iv) will provide a means for State or regional authorities to use existing or emerging mechanisms to set up storm water management programs, and would require multiple agencies either to become regional co-permittees or to be subject to a regional permit.

Paragraphs (i), (ii), (iii), and (iv) could also require flood control districts to be co-permittees, which was a major concern of counties and numerous cities. One municipality stated that the inclusion of flood control districts would greatly reduce the administrative burden required to prepare a single inter-city discharge agreement and would establish a common legal authority to implement the program. Numerous county agencies believed it imperative that flood control districts be brought into a system-wide permit strategy.

Paragraphs (i) and (iii) may not accommodate the concern of several commenters that the number of co-permittees be kept to a minimum. The fact that all the municipal separate storm sewers within the boundaries of the appropriate incorporated places will be addressed dictates that some permits will have several co-permittees. This is a major concern since it goes directly to achieving an effective initial storm water program. There is concern about being able to bring all the co-permittees together under intra-municipal agreements or contracts within regulatory deadlines. This problem would be resolved in the short term by selecting Option 1. However, Option 1 may still require inter-municipal agreements because of the designation authority under § 122.26 (b)(4)(ii) and (b)(7)(ii) of the proposal. In addition, such inter-jurisdictional problems will arise after October 1, 1992 when the moratorium on requiring NPDES permits for discharges from other municipal separate storm sewers ends. Under the permitting goals established by the CWA, multi-jurisdictional storm water programs and agreements cannot be avoided. Despite interest in limiting the number of co-permittees, EPA decided not to adopt Option 1 for the reasons already stated.

Section 402(p)(3)(B)(i) of the amended CWA provides that permits for municipal discharges from municipal storm sewers may be issued on a system-wide or jurisdiction-wide basis. This provision is an important mechanism for developing the comprehensive storm water management programs envisioned by the Act.

Under the permit application requirements of today's rule, if the appropriate co-applicants are identified, one permit application may be submitted for a large or medium municipal separate storm sewer system (see section VI.G.4 above). System-wide permit applications can in turn be used to issue system-wide permits which could cover all discharges in the system.

Where several municipal entities are responsible for obtaining a permit for various discharges within a single system, EPA will encourage system-wide permit applications involving the several municipal entities for a number of reasons. The system-wide approach not only provides an appropriate basis for planning activities and coordinating development, but also provides municipal entities participating in a system-wide application the means to spread the resource burden of monitoring, evaluating water quality impacts, and developing and implementing controls.

The system-wide approach provided in today's rule recognizes differences between individual municipalities with responsibilities for discharges from the municipal system. Today's application rule requires information to be submitted that enables the permit issuing authorities to develop tailored programs for each permittee with responsibility for certain components, segments, or portions of the municipal separate storm sewer system. The permit application requirements allow individual municipal entities, participating in system-wide applications, to submit site specific information regarding storm water quality management programs to reduce pollutants in system discharges as a whole, or from specific points within the system.

In some cases, it may be undesirable for all municipal entities with storm water responsibility within a municipal system to be co-permittees under one system-wide permit. The permit application requirements in today's rule allow individual municipal entities within the system to submit permit applications and obtain a permit for that portion of the storm sewer system for which they are responsible. Thus, several permits may be issued to cover various subdivisions of a single municipal system.

In summary, EPA believes that the definition of municipal storm sewer system adopted in today's rule has several distinct advantages that were identified in comments:

- The definition adopts features of several options;
- The definition targets areas that have the necessary police powers and land use authority to implement the program;
- The definition can utilize watersheds or accommodate existing administrative frameworks and storm water programs;
- The definition provides that all systems within a geographical area including highways and flood control districts will be covered, thereby avoiding fragmented and ill-coordinated programs;
- The definition has flexible designation authority; and
- The definition addresses major sources of pollutants without being overly broad.

H. Permit Application Requirements for Large and Medium Municipal Systems

1. Implementing the Permit Program

Given the differing nature of discharges from municipal separate storm sewer systems in different parts of the country and the varying water quality impacts of municipal storm sewer discharges on receiving waters, today's permit application requirements are designed to lead to the development of site-specific storm water management programs. In order to effectively implement this goal, EPA intends to retain the overall structure of the [illegible] municipal permit application [illegible] proposed in the December [illegible] proposal [illegible]

2. Structure of the [illegible]

EPA proposed a [illegible] application designed [illegible]

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developing site-specific storm water quality management programs in NPDES permits. In response to a request for comments on this aspect of the proposal, numerous comments were received. After reviewing these comments, EPA has decided to retain the two-part permit application. Many commenters agreed that the approach as proposed is appropriate for phasing in and developing site specific storm water management programs. One large municipality strongly endorsed the two-part application, stating that it would facilitate the identification of water quality problem areas and the development of priorities for control measures, thereby allowing for more cost-effective program development. Two State agencies expressed the same view, and noted that the two-part approach is reasonable and well structured for efficient development of programs. One large municipality noted it would allow the permit authority and the permit applicant the time needed to gain the knowledge and data to develop site-specific permits. A medium municipality expressed similar views.

Numerous commenters submitted endorsements of a proposal offered by one of the national municipal associations. This approach responded to EPA's request for comments on alternatives to a two-part application process. These comments recommended having permit applicants submit information regarding their existing legal authority, prepare source identification information, describe existing management plans, provide discharge characterization information based on existing data, and prepare a monitoring, characterization and illicit discharge and removal plan in a one-part application. The remaining requirements such as: implementing plans to remove illicit connections, obtaining legal authority, monitoring and characterization, plans for structural controls, preparation of control assessments, preparation of fiscal analysis, and management plan implementation would be part of the permit and take place during the compliance period of the permit. It was argued that this would result in a more orderly development of stormwater. management programs while allowing for quick implementation of efforts to eliminate illicit discharges and initiate some BMPs.

After careful review and consideration of these comments, EPA is convinced that this approach would not meet the goals and requirements of section 402 of the Clean Water Act. Section 402(p)(3)(B) of the CWA requires that permits effectively prohibit non-storm water discharges into storm sewers and incorporate controls that reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system design and engineering methods. The above comments suggesting an alternative for achieving this goal are not entirely compatible with these requirements. In light of the language in the statute, permit conditions should do more than plan for controls during the term of the permit. A strong effort to have the necessary police powers and controls based on pollutant data should be undertaken before permits are issued. In short, the one-part application described by these comments would result in permits that would focus too much on preparation and not enough on implementing controls for pollutants.

In comparison, EPA's approach requires municipalities to submit a two-part application over a two year period. Part one of the application would require information regarding existing programs and the means available to the municipality to control pollutants in its storm water discharges. In addition, part one would require field screening of major outfalls to detect illicit connections. Part two of the permit application would require a limited amount of representative quantitative data and a description of proposed storm water management plans. The purpose of the two-part application process is to develop information, in a reasonable time frame, that would build successful municipal storm water management programs and allow the permit writer to make informed decisions with regard to developing permit conditions. This will include initiating efforts to effectively prohibit non-storm water discharges into storm sewers, and initially implementing controls that reduce the discharge of pollutants to the maximum extent practicable, including management practices and control techniques during the term of the permit. Such an approach clearly meets the statutory mandate of section 402(p)(3)(B).

a. Part 1 Application. Part 1 of the permit application is intended to provide an adequate basis for identifying sources of pollutants to the municipal storm sewer system, to preliminarily identify discharges of storm water that are appropriate for individual permits, and to formulate a strategy for characterizing the discharges from municipal separate storm sewer systems. Several commenters supported retaining these components of the application process. The components of part 1 of the permit application include:

- General information regarding the permit applicant or co-applicants (§ 122.26(d)(1)(i));
- A description of the existing legal authority of the applicant(s) to control pollutants in storm water discharges and a plan to augment legal authority where necessary (§ 122.26(d)(1)(ii));
- Source identification information including: a topographic map, description of the historic use of ordinances or other controls which limited the discharge of non-storm water discharges to municipal separate storm sewer systems, the location of known municipal separate storm sewer outfalls, projected growth, location of structural controls, and location of waste disposal facilities (§ 122.26(d)(1)(iii));
- Information characterizing the nature of system discharges including existing quantitative data, the results of a field screening analysis to detect illicit discharges and illegal dumping to the municipal system, an identification of receiving waters with known water quality impacts associated with storm water discharges, a proposed plan to characterize discharges from the municipal storm sewer system by estimating pollutant loads and the concentration of representative discharges, and a plan to obtain representative data (§ 122.26(d)(1)(iv)); and
- A description of existing structural and non-structural controls to reduce the discharge of pollutants from the municipal storm sewer (§ 122.26(d)(1)(v)).

One commenter disagreed that source identification should be made part of the permit application process beyond the identification of major municipal storm sewer outfalls. In reply, EPA is convinced that the other elements of the source identification are critical for identifying sources of pollutants and creating a base of knowledge from which informed decisions about permit conditions and further data requirements can be determined. One county stated that it already had engaged in extensive monitoring and modeling of watersheds and that its programs should be substituted for EPA's. In response, EPA anticipates that information collected under various State, county or city programs that matches the information requirements in this rulema[illegible] applicants [illegible] rulem[illegible] the rule [illegible] the [illegible] techni[illegible]

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these programs. EPA disagrees that it would be appropriate to accept a substitution in its entirety without tailoring such a program to today's specific information requirements. One municipality noted that municipal systems are not well documented and responsibility for them is in question. In response, EPA notes that the source identification procedure is designed, in part, to address such shortcomings.

Several municipalities suggested that legal authority could be demonstrated by providing EPA with copies of appropriate local ordinances to demonstrate their legal authority and a statement from the city attorney. EPA agrees that these methods are appropriate for making this demonstration.

Several commenters noted that there was adequate existing municipal legal authority to carry out the program requirements or such authority could be obtained by the municipality. Other commenters stated that municipalities possess some authority over certain activities but may not have authority over discharges from roads and construction. Numerous commenters, however, claimed that certain municipalities had no existing legal authority to carry out the permit requirements and that obtaining all the necessary legal authority could take several years due to cumbersome legislative and political processes. In response, part 1 of the permit application will establish a schedule for the development of legal authority that will be needed to accomplish the goals of the permit application and permits. Some municipalities will have more advanced storm water programs with appropriate legal authority or the ability to establish necessary ordinances. Providing an appropriate schedule will not present difficulties in these circumstances. EPA also notes that the definitions of large and medium municipal separate storm sewer systems finalized in today's rule will in many cases result in a number of co-applicants participating in a system wide application. It is anticipated that the development of adequate inter-jurisdictional agreements specifying the various responsibilities of the co-permittees may in some cases be very complex, thereby justifying the development of a schedule to complete the task. For example, clarifying the authority over discharges from roads may present difficulties where a number of municipal entities operate different roads in a given jurisdiction. In other limited cases, the MEP standard for municipal permits may translate into permit conditions that extend the schedule for obtaining necessary legal authority into the term of the permit. These situations will be evaluated on a case-by-case basis by permit issuing authorities.

Numerous commenters supported the field screening analysis as proposed. Comments from three municipalities noted that it would be a cost effective means of identifying problem areas. One municipality noted that illicit connections can be reliably detected by the screening method proposed. In view of these comments EPA has decided to retain this portion of the regulation. However many commenters expressed concern over how the proposed approach would work given the particular circumstances under which some municipal storm water systems are arranged. Several commenters questioned the effectiveness of dry weather monitoring for several reasons, including the shallow depth of some cities' water tables. Accordingly, an alternative approach may be utilized by the municipal permittee, and this is discussed later in section VI.H.3.

Some comments suggested that if any field screening is required that it be done during the term of the permit. EPA believes that field screening should not be done during the term of the permit exclusively. Unless a field screening is accomplished during the permit application phase there will be scant knowledge, if any, upon which illicit connection programs can be established for the term of the permits. EPA views field screening during the application process as an appropriate means of beginning to meet the CWA's requirement of effectively prohibiting non-storm water discharges into municipal separate storm sewers.

The submittal of part 1 of the permit application will allow EPA, or approved NPDES States, to adjust part 2 permit application requirements to assure flexibility for submitting information under part 2, given the site specific characteristics of each municipal storm sewer system.

EPA agrees with the concerns of commenters regarding the estimate of the reduction of pollutant loads from existing management programs. EPA agrees that sufficient data may not be available to establish meaningful estimates. Therefore this component of the proposed part 1 is not a requirement of today's rule.

b. Part 2 Application. Part 2 of the proposed permit application is designed to supplement information found in part 1 and to provide municipalities with the opportunity of proposing a comprehensive program of structural and non-structural control measures that will control the discharge of pollutants, to the maximum extent practicable, from municipal storm sewers. The components of the proposed part 2 of the permit application included:

- A demonstration that the legal authority of the permit applicant satisfies regulatory criteria (§ 122.26(d)(2)(i));
- Supplementation of the source identification information submitted in part 1 of the application to assure the identification of all major outfalls and land use activities (§ 122.26(d)(2)(ii);
- Information to characterize discharges from the municipal system;
- A proposed management program to control the discharge of pollutants to the maximum extent practicable, from municipal storm sewers (§ 122.26(d)(2)(iv));
- Assessment of the performance of proposed controls (§ 122.26(d)(2)(v));
- A financial analysis estimating the cost of implementing the proposed management programs along with identifying sources of revenue § 122.26(d)(2)(vi);
- A description of the roles and responsibilities of co-applicants (§ 122.26(d)(2)(vii)).

One municipality agreed that the assessment of the performance of controls was a critical component of establishing a viable program and one that could be accomplished within the time frame of the permit application deadlines. One commenter suggested that the applicant describe what financial resources are currently available. In response, EPA will require applicants to describe the municipality's existing budget for storm water programs in part 1 of the permit application requirements. This information will be useful to evaluate the municipality's ability to prepare and implement management plans. In response to other comments, this information will also include an overview of the municipality's financial resources and a description of the municipality's budget, including overall indebtedness and assets.

EPA has retained the financial analysis in this portion of the rule on the advice of two municipal commenters who agreed that this was an important component of establishing a viable program and one that could be accomplished within the time frame of the permit application deadlines. Another commenter noted that this requirement is appropriate to [illegible] municipality's proposed management plan.

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3. Major Outfalls

In past rulemakings, a controversial issue has been the appropriate sampling requirements for municipal separate storm sewer systems. Earlier storm water rulemakings have been based primarily on the principle that all discharges to waters of the United States from municipal separate storm sewers located in urban areas must be covered by an individual permit. This approach requires that individual permit applications contain quantitative data to be submitted for all such discharges. This approach was criticized because of a potentially unmanageable number of outfalls in some municipal separate storm sewer systems. Most incorporated cities with a population of 100,000 or more do not know the exact number of outfalls from their municipal systems; but based on the comments, the number ranges from 500 to 8,000 or more.

In light of the increased flexibility provided by the WQA and the development of EPA's system-wide approach for regulating municipal separate storm sewer discharges, today's rule will not require submittal of individual permit applications with quantitative data for each outfall of a municipal system. Rather today's rule will encourage system-wide permit applications to provide information suitable for developing effective storm water management programs. Under this approach, not all outfalls of the municipal system will be sampled, but rather more specific and accurate models for estimating pollutant loads and discharge concentrations will be used. The use of these models will require the identification of sources which are responsible for discharging pollutants into municipal separate storm sewers and will not require as much data to calibrate due to the source-specific nature of the model. A number of standard and localized models have been developed for estimating pollutant loads from storm water discharges.

Several commenters support the use of models for developing management plans and estimating pollutant loadings and concentrations. EPA encourages their use where applicable to particular systems.

By adopting an approach that incorporates source identification measures, the amount of quantitative data required to characterize discharges from the municipal system will be reduced because of the increased accuracy of the site-specific models which can be used. Consistent with a system-wide permit application approach, EPA proposed to focus source identification measures on "major outfalls." The proposed definition of major outfalls includes any municipal separate storm sewer outfall that discharges from a pipe with a diameter of more than 36 inches or its equivalent (discharges from a drainage area of more than 50 acres), or for municipal separate storm sewers that receive storm water from lands zoned for industrial activities, an outfall that discharges from a pipe with a diameter of more than 12 inches or its equivalent (discharges from a drainage area of 2 acres or more).

Numerous entities offered comments on this definition. Several commenters concurred with this proposed definition. One commenter maintained that the data collected at such outfalls would be sufficient to estimate pollutant loads as well as concentrations using well calibrated models. Another municipality stated that 50 acres was an excellent approximation for the average drainage area served by a 36-inch storm sewer. Two States and one county supported the definition as proposed. One large municipal entity supported the definition, stating that screening major outfalls could be accomplished with available staff over a three month period. In light of these comments, EPA has decided to retain, in part, the definition as proposed.

Numerous commenters suggested alternative definitions or otherwise disagreed with the proposed definition. Most of these comments expressed concern about the number of outfalls that would have to be tested or screened if the definition was retained. For this reason EPA has decided to limit the total number of major outfalls or equivalent sampling points that have to be tested to 250 or 500 for medium or large systems respectively. This change is discussed in further detail below.

The following are examples of comments that opposed the definition of a "major outfall" as proposed. Several commenters stated that, in the southwest, 6 to 12 foot outfalls are the norm, and that smaller outfalls should not be addressed unless there is a compelling reason to suspect illicit connections. One commenter suggested a size of 54 inches and 50 acres, while another commenter suggested that 48 inches would be appropriate. One commenter suggested that the diameter for industrial pipes should be 18 inches, while another commenter suggested that 50 acres should be the only criterion.

One commenter noted that pipe size will vary according to rainfall patterns and that a single approach would not work universally. This comment, and other similar points of view as noted herein, convinces that Agency that a more flexible approach is needed to identify field screening and sampling locations. However, EPA is also convinced that a universal standard is necessary for purposes of identifying drainage areas within the municipal system and discrete areas of land use that are drained by certain sized outfalls. This information is critical since these conveyances, and lands they drain, are sources of pollutants to waters of the United States from municipal systems and are properly the subject of appropriate permit conditions.

Many commenters suggested placing a limit on the number of major outfalls addressed during the field screening phase of the permit application. Two municipalities stated that the proposed definition of major outfalls in terms to the pipe diameter was too small and that too many outfalls would be covered. One municipality stated that under the proposed definition, it would have over 4700 "major outfalls," a number viewed as being unacceptably large. Several municipalities argued that they would be penalized for over-design of their storm drain system. One municipality stated field screening of outfalls should be limited to 200 for medium cities and 500 for large cities. Some commenters suggested EPA set a percentage of major outfalls for screening, because all pipes in some municipalities meet the definition of major outfall. One commenter suggested that a sliding scale be used to determine the number of outfalls tested: those with 50 test all, those with 100–200 test 50%, etc. Other commenters suggested a flat percentage of outfalls or flat number such as 100.

4. Field Screening Program

EPA also received several comments in response to the proposed field screening methodology. Among the major concerns were: End of pipe sampling may not be practical and the more appropriate and accessible location is likely to be the nearest upstream manhole; the type of discharge should be the criterion for selecting sampling points as opposed to pipe size; a system wide evaluation is more appropriate than checking each outfall within some systems; major outfalls or pipe size will not reflect discharges from suspect or old land use areas; efforts should be focused on locations where illicit connections are expected; sites should be determined by looking at [illegible] within drainage basin areas based on land use within those basins; [illegible] and hydrology of the watershed should be the criteria for selecting points.

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screening should be performed at locations that will allow for the location of upstream discharges; the focus should be exclusively on drainage areas rather than pipe size, since pipe size will vary with slope; a prescribed percentage of total flow may be more appropriate; state water quality standards should be utilized along with focusing on actual quality in the reaches of a stream.

EPA is convinced by these comments that today's rule should allow applicants to either field screen all major outfalls as proposed (first procedure) or use a second procedure to provide for the strategic location of sampling points to pinpoint illicit connections. EPA agrees with comments that the size of the outfall will not always reflect the chance of uncovering illicit connections or discharges, and that field screening points should be easily accessible.

This second procedure is as follows: field screening points and/or outfalls are randomly located throughout the storm sewer system by placing a grid over a drainage system map and identifying those cells of the grid which contain a major outfall or segment of the storm sewer system. The grid shall be established using the following guidelines and criteria:

(1) A grid system consisting of perpendicular north-south and east-west lines spaced 1/4 mile apart shall be overlaid on a map of the municipal storm sewer system, creating a series of cells;

(2) All cells that contain a segment of the storm sewer system shall be identified; one field screening point shall be selected in each cell; major outfalls may be used as field screening points;

(3) Field screening points or major outfalls should be located downstream of any sources of suspected illegal or illicit activity;

(4) Field screening points shall be located to the degree practicable at the farthest manhole or other accessible location downstream in the system, within each cell; however, safety of personnel and accessibility of the location should be considered in making this determination;

(5) The assessment and selection of cells shall use the following criteria: Hydrological conditions; total drainage area of the site; population density of the site; traffic density; age of the structures or buildings in the area; history of the area; land use types;

(6) For medium municipal separate storm sewer systems, no more than 250 cells need have identified field screening points; in large municipal separate storm sewer systems, no more than 500 cells need to have identified field screening points for detecting illicit connections; cells established by the grid that contain no storm sewer segments will be eliminated from consideration; if fewer than 250 cells in medium municipal sewers are created, and fewer than 500 in large systems are created by the overlay on the municipal sewer map, then all those cells which contain a segment of the sewer system shall be subject to field screening (unless access to the separate storm sewer system is impossible);

(7) Large or medium municipal separate storm sewer systems which are unable to utilize the procedures described in paragraphs (1) through (6) above, because a sufficiently detailed map of the separate storm sewer systems is unavailable, shall field screen at least 250 or 500 major outfalls respectively using the following method: the applicant shall establish a grid system consisting of north-south and east-west lines spaced 1/4 mile apart overlaid on a map of the boundaries of a large or medium municipal entity described at § 122.26(b), thereby creating a series of cells; major outfalls in as many different cells as possible shall be selected until 500 major outfalls (large municipalities) or 250 major outfalls (medium municipalities) are selected; a field screening analysis shall be undertaken at these major outfalls.

The methodology outlined above is in response to public comments which indicated that the field screening and sampling of major outfalls as proposed would lead to insurmountable logistical problems in some municipal systems. EPA believes that the above is an effective approach to pinpointing suspected problem points along a given trunkline or segment of separate storm sewer system. Jurisdictions with no extensive or previous history of monitoring, or lack of an intensive monitoring program can utilize the methods described in establishing a program. Furthermore, the approach will allow for the prioritization of outfalls, sampling points, or areas within the municipality where there are suspected illicit connections or discharges, or other circumstances creating higher concentrations and loadings of pollutants.

Paragraph (7) enables municipalities to select major outfalls without regard to the municipal sewer system map that is required for using the procedure described in paragraphs (1) through (6). However, the applicant must still select outfalls within the cells created by overlaying a 1/4 mile grid over a map of the boundaries of the large or medium municipal entity defined under § 122.26(b), and select major outfalls within as many of those cells as possible, up to 500 (large municipal systems) or 250 (medium municipal systems). In this manner, as many different areas and land uses within the municipal system will be covered by the field screening component of the municipal application.

In order to keep the costs of the program within the anticipated limits of the proposed regulation, the number of outfalls or sampling locations using the grid system is to be limited to 500 for large municipal separate storm sewer systems and 250 for medium municipal separate storm sewer systems.

In response to several comments, EPA has clarified the definition of major outfalls with regard to the words, "pipe with an inside diameter of 36 inches or more or its equivalent" and "a pipe with an inside diameter of 12 inches or more or its equivalent." This definition has been modified to specify that single pipes or single conveyances with the appropriate diameter or equivalent are covered.

EPA's proposal required municipal permit applicants to submit a fiscal analysis of expenditures that will be required in order to implement the proposed management plans required in part 2 of the application. The description of fiscal resources should include a description of the source of the funds. Some commenters felt that a fiscal analysis should only be required during the term of the permit. In response, EPA believes that during the two years of permit application development, the permit applicant should be in a position to submit information on the ability and means for financing storm water management programs during the term of the permit. EPA views this information as an important means of evaluating the scope of program and whether the permittee will be devoting adequate resources to implementing the program before that program is mapped out in the permit itself.

5. Source Identification

The identification of sources which contribute pollutants to municipal separate storm sewers is a critical step in characterizing the nature and extent of pollutants in discharges and in developing appropriate control measures. Source identification can be useful for providing an analysis of pollutant source contribution and for identifying the relationship between pollutant sources and receiving water quality problems. In cases where end-of-pipe controls alone are not practicable, it is essential to identify the source of pollutants into the municipal storm sewer systems to support a targeted approach to control pollutant sources.

The relative contribution of pollutants from various sources will be highly site-specific. The first step in developing a targeted approach for controlling pollutants in discharges from municipal storm sewer systems is identifying the various sources in each drainage basin that will contribute pollutants to the municipal storm sewer system.

This rulemaking phases in the source identification requirements of the permit program by establishing minimum objectives in part 1 of the application and by requiring applicants to submit a source identification plan in part 2 of the application to provide additional information during the term of the permit. The minimum source identification requirements of part 1 of the application have been designed to provide sufficient information to provide an initial characterization of pollutants in the discharges from the municipal storm sewer system. EPA realizes that with many large, complex municipal storm sewer systems, it may be difficult to identify all outfalls during the permit application process. Accordingly, EPA is requiring that known outfalls be reported in part 1 of the application. Part 1 of the application will also include: A description of procedures and a proposed program to identify additional major outfalls; the identification of the drainage area associated with known outfalls; a description of major land use classifications in each drainage area, descriptions of soils, the location of industrial facilities, open dumps, landfills or RCRA hazardous waste facilities which discharge storm water to the municipal storm sewer system; and ten year projections of population growth and development activities (population data and development projections will be useful for future predictions of loadings to receiving waters from municipal storm sewer systems, and capacities required for treatment systems). In general, population projections should reflect various scenarios of development (high, medium, low relative to recent trends).

Part 2 of the application will supplement the information reported in part 1 of the application so that, at a minimum, all major outfalls are identified.

Under today's rule, municipal or public entities responsible for applying for and obtaining an NPDES permit will be required to identify the location of an open dump, sanitary landfill, municipal incinerator or hazardous waste treatment, storage, and disposal facility under RCRA which may discharge storm water to the system as well as all facilities which discharge storm water associated with industrial activity into a large or medium municipal separate storm sewer system.

Requiring these source identification measures is supported by the legislative history of section 405 of the WQA, which instructs that "[i]n writing any permit for a municipal separate storm sewer, EPA or the State should pay particular attention to the nature and uses of the drainage area and the location of any industrial facility, open dump, landfill, or hazardous waste treatment, storage, or disposal facility which may contribute pollutants to the discharge." (emphasis added) [Vol 133 Cong. Rec. S752 (daily ed. Jan. 14, 1987].

One municipality questioned the purpose of the topographic map and commented that the scale of the topographic map is too large to indicate any of the required outfall, drainage, industrial or structural control information. In response, the purpose of the topographic map is to identify receiving waters, major storm water sewer lines that contribute discharges to these waters, and potential sources of storm water pollution. EPA disagrees that a USGS 7.5 scale map is inappropriate for identifying these features within a municipal system. The scale afforded by such a map provides sufficient detail to allow specified delineation of outfalls, while not requiring an overly burdensome map in terms of size. Numerous commenters noted the value of source identification information and generally supported submitting this information in the permit application.

Many commenters questioned the value of the source identification information for the purpose of characterizing pollutant loads and concentrations. Conversely, one commenter opined that the requirement would provide sufficient information to estimate pollutant loadings from each outfall using loading models to estimate loadings by watershed. In response, the source identification information serves several purposes. It is the first step for identifying potential sources of pollutants from which more in depth analysis can be accomplished, under the discharge characterization component of the application. Also, where appropriate, it may be used in conjunction with models to estimate loadings and concentrations. EPA has also taken note of the many comments that question or dismiss the concept of determining pollutant loads and concentrations solely from source identification. Accordingly, EPA is convinced that at least some of the sampling requirements as proposed are necessary to facilitate more accurate system specific estimates of pollutant concentrations and loadings. These are discussed below, in the discharge characterization section.

One commenter suggested that aerial photos be submitted in lieu of topographic maps. EPA agrees that an aerial photograph of the appropriate scale that communicates the same information as a topographic map may be substituted. Today's final rule reflects this flexibility.

The source identification component of the municipal application also requires that municipal applicants identify the industrial activity within the drainage area associated with each major outfall. One commenter stated that where multiple storm sewers outfalls discharge to a stream reach, municipalities should be allowed to delineate a single sewer-shed for identifying sources of industrial activity. In response, the rule does not delimit an applicant's ability to identify industries in groups according to a common series of storm sewer outfalls, if that is an easier or more appropriate methodology for that particular applicant. However, EPA would view this as appropriate only where the land use is of one type, such as industrial. Where land use is mixed within the drainage area associated with each major outfall, such differences need to be identified.

In response to comments, to the extent that EPA is requesting that applicants identify the types of industrial facilities operating within the municipality, the municipality is free to use Standard Industrial Classification (SIC) or other systems which identify the principal products or services of the facility. One commenter disagreed with EPA's decision to require a list of water bodies that are listed under CWA sections 304(1), 319(a), 314(a), and 320, because the States already have this information and that requesting it from permittees could result in "omissions, misunderstandings, and mistakes." EPA believes that these waters should be identified in the application so that appropriate permit conditions can be developed that address storm water discharges that are adversely effecting such waters. EPA believes that having this information immediately at the disposal of the municipality and the permit writer will speed the process and alert the municipality of storm water discharges to listed water bodies and potentially polluted storm water discharges to those waters.

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6. Characterization of Discharges

The characterization plan and data collection required in today's rule as elements of Part-one and Part-two of the municipal permit application is comprised of several major components:

• A screening analysis to provide information to develop a program for detecting and controlling illicit connections and illegal dumping to the municipal separate storm sewer system;

• Initial quantitative data to allow the development of a representative sampling program to be incorporated as a permit condition;

• System-wide estimates of annual pollutant loadings and the mean concentration of pollutants in storm water discharges, and a schedule to provide estimates during the term of the permit for each major outfall of the seasonal pollutant loadings and the event mean concentration of pollutants in storm water discharges; and

• An identification of receiving waters with known water quality impacts associated with storm water discharges.

Several commenters noted the importance of developing and targeting management programs based on discharge characterization data and monitoring. Numerous other commenters stressed the importance of a program to identify and eliminate illicit connections and improper disposal. EPA agrees that discharge characterization is an important component of developing management programs. Most of the discharge characterization components of the municipal application procedure have been retained as proposed. However some changes and clarifications have been made, and these are noted below.

a. *Screening analysis for illicit discharges (part 1 of application).* Illicit discharges (non-storm water discharges without a NPDES permit), and illegal dumping to municipal separate storm sewer systems occur in a relatively haphazard manner. Due to the unpredictability of such discharges, today's permit applications require a field analysis for the development of priorities for detecting and controlling such discharges. A field screening approach will provide a means of detecting high levels of pollutants in dry weather flows, which is one indicator of illicit connections. Results of a field test of such discharges will provide further information about the nature of the discharge to determine if further investigation is warranted. Visual observation of dry weather flows has been shown to be one the most effective means for tracking down illicit connections and improper disposal.

As discussed in greater detail in section VI.H.7.b of today's preamble, EPA is proposing to require that municipal applicants submit a comprehensive plan to develop a program to detect and control illicit connections and illegal dumping. In order to develop appropriate priorities for these programs, applicants shall submit the results of a screening analysis to be performed on major outfalls or "field screening points" in the systems to detect the presence of illicit hookups and illegal dumping. The results of the screening analysis, referred to as the field screen, would be reported in part 1 of the permit application.

Under the requirements for a field screen, the applicant or co-applicants will submit a description of observations of dry weather discharges from major outfalls or "field screening points" identified in part 1 of the application. At a minimum, the field screen would include a description of visual observations made during a dry weather period. If any flow is observed during a dry weather period, two grab samples will be collected during a 24 hour period with a minimum period of four hours between samples. For all such samples, a description of the color, odor, turbidity, the presence of an oil sheen or surface scum as well as any other relevant observation regarding the potential presence of non-storm water discharges or illegal dumping would be provided. In addition, the applicant should provide the results of a field screen which includes on-site estimates of pH, total chlorine, total copper, total phenol, detergents (or surfacants) along with a description of the flow. EPA is not requiring analytical methods approved under 40 CFR part 136 be used exclusively in the field screen. Rather, the use of inexpensive field sampling techniques such as the use of colormetric detection methods is anticipated. Where the field screen does not involve analytical methods approved under 40 CFR part 136, the applicant is required to provide a description of the method used which includes the name of the manufacturer of the test method, including the range, and accuracy of the test. Appropriate field techniques for a field screen of dry weather discharges are discussed in EPA guidance for municipal storm water discharge permit applications.

It should be clarified that data from the field screen is generally not appropriate for comprehensive evaluation of water quality impacts, or estimating pollutant loadings. Rather, the information from the field screen in part 1 of the application will be used along with other information, such as the age of development and degree of industrial activity in the drainage basin, to identify areas or outfalls which are appropriate targets for management programs and for investigations directed at identifying and controlling non-storm water discharges to separate storm sewers during the term of the permit.

In the December 7, 1988, proposal, EPA proposed a second phase of the screening analysis requiring that wet-weather and dry-weather samples be collected and analyzed in accordance with analytical methods approved under 40 CFR part 136 from designated major outfalls for a larger set of pollutants identified with illicit connections. Comments essentially viewed this proposal as too ambitious for the permit application. One commenter recommended that this procedure could best be accomplished during the term of the permit. Some comments maintained that the collection of analytical samples as a follow up to an initial field screen analysis was not the most cost-effective, practicable or efficient method for pinpointing illicit connections. EPA recognizes that several municipal programs to detect and control illicit connections and other non-storm water discharges have been successfully developed and implemented without the use of extensive analytical sampling (for example, programs in Fort Worth, TX and Washtenaw County, MI). After identifying and analyzing the comments on this aspect of the proposal EPA has withdrawn this element of the proposal from today's rule. EPA believes that a follow-up phase to the initial field screening is more appropriate during the term of the permit. Thus, EPA has dropped the field screening requirement proposed for Part 2 of the application.

b. *Representative data (Part 2 of application).* The NURP study showed that pollutant concentrations in urban runoff can exhibit significant variation. Pollutant concentrations in such discharges vary during storm events and from storm event to storm event. Given the complex, variable nature of storm water discharges from municipal systems, EPA favors a permit scheme where the collection of representative data is primarily a task that will be accomplished through monitoring programs during the term of the permit. Permit writers have the necessary flexibility to develop monitoring requirements that more accurately reflect the true nature of highly variable and complex discharges.

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Today's rule provides for an initial assessment of the quality of discharges from municipal separate storm sewers based primarily on source identification measures and existing information received in the permit application. This information will be used to begin to characterize system discharges. The analysis developed under this approach will not rely soley on sampling data collected during the application process, but will also incorporate existing data bases such as the one developed under the NURP study. Today's rule requires that some quantitative data will be collected to ensure the system discharges can be appropriately represented by the various existing data bases and to provide a basis for developing a monitoring plan to be implemented as a permit condition.

Today's rule requires that quantitative data be submitted for discharges from selected storm events at between 5 and 10 outfalls or field screening points. The municipality will recommend and the Director will then designate the outfalls or field screening points as representative of the commercial, residential and industrial land use activities of the drainage area contributing to the system, on the basis of information received in part 1 of the application. The applicant will be required to collect samples of a storm discharge from three storm events occurring one month apart for each designated outfall or field screening point. This is a modification to the December 7, 1988, proposal wherein only one of the 5 to 10 outfalls was to be sampled during three storm events, and the remaining sampled only once. This requirement may be modified by the Director if the type and frequency of storm events require different sampling. The Director may require samples of discharges to be collected during snow melts or during specified seasons. The Director may also require additional testing during a single event if it is unlikely that there will be three storm events suitable for sampling during the year. Furthermore, the Director may allow exemptions to the three storm event requirement when climatic conditions create good cause for such exemptions; for example, arid regions or areas experiencing drought conditions during the period when applications are developed could be exempted.

EPA has added requirements to sample more storm events in response to comments that the sampling procedure proposed would not necessarily yield representative data. Commenters indicated that: rain events of different intensity may yield different levels and types of pollutants; a rain event after a dry spell of several months will not be representative when compared to rain events occurring closer together, due to the build up of constituents; one sample may reflect short term effects such as improper disposal rather than long term effects; and that rain events are generally too variable to rely on the limited sampling as proposed. Clearly the data collected from sampling storm water discharges has a tendency to vary greatly. The more sampling that is accomplished, the greater extent to which this variability may be accounted for and appropriate management programs developed.

In selecting the amount of data to be collected during the permit application process, EPA has attempted to balance the usefulness of this data against the economic and logistical constraints in actually obtaining it. In some cases the data obtained will support initial loading and concentration estimates obtained using various modeling techniques, from which appropriate permit conditions can be developed. Data obtained may be supplemented with further data collection during the term of the permit.

EPA believes that the requirement that selected major municipal outfalls or "field screening points" be sampled for more than one event will provide verification that the characterization of discharge is valid. Where an ongoing sampling program is defined for the term of the permit, samples taken during the first few years of this period can be used to verify the application results. If a municipality or an industry questions the conclusions drawn from the characterization sampling, it may at its discretion choose to perform additional sampling to either confirm or dispel these concerns.

All samples collected will be analyzed for all pollutants listed in Table II, (organic pollutants), and Table III, (toxic metals, cyanide and total phenol) of appendix D of 40 CFR part 122, and for the pollutants listed in Table M–1, below:

Table M–1

Total suspended solids (TSS).	Total dissolved solids.
COD	BOD.
Oil and grease	Fecal coliform.
Fecal streptococcus	pH.
Dissolved phosphorus	
Total ammonia plus organic nitrogen.	Total phosphorus.
Total Kjeldahl nitrogen	Nitrate plus nitrite.

A portion of the NURP program involved monitoring 120 priority pollutants in storm water discharges from lands used for residential, commercial and light industrial activities. The NURP program excluded testing for asbestos and dioxin. Results for seven other organic priority pollutants were not considered valid due to changes in, or constraints on test methods. Seventy-seven priority pollutants were detected in samples of storm water discharges from lands used for residential, commercial and light industries taken during the NURP study, including 14 inorganic and 63 organic pollutants. Table M–2 shows the priority pollutants which were detected in at least ten percent of the discharge samples which were sampled for priority pollutants.

TABLE M–2.—PRIORITY POLLUTANTS DETECTED IN AT LEAST 10% OF NURP SAMPLES

[In percent]

Metals and inorganics	Frequency of detection
Antimony	13
Arsenic	52
Beryllium	12
Cadmium	48
Chromium	58
Copper	91
Cyanides	23
Lead	94
Nickel	43
Selenium	11
Zinc	94
Pesticides:	
Alpha-hexachlorocyclohexane	20
Alpha-endosulfan	19
Chlordane	17
Lindane	15
Halogenated aliphatics:	
Methane, dichloro-	11
Phenols and cresols:	
Phenol	14
Phenol, pentachloro-	19
Phenol, 4-nitro	10
Phthalate esters:	
Phthalate, bis(2-ethylhexyl)	22
Polycyclic aromatic hydrocarbons:	
Chrysene	10
Fluoranthene	16
Phenanthrene	12
Pyrene	15

The NURP data also showed a significant number of these samples exceeded various freshwater water quality criteria. The exceedence of water quality criteria does not necessarily imply that an actual violation of standards will exist in the receiving water body in question. Rather, the enumeration of exceedences serves as a screening function to identify those constituents whose presence in urban storm water runoff may warrant high priority for further evaluation.

Members of this group represent all of the major organic chemical fractions.

found in Table II of appendix D of 40 CFR part 122 (volatiles, acid compounds, base/neutrals, pesticides). Today's rule requires testing for all organic constituents in Table II rather than limiting the sampling requirements to the 24 toxic constituents found in the NURP study because they will provide a better description of the discharge at essentially the same cost. (The cost of analyzing samples for organic chemicals strongly depends on the number of major organic chemical fractions tested). The NURP study focused on characterizing storm water discharges from lands used for residential, commercial and light industrial activities. In general, the NURP study did not focus on other sources of pollutants to municipal separate storm sewer systems and, therefore, does not reflect all potential pollutants that may be present in discharges from municipal separate storm sewer systems.

The sampling requirements for the permit application address a limited number of sampling locations but require analysis for a wide range of pollutants. Sampling for a wide range of pollutants as a permit application requirement should provide permit writers with appropriate data to target more specific pollutants when developing requirements for a monitoring program during the term of the permit.

Numerous commenters stated that monitoring for all priority pollutants seemed excessive. However, EPA is convinced that it is more appropriate for permit conditions to focus on and prioritize particular pollutant problems after data covering a broad spectrum of pollutants are developed. As noted above, NURP identified 77 priority pollutants in urban runoff, but only from residential, commercial, and light industrial (*e.g.* industrial parks) areas. One municipal entity stated that this approach is a reasonable and realistic means of providing some useful baseline data, while others recommended sampling a variety of parameters that are included in Tables M-1 and M-2. Another municipal entity stated that characterization of outfall discharge quality during storm events is necessary as a means of targeting source control activities.

EPA is working with the United States Geological Survey (USGS) to evaluate the availability of USGS technical assistance to municipalities through cooperative funding programs to aid in collecting representative quantitative data of storm water discharges from municipal systems.

USGS data collection programs with municipalities typically include storm water discharge samples obtained at various times during a storm hydrograph event. Various USGS field procedures can be used to obtain discharge data for pipes, culverts, etc., typically found in urban areas. Pollutant models can be calibrated with data and long-term rainfall records to simulate the quality of system discharges and compared to other storm water models.

In addition, EPA recognizes that many municipalities have participated in studies, such as NURP, that involve sampling of urban runoff as well as other components of discharges from municipal separate storm sewer systems. All existing storm water sampling data along with relevant water quality data, sediment data, fish tissue data or biosurvey data taken over the last ten years is considered relevant and, under today's rule, must be submitted with part 1 of the application. Sampling data that is submitted must be accompanied with a narrative description of the drainage area served by the outfall monitored, a description of the sampling and quality control program, and the location of receiving water monitoring.

EPA requested comments on the use of existing data, such as that generated under the NURP study, to satisfy the requirement of providing representative sampling data. Commenters did not agree on the value of NURP results as an indicator of representative data. Several commenters expressed the view that existing data could be used to satisfy in whole or in part the representative sampling requirements of the storm water permit application. However, commenters generally did not offer suggested criteria that could be used to verify the validity of existing data. One commenter believed that intensive sampling over a period of ten years in 12 basins, when combined with NURP data, would be adequate.

One commenter supported the use of data, such as that obtained from the NURP study, to target sampling programs. EPA supports such a methodology and has retained this portion of the proposed discharge characterization component. EPA received strong support from an environmental group for retaining this information requirement in part 1 of the application.

In light of these comments EPA believes it is appropriate to retain the representative sampling requirements without resorting to the use of existing data exclusively. Because of the inherent variability in reliability and applicability of existing data, EPA is convinced that a nationally consistent methodology for collecting data is appropriate. This data can then be used in conjunction with other existing data and models to develop appropriate site-specific management programs and more generalized management program strategies. Where existing data and data collected under today's rule [illegible] does not match, further sampling under the term of the permit will be accomplished to more accurately assess the discharge of pollutants.

c. Loading and Concentration Estimates (part 2 of application). The assessment of the water quality impacts of discharges from municipal separate storm sewer systems on receiving waters requires the analysis of both pollutant loadings and concentrations of pollutants in discharges.

The loading and concentration estimates in today's rule will be used to evaluate two types of water quality impacts: (1) Short-term impacts; and (2) long-term impacts. Specifically, the regulation requires estimates of the annual pollutant load of the cumulative discharges to waters of the United States from municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States municipal outfalls during a storm event for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods. Municipalities have options in the use of methodologies, including those presented in NURP for calculating loads.

Short term impacts from discharges from municipal separate storm sewers involve changes in water quality that occur during and shortly after storm events. Examples of short-term impacts that can lead to impairments include periodic dissolved oxygen depression due to the oxidation of contaminants, high bacteria levels, fish kills, acute effects of toxic pollutants, contact recreation impairments and loss of submerged macrophytes. Characterization of instream pollutant concentrations based on estimated pollutant concentrations in system discharges are important for evaluating these types of impacts.

Long-term water quality impacts from discharges from municipal separate storm sewers may be caused by contaminants associated with suspended solids that settle in receiving water sediments and by nutrients which enter receiving water systems [illegible] retention times. Pollutant loading data are important for evaluation of impairments such as loss of storage capacity in streams, estuaries, reservoirs, lakes and bays, lake eutrophication caused by high nutrient loadings, and destruction of benthic habitat. Other examples of the long-term water quality impacts include depressed dissolved oxygen caused by the oxidation of organics in bottom sediments and biological accumulation of toxics as a result of uptake by organisms in the food chain. An estimate of annual pollutant loading associated with discharges from municipal storm water sewer systems is necessary to evaluate the magnitude and severity of the environmental impacts of such discharges and to evaluate the effectiveness of controls which are imposed at a later time.

Municipal storm water sewer systems generally handle runoff from large drainage areas and the sources of pollution are usually very diffuse. The concentrations of many pollutants in discharges from these systems are often low relative to many industrial process and POTW discharges. The water quality impacts of low concentration pollution discharges tend to be cumulative and need to be evaluated in terms of aggregate loadings as well as pollutant concentrations. A site-specific loading analysis can be used to evaluate the relative contribution of various pollutant sources.

7. Storm Water Quality Management Plans

Today's rule facilitates the development of site-specific permit conditions by requiring large and medium municipal permit applicants to submit, along with other information, a description of existing structural and non-structural prevention and control measures on discharges of pollutants from municipal storm sewers in part I of the permit application. Section 122.26(d)(2)(iv) requires the applicant to identify in part 2 of the application, to the degree necessary to meet the MEP standard, additional prevention or control measures which will be implemented during the life of the permit. Although, in many cases, it will not be possible to identify all prevention and control measures that are appropriate as permit conditions, EPA believes that the process of identifying components of a comprehensive prevention and/or control program should begin early and that applicants should be given the opportunity to identify and propose the components of the program that they believe are appropriate for first preventing or controlling discharges of pollutants.

As noted earlier, EPA recognizes that problems associated with storm water, combined sewer overflows (CSOs) and infiltration and inflow (I&I) are all inter-related even though they are treated somewhat differently under the law. EPA believes that it is important to begin linking these programs and activities and, because of the potential cost to local governments, to investigate the use of innovative, nontraditional approaches to reducing or preventing contamination of storm water. The application process for developing municipal storm water management plans provides an ideal opportunity between steps 1 and 2 for considering the full range of nontraditional, preventive approaches.

The permit application requirements in today's rule require the applicant or co-applicants to develop management programs for four types of pollutant sources which discharge to large and medium municipal storm sewer systems. Discharges from large and medium municipal storm sewer systems are usually expected to be composed primarily of: (1) Runoff from commercial and residential areas; (2) storm water runoff from industrial areas; (3) runoff from construction sites; and (4) non-storm water discharges. Part 2 of the permit application has been designed to allow the applicant the opportunity to propose MEP control measures for each of these components of the discharge. Discharges from some municipal systems may also contain pollutants from other sources, such as runoff from land disposal activities (leaking septic tanks, landfills and land application of sewage sludge). Where other sources, such as land disposal, contribute significant amounts of pollutants to a municipal storm sewer system, appropriate control measures should be included on a site-specific basis. Proposed management programs will then be evaluated in the development of permit conditions.

There is some overlap in the manner in which these pollutant sources are characterized and their sources identified. For instance, improper disposal of oil into storm drains is often associated with do-it-yourself automobile oil changes in residential areas, or improper application or over-use of herbicides and pesticides in residential areas can also occur in industrial areas. Also, some control measures will reduce pollutant loads for multiple components of the municipal storm sewer discharge. These measures should be identified under all appropriate places in the application; as discussed below, however, double counting of pollutant removal must be avoided when the total assessment of control measures is performed.

Although many land use programs have multiple purposes, including the reduction of pollutants in discharges from municipal separate storm sewer systems, the proposed management programs in today's rule are intended to address only those controls which can be implemented by the permit applicant or co-applicants. EPA cannot abrogate its responsibilities under the CWA to implement the NPDES permit program by relying on pollution control programs that are outside the NPDES program. For example, municipal permit management programs may not rely exclusively on erosion or sediment control laws for implementing that portion of management programs that address discharges from construction sites, unless such laws implement NPDES permit program requirements entirely and that such implementation is a part of the permit.

EPA anticipates that storm water management programs will evolve and mature over time. The permits for discharges from municipal separate storm sewer systems will be written to reflect changing conditions that result from program development and implementation and corresponding improvements in water quality. The proposed permit applications will require applicants to provide a description of the range of control measures considered for implementation during the term of the permit. Flexibility in developing permit conditions will be encouraged by providing applicants an opportunity to identify in the permit application priority controls appropriate for the initial implementation of management programs. Many commenters endorsed the flexible site-specific storm water program approach as proposed as a method for addressing regional water quality control programs in a cost effective manner. To this extent, EPA agrees with one municipality that management programs should focus on more serious problems and sources of pollutants identified in the municipal system. However, EPA believes that to implement section 402(p)(3), comprehensive storm water management programs which address a number of major sources of pollutants to a system are necessary. Municipal programs should not be focused solely on a single source of pollution, such as illicit connections.

One commenter maintained that management program development should be flexible enough to allow for consideration of what is attainable based on the area's climate, vegetation, hydrology, and land uses. EPA agrees with this comment. Some strategies for reducing pollutants in the northeast will not be practical in the southwest, such as management programs for deicing activities. The permit application process will determine what strategies are appropriate in different locations.

Several commenters supported addressing storm water pollutant problems through management practices or programs rather than end of pipe controls or treatment. EPA agrees with this comment to the extent that storm water management practices are a general theme of this rulemaking with regard to municipal permits. However, there will be cases where such discharges are best addressed through technology such as retention, detention or infiltration ponds.

One commenter reacted unfavorably to the flexible site-specific management plan approach stating that there is no hard criteria upon which to judge the adequacy of programs. Another commenter felt that there should be a BAT standard for municipal permits. Another commenter stated that the rule should contain specific BMPs that the permittee must comply with. EPA disagrees with these comments. The Clean Water Act requires municipalities to apply for permits that will reduce pollutants in discharges to the maximum extent practicable and sets out the types of controls that are contemplated to deal with storm water discharges from municipalities. The language of CWA section 402(p)(3) contemplates that, because of the fundamentally different characteristics of many municipalities, municipalities will have permits tailored to meet particular geographical, hydrological, and climatic conditions. Management practices and programs may be incorporated into the terms of the permit where appropriate. Permit conditions, which require that storm water management programs be developed and implemented or require specific practices, are enforceable in accordance with the terms of the permit. EPA disagrees with the notion that this regulation, which addressed permit application requirements, should create mandatory permit requirements which may have no legitimate application to a particular municipality. The whole point of the permit scheme for these discharges is to avoid inflexibility in the types and levels of control. Further, to the degree that such mandatory requirements may be appropriate, these requirements should be established under the authority of section 402(p)(6) of the CWA and not in this rulemaking, which addresses permit application requirements.

Some commenters suggested that management programs should be developed as part of the permit conditions and not as part of the permit application. EPA agrees that management programs and their ongoing development should be part of the permit term. However, EPA is convinced, and many commenters agree, that the permit application should contain information on what the permittee has done to date and what it proposes and plans to do during the permit term based upon its discharge characterization and source identification data. This is a reasonable and logical approach and one that meets the intent and letter of section 402(p)(3) of the CWA. As stated above, this would be an appropriate method for implementing storm water management programs that should mature and evolve over time.

Applicants will propose priorities based on a consideration of appropriate controls including, but not limited to, consideration of controls that address: reducing pollutants to municipal separate storm sewer system discharges that are associated with storm water from commercial and residential areas (§ 122.26(d)(2)(iv)(A)); illicit discharges and illegal disposal (§ 122.26(d)(2)(iv)(B)); storm water from industrial areas (§ 122.26(d)(2)(iv)(C)); and runoff from construction sites (§ 122.26(d)(2)(iv)(D)). Permits for different municipalities will place different emphasis on controlling various components of discharges from municipal storm sewers. For example, the potential for cross-connections (such as municipal sewage or industrial process wastewater discharges to a municipal separate storm sewer) is generally expected to be greater in municipalities with older developed areas. On the other hand, municipalities with larger areas of new development will have a greater opportunity to focus controls to reduce pollutants in storm water generated by the area after it is developed, discharges from construction sites, and other planning activities.

EPA requested comments on the process and methods for developing appropriate priorities in management programs proposed in applications and how the development of these priorities can be coordinated with controls on other discharges to ensure the achievement of water quality standards and the goals of the CWA.

Discharges from diffuse sources in residential areas was recognized by several commenters as a significant source of pollutants. Accordingly, these elements of the management plans have been retained. In conjunction with the importance of developing programs for illicit connections, numerous commenters stated that education programs are a priority. Another commenter emphasized that ordinances prohibiting such discharges and their enforcement is a crucial means of a successful program in this regard. EPA agrees with these comments and consequently will retain those portions of management program development that include a description of a program for educational activities such as public information for the proper disposal of oil and toxic materials and the use of herbicides, pesticides and fertilizers.

Some commenters noted that discharge characterization is necessary for development of appropriate management plans. EPA agrees with these comments and has retained the discharge characterization components in this rulemaking. However, EPA disagrees that the results of all discharge characterization procedures (*i.e.*, part 1 and part 2) are necessary to describe and propose a program as required in part 2 of the application. The application of various models is available to permit applicants, where needed, to develop appropriate management programs. All available site specific discharge characterization data should be available to the permit writer to draft appropriate conditions for the term of the permit.

One commenter noted that an important aspect of developing management/plans is establishing the necessary legal authority to improve water quality. EPA agrees with this comment and has retained those aspects of the regulation which call for development and attainment of adequate legal authority in both parts of the municipal application.

One commenter stated that programs should address previously identified water quality problems in other programs that are required by section 304(1) of the CWA. EPA agrees that identified water quality problems need to be addressed by management programs, and the municipal permit application will call for an identification of these waters. However, EPA does not endorse addressing these waters to the exclusion of all others within the boundaries of the municipal separate storm sewer system. Some waters may experience substantial degradation after rain events and still not be listed under

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section 304(1). Further, water quality impacts in listed waters may not be related to storm water discharges, while other non-listed waters do have water quality impacts from storm water discharges. Similarly, EPA agrees with one commenter that it may be desirable to focus attention and resources on certain problem watersheds within a municipality, and controls may be imposed and programs prioritized on that basis. However, such a focus should not be to the exclusion of other waters and watersheds that have water quality problems (although less troublesome) traceable to storm water discharges. The CWA requires that permits address discharges to waters of the United States, not just waters previously targeted under special programs.

Some commenters expressed concern that the permit application requires the design of management programs before knowing what will be in the permits. EPA disagrees with the thrust of this comment, that is that the order of requirements is inappropriate. The permit applicant will have two years to develop proposed plans which can be considered by permit writers in the development of the permit. Based upon a consideration of the management program proposed by the municipality and other relevant information, permits can be tailored for individual programs. One commenter stated that the cornerstone of management programs are inspection and enforcement programs. EPA agrees that these two elements are important components. Without inspection and enforcement mechanisms the programs will undoubtedly falter. Accordingly these requirements in the description of management programs in the permit application have been retained. In a similar vein, one commenter emphasized the importance of developing legal authority, financial capability, and administrative infrastructure. EPA agrees with this comment and has retained those aspects of the regulation that call for a description of applicants plans and resources in these areas.

One commenter stressed that control of discharges into the municipal system from industries is an important goal of municipal storm water management programs. EPA agrees with this comment and has retained the proposed description of management programs to address discharges from industrial sources. Other commenters identified industries as the principal contributors of pollutants to municipal separate storm sewer systems.

In addition, EPA will continue to evaluate procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality in the studies required under section 402(p)(5) of the CWA. One purpose of these studies will be to evaluate the costs and water quality benefits associated with implementing these procedures and methods. This evaluation will address a number of factors which impact the implementation costs associated with these programs, such as the extent to which similar municipal ordinances are currently being implemented, the degree to which existing municipal programs (such as flood management programs or construction site inspections) can be expanded to address water quality concerns, the resource intensiveness of the control, and whether the control program will involve public or private expenditures. This information, along with information gained during permit implementation will aid in the dynamic long-term development of municipal storm water management programs.

a. *Measures to reduce pollutants in runoff from commercial and residential areas.* The NURP program evaluated runoff from lands primarily dedicated to residential and commercial activities. The areas evaluated in the study reflect some other activities, such as light industry, which are commonly dispersed among residential and commercial areas. The NURP study selected sampling locations that were thought to be relatively free of illicit discharges and storm water from heavy industrial sites including storm water runoff from heavy construction sites. Of course, in a study such as NURP it was impossible to totally isolate various contributions to the runoff. In developing the permit application requirements in today's rule EPA has, in general, relied on the NURP definition of urban runoff—runoff from lands used for residential, commercial and light industrial activities.

NURP and numerous other studies have shown that runoff from residential and commercial areas washes a number of pollutants into receiving waters. Of equal importance is the volume of storm water runoff leaving urban areas during storm events. Large intermittent volumes of runoff can destroy aquatic habitat. As the percentage of paved surfaces increases, the volume and rate of runoff and the corresponding pollutant loads also increase. Thus, the amount of storm water runoff from commercial and residential areas and the pollutant loadings associated with storm water runoff increases as development progresses; and they remain at an elevated level for the lifetime of the development.

Proposed § 122.26(d)(2)(iv)(A) requires municipal storm sewer system applicants to provide in part 2 of the application a description of a proposed management program that will describe priorities for implementing management programs based on a consideration of appropriate controls including:

- A description of maintenance activities and a maintenance schedule for structural controls;
- A description of planning procedures including a comprehensive master plan to control after construction is completed, the discharge of pollutants from municipal separate storm sewers which receive discharges from new development and significant redevelopment after construction is completed (in response to comment this contemplates an engineering policy and procedure strategy with long term planning);
- A description of practices for operating and maintaining public highways and procedures for reducing the impact on receiving waters of such discharges from municipal storm sewer system;
- A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies; and
- A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer which will include, as appropriate, controls such as educational activities and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

Water quality problems caused by municipal storm sewer discharges will generally be most acute in heavily developed areas. Prevention measures may be desirable and cost effective. However, structural control measures may also be effective, although opportunities for implementing these measures may be limited in previously developed areas. Commonly used structural technologies include a wide variety of treatment techniques, including first flush diversion systems, detention/infiltration basins, retention basins, extended detention basins, infiltration trenches, porous pavement, oil/grit separators, grass swales, and swirl concentrators. A major problem associated with sound storm water management is the need for operating

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and maintaining the system for its expected life.

The unavailability of land in highly developed areas often makes the use of structural controls infeasible for modifying many existing systems. Non-structural practices can play a more important role. Non-structural practices can include erosion control, streambank management techniques, street cleaning operations, vegetation/lawn maintenance controls, debris removal, road salt application management and public awareness programs.

As noted above, the first component of the proposed program to reduce pollutants in storm water from commercial and residential areas which discharge to municipal storm sewer systems is to describe maintenance activities and schedule. The second component of the proposed program to reduce pollutants in storm water from commercial and residential areas which discharge to municipal storm sewer systems provides that applicants describe the planning procedures and a comprehensive master plan that will assure that increases of pollutant loading associated with newly developed areas are, to the maximum extent practicable, limited. These measures should address storm water from commercial and residential areas which discharge to the municipal storm sewer that occur after the construction phase of development is completed. Controls for construction activities are addressed later in today's rule. One commenter noted the feasibility of developing management plans for newly developing areas. EPA agrees with this comment and has retained that portion of the regulation that deals with a description of controls for areas of new development. Similarly, one municipality stressed the importance and achievability of addressing storm water discharges from construction sites.

As urban development occurs, the volume of storm water and its rate of discharge increases. These increases are caused when pavement and structures cover soils and destroy vegetation which otherwise would slow and absorb runoff. Development also accelerates erosion through alteration of the land surface. Areas that are in the process of development offer the greatest potential for utilizing the full range of structural and non-structural best management practices. If these measures are to provide controls to reduce pollutant discharges after the area has been developed, comprehensive planning must be used to incorporate these measures as the area is in the process of developing. These measures offer an important opportunity to limit increases in pollutant loads.

The third component of § 122.26(d)(2)(iv)(A) provides a description of practices for operating and maintaining public roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems. General guidelines recommended for managing highway storm water runoff include litter control, pesticide/herbicide use management, reducing direct discharges, reducing runoff velocity, grassed channels, curb elimination, catchbasin maintenance, appropriate streetcleaning, establishing and maintaining vegetation, development of management controls for salt storage facilities, education and calibration practices for deicing application, infiltration practices, and detention/retention practices.

The fourth component of § 122.26(d)(2)(iv)(A) provides that applicants identify procedures that enable flood management agencies to consider the impact of flood management projects on the water quality of receiving streams. A well-developed storm water management program can reduce the amount of pollutants in storm water discharges as well as benefit flood control objectives. As discussed above, increased development can increase both the quantity of runoff from commercial and residential areas and the pollutant load associated with such discharges. Disturbing the land cover, altering natural drainage patterns, and increasing impervious area all increase the quantity and rate of runoff, thereby increasing both erosion and flooding potential. An integrated planning approach helps planners make the best decisions to benefit both flood control and water quality objectives.

The fifth component of § 122.26(d)(2)(iv)(A) would provide that municipal applicants submit a description of a program to reduce, to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer. Such a program may include controls such as educational activities and other measures for commercial applicators and distributors and controls for application in public rights-of-way and at municipal facilities. Discharges of these materials to municipal storm sewer systems can be controlled by proper application of these materials. Some commenters noted that insecticides used in residential areas are a probable source of pollutants in storm water discharges from residential areas, as well as salting and other de-icing activities. In response to this comment, part of a community management plan may include controls or education programs to limit the impacts of these sources of pollutants. One commenter noted that many communities already have household toxic disposal programs. Where appropriate these can be incorporated into municipal management programs.

Some commenters suggested substituting the management program description for residential and commercial areas with a simple identification of applicable management practices. EPA agrees that identification of appropriate management practices is a critical component of a program description for these areas. In essence, this is what the program description is designed to achieve. However, for the reasons discussed in greater detail above, EPA is convinced that an appropriate program must address all of the components of the management program for residential and commercial areas that are outlined in today's rule. Further, for the purposes of writing a permit with enforceable conditions, the application should identify a schedule to implement management practices. The applicant should be able to estimate the reduction in pollutant loads as a result of the development of certain management practices and programs (§ 122.26(d)(2)(v). A program may also include public education programs, which are not necessarily viewed as traditional BMPs.

b. *Measures for illicit discharges and improper disposal.* The CWA requires that NPDES permits for discharges from municipal storm sewers "shall include a requirement to effectively prohibit non-stormwater discharges into the storm sewers." In today's rule, EPA will begin to implement this statutory mandate by focusing on two types of discharges to large and medium municipal separate storm sewer systems. *See* § 122.26(d)(1)(iv)(D) and (d)(2)(iv)(B). One type of non-storm water discharges are illicit discharges which are plumbed into the system or that result from leakage of sanitary sewage system. The other class of non-storm water discharges result from the improper disposal of materials such as used oil and other toxic materials.

Illicit discharges. In some municipalities, illicit connections of sanitary, commercial and industrial discharges to storm sewer systems have had a significant impact on the water quality of receiving waters. Although the

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NURP study did not emphasize identifying illicit connections to storm sewers other than to assure that monitoring sites used in the study were free from sanitary sewage contamination, the study concluded that illicit connections can result in high bacterial counts and dangers to public health. The study also noted that removing such discharges presented opportunities for dramatic improvements in the quality of urban storm water discharges.

Other studies have shown that illicit connections to storm sewers can create severe, wide-spread contamination problems. For example, the Huron River Pollution Abatement Program inspected 660 businesses, homes and other buildings located in Washtenaw County, Michigan and identified 14% of the buildings as having improper storm drain connections. Illicit discharges were detected at a higher rate of 60% for automobile related businesses, including service stations, automobile dealerships, car washes, body shops and light industrial facilities. While some of the problems discovered in this study were the result of improper plumbing or illegal connections, a majority were approved connections at the time they were built. Many commenters emphasized the identification and elimination of illicit connections as a priority, including leakage from sanitary sewers. EPA agrees with these comments and intends to retain this portion of the program without modification.

A wide variety of technologies exist for detecting illicit discharges. The effectiveness of these measures largely depends upon the site-specific design of the system. Under today's rule, permit applicants would develop a description of a proposed management program, including priorities for implementing the program and a schedule to implement a program to identify illicit discharges to the municipal storm sewer system. This rulemaking will require the initial priorities for analyzing various portions of the system and the appropriate detection techniques to be used.

Improper disposal. The permit application requirements for municipal storm sewer systems include a requirement that the municipal permit applicant describe a program to assist and facilitate in the proper management of used oil and toxic materials. Improper management of used oil can lead to discharges to municipal storm sewers that in turn may have a significant impact on receiving water bodies. EPA estimates that, annually, 267 million gallons of used oil, including 135 million gallons of used oil from do-it-yourself automobile oil changes, are disposed of improperly. An additional 70 million gallons of used oil, most coming from service stations and repair shops, are used for road oiling. Many commenters emphasized the elimination of discharges composed of improperly disposed of oil and toxic material. One commenter identified motor oil as the major source of oil contamination and that EPA needs to encourage proper disposal of used oil. Several other commenters emphasized the importance of recycling programs for oil. EPA agrees with these comments and intends to retain this portion of the program without modification. One commenter identified public awareness and timely reporting of illegal dumping as critical components of this portion of the program. EPA agrees with this comment and intends for management programs to deal with this problem.

c. *Measures to reduce pollutants in storm water discharges through municipal separate storm sewers from municipal landfills, hazardous waste treatment, disposal and recovery facilities that are subject to section 313 of title III of SARA.* As discussed in section VI.C of today's preamble, industrial facilities that discharge storm water through a large or medium municipal separate storm sewer system are required to apply for a permit under § 122.26(c) or seek coverage under a promulgated general permit. Today's rule also requires the municipal storm sewer permittee to describe a program to address industrial dischargers that are covered under the municipal storm sewer permit. Today's rule requires the municipal applicant to identify such discharges (*see* source identification requirements under § 122.26(d)(2)(ii)), provide a description of a program to monitor pollutants in runoff from certain industrial facilities that discharge to the municipal separate storm sewer system, identify priorities and procedures for inspections, and establish and implement control measures for such discharges. Should a municipality suspect that an individual discharger is discharging pollutants in storm water above acceptable limits, and the owner/operator of the system has no authority over the discharge, the municipality should contact the NPDES permitting authority for appropriate action. Two example of possible action are: if the facility already has an individual permit, the permit may be reopened and further controls imposed; or if the facility is covered by a promulgated general permit, then an individual site-specific permit application may be required.

In the December 7, 1988, proposal, EPA requested comments concerning what storm water discharges from industrial facilities through municipal systems should be monitored. One of the proposed approaches was to require data on portions of the municipal system which receive storm water from facilities which are listed in the proposed regulatory definition at § 122.26(b)(14) of "storm water discharge associated with industrial activity" (with the exception of construction activities and uncontaminated storm water from oil and gas operations) which discharge through the municipal system. However, given the large number of facilities meeting this definition that discharge through municipal systems, a monitoring program that requires the submission of quantitative data regarding portions of the municipal systems receiving storm water from such facilities may not be practicable. Such a requirement could, for some systems, potentially become the most resource intensive requirements in the municipal permit. Therefore, EPA proposed various ways to develop appropriate targeting for monitoring programs.

EPA requested comments on a requirement that, at a minimum, monitoring programs address discharges from municipal separate storm sewer outfalls that contain storm water discharges from municipal landfills, hazardous waste treatment, disposal and recovery facilities, and runoff from industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Section 313 of title III requires that operators or certain facilities that manufacture, import, process, or otherwise use certain toxic chemicals report annually their releases of those chemicals to any environmental media. Section 313(b) of title III specifies that a facility is covered for the purposes of reporting if it meets all of the following criteria.

- The facility has ten or more full-time employees;
- The facility is in Standard Industrial Classification (SIC) codes 20 through 39;
- The facility manufactured (including quantities imported), processed, or otherwise used a listed chemical in amounts that exceed certain threshold quantities during the calendar year for which reporting is required.

Listed chemicals include 329 toxic chemicals listed at 40 CFR 372.45. After 1989, the threshold quantities of listed chemicals that the facility must manufacture, import or process in order to trigger the submission of a release

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report) is 25,000 pounds per year. The threshold for a use other than manufacturing, importing or processing of listed toxic chemicals is 10,000 pounds per year. EPA promulgated a final regulation clarifying these reporting requirements on February 16, 1988, (53 FR 4500).

EPA received numerous comments regarding limiting the types of facilities that are initially subject to monitoring and municipal management programs. Numerous municipalities agreed that focusing on the above facilities is an appropriate means for setting priorities for the development of control measures to eliminate or reduce pollutants associated with industrial facilities. Commenters agreed that the potential for toxic materials in discharges is high because of the high volume of such materials at these facilities and that information regarding discharges and material management practices will be available through section 313 of SARA. One commenter noted that building on an established program will contribute to establishing an effective storm water program. Accordingly, EPA has specified at § 122.26(d)(2)(ii)(C) that the municipal applicant must describe a program that identifies priorities and procedures for inspections and establishing and implementing control measures for these facilities.

Several commenters suggested that these facilities should not be singled out because the presence of the threshold amounts of SARA 313 chemicals does not indicate that significant quantities of those chemicals are likely to enter the facility's storm water runoff. Instead it was suggested that municipalities should monitor storm sewers as a whole to determine what chemicals are present and therefore what facilities are responsible. EPA disagrees with these comments. The object of these requirements is initially to set priorities for monitoring requirements. Then, if the situation requires, controls can be developed and instituted. If a facility is a member of this class of facilities and does not discharge excessive quantities of SARA 313 chemicals, then it may not be subjected to further monitoring and controls. As noted above, the selection of facilities is only a means of setting priorities for facilities for the development of municipal plans.

EPA agrees, however, that there will be other facilities that are significant sources of pollutants and should be addressed by municipalities as soon as possible under managemen programs. Accordingly, those industrial facilities that the municipal permit applicant determines to be contributing a substantial pollutant loading to the municipal storm sewer system shall be addressed in this portion of the municipal management program.

EPA also requested comments on monitoring programs for municipal discharges including the submission of quantitative data on the following constituents;

- Any pollutants limited in an effluent guidelines for the industry subcategories, where applicable;
- Any pollutant listed in a discharging facility's NPDES permits for process wastewater, where applicable;
- Oil and grease, pH, BOD5, COD, TSS, total phosphorus, total Kjeldahl nitrogen, and nitrate plus nitrite nitrogen;
- Any information on discharges required under 40 CFR 122.21(g)(7)(iii) and (iv).

These are the same constituents that are to be addressed in individual permit applicants for storm water discharges associated with industrial activity.

Several industries and municipalities submitted comments on this issue. Some commenters agreed that these are appropriate parameters. Some commenters advised that the ability of municipalities to implement this aspect of the program depended on industries submitting this data. Several industries provided comments suggesting that the approach should allow the permittee flexibility in determining which parameters are chosen because of the burdens of monitoring and the complexity of materials and flows in municipal systems.

In light of these comments, EPA has retained § 122.26(d)(2)(iv)(C) as proposed requiring municipalities to describe a monitoring program which utilizes the above parameters. Monitoring for these parameters provides consistency with the individual application requirements for industries, provides uniformity in municipal applications, and will narrow the parameters to conform to the types of industries discharging into the municipal systems. Monitoring programs may consist of programs undertaken by the municipality exclusively or requirements imposed on industry by the municipality, or a combination of approaches. Appropriate procedures are discussed in municipal permit application guidance.

EPA requested comments on appropriate means for municipalities to determine what facilities are contributing pollutants to municipal systems. Many commenters responded with numerous methodologies. Some of these have been addressed in guidance. Municipalities will have options in selecting the most appropriate methodology given their circumstances as described in their permit applications.

EPA initially favors establishing monitoring requirements to be applied to those outfalls that directly discharge to waters of the United States. EPA received one comment from a municipality with regard to this issue which agreed that this was the most logical approach. Monitoring of outfalls close to the point of discharge to waters of the United States is generally preferable when attempting to identify priorities for developing pollutant control programs. However, under certain circumstances, it may be preferable to monitor at the point where the runoff from the industrial facility discharges to the municipal system. For example, if many facilities discharge substantially similar storm water to a municipal system it may be more practicable to monitor discharges from representative facilities in order to characterize pollutants in the discharge.

As noted by numerous industries, if municipal characterization plans reveal problems from certain industrial dischargers, then such facilities may be required to provide further data from their own monitoring. As noted above, EPA envisions that this data could then be used to develop appropriate control practices or techniques and/or require individual permit applications if a general permit covering the facility proves inadequate.

Comments were also solicited as to whether end-of-pipe treatment generally was more appropriate than source controls for storm water from industrial facilities which discharge to municipal systems. Many commenters, including both municipalities and industries, stated that source controls are the only practical and feasible means of controlling pollutants in storm water runoff, and specifically opposed the concept of end-of-pipe treatment or other controls. Some commenters maintained that, from an economic and environmental standpoint, end-of-pipe treatment may be the only effective means. One advised that the prompt cleanup of spills, controlled wash down of process areas, covering of material loading areas, storm water runoff diversion, covered storage areas, detention basins or other such mechanisms would prevent storm water from mixing with pollutants and possibly discharging them into receiving waters. Another noted that in the urban areas, there is little potential for treatment; consequently, it would seem that controls and/or retrofitting existing facilities would be necessary when violations are found and that citizens will be better served by source controls appropriate to the individual problem.

EPA agrees with these comments to the extent that source controls and management programs are the general thrust of these regulations. However, in some situations end-of-pipe treatment, such as holding ponds, may be the only reasonable alternative. EPA disagrees with one industrial commenter that the municipalities should be almost entirely responsible for treating municipal discharges at the end of-the-pipe without reliance on source controls by industrial dischargers. Municipal programs may require controls on industrial sources with demonstrated storm water discharge problems. One industrial association noted that its member companies already have incentive to properly handle their materials and facilities because of other environmental programs with spill and erosion controls.

Numerous commenters stated that the program addressing industrial dischargers through municipal systems needs to be clearly defined in order to eliminate, as much as possible, potential conflicts between the system operator and dischargers. EPA has provided a framework for development of management plans to control pollutants from these particular sources. However, because of the differences in municipal systems and hydrology nationwide, EPA is not convinced that program specificity is an appropriate approach. The concept of the management program is to provide flexibility to the permit applicants to develop regional site specific control programs.

One commenter suggested that required controls should be limited to a facility's proportional contribution (based on concentration) of pollutants. EPA disagrees. Most facilities discharging through a municipal separate storm sewer will need to be covered by a general or individual permit. These permits will control the introduction of pollutants from that facility through the municipal storm sewer to the waters of the U.S. Any additional controls placed on the facility by the municipality will be at the discretion of the municipality. EPA is not requiring municipalities to adopt a particular level of controls on industrial facilities as suggested by the commenter.

One commenter questioned how dischargers that discharged both into the waters of the United States and through a municipal system will be addressed and whether there is a potential for inconsistent requirements. Industries that discharge storm water associated with industrial activity into the waters of the United States are required to be covered by individual permits or general permits for such discharges. Dischargers of storm water associated with industrial activity through municipal separate storm sewer systems will be subject to municipal management programs that address such discharges as well as to an individual or general NPDES permit for those discharges. EPA does not believe there is a significant risk of inconsistent requirements, since each industrial facility must meet BAT/BCT-level controls in its NPDES permit. EPA doubts that municipalities will impose much more stringent controls.

Many commenters stated that if cities and municipalities are to be responsible for industrial storm water discharges through their system, then municipalities should have authority to make determinations as to what industries should be regulated, how they are regulated, and when enforcement actions are undertaken. In response, EPA notes that the proposal has been changed and that municipalities will not be solely responsible for industries discharging through their system. Nonetheless, municipalities will be required to meet the terms of their permits related to industrial dischargers. Municipalities may undertake programs that go beyond the threshold requirements of the permit. Some municipal entities stated that municipal permittees should be able to require permit applications from industries in the same manner that EPA does and also require permits. In response, if operators of large and medium municipal separate storm sewer systems wish to employ such a program, then this portion of the management program may incorporate such practices.

d. *Measures to reduce pollutants in runoff from construction sites into municipal systems.* Section VI.F.8 of today's rule discusses EPA's proposal to define the term "storm water discharge associated with industrial activity" to include runoff from construction sites, including preconstruction activities except operations that result in the disturbance of less than 5 acres total land area which are not part of a larger common plan of development or sale. Under today's rule, facilities that discharge runoff from construction sites that meet this definition will be required to submit permit applications unless they are to be covered by another individual or general NPDES permit. Permit application requirements for such discharges are at 40 CFR 122.26(c)(1)(ii).

Section 122.26(d)(2)(iv)(D) of today's rule requires applicants for a permit for large or medium municipal separate storm sewer systems to submit a description of a proposed management program to control pollutants in construction site runoff that discharges to municipal systems. Under this provision, municipal applicants will submit a description of a program for implementing and maintaining structural and non-structural best management practices for controlling storm water runoff at construction sites. The program will address procedures for site planning, enforceable requirements for nonstructural and structural best management practices, procedures for inspecting sites and enforcing control measures, and educational and training measures. Generally, construction site ordinances are effective when they are implemented. However, in many areas, even though ordinances exist, they have limited effectiveness because they are not adequately implemented. Maintaining best management practices also presents problems. Retention and infiltration basins fill up and silt fences may break or be overtopped. Weak inspection and enforcement point to the need for more emphasis on training and education to complement regulatory programs. Permits issued to municipalities will address these concerns.

8. Assessment of Controls

EPA proposed that municipal applicants provide an initial assessment of the effectiveness of the control method for structural or non-structural controls which have been proposed in the management program. Some commenters stated that the assessment of controls should be left to the term of the permit because the effectiveness of controls will be hard to establish. EPA believes that an initial estimate or assessment is needed because the performance of appropriate management controls is highly dependent on site-specific factors. The assessment will be used in conjunction with the development of pollutant loading and concentration estimates (see VI.H.6.c) and the evaluation of water quality benefits associated with implementing controls. Such assessements do not have to be verified with quantitative data, but can be based on accepted engineering design practices. Furthermore precise assessments based upon quantitative data can be undertaken during the term of the permit.

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I. Annual Reports

As discussed earlier in today's preamble EPA has provided for proposed flexible permit application requirements to facilitate the development of site-specific programs to control the discharge of pollutants from large and medium municipal separate storm sewer systems. Many municipalities are in the early stages of the complex task of developing a program suitable for controlling pollutants in discharges under a NPDES permit, while other municipalities have relatively sophisticated programs in place. In order to ensure that such site-specific programs are developed in a timely manner, EPA proposed to require permittees of municipal separate storm sewer systems to submit status reports every year which reflect the development of their control programs.

The reports will be used by the permitting authority to aid in evaluating compliance with permit conditions and where necessary, modify permit conditions to address changed conditions. EPA requested comments on the appropriate content of the annual reports. Based on these comments EPA has added the following in these reports: an analysis of data, including monitoring data, that is accumulated throughout the year; new outfalls or discharges; annual expenditures; identification of water quality improvements or degradation on watershed basis; budget for year following each annual report; and administrative information including enforcement activities, inspections, and public education programs. EPA views this information as important for evaluating the municipal program. Annual monitoring data and identified water quality improvements are important for evaluating the success of management programs in reducing pollutants. If new outfalls come into existence during the term of the permit, these may be sources of pollutants and appropriate permit conditions will be developed. Annual reports should reflect the level of enforcement activity and inspections undertaken to ensure that the legal authority developed by the municipality is properly exercised. Many of the management programs depend upon an ongoing high level of public education. Accordingly, the undertaking of these programs on an annual basis should be documented.

J. Application Deadlines

The CWA provided a statutory time frame for implementing the storm water permit application process and issuance and compliance with permits.

The CWA requires EPA to promulgate permit application requirements for storm water discharges associated with industrial activity and for large municipal separate storm sewer systems by "no later than two years" after the date of enactment (*i.e.* no later than February 4, 1989). In conjunction with this requirement, the Act requires that permit applications for these classes of discharges be submitted within one year after the statutory date by which EPA is to promulgate permit application requirements by providing that such applications "shall be filed no later than three years" after the date of enactment of the WQA (*i.e.*, no later than February 4, 1990).

The CWA also requires EPA to promulgate final regulations governing storm water permit application requirements for discharges from municipal separate storm sewer systems serving a population of 100,000 or more but less than 250,000 by "no later than four years" after enactment (*i.e.* no later than February 4, 1991). Permit applications for medium municipal separate storm sewer systems "shall be filed no later than five years" after the date of enactment of the CWA (*i.e.*, no later than February 4, 1992). The CWA did not establish the time period between designation and permit application submittal for case-by-case designations under section 402(p)(2)(E).

Comments on earlier rulemakings involving storm water application deadlines have established that applicants need adequate time to obtain "representative" storm water samples. Many commenters have indicated that at least one full year is needed to obtain such samples. This is because many discharges are located in areas where testing during dry seasons or winter would not be feasible. The intermittent and unpredictable nature of storm water discharges can result in difficult and time-consuming data gathering. Moreover, some operators of municipal separate storm sewer systems have many storm water discharges associated with industrial activity, which can require considerable time to identify, analyze, and submit applications. This creates a tremendous practical problem for the extremely high number of unpermitted storm water discharges. The public's interest in a sound storm water program and the development of a useful storm water data base is best served by establishing an application deadline which will allow sufficient time to gather, analyze, and prepare meaningful applications. Based on a consideration of these factors, EPA proposed that individual permit applications for storm water discharges associated with industrial activity which currently are not covered by a permit and that are required to obtain a permit, be submitted one year after the final rule is promulgated.

EPA received numerous comments from industries on the one year requirement for submitting applications. Several commenters supported the proposed deadline as realistic, while others believed more time was needed to meet the information and quantitative requirement.

EPA rejects the assertion by some commenters that a year is too short a period of time to obtain the required quantitative data. Today's rule generally requires applications for storm water discharges associated with industrial activity to be submitted on or before November 18, 1991. Operators of storm water discharges associated with industrial activity which discharge through a municipal separate storm sewer are subject to the same application deadline as other storm water discharges associated with industrial activity. Since final regulation at § 122.21(g)(7) provides considerable latitude for selecting rain events for quantitative data, EPA is convinced that in most cases data can be obtained during the one year time frame. If data cannot be collected during the one year time frame because of anomalous weather (*e.g.* drought conditions), then permitting authorities may grant additional time for submitting that data on a case-by-case basis. *See* § 122.21(g)(7).

Operators of storm water discharges which are currently covered by a permit will not be required to submit a permit application until their existing permit expires. In recognition of the time required to collect storm water discharge data, EPA will allow facilities which currently have a NPDES permit for a storm water discharge and which must reapply for permit renewal during the first year following promulgation of today's permit application requirements, the option of applying in accordance with existing Form 1 and Form 2C requirements (in lieu of applying in accordance with the revised application requirements).

As discussed in section VI.D.4 and section VI.F.8 of today's preamble, EPA has established a two part permit application both for both group applications for sufficiently similar facilities that discharge storm water associated with industrial activity and for operators of large or medium municipal separate storm sewer systems. The deadlines for submittal permit applications in today's rule provide adequate time for: (1) Applicants to prepare Part 1 of the application; (2) EPA or an approved State to adequately review applications; and (3) applicants to prepare the contents of the part 2 application.

Part 1 of the group application for storm water discharges associated with industrial activity must be submitted within 120 days from the publication of these final permit application regulations. This time is necessary to form groups and for individual members of the group to prepare the non-quantitative information required in part 1 of the application. Part 1 of the group application will be submitted to EPA Headquarters in Washington, DC and reviewed within 60 days after being received. Part 2 of the application would then be submitted within one year after the part 1 application is approved. It should be noted that many facilities located in States in which general permits can be issued, will be eligible for coverage by a storm water general permit to be promulgated in the near future. Such facilities may either seek coverage under such general permits or participate in the group application.

Several comments were received by EPA that indicated that a period of 120 days was too short a period for groups to be formed. EPA disagrees with these comments. The information that EPA is requiring to be submitted by the group or group representative is information that is generally available such as the location of the facility, its industrial activity, and material management practices. EPA believes that 120 days is sufficient to gather and submit this information along with an identification of 10% of the facilities which will submit quantitative data. To ameliorate any difficulties for applicants, EPA has provided a means for late facilities to "add on" where appropriate, on a case-by-case basis, as discussed in section VI.F.4. above.

Several comments were received with regard to the requirement that new dischargers submit an application at least 180 days before the date on which the discharge is to commence. One commenter noted that it will be difficult for a facility to know when a storm water discharge is to commence since precipitation and runoff cannot be predicted to any degree of accuracy. In response, new dischargers must apply for a storm water permit application 180 days before that facility commences manufacturing, processing, or raw material storage operations which may result in the discharge of pollutants from storm water runoff, and 90 days for new construction sites.

For large municipal separate storm sewer systems (systems serving a population of more than 250,000), EPA proposed that part 1 of the permit application be submitted within one year of the date of the final regulations, with approval or disapproval by the permit issuing authority of the provisions of the part 1 permit application within 90 days after receiving part 1 of the application. The Part 2 portion of the application was to be submitted within two years of the date of promulgation.

For medium municipal separate storm sewer systems (systems serving a population of more than 100,000, but less than 250,000), EPA proposed that permit applications would be required nine months after the date of the final rule, with approval or disapproval of the provisions of the part 1 permit application within 90 days after receiving the part 1 application. The part 2 portion of the application would then be submitted no later than one year after the part 1 application has been approved.

Numerous comments were received by EPA from municipalities on these proposed deadlines. Many of these comments reflect the sentiment that the deadlines are too tight and that the required information would not be available for submission within the required time frame. Some commenters suggested deadlines that would add over three years to the permit application process. Other commenters suggested a revamped application process and a shorter deadline of 18 months. Some commenters explained that additional time would be needed to obtain adequate legal authority, while another stated that an inventory of outfalls required more time. One commenter maintained that intergovernmental agreements will require more time to prepare, and others expressed the view that more time was needed for the review of part 1 of the application by permitting authorities. Others felt more time was needed for collecting data, or hiring additional staff to accomplish the work. Most of these commenters did not provide specific details regarding what would be an appropriate amount of time and why.

After reviewing these comments EPA has decided to modify some of the deadlines as proposed. EPA is convinced that to properly achieve the goals of the CWA, the permit application requirements as discussed in previous sections are appropriate; but that the deadlines for medium municipal separate storm sewer systems should be adjusted so that the program's goals can be properly accomplished. After reviewing comments, EPA believes that medium municipalities will have fewer resources and existing institutional arrangements than large cities and therefore more time should be granted to these cities for submitting parts 1 and 2 of the application.

Accordingly EPA will require large municipal systems to submit part 1 of the permit application no later than November 18, 1991. Part 1 will be reviewed and approved or disapproved by the Director within 90 days. Part 2 of the application will then be submitted November 16, 1992. Medium municipal systems will submit part 1 of the application on May 18, 1992. Approval or disapproval by the Director will be accomplished within 90 days. Part 2 of the application will be submitted by May 17, 1993. These deadlines will give large systems two years to complete the application process, and medium systems 2 years and 6 months to submit applications. EPA is convinced that the permit application schedule is warranted and should provide adequate time to prepare the application.

In establishing these regulatory deadlines EPA is fully aware that they are not synchronized with the statutory deadlines as established by Congress. One commenter argued that the deadlines as proposed were contrary to the deadlines established by Congress and that EPA had no authority to extend these deadlines. (For large municipal separate storm sewer systems and storm water discharges associated with industrial activity, Congress established a deadline of February 4, 1990, for submission of permit applications; for medium municipal separate storm sewer systems, the deadline is February 4, 1992.) In response, this regulation provides certain deadlines for meeting the substantive requirements of this rulemaking—requirements which EPA is convinced are necessary for the development of enforceable and sound storm water permits. EPA believes it is important to give applicants sufficient time to reasonably comply with the permit application requirements set out today. EPA will therefore accept applications for storm water discharge permits up to the dates specified in today's rule. By establishing these regulatory deadlines, however, EPA is not attempting to waive or revoke the statutory deadlines established in Section 402(p) of the CWA and does not assert the authority to do so. The statutory permit application deadlines continue to be enforceable requirements.

EPA was not able to promulgate the final application regulations for storm water discharges before the February 4, 1990, deadline for industrial and large municipal dischargers despite its best efforts. Further, as noted above, EPA is not able to waive the statutory deadline. Dischargers concerned with complying with the statutory deadline should submit a permit application as required under this rulemaking as expeditiously as possible.

Operators of storm water discharges that are not specifically required to file a permit application under today's rule may be required to obtain a permit for their discharge on the basis of a case-by-case designation by the Administrator or the NPDES State.

The Administrator or NPDES State may also designate storm water discharges (except agricultural storm water discharges), that contribute to a violation of a water quality standard or that are significant contributors of pollutants to waters of the United States for a permit. Prior to a case-by-case determination that an individual permit is required for a storm water discharge, the Administrator or NPDES State may require the operator of the discharge to submit a permit application. 40 CFR 124.52(c) requires the operator of designated storm water discharges to submit a permit application within 60 days of notice, unless permission for a later date is granted. The 60-day deadline is consistent with the procedures for designating other discharges for a NPDES permit on a case-by-case basis found at 40 CFR 124.52. The 60-day deadline recognizes that case-by-case designations often require an expedited response, however, flexibility exists to allow for case-by-case extensions.

The December 7, 1988, proposal also proposed Part 504 State Storm Water Management Programs. The Agency has not included this component in today's rule. The Agency believes this program element is appropriate for addressing in regulations promulgated under section 402(p)(6) of the CWA.

VII. Economic Impact

EPA has prepared an Information Collection Request for the purpose of estimating the information collection burden imposed on Federal, State and local governments and industry for revisions to NPDES permit application requirements for storm water discharges codified in 40 CFR part 122. EPA is promulgating these revisions in response to Section 402(p)(4) of the Clean Water Act, as amended by the Water Quality Act of 1987 (WQA). The revisions would apply to: Storm water discharges associated with industrial activity; discharges from municipal separate storm sewer systems serving a population of 250,000 or more and discharges from municipal separate storm sewer systems serving a population of 100,000 or more, but less than 250,000.

The estimated annual cost of applying for NPDES permits for discharges from municipal separate storm sewer systems is $4.2 million. EPA estimates that an average permit application for a large municipality will cost $76,681 and require 4,534 hours to prepare. The average application for a medium municipality will cost $49,249 (2,912 hours) to prepare. The annual respondent cost for NPDES permit applications, notices of intent, and notifications for facilities with discharges associated with industrial activity is estimated to be $9.5 million (271,248 hours). EPA estimates that the average preparation cost of an individual industrial permit application would be $1,007 (28.6 hours). Average Group application will cost $74.00 per facility (2.1 hours). The average cost of the notification and notice of intent to be covered by general permit is $17.00 (0.5 hours).

The annual cost to the Federal Government and approved States for administration of the program is estimated to be $588,603. The total cost for municipalities, industry, and State and Federal authorities is estimated to be $14.5 million annually.

In general, the cost estimates provided in the ICR focus primarily on the costs associated with developing, submitting and reviewing the permit applications associated with today's rule. EPA will continue to evaluate procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality in the studies required under section 402(p)(5) of the CWA. Executive Order 12291 requires EPA and other agencies to perform regulatory analyses of major regulations. Major rules are those which impose a cost on the economy of $100 million or more annually or have certain other economic impacts. Today's proposed amendments would generally make the NPDES permit application regulations more flexible and less burdensome for the regulated community. These regulations do not satisfy any of the criteria specified in section 1(b) of the Executive Order and, as such, do not constitute a major rule. This regulation was submitted to the Office of Management and Budget (OMB) for review.

VIII. Paperwork Reduction Act

The information collection requirements in this rule have been submitted for approval to the Office of Management and Budget (OMB) under provision of the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* and have been assigned OMB control number 2040–0086.

Public reporting burden for permit applications for storm water discharges associated with industrial activity (other than from construction facilities) is estimated to average 28.6 hours per individual permit application, 0.5 hours per notice of intent to be covered by general permit, and 2.1 hours per group applicant. The public reporting burden for permit applications for storm water discharges associated with industrial activity from construction activities submitting individual applications is estimated to average 4.5 hours per response. The public reporting burden for facilities which discharge storm water associated with industrial activity to municipal separate storm sewers serving a population over 100,000 to notify the operator of the municipal separate storm sewer system is estimated to average 0.5 hours per response.

The reporting burden for system-wide permit applications for discharges from municipal separate storm sewer systems serving a population of 250,000 or more is estimated to average 4,534 hours per response. The reporting burden for system-wide permit applications for discharges from municipal separate storm sewer systems serving a population of 100,000 or more, but less than 250,000 is estimated to average 2,912 hours per response. Estimates of reporting burden include time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

IX. Regulatory Flexibility Act

Under the Regulatory Flexibility Act, 5 U.S.C. 601 *et seq.*, EPA is required to prepare a Regulatory Flexibility Analysis to assess the impact of rules on small entities. No Regulatory Flexibility Analysis is required, however, where the head of the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities.

Today's amendments to the regulations would generally make the NPDES permit applications regulations more flexible and less burdensome for permittees. Accordingly, I hereby

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certify, pursuant to 5 U.S.C. 605(b), that these amendments do not, have a significant impact on a substantial number of small entities.

List of Subjects in 40 CFR Parts 122, 123, and 124

Administrative practice and procedure, Environmental protection, Reporting and recordkeeping requirements, Water pollution control.

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

Dated: October 31, 1990.

William K. Reilly,

Administrator.

For the reasons stated in the preamble, parts 122, 123, and 124 of title 40 of the Code of Federal Regulations are amended as follows:

PART 122—EPA ADMINISTERED PERMIT PROGRAMS; THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Subpart B—Permit Application and Special NPDES Program Requirements

1. The authority citation for part 122 continues to read as follows:

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

2. Section 122.1 is amended by revising paragraph (b)(2)(iv) to read as follows:

§ 122.1 Purpose and scope.

* * * * *

(b) * * *

(2) * * *

(iv) Discharges of storm water as set forth in § 122.26; and

* * * * *

3. Section 122.21 is amended by revising paragraph (c)(1), by removing the last sentence of paragraph (f)(7), by removing paragraph (f)(9), by adding two sentences at the end of paragraph (g)(3), by revising paragraph (g)(7) introductory text, by removing and reserving paragraph (g)(10) and by revising the introductory text of paragraph (k) to read as follows:

§ 122.21 Application for a permit (applicable to State programs, see § 123.25).

* * * * *

(c) *Time to apply.* (1) Any person proposing a new discharge, shall submit an application at least 180 days before the date on which the discharge is to commence, unless permission for a later date has been granted by the Director. Facilities proposing a new discharge of storm water associated with industrial activity shall submit an application 180 days before that facility commences industrial activity which may result in a discharge of storm water associated with that industrial activity. Facilities described under § 122.26(b)(14)(x) shall submit applications at least 90 days before the date on which construction is to commence. Different submittal dates may be required under the terms of applicable general permits. Persons proposing a new discharge are encouraged to submit their applications well in advance of the 90 or 180 day requirements to avoid delay. See also paragraph (k) of this section and § 122.26 (c)(1)(i)(G) and (c)(1)(ii).

* * * * *

(g) * * *

(3) * * * The average flow of point sources composed of storm water may be estimated. The basis for the rainfall event and the method of estimation must be indicated.

* * * * *

(7) *Effluent characteristics.* Information on the discharge of pollutants specified in this paragraph (except information on storm water discharges which is to be provided as specified in § 122.26). When "quantitative data" for a pollutant are required, the applicant must collect a sample of effluent and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method. When an applicant has two or more outfalls with substantially identical effluents, the Director may allow the applicant to test only one outfall and report that the quantitative data also apply to the substantially identical outfalls. The requirements in paragraphs (g)(7) (iii) and (iv) of this section that an applicant must provide quantitative data for certain pollutants known or believed to be present do not apply to pollutants present in a discharge solely as the result of their presence in intake water; however, an applicant must report such pollutants as present. Grab samples must be used for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform and fecal streptococcus. For all other pollutants, 24-hour composite samples must be used. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period greater than 24 hours. In addition, for discharges other than storm water discharges, the Director may waive composite sampling for any outfall for which the applicant demonstrates that the use of an automatic sampler is infeasible and that the minimum of four (4) grab samples will be a representative sample of the effluent being discharged. For storm water discharges, all samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inch and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area. For all applicants, a flow-weighted composite shall be taken for either the entire discharge or for the first three hours of the discharge. The flow-weighted composite sample for a storm water discharge may be taken with a continuous sampler or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire discharge or for the first three hours of the discharge, with each aliquot being separated by a minimum period of fifteen minutes (applicants submitting permit applications for storm water discharges under § 122.26(d) may collect flow weighted composite samples using different protocols with respect to the time duration between the collection of sample aliquots, subject to the approval of the Director). However, a minimum of one grab sample may be taken for storm water discharges from holding ponds or other impoundments with a retention period greater than 24 hours. For a flow-weighted composite sample, only one analysis of the composite of aliquots is required. For storm water discharge samples taken from discharges associated with industrial activities, quantitative data must be reported for the grab sample taken during the first thirty minutes (or as soon thereafter as practicable) of the discharge for all pollutants specified in § 122.26(c)(1). For all storm water permit applicants taking flow-weighted composites, quantitative data must be reported for all pollutants specified in § 122.26 except pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform, and fecal streptococcus. The Director may allow or establish appropriate site-specific sampling procedures or requirements, including sampling locations, the season in which the sampling takes place, the minimum duration between the previous measurable storm event and the [illegible] event sampled, the minimum or maximum level of precipitation required for an appropriate storm event, the [illegible] of precipitation sampled ([illegible] rain fall), protocols for [illegible] samples under 40 CFR part 136, and additional time for submitting data on a

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case-by-case basis. An applicant is expected to "know or have reason to believe" that a pollutant is present in an effluent based on an evaluation of the expected use, production, or storage of the pollutant, or on any previous analyses for the pollutant. (For example, any pesticide manufactured by a facility may be expected to be present in contaminated storm water runoff from the facility.)

* * * * *

(k) *Application requirements for new sources and new discharges.* New manufacturing, commercial, mining and silvicultural dischargers applying for NPDES permits (except for new discharges of facilities subject to the requirements of paragraph (h) of this section or new discharges of storm water associated with industrial activity which are subject to the requirements of § 122.26(c)(1) and this section (except as provided by § 122.26(c)(1)(ii)) shall provide the following information to the Director, using the application forms provided by the Director:

* * * * *

4. Section 122.22(b) introductory text is revised to read as follows:

§ 122.22 Signatories to permit applications and reports (applicable to State programs, see § 123.25).

* * * * *

(b) All reports required by permits, and other information requested by the Director shall be signed by a person described in paragraph (a) of this section, or by a duly authorized representative of that person. A person is a duly authorized representative only if:

* * * * *

5. Section 122.26 is revised to read as follows:

§ 122.26 Storm water discharges (applicable to State NPDES programs, see § 123.25).

(a) *Permit requirement.* (1) Prior to October 1, 1992, discharges composed entirely of storm water shall not be required to obtain a NPDES permit except:

(i) A discharge with respect to which a permit has been issued prior to February 4, 1987;

(ii) A discharge associated with industrial activity (see § 122.26(a)(4));

(iii) A discharge from a large municipal separate storm sewer system;

(iv) A discharge from a medium municipal separate storm sewer system;

(v) A discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. This designation may include a discharge from any conveyance or system of conveyances used for collecting and conveying storm water runoff or a system of discharges from municipal separate storm sewers, except for those discharges from conveyances which do not require a permit under paragraph (a)(2) of this section or agricultural storm water runoff which is exempted from the definition of point source at § 122.2. The Director may designate discharges from municipal separate storm sewers on a system-wide or jurisdiction-wide basis. In making this determination the Director may consider the following factors:

(A) The location of the discharge with respect to waters of the United States as defined at 40 CFR 122.2.

(B) The size of the discharge;

(C) The quantity and nature of the pollutants discharged to waters of the United States; and

(D) Other relevant factors.

(2) The Director may not require a permit for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing or treatment operations or transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(3) *Large and medium municipal separate storm sewer systems.* (i) Permits must be obtained for all discharges from large and medium municipal separate storm sewer systems.

(ii) The Director may either issue one system-wide permit covering all discharges from municipal separate storm sewers within a large or medium municipal storm sewer system or issue distinct permits for appropriate categories of discharges within a large or medium municipal separate storm sewer system including, but not limited to: all discharges owned or operated by the same municipality; located within the same jurisdiction; all discharges within a system that discharge to the same watershed; discharges within a system that are similar in nature; or for individual discharges from municipal separate storm sewers within the system.

(iii) The operator of a discharge from a municipal separate storm sewer which is part of a large or medium municipal separate storm sewer system must either:

(A) Participate in a permit application (to be a permittee or a co-permittee) with one or more other operators of discharges from the large or medium municipal storm sewer system which covers all, or a portion of all, discharges from the municipal separate storm sewer system;

(B) Submit a distinct permit application which only covers discharges from the municipal separate storm sewers for which the operator is responsible; or

(C) A regional authority may be responsible for submitting a permit application under the following guidelines:

(*1*) The regional authority together with co-applicants shall have authority over a storm water management program that is in existence, or shall be in existence at the time part 1 of the application is due;

(*2*) The permit applicant or co-applicants shall establish their ability to make a timely submission of part 1 and part 2 of the municipal application;

(*3*) Each of the operators of municipal separate storm sewers within the systems described in paragraphs (b)(4) (i), (ii), and (iii) or (b)(7) (i), (ii), and (iii) of this section, that are under the purview of the designated regional authority, shall comply with the application requirements of paragraph (d) of this section.

(iv) One permit application may be submitted for all or a portion of all municipal separate storm sewers within adjacent or interconnected large or medium municipal separate storm sewer systems. The Director may issue one system-wide permit covering all, or a portion of all municipal separate storm sewers in adjacent or interconnected large or medium municipal separate storm sewer systems.

(v) Permits for all or a portion of all discharges from large or medium municipal separate storm sewer systems that are issued on a system-wide, jurisdiction-wide, watershed or other basis may specify different conditions relating to different discharges covered by the permit, including different management programs for different drainage areas which contribute storm water to the system.

(vi) Co-permittees need only comply with permit conditions relating to discharges from the municipal separate storm sewers for which they are operators.

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(4) *Discharges through large and medium municipal separate storm sewer systems.* In addition to meeting the requirements of paragraph (c) of this section, an operator of a storm water discharge associated with industrial activity which discharges through a large or medium municipal separate storm sewer system shall submit, to the operator of the municipal separate storm sewer system receiving the discharge no later than May 15, 1991, or 180 days prior to commencing such discharge: the name of the facility; a contact person and phone number; the location of the discharge; a description, including Standard Industrial Classification, which best reflects the principal products or services provided by each facility; and any existing NPDES permit number.

(5) *Other municipal separate storm sewers.* The Director may issue permits for municipal separate storm sewers that are designated under paragraph (a)(1)(v) of this section on a system-wide basis, jurisdiction-wide basis, watershed basis or other appropriate basis, or may issue permits for individual discharges.

(6) *Non-municipal separate storm sewers.* For storm water discharges associated with industrial activity from point sources which discharge through a non-municipal or non-publicly owned separate storm sewer system, the Director, in his discretion, may issue: a single NPDES permit, with each discharger a co-permittee to a permit issued to the operator of the portion of the system that discharges into waters of the United States; or, individual permits to each discharger of storm water associated with industrial activity through the non-municipal conveyance system.

(i) All storm water discharges associated with industrial activity that discharge through a storm water discharge system that is not a municipal separate storm sewer must be covered by an individual permit, or a permit issued to the operator of the portion of the system that discharges to waters of the United States, with each discharger to the non-municipal conveyance a co-permittee to that permit.

(ii) Where there is more than one operator of a single system of such conveyances, all operators of storm water discharges associated with industrial activity must submit applications.

(iii) Any permit covering more than one operator shall identify the effluent limitations, or other permit conditions, if any, that apply to each operator.

(7) *Combined sewer systems.* Conveyances that discharge storm water runoff combined with municipal sewage are point sources that must obtain NPDES permits in accordance with the procedures of § 122.21 and are not subject to the provisions of this section.

(8) Whether a discharge from a municipal separate storm sewer is or is not subject to regulation under this section shall have no bearing on whether the owner or operator of the discharge is eligible for funding under title II, title III or title VI of the Clean Water Act. *See* 40 CFR part 35, subpart I, appendix A(b)H.2.j.

(b) *Definitions.* (1) *Co-permittee* means a permittee to a NPDES permit that is only responsible for permit conditions relating to the discharge for which it is operator.

(2) *Illicit discharge* means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

(3) *Incorporated place* means the District of Columbia, or a city, town, township, or village that is incorporated under the laws of the State in which it is located.

(4) *Large municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 250,000 or more as determined by the latest Decennial Census by the Bureau of Census (appendix F); or

(ii) Located in the counties listed in appendix H, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(4)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; and

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a large municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraph (b)(4) (i), (ii), (iii) of this section.

(5) *Major municipal separate storm sewer outfall* (or "major outfall") means a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for municipal separate storm sewers that receive storm water from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

(6) *Major outfall* means a major municipal separate storm sewer outfall.

(7) *Medium municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 100,000 or more but less than 250,000, as determined by the latest Decennial Census by the Bureau of Census (appendix G); or

(ii) Located in the counties listed in appendix I, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

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(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(7)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; or

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a medium municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (b)(7) (i), (ii), (iii) of this section.

(8) *Municipal separate storm sewer* means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

(9) *Outfall* means a *point source* as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the United States and are used to convey waters of the United States.

(10) *Overburden* means any material of any nature, consolidated or unconsolidated, that overlies a mineral deposit, excluding topsoil or similar naturally-occurring surface materials that are not disturbed by mining operations.

(11) *Runoff coefficient* means the fraction of total rainfall that will appear at a conveyance as runoff.

(12) *Significant materials* includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

(13) *Storm water* means storm water runoff, snow melt runoff, and surface runoff and drainage.

(14) *Storm water discharge associated with industrial activity* means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR part 122. For the categories of industries identified in paragraphs (b)(14) (i) through (x) of this section, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR part 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in paragraph (b)(14)(xi) of this section, the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (b)(14)(i)–(xi) of this section) include those facilities designated under the provisions of paragraph (a)(1)(v) of this section. The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection:

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) in paragraph (b)(14) of this section);

(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, 373;

(iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(1) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221–25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (b)(14) (i)–(vii) or (ix)–(xi) of this section are associated with industrial activity;

(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA;

(x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;

(xi) Facilities under Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221–25, (and which are not otherwise included within categories (ii)–(x));

(c) *Application requirements for storm water discharges associated with industrial activity*—(1) *Individual application.* Dischargers of storm water associated with industrial activity are required to apply for an individual permit, apply for a permit through a group application, or seek coverage under a promulgated storm water general permit. Facilities that are required to obtain an individual permit, or any discharge of storm water which the Director is evaluating for designation (*see* 40 CFR 124.52(c)) under paragraph (a)(1)(v) of this section and is not a municipal separate storm sewer, and which is not part of a group application described under paragraph (c)(2) of this section, shall submit an NPDES application in accordance with the requirements of § 122.21 as modified and supplemented by the provisions of the remainder of this paragraph. Applicants for discharges composed entirely of storm water shall submit Form 1 and Form 2F. Applicants for discharges composed of storm water and non-storm water shall submit Form 1, Form 2C, and Form 2F. Applicants for new sources or new discharges (as defined in § 122.2 of this part) composed of storm water and non-storm water shall submit Form 1, Form 2D, and Form 2F.

(i) Except as provided in § 122.26(c)(1)(ii)–(iv), the operator of a storm water discharge associated with industrial activity subject to this section shall provide:

(A) A site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) of the facility including: each of its drainage and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each past or present area used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied, each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility;

(B) An estimate of the area of impervious surfaces (including paved areas and building roofs) and the total area drained by each outfall (within a mile radius of the facility) and a narrative description of the following: Significant materials that in the three years prior to the submittal of this application have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of such materials; materials management practices employed, in the three years prior to the submittal of this application, to minimize contact by these materials with storm water runoff; materials loading and access areas; the location, manner and frequency in which pesticides, herbicides, soil conditioners and fertilizers are applied; the location and a description of existing structural and non-structural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the ultimate disposal of any solid or fluid wastes other than by discharge;

(C) A certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by a NPDES permit; tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. The certification shall include a description of the method used, the date of any testing, and the on-site drainage points that were directly observed during a test;

(D) Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility that have taken place within the three years prior to the submittal of this application;

(E) Quantitative data based on samples collected during storm events and collected in accordance with § 122.21 of this part from all outfalls containing a storm water discharge associated with industrial activity for the following parameters:

(*1*) Any pollutant limited in an effluen guideline to which the facility is subject;

(*2*) Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit);

(*3*) Oil and grease, pH, BOD5, COD, TSS, total phosphorus, total Kjeldahl nitrogen, and nitrate plus nitrite nitrogen;

(*4*) Any information on the discharge required under paragraph § 122.21(g)(7)(iii) and (iv) of this part;

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(5) Flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, and the method of flow measurement or estimation; and

(6) The date and duration (in hours) of the storm event(s) sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event (in hours);

(F) Operators of a discharge which is composed entirely of storm water are exempt from the requirements of § 122.21 (g)(2), (g)(3), (g)(4), (g)(5), (g)(7)(i), (g)(7)(ii), and (g)(7)(v); and

(G) Operators of new sources or new discharges (as defined in § 122.2 of this part) which are composed in part or entirely of storm water must include estimates for the pollutants or parameters listed in paragraph (c)(1)(i)(E) of this section instead of actual sampling data, along with the source of each estimate. Operators of new sources or new discharges composed in part or entirely of storm water must provide quantitative data for the parameters listed in paragraph (c)(1)(i)(E) of this section within two years after commencement of discharge, unless such data has already been reported under the monitoring requirements of the NPDES permit for the discharge. Operators of a new source or new discharge which is composed entirely of storm water are exempt from the requirements of § 122.21 (k)(3)(ii), (k)(3)(iii), and (k)(5).

(ii) The operator of an existing or new storm water discharge that is associated with industrial activity solely under paragraph (b)(14)(x) of this section, is exempt from the requirements of § 122.21(g) and paragraph (c)(1)(i) of this section. Such operator shall provide a narrative description of:

(A) The location (including a map) and the nature of the construction activity;

(B) The total area of the site and the area of the site that is expected to undergo excavation during the life of the permit;

(C) Proposed measures, including best management practices, to control pollutants in storm water discharges during construction, including a brief description of applicable State and local erosion and sediment control requirements;

(D) Proposed measures to control pollutants in storm water discharges that will occur after construction operations have been completed, including a brief description of applicable State or local erosion and sediment control requirements;

(E) An estimate of the runoff coefficient of the site and the increase in impervious area after the construction addressed in the permit application is completed, the nature of fill material and existing data describing the soil or the quality of the discharge; and

(F) The name of the receiving water.

(iii) The operator of an existing or new discharge composed entirely of storm water from an oil or gas exploration, production, processing, or treatment operation, or transmission facility is not required to submit a permit application in accordance with paragraph (c)(1)(i) of this section, unless the facility:

(A) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 117.21 or 40 CFR 302.6 at anytime since November 16, 1987; or

(B) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 110.6 at any time since November 16, 1987; or

(C) Contributes to a violation of a water quality standard.

(iv) The operator of an existing or new discharge composed entirely of storm water from a mining operation is not required to submit a permit application unless the discharge has come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(v) Applicants shall provide such other information the Director may reasonably require under § 122.21(g)(13) of this part to determine whether to issue a permit and may require any facility subject to paragraph (c)(1)(ii) of this section to comply with paragraph (c)(1)(i) of this section.

(2) *Group application for discharges associated with industrial activity.* In lieu of individual applications or notice of intent to be covered by a general permit for storm water discharges associated with industrial activity, a group application may be filed by an entity representing a group of applicants (except facilities that have existing individual NPDES permits for storm water) that are part of the same subcategory (*see* 40 CFR subchapter N, part 405 to 471) or, where such grouping is inapplicable, are sufficiently similar as to be appropriate for general permit coverage under § 122.28 of this part. The part 1 application shall be submitted to the Office of Water Enforcement and Permits, U.S. EPA, 401 M Street, SW., Washington, DC 20460 (EN-336) for approval. Once a part 1 application is approved, group applicants are to submit Part 2 of the group application to the Office of Water Enforcement and Permits. A group application shall consist of:

(i) *Part 1.* Part 1 of a group application shall:

(A) Identify the participants in the group application by name and location. Facilities participating in the group application shall be listed in nine subdivisions, based on the facility location relative to the nine precipitation zones indicated in appendix E to this part.

(B) Include a narrative description summarizing the industrial activities of participants of the group application and explaining why the participants, as a whole, are sufficiently similar to be a covered by a general permit;

(C) Include a list of significant materials stored exposed to precipitation by participants in the group application and materials management practices employed to diminish contact by these materials with precipitation and storm water runoff;

(D) Identify ten percent of the dischargers participating in the group application (with a minimum of 10 dischargers, and either a minimum of two dischargers from each precipitation zone indicated in appendix E of this part in which ten or more members of the group are located, or one discharger from each precipitation zone indicated in appendix E of this part in which nine or fewer members of the group are located) from which quantitative data will be submitted in part 2. If more than 1,000 facilities are identified in a group application, no more than 100 dischargers must submit quantitative data in Part 2. Groups of between four and ten dischargers may be formed. However, in groups of between four and ten, at least half the facilities must submit quantitative data, and at least one facility in each precipitation zone in which members of the group are located must submit data. A description of why the facilities selected to perform sampling and analysis are representative of the group as a whole in terms of the information provided in paragraph (c)(1)(i)(B) and (i)(C) of this section, shall accompany this section. Different factors impacting the nature of the storm water discharges, such as processes used and material management, shall be represented, to the extent feasible, in a manner roughly equivalent to their proportion in the group.

(ii) *Part 2.* Part 2 of a group application shall contain quantitative

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data (NPDES Form 2F), as modified by paragraph (c)(1) of this section, so that when part 1 and part 2 of the group application are taken together, a complete NPDES application (Form 1, Form 2C, and Form 2F) can be evaluated for each discharger identified in paragraph (c)(2)(i)(D) of this section.

(d) *Application requirements for large and medium municipal separate storm sewer discharges.* The operator of a discharge from a large or medium municipal separate storm sewer or a municipal separate storm sewer that is designated by the Director under paragraph (a)(1)(v) of this section, may submit a jurisdiction-wide or system-wide permit application. Where more than one public entity owns or operates a municipal separate storm sewer within a geographic area (including adjacent or interconnected municipal separate storm sewer systems), such operators may be a coapplicant to the same application. Permit applications for discharges from large and medium municipal storm sewers or municipal storm sewers designated under paragraph (a)(1)(v) of this section shall include;

(1) *Part 1.* Part 1 of the application shall consist of:

(i) *General information.* The applicants' name, address, telephone number of contact person, ownership status and status as a State or local government entity.

(ii) *Legal authority.* A description of existing legal authority to control discharges to the municipal separate storm sewer system. When existing legal authority is not sufficient to meet the criteria provided in paragraph (d)(2)(i) of this section, the description shall list additional authorities as will be necessary to meet the criteria and shall include a schedule and commitment to seek such additional authority that will be needed to meet the criteria.

(iii) *Source identification.* (A) A description of the historic use of ordinances, guidance or other controls which limited the discharge of non-storm water discharges to any Publicly Owned Treatment Works serving the same area as the municipal separate storm sewer system.

(B) A USGS 7.5 minute topographic map (or equivalent topographic map with a scale between 1:10,000 and 1:24,000 if cost effective) extending one mile beyond the service boundaries of the municipal storm sewer system covered by the permit application. The following information shall be provided:

(*1*) The location of known municipal storm sewer system outfalls discharging to waters of the United States;

(*2*) A description of the land use activities (e.g. divisions indicating undeveloped, residential, commercial, agricultural and industrial uses) accompanied with estimates of population densities and projected growth for a ten year period within the drainage area served by the separate storm sewer. For each land use type, an estimate of an average runoff coefficient shall be provided;

(*3*) The location and a description of the activities of the facility of each currently operating or closed municipal landfill or other treatment, storage or disposal facility for municipal waste;

(*4*) The location and the permit number of any known discharge to the municipal storm sewer that has been issued a NPDES permit;

(*5*) The location of major structural controls for storm water discharge (retention basins, detention basins, major infiltration devices, etc.); and

(*6*) The identification of publicly owned parks, recreational areas, and other open lands.

(iv) *Discharge characterization.* (A) Monthly mean rain and snow fall estimates (or summary of weather bureau data) and the monthly average number of storm events.

(B) Existing quantitative data describing the volume and quality of discharges from the municipal storm sewer, including a description of the outfalls sampled, sampling procedures and analytical methods used.

(C) A list of water bodies that receive discharges from the municipal separate storm sewer system, including downstream segments, lakes and estuaries, where pollutants from the system discharges may accumulate and cause water degradation and a brief description of known water quality impacts. At a minimum, the description of impacts shall include a description of whether the water bodies receiving such discharges have been:

(*1*) Assessed and reported in section 305(b) reports submitted by the State, the basis for the assessment (evaluated or monitored), a summary of designated use support and attainment of Clean Water Act (CWA) goals (fishable and swimmable waters), and causes of nonsupport of designated uses;

(*2*) Listed under section 304(l)(1)(A)(i), section 304(l)(1)(A)(ii), or section 304(l)(1)(B) of the CWA that is not expected to meet water quality standards or water quality goals;

(*3*) Listed in State Nonpoint Source Assessments required by section 319(a) of the CWA that, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain water quality standards due to storm sewers, construction, highway maintenance and runoff from municipal landfills and municipal sludge adding significant pollution (or contributing to a violation of water quality standards);

(*4*) Identified and classified according to eutrophic condition of publicly owned lakes listed in State reports required under section 314(a) of the CWA (include the following: A description of those publicly owned lakes for which uses are known to be impaired; a description of procedures, processes and methods to control the discharge of pollutants from municipal separate storm sewers into such lakes; and a description of methods and procedures to restore the quality of such lakes);

(*5*) Areas of concern of the Great Lakes identified by the International Joint Commission;

(*6*) Designated estuaries under the National Estuary Program under section 320 of the CWA;

(*7*) Recognized by the applicant as highly valued or sensitive waters;

(*8*) Defined by the State or U.S. Fish and Wildlife Services's National Wetlands Inventory as wetlands; and

(*9*) Found to have pollutants in bottom sediments, fish tissue or biosurvey data.

(D) *Field screening.* Results of a field screening analysis for illicit connections and illegal dumping for either selected field screening points or major outfalls covered in the permit application. At a minimum, a screening analysis shall include a narrative description, for either each field screening point or major outfall, of visual observations made during dry weather periods. If any flow is observed, two grab samples shall be collected during a 24 hour period with a minimum period of four hours between samples. For all such samples, a narrative description of the color, odor, turbidity, the presence of an oil sheen or surface scum as well as any other relevant observations regarding the potential presence of non-storm water discharges or illegal dumping shall be provided. In addition, a narrative description of the results of a field analysis using suitable methods to estimate pH, total chlorine, total copper, total phenol, and detergents (or surfactants) shall be provided along with a description of the flow rate. Where the field analysis does not involve analytical methods approved under 40 CFR part 136, the applicant shall provide a description of the method used including the name of the manufacturer of the test method along with the range and accuracy of the test. Field screening points shall be either major outfalls or other outfall points (or

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any other point of access such as manholes) randomly located throughout the storm sewer system by placing a grid over a drainage system map and identifying those cells of the grid which contain a segment of the storm sewer system or major outfall. The field screening points shall be established using the following guidelines and criteria:

(*1*) A grid system consisting of perpendicular north-south and east-west lines spaced ¼ mile apart shall be overlayed on a map of the municipal storm sewer system, creating a series of cells;

(*2*) All cells that contain a segment of the storm sewer system shall be identified; one field screening point shall be selected in each cell; major outfalls may be used as field screening points;

(*3*) Field screening points should be located downstream of any sources of suspected illegal or illicit activity;

(*4*) Field screening points shall be located to the degree practicable at the farthest manhole or other accessible location downstream in the system, within each cell; however, safety of personnel and accessibility of the location should be considered in making this determination;

(*5*) Hydrological conditions; total drainage area of the site; population density of the site; traffic density; age of the structures or buildings in the area; history of the area; and land use types;

(*6*) For medium municipal separate storm sewer systems, no more than 250 cells need to have identified field screening points; in large municipal separate storm sewer systems, no more than 500 cells need to have identified field screening points; cells established by the grid that contain no storm sewer segments will be eliminated from consideration; if fewer than 250 cells in medium municipal sewers are created, and fewer than 500 in large systems are created by the overlay on the municipal sewer map, then all those cells which contain a segment of the sewer system shall be subject to field screening (unless access to the separate storm sewer system is impossible); and

(*7*) Large or medium municipal separate storm sewer systems which are unable to utilize the procedures described in paragraphs (d)(1)(iv)(D) (*1*) through (*6*) of this section, because a sufficiently detailed map of the separate storm sewer systems is unavailable, shall field screen no more than 500 or 250 major outfalls respectively (or all major outfalls in the system, if less); in such circumstances, the applicant shall establish a grid system consisting of north-south and east-west lines spaced ¼ mile apart as an overlay to the boundaries of the municipal storm sewer system, thereby creating a series of cells; the applicant will then select major outfalls in as many cells as possible until at least 500 major outfalls (large municipalities) or 250 major outfalls (medium municipalities) are selected; a field screening analysis shall be undertaken at these major outfalls.

(E) *Characterization plan.* Information and a proposed program to meet the requirements of paragraph (d)(2)(iii) of this section. Such description shall include: the location of outfalls or field screening points appropriate for representative data collection under paragraph (d)(2)(iii)(A) of this section, a description of why the outfall or field screening point is representative, the seasons during which sampling is intended, a description of the sampling equipment. The proposed location of outfalls or field screening points for such sampling should reflect water quality concerns (*see* paragraph (d)(1)(iv)(C) of this section) to the extent practicable.

(v) *Management programs.* (A) A description of the existing management programs to control pollutants from the municipal separate storm sewer system. The description shall provide information on existing structural and source controls, including operation and maintenance measures for structural controls, that are currently being implemented. Such controls may include, but are not limited to: Procedures to control pollution resulting from construction activities; floodplain management controls; wetland protection measures; best management practices for new subdivisions; and emergency spill response programs. The description may address controls established under State law as well as local requirements.

(B) A description of the existing program to identify illicit connections to the municipal storm sewer system. The description should include inspection procedures and methods for detecting and preventing illicit discharges, and describe areas where this program has been implemented.

(vi) *Fiscal resources.* (A) A description of the financial resources currently available to the municipality to complete part 2 of the permit application. A description of the municipality's budget for existing storm water programs, including an overview of the municipality's financial resources and budget, including overall indebtedness and assets, and sources of funds for storm water programs.

(2) *Part 2.* Part 2 of the application shall consist of:

(i) *Adequate legal authority.* A demonstration that the applicant can operate pursuant to legal authority established by statute, ordinance or series of contracts which authorizes or enables the applicant at a minimum to:

(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;

(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer;

(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water;

(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;

(E) Require compliance with conditions in ordinances, permits, contracts or orders; and

(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

(ii) *Source identification.* The location of any major outfall that discharges to waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(*1*) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;

(iii) *Characterization data.* When "quantitative data" for a pollutant are required under paragraph (d)(a)(iii)(A)(*3*) of this paragraph, the applicant must collect a sample of effluent in accordance with 40 CFR 122.21(g)(7) and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method. The applicant must provide information characterizing the quality and quantity of discharges covered in the permit application, including:

(A) Quantitative data from representative outfalls designated by the Director (based on information received

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in part 1 of the application, the Director shall designate between five and ten outfalls or field screening points as representative of the commercial, residential and industrial land use activities of the drainage area contributing to the system or, where there are less than five outfalls covered in the application, the Director shall designate all outfalls) developed as follows:

(*1*) For each outfall or field screening point designated under this subparagraph, samples shall be collected of storm water discharges from three storm events occurring at least one month apart in accordance with the requirements at § 122.21(g)(7) (the Director may allow exemptions to sampling three storm events when climatic conditions create good cause for such exemptions);

(*2*) A narrative description shall be provided of the date and duration of the storm event(s) sampled, rainfall estimates of the storm event which generated the sampled discharge and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event;

(*3*) For samples collected and described under paragraphs (d)(2)(iii)(A)(*1*) and (A)(*2*) of this section, quantitative data shall be provided for: the organic pollutants listed in Table II; the pollutants listed in Table III (toxic metals, cyanide, and total phenols) of appendix D of 40 CFR part 122, and for the following pollutants:

Total suspended solids (TSS)
Total dissolved solids (TDS)
COD
BOD_5
Oil and grease
Fecal coliform
Fecal streptococcus
pH
Total Kjeldahl nitrogen
Nitrate plus nitrite
Dissolved phosphorus
Total ammonia plus organic nitrogen
Total phosphorus

(*4*) Additional limited quantitative data required by the Director for determining permit conditions (the Director may require that quantitative data shall be provided for additional parameters, and may establish sampling conditions such as the location, season of sample collection, form of precipitation (snow melt, rainfall) and other parameters necessary to insure representativeness);

(B) Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under § 122.21(c)(7)) for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

(C) A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(*1*) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section; and

(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.

(iv) *Proposed management program.* A proposed management program covers the duration of the permit. It shall include a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate. The program shall also include a description of staff and equipment available to implement the program. Separate proposed programs may be submitted by each coapplicant. Proposed programs may impose controls on a systemwide basis, a watershed basis, a jurisdiction basis, or on individual outfalls. Proposed programs will be considered by the Director when developing permit conditions to reduce pollutants in discharges to the maximum extent practicable. Proposed management programs shall describe priorities for implementing controls. Such programs shall be based on:

(A) A description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description shall include:

(*1*) A description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers;

(*2*) A description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed. (Controls to reduce pollutants in discharges from municipal separate storm sewers containing construction site runoff are addressed in paragraph (d)(2)(iv)(D) of this section;

(*3*) A description of practices for operating and maintaining public streets, roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities;

(*4*) A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible;

(*5*) A description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges (this program can be coordinated with the program developed under paragraph (d)(2)(iv)(C) of this section); and

(*6*) A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

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(B) A description of a program, including a schedule, to detect and remove (or require the discharger to the municipal separate storm sewer to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. The proposed program shall include:

(*1*) A description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; this program description shall address all types of illicit discharges, however the following category of non-storm water discharges or flows shall be addressed where such discharges are identified by the municipality as sources of pollutants to waters of the United States: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers, uncomtaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (program descriptions shall address discharges or flows from fire fighting only where such discharges or flows are identified as significant sources of pollutants to waters of the United States);

(*2*) A description of procedures to conduct on-going field screening activities during the life of the permit, including areas or locations that will be evaluated by such field screens;

(*3*) A description of procedures to be followed to investigate portions of the separate storm sewer system that, based on the results of the field screen, or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water (such procedures may include: sampling procedures for constituents such as fecal coliform, fecal streptococcus, surfactants (MBAS), residual chlorine, fluorides and potassium; testing with fluorometric dyes; or conducting in storm sewer inspections where safety and other considerations allow. Such description shall include the location of storm sewers that have been identified for such evaluation);

(*4*) A description of procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer;

(*5*) A description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers;

(*6*) A description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials; and

(*7*) A description of controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems where necessary;

(C) A description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system. The program shall:

(*1*) Identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;

(*2*) Describe a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of quantitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease, COD, pH, BOD_5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21(g)(7) (iii) and (iv).

(D) A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system, which shall include:

(*1*) A description of procedures for site planning which incorporate consideration of potential water quality impacts;

(*2*) A description of requirements for nonstructural and structural best management practices;

(*3*) A description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality; and

(*4*) A description of appropriate educational and training measures for construction site operators.

(v) *Assessment of controls.* Estimated reductions in loadings of pollutants from discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water.

(vi) *Fiscal analysis.* For each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2) (iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds.

(vii) Where more than one legal entity submits an application, the application shall contain a description of the roles and responsibilities of each legal entity and procedures to ensure effective coordination.

(viii) Where requirements under paragraph (d)(1)(iv)(E), (d)(2)(ii), (d)(2)(iii)(B) and (d)(2)(iv) of this section are not practicable or are not applicable, the Director may exclude any operator of a discharge from a municipal separate storm sewer which is designated under paragraph (a)(1)(v), (b)(4)(ii) or (b)(7)(ii) of this section from such requirements. The Director shall not exclude the operator of a discharge from a municipal separate storm sewer identified in appendix F, G, H or I of part 122, from any of the permit application requirements under this paragraph except where authorized under this section.

(e) *Application deadlines.* Any operator of a point source required to obtain a permit under paragraph (a)(1) of this section that does not have an effective NPDES permit covering its storm water outfalls shall submit an application in accordance with the following deadlines:

(1) For any storm water discharge associated with industrial activity identified in paragraph (b)(14) (i)-(xi) of this section, that is not part of a group application as described in paragraph (c)(2) of this section or which is not covered under a promulgated storm water general permit, a permit application made pursuant to paragraph (c) of this section shall be submitted to the Director by November 18, 1991;

(2) For any group application submitted in accordance with paragraph (c)(2) of this section:

(i) Part 1 of the application shall be submitted to the Director, Office of Water Enforcement and Permits by March 18, 1991;

(ii) Based on information in the part 1 application, the Director will approve or deny the members in the group application within 60 days after receiving part 1 of the group application.

(iii) Part 2 of the application shall be submitted to the Director, Office of Water Enforcement and Permits no later than 12 months after the date of approval of the part 1 application.

(iv) Facilities that are rejected as members of a group by the permitting authority shall have 12 months to file an individual permit application from the date they receive notification of their rejection.

(v) A facility listed under paragraph (b)(14) (i)–(xi) of this section may add on to a group application submitted in accordance with paragraph (e)(2)(i) of this section at the discretion of the Office of Water Enforcement and Permits, and only upon a showing of good cause by the facility and the group applicant; the request for the addition of the facility shall be made no later than February 18,1992; the addition of the facility shall not cause the percentage of the facilities that are required to submit quantitative data to be less than 10%, unless there are over 100 facilities in the group that are submitting quantitative data; approval to become part of group application must be obtained from the group or the trade association representing the individual facilities.

(3) For any discharge from a large municipal separate storm sewer system;

(i) Part 1 of the application shall be submitted to the Director by November 18, 1991;

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application;

(iii) Part 2 of the application shall be submitted to the Director by November 16, 1992.

(4) For any discharge from a medium municipal separate storm sewer system;

(i) Part 1 of the application shall be submitted to the Director by May 18, 1992.

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application.

(iii) Part 2 of the application shall be submitted to the Director by May 17, 1993.

(5) A permit application shall be submitted to the Director within 60 days of notice, unless permission for a later date is granted by the Director (*see* 40 CFR 124.52(c)), for:

(i) A storm water discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines that the discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States (see paragraph (a)(1)(v) of this section);

(ii) A storm water discharge subject to paragraph (c)(1)(v) of this section.

(6) Facilities with existing NPDES permits for storm water discharges associated with industrial activity shall maintain existing permits. New applications shall be submitted in accordance with the requirements of 40 CFR 122.21 and 40 CFR 122.26(c) 180 days before the expiration of such permits. Facilities with expired permits or permits due to expire before May 18, 1992, shall submit applications in accordance with the deadline set forth under paragraph (e)(1) of this section.

(f) *Petitions.* (1) Any operator of a municipal separate storm sewer system may petition the Director to require a separate NPDES permit (or a permit issued under an approved NPDES State program) for any discharge into the municipal separate storm sewer system.

(2) Any person may petition the Director to require a NPDES permit for a discharge which is composed entirely of storm water which contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

(3) The owner or operator of a municipal separate storm sewer system may petition the Director to reduce the Census estimates of the population served by such separate system to account for storm water discharged to combined sewers as defined by 40 CFR 35.2005(b)(11) that is treated in a publicly owned treatment works. In municipalities in which combined sewers are operated, the Census estimates of population may be reduced proportional to the fraction, based on estimated lengths, of the length of combined sewers over the sum of the length of combined sewers and municipal separate storm sewers where an applicant has submitted the NPDES permit number associated with each discharge point and a map indicating areas served by combined sewers and the location of any combined sewer overflow discharge point.

(4) Any person may petition the Director for the designation of a large or medium municipal separate storm sewer system as defined by paragraphs (b)(4)(iv) or (b)(7)(iv) of this section.

(5) The Director shall make a final determination on any petition received under this section within 90 days after receiving the petition.

6. Section 122.28(b)(2)(i) is revised to read as follows:

§ 122.28 General permits (applicable to State NPDES programs, see § 123.25).

* * * * *

(b) * * *

(2) *Requiring an individual permit.* (i) The Director may require any discharger authorized by a general permit to apply for and obtain an individual NPDES permit. Any interested person may petition the Director to take action under this paragraph. Cases where an individual NPDES permit may be required include the following:

(A) The discharger or "treatment works treating domestic sewage" is not in compliance with the conditions of the general NPDES permit;

(B) A change has occurred in the availability of demonstrated technology or practices for the control or abatement of pollutants applicable to the point source or treatment works treating domestic sewage;

(C) Effluent limitation guidelines are promulgated for point sources covered by the general NPDES permit;

(D) A Water Quality Management plan containing requirements applicable to such point sources is approved;

(E) Circumstances have changed since the time of the request to be covered so that the discharger is no longer appropriately controlled under the general permit, or either a temporary or permanent reduction or elimination of the authorized discharge is necessary;

(F) Standards for sewage sludge use or disposal have been promulgated for the sludge use and disposal practice covered by the general NPDES permit; or

(G) The discharge(s) is a significant contributor of pollutants. In making this determination, the Director may consider the following factors:

(*1*) The location of the discharge with respect to waters of the United States;

(*2*) The size of the discharge;

(*3*) The quantity and nature of the pollutants discharged to waters of the United States; and

(*4*) Other relevant factors;

* * * * *

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7. Section 122.42 is amended by adding paragraph (c) to read as follows:

§ 122.42 Additional conditions applicable to specified categories of NPDES permits (applicable to State NPDES programs, see § 123.25).

* * * * *

(c) *Municipal separate storm sewer systems.* The operator of a large or medium municipal separate storm sewer system or a municipal separate storm sewer that has been designated by the Director under § 122.26(a)(1)(v) of this part must submit an annual report by the anniversary of the date of the issuance of the permit for such system. The report shall include:

(1) The status of implementing the components of the storm water management program that are established as permit conditions;

(2) Proposed changes to the storm water management programs that are established as permit condition. Such proposed changes shall be consistent with § 122.26(d)(2)(iii) of this part; and

(3) Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under § 122.26(d)(2)(iv) and (d)(2)(v) of this part;

(4) A summary of data, including monitoring data, that is accumulated throughout the reporting year;

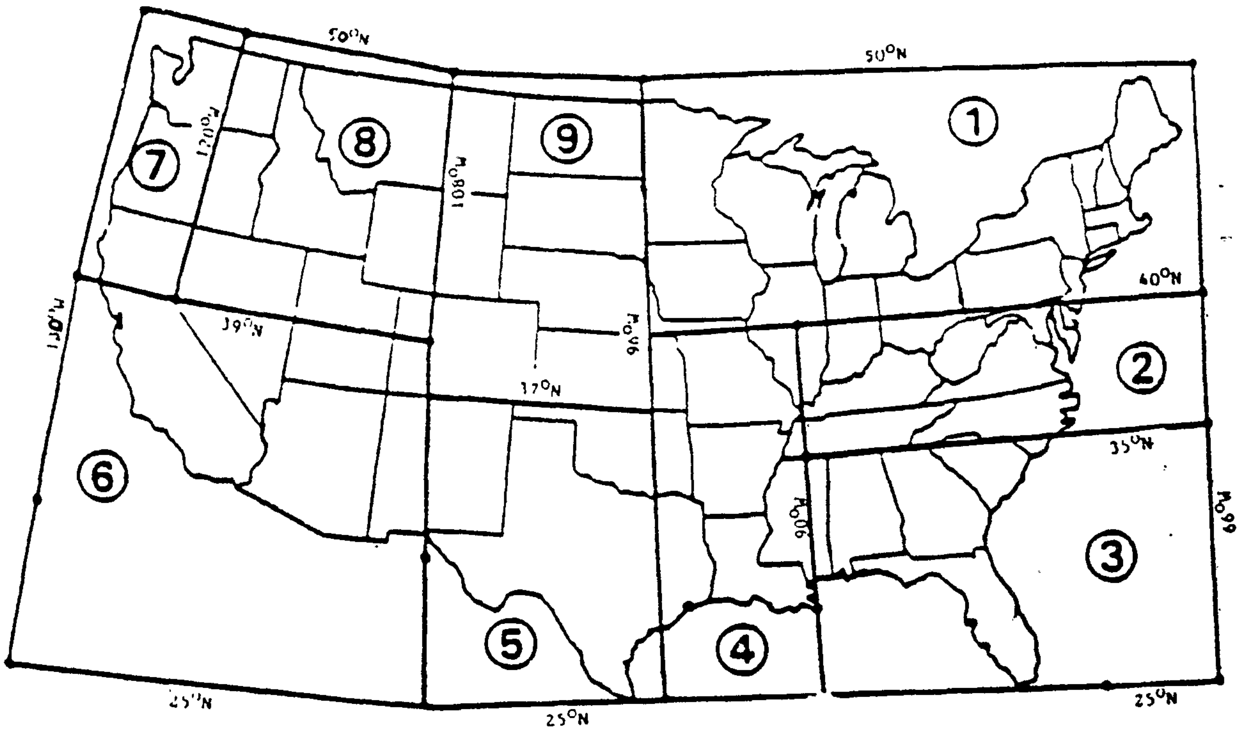
(5) Annual expenditures and budget for year following each annual report;

(6) A summary describing the number and nature of enforcement actions, inspections, and public education programs;

(7) Identification of water quality improvements or degradation;

7a. Part 122 is amended by adding appendices E through I as follows:

Appendix E to Part 122—Rainfall Zones of the United States



Not Shown: Alaska (Zone 7); Hawaii (Zone 7); Northern Mariana Islands (Zone 7); Guam (Zone 7); American Samoa (Zone 7); Trust Territory of the Pacific Islands (Zone 7); Puerto Rico (Zone 3) Virgin Islands (Zone 3).

Source: Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality, prepared for U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Division, Washington, DC, 1986.

Appendix F to Part 122—Incorporated Places With Populations Greater Than 250,000 According to Latest Decennial Census by Bureau of Census.

State	Incorporated place
Alabama	Birmingham.
Arizona	Phoenix.
	Tucson.
California	Long Beach.
	Los Angeles.
	Oakland.
	Sacramento.
	San Diego.
	San Francisco.
	San Jose.
Colorado	Denver.
District of Columbia	
Florida	Jacksonville.
	Miami.
	Tampa.
Georgia	Atlanta.
Illinois	Chicago.
Indiana	Indianapolis.
Kansas	Wichita.
Kentucky	Louisville.
Louisiana	New Orleans.
Maryland	Baltimore.
Massachusetts	Boston.
Michigan	Detroit.
Minnesota	Minneapolis
	St. Paul.

State	Incorporated place
Missouri	Kansas City
	St. Louis.
Nebraska	Omaha.
New Jersey	Newark.
New Mexico	Albuquerque
New York	Buffalo.
	Bronx Borough.
	Brooklyn Borough.
	Manhattan Borough.
	Queens Borough.
	Staten Island Borough.
North Carolina	Charlotte.
Ohio	Cincinnati.
	Cleveland.
	Columbus.
	Toledo.
Oklahoma	Oklahoma City
	Tulsa.
Oregon	Portland.
Pennsylvania	Philadelphia
	Pittsburgh
Tennessee	Memphis.
	Nashville/Davidson
Texas	Austin.
	Dallas.
	El Paso.
	Fort Worth
	Houston.
	San Antonio
Virginia	Norfolk.
	Virginia Beach
Washington	Seattle.
Wisconsin	Milwaukee

Appendix G to Part 122—Incorporated Places With Populations Greater Than 100,000 and Less Than 250,000 According to Latest Decennial Census by Bureau of Census

State	Incorporated place
Alabama	Huntsville.
	Mobile.
	Montgomery
Alaska	Anchorage
Arizona	Mesa.
	Tempe.
Arkansas	Little Rock.
California	Anaheim.
	Bakersfield
	Berkeley
	Concord.
	Fremont.
	Fresno.
	Fullerton.
	Garden Grove.
	Glendale.
	Huntington Beach.
	Modesto.
	Oxnard.
	Pasadena.
	Riverside.
	San Bernadino.
	Santa Ana.
	Stockton.
	Sunnyvale.
	Torrance.
Colorado	Aurora.
	Colorado Springs.
	Lakewood.
	Pueblo.
Connecticut	Bridgeport.
	Hartford.
	New Haven.
	Stamford.
	Waterbury.
Florida	Fort Lauderdale.
	Hialeah.
	Hollywood.
	Orlando.
	St. Petersburg.
Georgia	Columbus.
	Macon.
	Savannah.
Idaho	Boise City.
Illinois	Peoria.
	Rockford.
Indiana	Evansville.
	Fort Wayne.
	Gary.
	South Bend.
Iowa	Cedar Rapids.
	Davenport.
	Des Moines.
Kansas	Kansas City.
	Topeka.
Kentucky	Lexington-Fayette
Louisiana	Baton Rouge
	Shreveport.
Massachusetts	Springfield.
	Worcester
Michigan	Ann Arbor.
	Flint.
	Grand Rapids.
	Lansing.
	Livonia.
	Sterling Heights.
	Warren.
Mississippi	Jackson.
Missouri	Independence.
	Springfield.
Nebraska	Lincoln.
Nevada	Las Vegas
	Reno.
New Jersey	Elizabeth.
	Jersey City.
	Paterson.
New York	Albany.
	Rochester.
	Syracuse.
	Yonkers.
North Carolina	Durham.
	Greensboro.
	Raleigh.
	Winston-Salem
Ohio	Akron.
	Dayton.
	Youngstown
Oregon	Eugene.
Pennsylvania	Allentown.
	Erie.
Rhode Island	Providence.
South Carolina	Columbia.
Tennessee	Chattanooga.
	Knoxville.
Texas	Amarillo.
	Arlington.
	Beaumont.
	Corpus Christi
	Garland.
	Irving.
	Lubbock.
	Pasadena.
	Waco.
Utah	Salt Lake City.
Virginia	Alexandria.
	Chesapeake.
	Hampton.
	Newport News.
	Portsmouth.
	Richmond.
	Roanoke.
Washington	Spokane.
	Tacoma.
Wisconsin	Madison.

Appendix H to Part 122—Counties with Unincorporated Urbanized Areas With a Population of 250,000 or More According to the Latest Decennial Census by the Bureau of Census

State	County	Unincorporated urbanized population
California	Los Angeles	912,864
	Sacramento	449,056
	San Diego	304,758
Delaware	New Castle	257,184
Florida	Dade	781,949
Georgia	DeKalb	386,379
Hawaii	Honolulu	688,178
Maryland	Anne Arundel	271,458
	Baltimore	601,308
	Montgomery	447,993
	Prince George's	450,188
Texas	Harris	409,601
Utah	Salt Lake	304,632
Virginia	Fairfax	527,178
Washington	King	336,800

Appendix I to Part 122—Counties With Unincorporated Urbanized Areas Greater Than 100,000, But Less Than 250,000 According to the Latest Decennial Census by the Bureau of Census

State	County	Unincorporated urbanized population
Alabama	Jefferson	102,917
Arizona	Pima	111,479
California	Alameda	187,474
	Contra Costa	158,452
	Kern	117,231
	Orange	210,693
	Riverside	115,719
	San Bernardino	148,944
Florida	Broward	159,370
	Escambia	147,892
	Hillsborough	238,292
	Orange	245,325
	Palm Beach	167,089
	Pinellas	194,389
	Polk	104,150
	Sarasota	110,000
Georgia	Clayton	100,742
	Cobb	204,121
	Richmond	118,529
Kentucky	Jefferson	224,958
Louisiana	Jefferson	140,836
North Carolina	Cumberland	142,727
Nevada	Clark	201,775
Oregon	Multnomah	141,190
	Washington	108,345
South Carolina	Greenville	135,384
	Richland	124,004
Virginia	Arlington	152,599
	Henrico	161,204
	Chesterfield	108,349
Washington	Snohomish	103,493
	Pierce	188,113

PART 123—STATE PROGRAM REQUIREMENTS

8. The authority citation for part 123 continues to read as follows:

R0008323

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

9. Section 123.25 is amended by revising paragraph (a)(9) to read as follows:

§ 123.25 Requirements for permitting.

(a) * * *

(9) § 122.26—(Storm water discharges);

* * * * *

PART 124—PROCEDURES FOR DECISIONMAKING

10. The authority citation for part 124 continues to read as follows:

Authority: Resource Conservation and Recovery Act, 42 U.S.C. 6901 *et seq.*; Safe Drinking Water Act, 42 U.S.C. 300f *et seq.*; Clean Water Act, 33 U.S.C. 1251 *et seq.*; and Clean Air Act, 42 U.S.C. 1857 *et seq.*

11. Section 124.52 is revised to read as follows:

§ 124.52 Permits required on a case-by-case basis.

(a) Various sections of part 122, subpart B allow the Director to determine, on a case-by-case basis, that certain concentrated animal feeding operations (§ 122.23), concentrated aquatic animal production facilities (§ 122.24), storm water discharges (§ 122.26), and certain other facilities covered by general permits (§ 122.28) that do not generally require an individual permit may be required to obtain an individual permit because of their contributions to water pollution.

(b) Whenever the Regional Administrator decides that an individual permit is required under this section, except as provided in paragraph (c) of this section, the Regional Administrator shall notify the discharger in writing of that decision and the reasons for it, and shall send an application form with the notice. The discharger must apply for a permit under § 122.21 within 60 days of notice, unless permission for a later date is granted by the Regional Administrator. The question whether the designation was proper will remain open for consideration during the public comment period under § 124.11 or § 124.118 and in any subsequent hearing.

(c) Prior to a case-by-case determination that an individual permit is required for a storm water discharge under this section (*see* 40 CFR 122.26 (a)(1)(v) and (c)(1)(v)), the Regional Administrator may require the discharger to submit a permit application or other information regarding the discharge under section 308 of the CWA. In requiring such information, the Regional Administrator shall notify the discharger in writing and shall send an application form with the notice. The discharger must apply for a permit under § 122.26 within 60 days of notice, unless permission for a later date is granted by the Regional Administrator. The question whether the initial designation was proper will remain open for consideration during the public comment period under § 124.11 or § 124.118 and in any subsequent hearing.

Note: The following form will not appear in the Code of Federal Regulations.

BILLING CODE 6560-50-M

R0008324

Please print or type in the unshaded areas only

EPA ID Number (copy from Item 1 of Form 1)

Form Approved. OMB No. 2040-0086
Approval expires 5/31/92

Form 2F NPDES

EPA

United States Environmental Protection Agency
Washington, DC 20460

Application for Permit To Discharge Stormwater Discharges Associated with Industrial Activity

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 28.6 hours per application, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of this collection of information, or suggestions for improving this form, including suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M St., SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

I. Outfall Location

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. Outfall Number (list)	B. Latitude			C. Longitude			D. Receiving Water (name)

II. Improvements

A. Are you now required by any Federal, State, or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

1. Identification of Conditions, Agreements, Etc.	2. Affected Outfalls		3. Brief Description of Project	4. Final Compliance Date	
	number	source of discharge		a. req.	b. proj.

B. You may attach additional sheets describing any additional water pollution (or other environmental projects which may affect your discharges) you now have under way or which you plan. Indicate whether each program is now under way or planned, and indicate your actual or planned schedules for construction.

III. Site Drainage Map

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including: each of its intake and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied; each of its hazardous waste treatment, storage or disposal units (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility.

 Continue on Page 2

R0008325

Continued from the Front

IV. Narrative Description of Pollutant Sources

A. For each outfall, provide an estimate of the area (include units) of impervious surfaces (including paved areas and building roofs) drained to the outfall, and an estimate of the total surface area drained by the outfall.

Outfall Number	Area of Impervious Surface *(provide units)*	Total Area Drained *(provide units)*	Outfall Number	Area of Impervious Surface *(provide units)*	Total Area Drained *(provide units)*

B. Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage, or disposal; past and present materials management practices employed, in the last three years, to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied

C. For each outfall, provide the location and a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the schedule and type of maintenance for control and treatment measures and the ultimate disposal of any solid or fluid wastes other than by discharge

Outfall Number	Treatment	List Codes from Table 2F-1

V. Nonstormwater Discharges

A. I certify under penalty of law that the outfall(s) covered by this application have been tested or evaluated for the presence of nonstormwater discharges, and that all nonstormwater discharges from these outfall(s) are identified in either an accompanying Form 2C or Form 2E application for the outfall.

Name and Official Title *(type or print)*	Signature	Date Signed

B. Provide a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test.

VI. Significant Leaks or Spills

Provide existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years, including the approximate date and location of the spill or leak, and the type and amount of material released.

 Continue on Page 3

Continued from Page 2

EPA ID Number *(copy from Item I of Form 1)*

VII. Discharge Information

A,B,C, & D: See instructions before proceeding. Complete one set of tables for each outfall. Annotate the outfall number in the space provided. Tables VII-A, VII-B, and VII-C are included on separate sheets numbered VII-1 and VII-2.

E: Potential discharges not covered by analysis - Is any pollutant listed in Table 2F-2 a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ Yes *(list all such pollutants below)* ☐ No *(go to Section VIII)*

VIII. Biological Toxicity Testing Data

☐ Yes *(list results below)* ☐ No *(go to Section IX)*

IX. Contract Analysis Information

☐ Yes ☐ No *(go to Section X)*

A. Name	B. Address	C. Area Code & Phone No.	D. Pollutants Analyzed

X. Certification

A. Name & Official Title *(type or print)*	B. Area Code and Phone No.
C. Signature	D. Date Signed

R0008327

EPA ID Number *(copy from item I of Form 1)*

Form Approved. OMB No. 2040-0086
Approval expires 5/31/92

VII. Discharge Information *(Continued from page 3 of Form 2F)*

Part A - You must provide the results of **at least** one analysis for **every pollutant** in this table. Complete one table for each outfall. See instructions for additional details.

Pollutant and CAS Number *(if available)*	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		
Oil and Grease						
Biological Oxygen Demand (BOD5)						
Chemical Oxygen Demand (COD)						
Total Suspended Solids (TSS)						
Total Kjeldahl Nitrogen						
Nitrate plus Nitrite Nitrogen						
Total Phosphorus						
pH	Minimum	Maximum	Minimum	Maximum		

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number *(if available)*	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		

Continue on Reverse

Continued from the Front

Part C - List each pollutant shown in Tables 2F-2, 2F-3, and 2F-4 that you know or have reason to believe is present. See the instructions for additional details and requirements. Complete one table for each outfall.

Pollutant and CAS Number *(if available)*	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1. Date of Storm Event	2. Duration of Storm *(in minutes)*	3. Total rainfall during storm event *(in inches)*	4. Number of hours between beginning of storm measured and end of previous measurable rain event	5. Maximum floe rate during rain event *(gallons/minute or specify units*	6. Total flow from rain event *(gallons or specify units)*	7. Season sample was taken	8. Form of Precipitation *(rainfall, snowmelt)*

9. Provide a description of the method of flow measurement or estimate.

R0008329

Instructions - Form 2F
Application for Permit to Discharge Storm Water Associated with Industrial Activity

Who Must File Form 2F

Form 2F must be completed by operators of facilities which discharge storm water associated with industrial activity or by operators of storm water discharges that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard.

Operators of discharges which are composed entirely of storm water must complete Form 2F (EPA Form 3510-2F) in conjunction with Form 1 (EPA Form 3510-1).

Operators of discharges of storm water which are combined with process wastewater (process wastewater is water that comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, waste product, or wastewater) must complete and submit Form 2F, Form 1, and Form 2C (EPA Form 3510-2C).

Operators of discharges of storm water which are combined with nonprocess wastewater (nonprocess wastewater includes noncontact cooling water and sanitary wastes which are not regulated by effluent guidelines or a new source performance standard, except discharges by educational, medical, or commercial chemical laboratories) must complete Form 1, Form 2F, and Form 2E (EPA Form 3510-2E).

Operators of new sources or new discharges of storm water associated with industrial activity which will be combined with other nonstormwater new sources or new discharges must submit Form 1, Form 2F, and Form 2D (EPA Form 3510-2D).

Where to File Applications

The application forms should be sent to the EPA Regional Office which covers the State in which the facility is located. Form 2F must be used only when applying for permits in States where the NPDES permits program is administered by EPA. For facilities located in States which are approved to administer the NPDES permits program, the State environmental agency should be contacted for proper permit application forms and instructions.

Information on whether a particular program is administered by EPA or by a State agency can be obtained from your EPA Regional Office. Form 1, Table 1 of the "General Instructions" lists the addresses of EPA Regional Offices and the States within the jurisdiction of each Office.

Completeness

Your application will not be considered complete unless you answer every question on this form and on Form 1. If an item does not apply to you, enter "NA" (for not applicable) to show that you considered the question.

Public Availability of Submitted Information

You may not claim as confidential any information required by this form or Form 1, whether the information is reported on the forms or in an attachment. Section 402(j) of the Clean Water Act requires that all permit applications will be available to the public. This information will be made available to the public upon request.

Any information you submit to EPA which goes beyond that required by this form, Form 1, or Form 2C you may claim as confidential, but claims for information which are effluent data will be denied.

If you do not assert a claim of confidentiality at the time of submitting the information, EPA may make the information public without further notice to you. Claims of confidentiality will be handled in accordance with EPA's business confidentiality regulations at 40 CFR Part 2.

Definitions

All significant terms used in these Instructions and in the form are defined in the glossary found in the General Instructions which accompany Form 1.

EPA ID Number

Fill in your EPA Identification Number at the top of each odd-numbered page of Form 2F. You may copy this number directly from item I of Form 1.

Item I

You may use the map you provided for item XI of Form 1 to determine the latitude and longitude of each of your outfalls and the name of the receiving water.

Item II-A

If you check "yes" to this question, complete all parts of the chart, or attach a copy of any previous submission you have made to EPA containing the same information.

Item II-B

You are not required to submit a description of future pollution control projects if you do not wish to or if none is planned.

Item III

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including:

each of its drainage and discharge structures;

the drainage area of each storm water outfall;

paved areas and building within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied;

each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste for less than 90 days under 40 CFR 262.34);

each well where fluids from the facility are injected underground; and

springs, and other surface water bodies which receive storm water discharges from the facility;

Item IV-A

For each outfall, provide an estimate of the area drained by the outfall which is covered by impervious surfaces. For the purpose of this application, impervious surfaces are surfaces where storm water runs off at rates that are significantly higher than background rates (e.g., predevelopment levels) and include paved areas, building roofs, parking lots, and roadways. Include an estimate of the total area (including all impervious and pervious areas) drained by each outfall. The site map required under item III can be used to estimate the total area drained by each outfall.

Item IV-B

Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored, or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of these materials; past and present materials management practices employed, in the last three years, to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied. Significant materials should be identified by chemical name, form (e.g., powder, liquid, etc.), and type of container or treatment unit. Indicate any materials treated, stored, or disposed of together. "Significant materials" includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of CERCLA; any chemical the facility is required to report pursuant to Section 313 of Title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

Item IV-C

For each outfall, structural controls include structures which enclose material handling or storage areas, covering materials, berms, dikes, or diversion ditches around manufacturing, production, storage or treatment units, retention ponds, etc. Nonstructural controls include practices such as spill prevention plans, employee training, visual inspections, preventive maintenance, and housekeeping measures that are used to prevent or minimize the potential for releases of pollutants.

Item V

Provide a certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by an NPDES permit. Tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. Part B must include a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test. All non-storm water discharges must be identified in a Form 2C or Form 2E which must accompany this application (see beginning of instructions under section titled "Who Must File Form 2F" for a description of when Form 2C and Form 2E must be submitted).

Item VI

Provide a description of existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years.

Item VII-A, B, and C

These items require you to collect and report data on the pollutants discharged for each of your outfalls. Each part of this item addresses a different set of pollutants and must be completed in accordance with the specific instructions for that part. The following general instructions apply to the entire item.

General Instructions

Part A requires you to report at least one analysis for each pollutant listed. Parts B and C require you to report analytical data in two ways. For some pollutants addressed in Parts B and C, if you know or have reason to know that the pollutant is present in your discharge, you may be required to list the pollutant and test (sample and analyze) and report the levels of the pollutants in your discharge. For all other pollutants addressed in Parts B and C, you must list the pollutant if you know or have reason to know that the pollutant is present in the discharge, and either report quantitative data for the pollutant or briefly describe the reasons the pollutant is expected to be discharged. (See specific instructions on the form and below for Parts A through C.) Base your determination that a pollutant is present in or absent from your discharge on your knowledge of your raw materials, material management practices, maintenance chemicals, history of spills and releases, intermediate and final products and byproducts, and any previous analyses known to you of your effluent or similar effluent.

A. **Sampling:** The collection of the samples for the reported analyses should be supervised by a person experienced in performing sampling of industrial wastewater or storm water discharges. You may contact EPA or your State permitting authority for detailed guidance on sampling techniques and for answers to specific questions. Any specific requirements contained in the applicable analytical methods should be followed for sample containers, sample preservation, holding times, the collection of duplicate samples, etc. The time when you sample should be representative, to the extent feasible, of your treatment system operating properly with no system upsets. Samples should be collected from the center of the flow channel, where turbulence is at a maximum, at a site specified in your present permit, or at any site adequate for the collection of a representative sample.

   For pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, and fecal coliform, grab samples taken during the first 30 minutes (or as soon thereafter as practicable) of the discharge must be used (you are not required to analyze a flow-weighted composite for these parameters). For all other pollutants both a grab sample collected during the first 30 minutes (or as soon thereafter as practicable) of the discharge and a flow-weighted composite sample must be analyzed. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period of greater than 24 hours.

   All samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area.

   A grab sample shall be taken during the first thirty minutes of the discharge (or as soon thereafter as practicable), and a flow-weighted composite shall be taken for the entire event or for the first three hours of the event.

   Grab and composite samples are defined as follows:

Grab sample: An individual sample of at least 100 milliliters collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge. This sample is to be analyzed separately from the composite sample.

Flow-Weighted Composite sample: A flow-weighted composite sample may be taken with a continuous sampler that proportions the amount of sample collected with the flow rate or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire event or for the first three hours of the event, with each aliquot being at least 100 milliliters and collected with a minimum period of fifteen minutes between aliquot collections. The composite must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically. Where GC/MS Volatile Organic Analysis (VOA) is required, aliquots must be combined in the laboratory immediately before analysis. Only one analysis for the composite sample is required.

Data from samples taken in the past may be used, provided that:

All data requirements are met;

Sampling was done no more than three years before submission; and

All data are representative of the present discharge.

Among the factors which would cause the data to be unrepresentative are significant changes in production level, changes in raw materials, processes, or final products, and changes in storm water treatment. When the Agency promulgates new analytical methods in 40 CFR Part 136, EPA will provide information as to when you should use the new methods to generate data on your discharges. Of course, the Director may request additional information, including current quantitative data, if they determine it to be necessary to assess your discharges. The Director may allow or establish appropriate site-specific sampling procedures or requirements, including sampling locations, the season in which the sampling takes place, the minimum duration between the previous measurable storm event and the storm event sampled, the minimum or maximum level of precipitation required for an appropriate storm event, the form of precipitation sampled (snow melt or rainfall), protocols for collecting samples under 40 CFR Part 136, and additional time for submitting data on a case-by-case basis.

B. **Reporting:** All levels must be reported as concentration and as total mass. You may report some or all of the required data by attaching separate sheets of paper instead of filling out pages VII-1 and VII-2 if the separate sheets contain all the required information in a format which is consistent with pages VII-1 and VII-2 in spacing and in identification of pollutants and columns. Use the following abbreviations in the columns headed "Units."

Concentration		Mass	
ppm	parts per million	lbs	pounds
mg/1	milligrams per liter	ton	tons (English tons)
ppb	parts per billion	mg	milligrams
ug/1	micrograms per liter	g	grams
kg	kilograms	T	tonnes (metric tons)

All reporting of values for metals must be in terms of "total recoverable metal," unless:

(1) An applicable, promulgated effluent limitation or standard specifies the limitation for the metal in dissolved, valent, or total form; or

(2) All approved analytical methods for the metal inherently measure only its dissolved form (e.g., hexavalent chromium); or

(3) The permitting authority has determined that in establishing case-by-case limitations it is necessary to express the limitations on the metal in dissolved, valent, or total form to carry out the provisions of the CWA. If you measure only one grab sample and one flow-weighted composite sample for a given outfall, complete only the "Maximum Values" columns and insert "1" into the "Number of Storm Events Sampled" column. The permitting authority may require you to conduct additional analyses to further characterize your discharges.

If you measure more than one value for a grab sample or a flow-weighted composite sample for a given outfall and those values are representative of your discharge, you must report them. You must describe your method of testing and data analysis. You also must determine the average of all values within the last year and report the concentration mass under the "Average Values" columns, and the total number of storm events sampled under the "Number of Storm Events Sampled" columns.

C. Analysis: You must use test methods promulgated in 40 CFR Part 136; however, if none has been promulgated for a particular pollutant, you may use any suitable method for measuring the level of the pollutant in your discharge provided that you submit a description of the method or a reference to a published method. Your description should include the sample holding time, preservation techniques, and the quality control measures which you used. If you have two or more substantially identical outfalls, you may request permission from your permitting authority to sample and analyze only one outfall and submit the results of the analysis for other substantially identical outfalls. If your request is granted by the permitting authority, on a separate sheet attached to the application form, identify which outfall you did test, and describe why the outfalls which you did not test are substantially identical to the outfall which you did test.

Part VII-A

Part VII-A must be completed by all applicants for all outfalls who must complete Form 2F.

Analyze a grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results except use only grab samples for pH and oil and grease. See discussion in General Instructions to Item VII for definitions of grab sample collected during the first thirty minutes of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Part VII-B

List all pollutants that are limited in an effluent guideline which the facility is subject to (see 40 CFR Subchapter N to determine which pollutants are limited in effluent guidelines) or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See discussion in General instructions to item VII for definitions of grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Analyze a grab sample collected during the first thirty minutes of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results, except as provided in the General Instructions.

Part VII-C

Part VII-C must be completed by all applicants for all outfalls which discharge storm water associated with industrial activity, or that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard. Use both a grab sample and a composite sample for all pollutants you analyze for in this part except use grab samples for residual chlorine and fecal coliform. The "Average Values" column is not compulsory but should be filled out if data are available. Part C requires you to address the pollutants in Table 2F-2, 2F-3, and 2F-4 for each outfall. Pollutants in each of these Tables are addressed differently.

Table 2F-2: For each outfall, list all pollutants in Table 2F-2 that you know or have reason to believe are discharged (except pollutants previously listed in Part VII-B). If a pollutant is limited in an effluent guideline limitation which the facility is subject to (e.g., use of TSS as an indicator to control the discharge of iron and aluminum), the pollutant should be listed in Part VII-B. If a pollutant in table 2F-2 is indirectly limited by an effluent guideline limitation through an indicator, you must analyze for it and report data in Part VII-C. For other pollutants listed in Table 2F-2 (those not limited directly or indirectly by an effluent limitation guideline), that you know or have reason to believe are discharges, you must either report quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Table 2F-3: For each outfall, list all pollutants in Table 2F-3 that you know or have reason to believe are discharged. For every pollutant in Table 2F-3 expected to be discharged in concentrations of 10 ppb or greater, you must submit quantitative data. For acrolein, acrylonitrile, 2,4 dinitrophenol, and 2-methyl-4,6 dinitrophenol, you must submit quantitative data if any of these four pollutants is expected to be discharged

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in concentrations of 100 ppb or greater. For every pollutant expected to be discharged in concentrations less than 10 ppb (or 100 ppb for the four pollutants listed above), then you must either submit quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Small Business Exemption - If you are a "small business," you are exempt from the reporting requirements for the organic toxic pollutants listed in Table 2F-3. There are two ways in which you can qualify as a "small business". If your facility is a coal mine, and if your probable total annual production is less than 100,000 tons per year, you may submit past production data or estimated future production (such as a schedule of estimated total production under 30 CFR 795.14(c)) instead of conducting analyses for the organic toxic pollutants. If your facility is not a coal mine, and if your gross total annual sales for the most recent three years average less than $100,000 per year (in second quarter 1980 dollars), you may submit sales data for those years instead of conducting analyses for the organic toxic pollutants. The production or sales data must be for the facility which is the source of the discharge. The data should not be limited to production or sales for the process or processes which contribute to the discharge, unless those are the only processes at your facility. For sales data, in situations involving intracorporate transfer of goods and services, the transfer price per unit should approximate market prices for those goods and services as closely as possible. Sales figures for years after 1980 should be indexed to the second quarter of 1980 by using the gross national product price deflator (second quarter of 1980=100). This index is available in National Income and Product Accounts of the United States (Department of Commerce, Bureau of Economic Analysis).

Table 2F-4: For each outfall, list any pollutant in Table 2F-4 that you know or believe to be present in the discharge and explain why you believe it to be present. No analysis is required, but if you have analytical data, you must report them. **Note:** Under 40 CFR 117.12(a)(2), certain discharges of hazardous substances (listed at 40 CFR 177.21 or 40 CFR 302.4) may be exempted from the requirements of section 311 of CWA, which establishes reporting requirements, civil penalties, and liability for cleanup costs for spills of oil and hazardous substances. A discharge of a particular substance may be exempted if the origin, source, and amount of the discharged substances are identified in the NPDES permit application or in the permit, if the permit contains a requirement for treatment of the discharge, and if the treatment is in place. To apply for an exclusion of the discharge of any hazardous substance from the requirements of section 311, attach additional sheets of paper to your form, setting forth the following information:

1. The substance and the amount of each substance which may be discharged.
2. The origin and source of the discharge of the substance.
3. The treatment which is to be provided for the discharge by:
   a. An onsite treatment system separate from any treatment system treating your normal discharge;
   b. A treatment system designed to treat your normal discharge and which is additionally capable of treating the amount of the substance identified under paragraph 1 above; or
   c. Any combination of the above.

See 40 CFR 117.12(a)(2) and (c), published on August 29, 1979, in 44 FR 50766, or contact your Regional Office (Table 1 on Form 1, Instructions), for further information on exclusions from section 311.

Part VII-D

If sampling is conducted during more than one storm event, you only need to report the information requested in Part VII-D for the storm event(s) which resulted in any maximum pollutant concentration reported in Part VII-A, VII-B, or VII-C.

Provide flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, the method of flow measurement, or estimation. Provide the data and duration of the storm event(s) sampled, rainfall measurements, or estimates of the storm event which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event.

Part VII-E

List any toxic pollutant listed in Tables 2F-2, 2F-3, or 2F-4 which you currently use or manufacture as an intermediate or final product or byproduct. In addition, if you know or have reason to believe that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is discharged or if you use or manufacture 2,4,5-trichlorophenoxy acetic acid (2,4,5,-T); 2-(2,4,5-trichlorophenoxy) propanoic acid (Silvex, 2,4,5,-TP); 2-(2,4,5-trichlorophenoxy) ethyl, 2,2-dichloropropionate (Erbon); O,O-dimethyl O-(2,4,5-trichlorphenyl) phosphorothioate (Ronnel); 2,4,5-trichlorophenol (TCP); or hexachlorophene (HCP); then list TCDD. The Director may waive or modify the requirement if you demonstrate that it would be unduly burdensome to identify each toxic pollutant and the Director has adequate information to issue your permit. You may not claim this information as confidential; however, you do not have to distinguish between use or production of the pollutants or list the amounts.

Item VIII

Self explanatory. The permitting authority may ask you to provide additional details after your application is received.

Item X

The Clean Water Act provides for severe penalties for submitting false information on this application form.

Section 309(c)(4) of the Clean Water Act provides that "Any person who knowingly makes any false material statement, representation, or certification in any application, . . . shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction of such person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both." 40 CFR Part 122.22 requires the certification to be signed as follows:

(A) **For a corporation:** by a responsible corporate official. For purposes of this section, a responsible corporate official means (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25,000,000 (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

Note: EPA does not require specific assignments or delegation of authority to responsible corporate officers identified in 122.22(a)(1)(i). The Agency will presume that these responsible corporate officers have the requisite authority to sign permit applications unless the corporation has notified the Director to the contrary. Corporate procedures governing authority to sign permit applications may provide for assignment or delegation to applicable corporate position under 122.22(a)(1)(ii) rather than to specific individuals.

(B) **For a partnership or sole proprietorship:** by a general partner or the proprietor, respectively; or

(C) **For a municipality, State, Federal, or other public agency:** by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of EPA).

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Table 2F-1

Codes for Treatment Units

Physical Treatment Processes

1-A	Ammonia Stripping	1-M	Grit Removal
1-B	Dialysis	1-N	Microstraining
1-C	Diatomaceous Earth Filtration	1-O	Mixing
1-D	Distillation	1-P	Moving Bed Filters
1-E	Electrodialysis	1-Q	Multimedia Filtration
1-F	Evaporation	1-R	Rapid Sand Filtration
1-G	Flocculation	1-S	Reverse Osmosis (Hyperfiltration)
1-H	Flotation	1-T	Screening
1-I	Foam Fractionation	1-U	Sedimentation (Setting)
1-J	Freezing	1-V	Slow Sand Filtration
1-K	Gas-Phase Separation	1-W	Solvent Extraction
1-L	Grinding (Comminutors)	1-X	Sorption

Chemical Treatment Processes

2-A	Carbon Adsorption	2-G	Disinfection (Ozone)
2-B	Chemical Oxidation	2-H	Disinfection (Other)
2-C	Chemical Precipitation	2-I	Electrochemical Treatment
2-D	Coagulation	2-J	Ion Exchange
2-E	Dechlorination	2-K	Neutralization
2-F	Disinfection (Chlorine)	2-L	Reduction

Biological Treatment Processes

3-A	Activated Sludge	3-E	Pre-Aeration
3-B	Aerated Lagoons	3-F	Spray Irrigation/Land Application
3-C	Anaerobic Treatment	3-G	Stabilization Ponds
3-D	Nitrification-Denitrification	3-H	Trickling Filtration

Other Processes

4-A	Discharge to Surface Water	4-C	Reuse/Recycle of Treated Effluent
4-B	Ocean Discharge Through Outfall	4-D	Underground Injection

Sludge Treatment and Disposal Processes

5-A	Aerobic Digestion	5-M	Heat Drying
5-B	Anaerobic Digestion	5-N	Heat Treatment
5-C	Belt Filtration	5-O	Incineration
5-D	Centrifugation	5-P	Land Application
5-E	Chemical Conditioning	5-Q	Landfill
5-F	Chlorine Treatment	5-R	Pressure Filtration
5-G	Composting	5-S	Pyrolysis
5-H	Drying Beds	5-T	Sludge Lagoons
5-I	Elutriation	5-U	Vacuum Filtration
5-J	Flotation Thickening	5-V	Vibration
5-K	Freezing	5-W	Wet Oxidation
5-L	Gravity Thickening		

Table 2F-2

Conventional and Nonconventional Pollutants Required To Be Tested by Existing Discharger if Expected To Be Present

Bromide
Chlorine, Total Residual
Color
Fecal Coliform
Fluoride
Nitrate-Nitrite
Nitrogen, Total Kjedahl
Oil and Grease
Phosphorus, Total Radioactivity
Sulfate
Sulfide
Sulfite
Surfactants
Aluminum, Total
Barium, Total
Boron, Total
Cobalt, Total
Iron, Total
Magnesium, Total
Molybdenum, Total
Magnesium, Total
Tin, Total
Titanium, Total

Table 2F-3

Toxic pollutants required to be identified by applicant if expected to be present

Toxic Pollutants and Total Phenol

Antimony, Total	Copper, Total	Silver, Total
Arsenic, Total	Lead, Total	Thallium, Total
Beryllium, Total	Mercury, Total	Zinc, Total
Cadmium, Total	Nickel, Total	Cyanide, Total
Chromium Total	Selenium, Total	Phenols, Total

GC/MS Fraction Volatiles Compounds

Acrolein	Dichlorobromomethane	1,1,2,2,-Tetrachloroethane
Acrylonitrile	1,1-Dichloroethane	Tetrachloroethylene
Benzene	1,2-Dichloroethane	Toluene
Bromoform	1,1-Dichloroethylene	1,2-Trans-Dichloroethylene
Carbon Tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
Chlorobenzene	1,3-Dichloropropylene	1,1,2-Trichloroethane
Chlorodibromomethane	Ethylbenzene	Trichloroethylene
Chloroethane	Methyl Bromide	Vinyl Chloride
2 Chloroethylvinyl Ether	Methyl Chloride	
Chloroform	Methylene Chloride	

Acid Compounds

2 Chlorophenol	2,4-Dinitrophenol	Pentachlorophenol
2,4 Dichlorophenol	2-Nitrophenol	Phenol
2,4-Dimethylphenol	4-Nitrophenol	2,4,6-Trichlorophenol
4,6-Dinitro O-Cresol	p-Chloro-M-Cresol	

Base/Neutral

Acenaphthene	2-Chloronaphthalene	Fluoranthene
Acenaphthylene	4-Chlorophenyl Phenyl Ether	Fluorene
Anthracene	Chrysene	Hexachlorobenzene
Benzidine	Dibenzo(a,h)anthracene	Hexachlorobutadiene
Benzo(a)anthracene	1,2-Dichlorobenzene	Hexachloroethane
Benzo(a)pyrene	1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene
3,4-Benzofluoranthene	1,4-Dichlorobenzene	Isophorone
Benzo(ghi)perylene	3,3'-Dichlorobenzidine	Napthalene
Benzo(k)fluoranthene	Diethyl Phthalate	Nitrobenzene
Bis(2-chloroethoxy)methane	Dimethyl Phthalate	N-Nitrosodimethylamine
Bis(2-chloroethyl)ether	Di-N-Butyl Phthalate	N-Nitrosodi-N-Propylamine
Bis(2-chloroisopropyl)ether	2,4-Dinitrotoluene	N-Nitrosodiphenylamine
Bis(2-ethylyhexyl)phthalate	2,6-Dinitrotoluene	Phenanthrene
4-Bromophenyl Phenyl Ether	Di-N-Octylphthalate	Pyrene
Butylbenzyl Phthalate	1,2-Diphenylhydrazine (as Azobenzene)	1,2,4-Trichlorobenzene

Pesticides

Aldrin	Dieldrin	PCB-1254
Alpha-BHC	Alpha-Endosulfan	PCB-1221
Beta-BHC	Beta-Endosulfan	PCB-1232
Gamma-BHC	Endosulfan Sulfate	PCB-1248
Delta-BHC	Endrin	PCB-1260
Chlordane	Endrin Aldehyde	PCB-1016
4,4'-DDT	Heptachlor	Toxaphene
4,4'-DDE	Heptachlor Epoxide	
4,4'-DDD	PCB-1242	

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Table 2F-4

Hazardous substances required to be identified by applicant if expected to be present

Toxic Pollutant

Asbestos

Hazardous Substances

Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos
Cresol
Crotonaldehyde
Cyclohexane
2,4-D (2,4-Dichlorophenoxyacetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid
Dichlorvos
Diethyl amine
Dimethyl amine
Dinitrobenzene
Diquat
Disulfoton
Diuron
Epichlorohydrin
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion
Isoprene
Isopropanolamine
Kelthane
Kepone
Malathion
Mercaptodimethur
Methoxychlor
Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mevinphos
Mexacarbate
Monoethyl amine
Monomethyl amine
Naled
Napthenic acid
Nitrotoluene
Parathion
Phenolsulfonate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Stronthium
Strychnine
Styrene
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)
TDE (Tetrachlorodiphenyl ethane)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofan
Triethylamine
Trimethylamine
Uranium
Vanadium
Vinyl acetate
Xylene
Xylenol
Zirconium

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Part II

Environmental Protection Agency

Water Pollution Control, NPDES General Permits and Fact Sheets: Storm Water Discharges From Industrial Activity; Notice

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TABLE 4.—ADVANCED BMP ALTERNATIVES

Prevention	Containment	Mitigation		Waste disposal
		Cleanup	Treatment	
Monitoring	Secondary containment	Physical	Liquid-solids separation.	Landfill.
Nondestructive	Flow diversion to secondary containment.	Mechanical	Volatilization	Land treatment.
Labeling	Vapor control	Chemical	Coagulation/precipitation.	Reclamation.
Covering	Dust control		Neutralization	Discharge to surface water.
Pneumatic and vacuum conveying	Sealing		Ion exchange	Deep well injection.
Vehicle positioning			Chemical oxidation	Discharge to POTW.
Dry cleanup			Biological treatment	Offsite disposal.
			Thermal oxidation	

3. Traditional Storm Water Management Practices

In some situations, traditional storm water management practices such as grass swales, catch basin design and maintenance, infiltration devices, unlined retention or detention basins, water reuse, and oil and grit separators can be applied to an industrial setting. However, care must be taken to evaluate the potential of many of these traditional devices for ground water contamination. In some cases, it is appropriate to limit traditional storm water management practices to those areas of the drainage system that generate storm water discharges with relatively low levels of pollutants (e.g., many rooftops, parking lots, etc.). At facilities located in northern areas of the country, snow removal activities may play an important role in a storm water management program. In addition, other types of controls such as spill prevention measures can be considered to prevent catastrophic events that can lead to surface or ground water contamination.

4. Diversion of Discharge to Sewage Treatment Plant

Where storm water discharges contain significant amounts of pollutants that can be removed by a sewage treatment plant, the storm water discharge can be discharged to the sanitary sewage system. Such diversions must be coordinated with the operators of the sewage treatment plant and the collection system to avoid worsening problems with either combined sewer overflows (CSOs), basement flooding or wet weather operation of the treatment plant. Where CSO discharges, flooding or plant operation problems can result, onsite storage followed by a controlled release during dry weather conditions may be considered.

5. End-of-Pipe Treatment

End-of-pipe treatment requirements are typically imposed through numeric effluent limitations, which provide the discharger with flexibility to design the most cost effective type of treatment for the given facility.

At many types of industrial facilities, it may be appropriate to collect and treat the runoff from targeted areas of the facility. This approach was taken with 10 industrial categories with national effluent guideline limitations for storm water discharges. There are several basic similarities among the national effluent guideline limitations for storm water discharges:

- To meet the numeric effluent limitation, most, if not all, facilities must collect and temporarily store onsite runoff from targeted areas of the plant.
- The effluent guideline limitations do not apply to discharges whenever rainfall events, either chronic or catastrophic, cause an overflow of storage devices designed, constructed, and operated to contain a design storm. The 10-year, 24-hour storm, or the 25-year, 24-hour storm commonly are used as the design storm in the effluent guideline limitations.
- Most technology-based treatment standards are based on relatively simple technologies such as settling of solids, neutralization, and drum filtration. Potential ground water impacts should also be considered by operators when designing storage devices.

V. The Federal/Municipal Partnership: The Role of Municipal Operators of Large and Medium Municipal Separate Storm Sewer Systems

A key issue in developing a workable regulatory program for controlling pollutants in storm water discharges associated with industrial activity is the proper use and coordination of limited regulatory resources. This is especially important when addressing the appropriate role of municipal operators of large and medium municipal separate storm sewer systems in the control of pollutants in storm water associated with industrial activity which discharge through municipal separate storm sewer systems.

Several key policy factors arise when considering the appropriate strategy for regulating storm water discharges associated with industrial activity through municipal separate storm sewer systems. These factors include the following:

- The role and responsibilities of municipalities to control pollutants from nonmunicipal facilities which are discharged through a storm sewer owned or operated by the municipality.
- The large number of storm water discharges through municipal systems (the Agency anticipates that the majority of storm water discharges associated with industrial activity from many industrial classes discharge through municipal separate storm sewer systems).
- The ability of municipalities to recognize and represent local concerns and considerations.
- The ability of municipal operators to assist EPA and authorized NPDES States in identifying local priorities for controlling storm water discharges associated with industrial activity through specific municipal systems.
- The ability of municipal operators to assist EPA and authorized NPDES States to oversee effectively the development of appropriate site-specific controls for storm water discharges associated with industrial activity through municipal systems and to effectively require compliance with such controls.
- The authorities provided by the CWA (including those provided to the public) to review information developed

under the NPDES program and to enforce NPDES permits.

• The requirements of the CWA to develop and implement the NPDES permit program.

On November 16, 1990 (55 FR 47990), EPA promulgated a permitting scheme where controls for storm water discharges associated with industrial activity through large and medium municipal separate storm sewer systems may be addressed by two permits issued in a coordinated manner. This complementary permit approach envisions cooperative efforts by the permit issuing agency and municipal operators of large and medium municipal separate storm sewer systems to develop programs that will result in controls on pollutants in storm water discharges associated with industrial activity which discharge through municipal systems.

Under the complementary permit approach, storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems are required to obtain permit coverage. Permits for these discharges will establish requirements (such as controls or monitoring) for industrial operators of the discharge into the municipal system. In addition, these permits provide a basis for enforcement actions directly against the owner or operator of storm water discharges associated with industrial activity.

A second permit, issued to the operator of the large or medium municipal separate storm sewer, establishes the responsibilities of the municipal operators in controlling pollutants from storm water associated with industrial activity which discharges through their system. The framework for permits for discharges from large and medium municipal separate storm sewer systems has been developed to establish the responsibilities of the municipal operator to control pollutants discharged through these municipal systems. At the heart of the permit program for discharges from municipal separate storm sewer systems serving a population of 100,000 or more are requirements that municipal applicants develop and implement municipal storm water management programs. The municipal storm water management programs that will be incorporated into NPDES permits for discharges from municipal separate storm sewer systems will generally address (in addition to other possible requirements) the following three major components:

• Reducing pollutants in storm water discharges from municipal landfills; hazardous waste treatment, storage and disposal facilities; facilities subject to the Emergency Planning and Community Right-to-Know Act (EPCRA), section 313; and other priority industrial facilities through municipal separate storm sewers.

• Reducing pollutants in construction site runoff through municipal separate storm sewers.

• Identifying and controlling non-storm water discharges to municipal separate storm sewer systems.

These components of a municipal program can initiate the role of the municipality in assisting EPA and authorized NPDES States in implementing controls to reduce pollutants in storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems. Municipal programs to reduce pollutants in industrial site runoff and construction site runoff through municipal separate storm sewer systems specifically will address municipal responsibilities in controlling pollutants from industrial facilities. In addition, programs to identify and control non-storm water discharges to municipal separate storm sewer systems will in many cases focus on industrial areas because these areas often have a high potential for illicit connections, spills or improper dumping.

Consistent with the final permit application regulations published on November 16, 1990, (55 FR 47990), the proposed general permit accompanying this fact sheet have been developed to assist in establishing a cooperative approach between EPA and municipal operators of large and medium municipal separate storm sewer systems for controlling pollutants from storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems. These requirements will be coordinated with requirements in permits for discharges from large and medium municipal separate storm sewer systems. Major features of the proposed general permit that establish the framework for this cooperative approach include:

• Operators of storm water discharges associated with industrial activity which discharge through a large or medium municipal separate storm sewer system may be required to submit a copy of the notice of intent to the municipal operators of large or medium municipal system receiving the discharge.

• Requirements to monitor and reduce pollutants in discharges will be established for storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems (as well as other storm water discharges associated with industrial activity). Any records, reports, or information obtained by the Director as part of the permit implementation process, including site-specific storm water pollution prevention programs that are developed pursuant to the proposed general permit, are available to municipalities under section 308(b) of the CWA. This will assist municipalities in reviewing the adequacy of such requirements and developing priorities among industrial storm water sources.

• Industrial permittees with discharges through large and medium municipal systems may be required to submit discharge monitoring reports to municipal operators of these systems (as well as to the permitting issuing agency) or other monitoring results as required by the operator of the municipal separate storm sewer to assist the municipal operator in identifying priorities.

These permit conditions, along with appropriate conditions in permits for discharges from large and medium municipal separate storm sewer systems, will allow municipal operators of these systems to assist EPA in:

• Identifying priority storm water discharges associated with industrial activity to their system

• Reviewing and evaluating storm water pollution prevention plans

• Compliance efforts regarding storm water discharges associated with industrial activity to their municipal systems.

VI. Summary of Common Permit Conditions

The following section describes the permit conditions common to discharges from all the industrial activities covered by today's permit. These conditions reflect the baseline permit requirements established for most regulated industries in EPA's General Permits for Storm Water Discharges Associated with Industrial Activity (57 FR 41344–41356 September 9, 1992, and 57 FR 44438–44470 September 25, 1992). Permit requirements which vary from industry to industry are discussed in part VIII of this fact sheet.

A. Notification Requirement

General permits for storm water discharges associated with industrial

federal register

Friday
August 9, 1996

Part III

Environmental Protection Agency

40 CFR Part 122
Interpretative Policy Memorandum on Reapplication Requirements for Municipal Separate Storm Sewer Systems; Final Rule

R0008344

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 122

[FRL-5533-7]

Interpretative Policy Memorandum on Reapplication Requirements for Municipal Separate Storm Sewer Systems

AGENCY: Environmental Protection Agency (EPA).

ACTION: Policy statement; interpretation.

SUMMARY: By today's notice EPA announces federal policy, signed by Robert Perciasepe, Assistant Administrator for Water, on May 17, 1996, regarding application requirements for renewal or reissuance of National Pollutant Discharge Elimination System (NPDES) permits for municipal separate storm sewer systems (MS4s). Today's action responds to requests from municipalities and NPDES permit writers for clarification about regulations which do not appear to address reapplication requirements, i.e., permit reissuance. Today's notice explains that MS4 permit applicants and NPDES permit writers have considerable discretion to customize appropriate and streamlined reapplication requirements on a case-by-case basis, specifically, by using the fourth year annual report as the principal reapplication document.

EFFECTIVE DATE: This policy is effective May 17, 1996.

FOR FURTHER INFORMATION CONTACT: Marilyn Fonseca, Office of Wastewater Management, MC-4203, U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460, (202)-260-0592, e-mail: Fonseca.Marilyn@epamail.epa.gov

SUPPLEMENTARY INFORMATION: The text of this policy is as follows:

Municipal Separate Storm Sewer System Permit Reapplication Policy

The 1987 amendments to the Clean Water Act added Section 402(p) which directed the Environmental Protection Agency to establish regulations governing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Early in the program, Congress specifically required NPDES permits for municipal separate storm sewer systems (MS4s) serving populations over 100,000. In response, EPA promulgated regulations in 1990 that established permit application requirements for MS4s that serve populations over 100,000. MS4 permits have since been drafted and finalized for many municipal systems. A number of MS4 permits are due to expire and must be reissued.

EPA is providing this policy memorandum to outline permit reapplication requirements for regulated MS4s. There are three components to EPA's reapplication policy. First, EPA is not requiring that the process used for part 1 and 2 of the initial permit application be repeated in full. Second, EPA has identified basic information that should be included in every reapplication package. Finally, EPA is seeking to improve existing MS4 storm water management programs by using information and experience municipalities have gained during the previous permit term.

Is a Permit Reapplication Necessary?

Yes. The requirement that all point source discharges authorized by a NPDES permit must reapply is well established at 40 CFR 122.41(b) and 122.46(a):

> Duty to reapply. If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit.
>
> Duration of permits. NPDES permits shall be effective for a fixed term not to exceed 5 years.

The reapplication requirement is also found at 40 CFR 122.21(d):

> Duty to reapply. . . . All other permittees with currently effective permits shall submit a new application 180 days before the existing permit expires.

Therefore, all regulated Phase I MS4s need to participate in a permit reapplication process.

Where a complete reapplication package has been submitted as directed by the permit authority, conditions of an expired MS4 permit will continue until the effective date of a new permit, as stated in 40 CFR 122.6(a) and (b):

> (a) EPA permits. When EPA is the permit-issuing authority, the conditions of an expired permit continue in force . . . until the effective date of a new permit . . . and (b) Effect. Permits continued under this section remain fully effective and enforceable.

Are Initial MS4 Permit Application Requirements Applicable To Permit Reapplication?

No. The scope of the initial permit application requirements was comprehensive and regulated MS4s invested considerable resources to develop these applications. The initial applications have laid the foundation for the long-term implementation of MS4 storm water management programs. EPA believes reapplications should focus on maintenance and improvement of these programs.

The MS4 permit application requirements at 40 CFR 122.26(d)(1) and (2) apply to the first round permit applications required of large and medium MS4s. The permit application deadline regulations in 40 CFR 122.26(e) (3) & (4) clearly reflect the "one time" nature of the Part I & II application requirements for large and medium MS4s. EPA has not promulgated regulations applicable to reapplication for MS4s. Requirements to demonstrate adequate legal authority, perform source identification (e.g., identify major outfalls and facility inventory), characterize data, and develop a storm water management program should have been addressed in the initial application phase. Therefore, to request the same information again, where it has already been provided and has not changed, would be needlessly redundant. Thus, as a practical matter, most first-time permit application requirements are unnecessary for purposes of second round MS4 permit application.

What Basic Information Must Be Submitted for an MS4 Permit Reapplication?

EPA is committed to allowing permitting authorities to develop flexible reapplication requirements that are site-specific. In the absence of reapplication regulations specific to MS4s, minimum reapplication requirements are drawn from the generic NPDES permit application regulations at 40 CFR 122.21(f). EPA regulations suggest the following basic information be included as part of any permit reapplication:

—name and mailing address(es) of the permittee(s) that operate the MS4, and

—names and titles of the primary administrative and technical contacts for the municipal permittee(s).

In addition, in the reapplication, municipalities should identify any proposed changes or improvements to the storm water management program and monitoring activities for the upcoming five year term of the permit, if those proposed changes have not already been submitted pursuant to 40 CFR 122.42(c). [A requirement to submit proposed changes to the storm water management program is specified in the annual reporting requirements in 40 CFR 122.42(c)(2).] EPA encourages permitting authorities to make use of the fourth year annual report as the basic permit reapplication package.

Changes to the storm water management program may be justified due to the availability of new information on the relative magnitude of a problem or new data on water quality impacts of the storm water discharges. Municipalities may also propose to de-emphasize some program components and strengthen others, based on the experience gained under the first permit. Proposed elimination of a program component might be justified upon permit renewal; for example, when a component is no longer a problem area (i.e., all detention basins have been retrofitted) or when a different water quality program would serve the same goals.

The components of the original storm water management program which are found to be effective should be continued and made an ongoing part of the proposed new storm water management program. Such components may include:

—continued emphasis on public education programs, particularly programs on proper disposal of waste oil and household hazardous waste and pesticide application;
—continued, if not greater, emphasis on addressing impacts of new development/construction;
—proper storm design criteria for all new developments;
—retrofitting and/or upgrading of the existing storm sewer system according to a priority system;
—more frequent maintenance of storm sewer systems and storm water treatment systems;
—coordination with adjacent MS4s on monitoring or other efforts; and
—using a watershed approach to storm water management.

The accumulated annual report information as outlined in 40 CFR 122.42(c) should be evaluated and, to the extent applicable, be incorporated by reference into the reapplication package.

To reiterate, MS4s may use the fourth year annual report, which emphasizes proposed changes to the storm water management program, with the additional required basic information, as the MS4 permit reapplication. Changes to the storm water management program should be jointly developed by the permitting authority and the permit applicant. In this regard, we urge permit issuance authorities and permittees to work together to assure that the permit reapplication is complete and addresses all appropriate issues. The permitting agency may request additional technical information be submitted in the reapplication. NPDES permitting authorities, therefore, can exercise their information gathering authority under CWA Section 308, or analogous State provisions to complete the permit reapplication on a case-by case basis, as appropriate.

What Additional Information Should Be Considered for a Reapplication?

EPA also recommends the following information be provided by reapplicants to the permitting authority, as outlined in 40 CFR 122.26(d)(1)(iv)(C):

—identification of any previously unidentified water bodies that receive discharges from the MS4, and
—a summary of any known water quality impacts on the newly identified receiving waters (based on best available data).

In addition, EPA recommends the following information be provided to the permitting authority as well:

—a description of changes in co-applicants since issuance of initial MS4 permit, and
—identification number of the existing NPDES MS4 permit.

Further, EPA encourages permitting authorities to work with permittees to determine if storm water monitoring efforts are appropriate and useful. For example, during the previous permit term, municipalities may have found that their monitoring program was not fully successful in characterizing the nature and extent of storm water problems. Reapplication is an appropriate time for MS4s to evaluate their monitoring program and propose changes to make the program more appropriate and useful. To accomplish this, municipalities may wish to consider using monitoring techniques other than end-of-the pipe chemical-specific monitoring, including habitat assessments, bioassessments and/or other biological methods.

Permitting authorities should incorporate any such new information, together with assembled materials from the initial application and the existing permit, to form the administrative record for any reissued MS4 permits. Such administrative records should be made publicly available as part of the process to reissue the permit.

Dated: June 28, 1996.

Michael B. Cook,

Director, Office of Wastewater Management.

[FR Doc. 96-20228 Filed 8-8-96; 8:45 am]

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R0008346

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 1 1996

OFFICE OF
WATER

MEMORANDUM

SUBJECT: Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits

FROM: Robert Perciasepe
Assistant Administrator

TO: EPA Water Management Division Directors

The purpose of this memorandum is to transmit to you the final Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits. The policy addresses issues relating to the type of effluent limitations that are most appropriate for National Pollutant Discharge Elimination System storm water permits to provide for the attainment of water quality standards. Since this policy applies only to water quality-based effluent limitations, it is not intended to affect technology-based limitations, such as those based on effluent guidelines or the permit writers best professional judgement, that are incorporated into storm water permits. With this policy, the Office of Water is seeking to fulfill objectives of the 1996-1997 National Water Program Agenda for the Future (January 16, 1996), including reducing the threat of wet weather discharges to water quality, providing States and local governments with greater flexibility to solve wet weather problems, and identifying and taking appropriate steps to reduce the existing burden of the Storm Water Phase I program.

Numerous parties were involved in preparing this policy. In addition to receiving significant input from the Urban Wet Weather Flows Advisory Committee, EPA also consulted with State and Regional Storm Water Coordinators.

If you have questions regarding this policy, please contact William Hall at (202) 260-1458 or Bill Swietlik at (202) 260-9529. I thank you for your assistance.

Attachment

INTERIM PERMITTING APPROACH FOR WATER QUALITY-BASED EFFLUENT LIMITATIONS IN STORM WATER PERMITS

In response to recent questions regarding the type of water quality-based effluent limitations that are most appropriate for National Pollutant Discharge Elimination System (NPDES) storm water permits, the Environmental Protection Agency (EPA) is adopting an interim permitting approach for regulating wet weather storm water discharges. Due to the nature of storm water discharges, and the typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA will use an interim permitting approach for NPDES storm water permits.

The interim permitting approach uses best management practices (BMPs) in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. In cases where adequate information exists to develop more specific conditions or limitations to meet water quality standards, these conditions or limitations are to be incorporated into storm water permits, as necessary and appropriate. This interim permitting approach is not intended to affect those storm water permits that already include appropriately derived numeric water quality-based effluent limitations. Since the interim permitting approach only addresses water quality-based effluent limitations, it also does not affect technology-based effluent limitations, such as those based on effluent limitations guidelines or developed using best professional judgement, that are incorporated into storm water permits.

Each storm water permit should include a coordinated and cost-effective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits. Such a monitoring program may include ambient monitoring, receiving water assessment, discharge monitoring (as needed), or a combination of monitoring procedures designed to gather necessary information.

This interim permitting approach applies only to EPA; however, EPA also encourages authorized States and Tribes to adopt similar policies for storm water permits. This interim permitting approach provides time, where necessary, to more fully assess the range of issues and possible options for the control of storm water discharges for the protection of water quality. This interim permitting approach may be modified as a result of the ongoing Urban Wet Weather Flows Federal Advisory Committee policy dialogue on this subject.

Qs & As FOR INTERIM PERMITTING APPROACH FOR WATER QUALITY-BASED EFFLUENT LIMITATIONS IN STORM WATER PERMITS

Question 1: Must EPA require that storm water dischargers, industrial or municipal, be subject to numeric water quality-based effluent limitations (expressed as concentration and mass) in order to attain water quality standards (WQS)?

Answer 1: No. Although National Pollutant Discharge Elimination System (NPDES) permits must contain conditions to ensure that water quality standards are met, this does not require the use of numeric water quality-based effluent limitations. Under the Clean Water Act (CWA) and NPDES regulations, permitting authorities may employ a variety of conditions and limitations in storm water permits, including best management practices, performance objectives, narrative conditions, monitoring triggers, action levels (e.g., monitoring benchmarks, toxicity reduction evaluation action levels), etc., as the necessary water quality-based limitations, where numeric water quality-based effluent limitations are determined to be unnecessary or infeasible.

Analysis:

A. The Clean Water Act does not require numeric effluent limitations.

Section 301 of the CWA requires that discharger permits include effluent limitations necessary to meet State or Tribal WQS. Section 502 defines "effluent limitation" to mean any restriction on quantities, rates, and concentrations of constituents discharged from point sources. The CWA does not say that effluent limitations need be numeric. As a result, EPA and States have flexibility in terms of how to express effluent limitations.

B. EPA's regulations do not always require numeric effluent limitations.

EPA has, through regulation, interpreted the statute to allow for non-numeric limitations (e.g., "best management practices" or BMPs, see 40 CFR 122.2) to supplement or replace numeric limitations in specific instances that meet the criteria specified at 40 CFR 122.44(k). This regulation essentially codifies a court case addressing storm water discharges. NRDC v. Costle, 568 F.2d 1369 (D.C. Cir. 1977). In that case, the Court stated that EPA need not establish numeric effluent limitations where such limitations were infeasible.

C. EPA has interpreted the statute and regulations to allow BMPs in lieu of numeric limitations.

EPA has defended use of BMPs as a substitute for numeric limitations in litigation involving storm water discharges (CBE v. EPA, 91-70056 (9th Cir.)(brief on merits)) and in correspondence (Letter from Michael Cook, EPA, to Peter Lehner, NRDC, May 31, 1995). EPA has found that numeric limitations for storm water permits can be very difficult to develop at this time because of the existing state of knowledge about the intermittent and variable nature of these types of discharges and their effects on receiving waters. Some storm water permits, however, currently do contain numeric water quality-based effluent limitations where adequate information exists to derive such limitations.

Question 2: Has EPA provided guidance on a methodology for deriving numeric water quality-based effluent limitations?

Answer 2: Yes, but primarily for continuous wastewater discharges at low flow conditions in the receiving water, not intermittent wet weather discharges during high flow conditions. Regulations at 40 CFR 122.44(d) specify the requirements under which permitting authorities establish water quality-based effluent limitations when a facility has the "reasonable potential" to cause or contribute to an excursion of numeric or narrative water quality criteria. In addition, EPA guidance in the Technical Support Document for Water Quality-Based Toxics Control (TSD) and the NPDES Permit Writers Training Manual, supplemented with total maximum daily load (TMDL) and modeling guidance, supports issuing permits that include numeric water quality-based effluent limitations. This guidance was based on crafting numeric water quality-based effluent limitations using TMDLs, or calculations similar to those used in developing TMDLs, and wasteload allocations (WLAs) derived through modeling. EPA expects the Urban Wet Weather Flows Federal Advisory Committee (60 FR 21189, May 1, 1995) will review this issue at greater length and may provide recommendations on how to proceed.

Question 3: Why can numeric water quality-based effluent limitations be difficult to derive for storm water permits?

Answer 3: Storm water discharges are highly variable both in terms of flow and pollutant concentrations, and the relationships between discharges and water quality can be complex. The water quality impacts of storm water discharges are related to the uses designated by States and

Tribes in their WQS, the quality of the storm water discharge (e.g., conventional or toxic pollutants conveyed to the receiving water) and quantity of the storm water (e.g., erosion and loss of habitat caused by increased flows and velocity). Uses may be impacted by both water quality and water quantity. Depending on site-specific considerations, some of the water quality impacts of storm water discharges may be more related to the physical effects (e.g. stream bank erosion, streambed scouring, extreme temperature variations, sediment smothering) than the type and amount of pollutants present in the discharge. For municipal storm water discharges in particular, the current use of system-wide permits and a variety of jurisdiction-wide BMPs, including educational and programmatic BMPs, does not easily lend itself to the existing methodologies for deriving numeric water quality-based effluent limitations. These methodologies were designed primarily for process wastewater discharges which occur at predictable rates with predictable pollutant loadings under low flow conditions in receiving waters. Using these methodologies, limitations are typically derived for each specific outfall to be protective of low flows in the receiving water. Because of this, permit writers have not made wide-spread use of the existing methodologies and models for storm water discharge permits. In addition, wet weather modeling is technically more difficult and expensive than the simple dilution models generally used in the permitting process.

Question 4: Has EPA previously recognized the technical difficulty in deriving numeric water quality-based effluent limitations for storm water discharges?

Answer 4: Yes. EPA recognized the technical difficulty in deriving numeric water quality-based effluent limitations for wet weather discharges in its brief on the merits in Citizens for a Better Environment (CBE) v. United States Environmental Protection Agency, 91-70056 (9th Cir.) and in the Great Lakes Water Quality Guidance (58 FR 20841, April 16, 1993).

In the CBE case, EPA explained why it was technically infeasible to derive numeric water quality-based effluent limitations for the discharge of metals in storm water into South San Francisco Bay and asserted that a water quality-based effluent limitation could take the form of a narrative statement, such as a BMP, if it was infeasible to derive a numeric limitation. In explaining its arguments in the CBE case, EPA cited 40 CFR 122.44(k)(2), which provides that BMPs may be imposed in NPDES permits "to control or abate the discharge of pollutants when ... (2) [n]umeric effluent limitations are infeasible."

In the Great Lakes Water Quality Guidance, EPA did not extend the method for calculating wasteload allocations, the basis for numeric water quality-based effluent limitations, to storm water or combined sewer overflow (CSO) discharges because the varying nature of these discharges is inconsistent with the assumptions used in developing the guidance. The Great Lakes Water Quality Guidance defers to national guidance and policy on wet weather and does not seek to establish a separate and distinct set of wet weather requirements. EPA expects the Urban Wet Weather Flows Advisory Committee to provide recommendations about how to address the broader technical issues involved in achieving compliance with WQS in a wet weather context.

Question 5: What are the potential problems of using standard methodologies to derive numeric water quality-based effluent limitations for storm water permits?

Answer 5: Correctly derived numeric water quality-based effluent limitations provide a greater degree of confidence that a discharge will not cause or contribute to an exceedance of the WQS, because numeric water quality-based effluent limitations are derived directly from the numeric component of those standards. In addition, numeric water quality-based effluent limitations can avoid the expense associated with overly protective treatment technologies because numeric water quality-based effluent limitations provide a more precisely quantifed target for permittees. Potential problems of incorporating inappropriate numeric water quality-based effluent limitations rather than BMPs in storm water permits at this time are significant in some cases. Deriving numeric water quality-based effluent limitations for any NPDES permit without an adequate effluent characterization, or an adequate receiving water exposure assessment (which could include the use of dynamic modeling or continuous simulations) may result in the imposition of inappropriate numeric limitations on a discharge. Examples of this include the imposition of numeric water quality criteria as end-of-pipe limitations without properly accounting for the receiving water assimilation of the pollutant or failure to account for a mixing zone (if allowed by applicable State or Tribal WQS). This could lead to overly stringent permit requirements, and excessive and expensive controls on storm water discharges, not necessary to provide for attainment of WQS. Conversely, an inadequate effluent characterization could lead to water quality-based effluent limitations that are not stringent enough to provide for attainment of WQS. This could result because effluent characterization and exposure assessments for discharges with high variability of pollutant concentrations, loadings, and flow are more difficult than with process wastewater discharges at low flows.

Question 6: How are water quality-based effluent limitations developed for combined sewer overflow (CSO) discharges?

Answer 6: The CSO Control Policy issued by EPA on April 19, 1994 (59 FR 18688) provides direction on compliance with the technology-based and water quality-based requirements of the CWA for communities with combined sewer systems. The CSO Policy provides for implementation of technology-based requirements (expressed as "nine minimum controls") by January 1, 1997.

In addition, under the CSO Policy, communities are also expected to develop long-term control plans that will provide for attainment of WQS through either the "presumption approach" or the "demonstration approach." Under the presumption approach, CSO controls would be presumed to attain WQS if certain performance criteria are met. A program that meets the criteria specified in the CSO policy is presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable based on characterization, monitoring, and modeling of the system, including consideration of sensitive areas. Under the demonstration approach, the permittee would demonstrate that the selected CSO controls, when implemented, would be adequate to meet the water quality-based requirements of the CWA.

The CSO Policy anticipates that it will be difficult in the early stages of permitting to determine whether numeric water quality-based effluent limitations are necessary for CSOs, and, if so, what the limitations should be. For that reason, in the absence of sufficient data to evaluate the need for numeric water quality-based effluent limitations, the Policy recommends that the first phase of CSO permits ("Phase I") contain a narrative requirement to comply with WQS. Further, so-called "Phase II" permits would contain water quality-based effluent limitations, as provided in 40 CFR 122.44(d)(1) and 122.44(k), that may take the form of numeric performance or design standards, such as a certain number of overflow events or a certain percent volume capture. Generally, only after the long-term control plan is in place and after collection of sufficient water quality data (including applicable wasteload allocations developed during a TMDL process) would numeric water quality-based effluent limitations be included in the permit. This would likely occur only after several permitting cycles.

Question 7: If BMPs alone are demonstrated to provide adequate water quality protection, are additional controls necessary?

Answer 7: No. If the permitting authority determines that, through implementation of appropriate BMPs required by the NPDES storm water permit, the discharges have the necessary controls to provide for attainment of WQS and any technology-based requirements, additional controls need not be included in the permit. Conversely, if a discharger (municipal or industrial) fails or refuses to adopt and implement adequate BMPs , the permitting authority may have to consider other approaches to ensure water quality protection.

If, however, the permitting authority has adequate information on which to base more specific conditions or limitations, such limitations are to be incorporated into storm water permits, as necessary and appropriate. Such conditions or limitations may include an integrated suite of BMPs, performance objectives, narrative standards, monitoring triggers, numeric water quality-based effluent limitations, action levels, etc. Storm water permits may also need to include additional requirements to receive State or Tribal 401 certifications.

Question 8: What is EPA doing to develop information about the linkage between BMPs and water quality and to facilitate a watershed-based approach to storm water permitting?

Answer 8: The Agency has cooperative agreements with WERF (Water Environment Research Foundation) and ASCE (American Society of Civil Engineers) to research which BMPs are most effective under which circumstances. The results of this research should provide permitting authorities and permittees with information about how to evaluate the effectiveness of different kinds of BMPs in different circumstances and to select the most appropriate controls to achieve water quality objectives. EPA also has cooperative agreements with the Watershed Management Institute and other organizations to conduct research over the next two to four years that will examine the capability of storm water BMPs to improve receiving water quality and restore/protect the biological integrity of those waters. EPA expects the Urban Wet Weather Flows Federal Advisory Committee to provide recommendations on how to permit storm water discharges on a watershed basis.

Question 9: The interim permitting approach states that permits should include monitoring programs to generate necessary

information to determine the extent to which permits are providing for the attainment of water quality standards. What types of monitoring should be included and how much monitoring is necessary?

Answer 9: The amount and types of monitoring necessary will vary depending on the individual circumstances of each storm water discharge. EPA encourages dischargers and permitting authorities to carefully evaluate monitoring needs and storm water program objectives so as to select useful and cost-effective monitoring approaches. For most dischargers, storm water monitoring can be conducted for two basic reasons: 1) to identify if problems are present, either in the receiving water or in the discharge, and to characterize the cause(s) of such problems; and 2) to assess the effectiveness of storm water controls in reducing contaminants and making improvements in water quality.

Under the NPDES storm water program, large and medium municipal separate storm sewer system permittees are required to conduct monitoring. EPA recommends that each such municipal permittee design the monitoring effort to be supportive of the goals and objectives of its storm water management program when developing such a program for the term of its NPDES permit. To accomplish this, a municipal permittee may use a variety of storm water monitoring tools including receiving water chemistry; receiving water biological assessments (benthic invertebrate surveys, fish surveys, habitat assessments, etc.); effluent monitoring; including chemical, whole effluent and visual examinations; illicit connections screening; and combinations thereof, or other methods. Techniques that assess receiving waters will help to identify the degree to which storm water discharges are contributing to any water quality problems. Techniques that assess storm water discharge characteristics will help to identify potential causes of any identified water quality problems. The municipal permittee, in conjunction with the applicable NPDES permitting authority, should determine which monitoring approaches would be most appropriate given the objectives of the storm water management program. If municipal permittees conduct ambient monitoring, it may be most cost-effective to pool resources with other organizations (including, for example, other municipalities, States, and Tribes) conducting monitoring within the same watershed. This could be best accomplished through a coordinated watershed monitoring strategy.

For industrial storm water dischargers, monitoring may be required under the terms of an NPDES permit for storm water discharges. For those industrial storm water permits that do require monitoring, this is typically done to characterize contaminants that might be found in the industrial runoff and/or to assess the effectiveness of the industrial storm water pollution prevention plan in reducing these contaminants. This typically involves end-of-pipe chemical-specific monitoring. End-of-pipe monitoring may be more appropriate for an industrial facility than for a municipal permittee, given the industrial facility's more discrete site characteristics, which make management strategies such as collection and treatment more feasible. Industries, for the most part, have readily defined storm water conveyances into which runoff flows from discrete drainage areas. Industries may more readily identify and control existing on-site sources of storm water contamination or provide collection and treatment within these discrete drainage areas to control pollutant concentrations in their storm water discharges.

EPA and other organizations are currently working to improve approaches for monitoring storm water and the potential effects upon water quality. These new approaches are called storm water program "environmental indicators." Environmental indicators are designed to be more meaningful monitoring tools that storm water dischargers can use to conduct storm water monitoring for the purposes described above. A manual describing each of the recommended storm water program environmental indicators is being prepared by the Center for Watershed Protection in Silver Spring, Maryland. That manual is expected to be ready by the end of August 1996 and should provide useful information for storm water dischargers contemplating the need to develop a cost-effective, meaningful storm water monitoring program. In addition, EPA expects the Urban Wet Weather Flows Federal Advisory Committee to provide recommendations on how to better monitor storm water and other wet weather discharges using a watershed approach.

Question 10: Does this interim permitting approach apply to both storm water discharges associated with industrial activity and storm water discharges from municipal separate storm sewer systems?

Answer 10: Yes. The interim permitting approach is applicable to both discharges from municipal separate storm sewer systems and storm water discharges associated with industrial activity (as defined by 40 CFR 122.26(b)(14)). The interim permitting approach would not affect, however, permits that already incorporate appropriately derived numeric water quality-based effluent limitations. Since the interim permitting approach only addresses water quality-based effluent limitations, it also does not affect technology-based effluent limitations, such as those based on effluent limitations guidelines or developed using best professional judgement, that are incorporated into storm water permits. In addition, particularly for some industries, adequate information may already have been collected with which to assess the reasonable potential for a storm water discharge to cause or contribute to an excursion of a WQS, and from which a numeric water quality-based effluent limitation can be (or has been) appropriately derived. An adequate amount of storm water pollutant source information may also exist with which to assess the effectiveness of the industrial storm water control measures in complying with the limitations and in reducing storm water contaminants for protecting water quality.

[Federal Register: August 26, 1996 (Volume 61, Number 166)] [Notices]
[Page 43761]
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ENVIRONMENTAL PROTECTION AGENCY
[FRL-5559-9]

Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits

AGENCY: Environmental Protection Agency.

ACTION: Notice.

SUMMARY: Notice is hereby given that the Environmental Protection Agency (EPA) has issued a policy outlining an interim approach for incorporating water quality-based effluent limitations into storm water permits.

Background and Purpose

Due to the nature of storm water discharges, and the typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA has developed an interim permitting approach for National Pollution Discharge Elimination System (NPDES) storm water permits. While this interim permitting approach applies only to EPA, the Agency also encourages authorized States and Tribes to adopt similar policies for storm water permits.

The policy addresses issues related to the type of effluent limitations that are most appropriate for NPDES storm water permits to provide for the attainment of water quality standards. Since the policy only applies to water quality-based effluent limitations, it is not intended to affect technology-based limitations, such as those based on effluent guidelines or the permit writer's best professional judgements, that are incorporated into storm water permits. With this policy, the Office of Water is seeking to fulfill objectives of the 1996-1997 National Water Program Agenda for the Future, including reducing the threat of wet weather discharges to water quality, providing States and local governments with greater flexibility to solve wet weather problems, and identifying and taking appropriate steps to reduce the existing burden of the Storm Water Phase I program. Numerous parties were involved in preparing this policy. In addition to receiving significant input from the Urban Wet Weather Flows (UWWF) Federal Advisory Committee, EPA also consulted with the States and Regional Storm Water Coordinators. This interim permitting approach may be modified as a result of ongoing policy dialogue with the UWWF Federal Advisory Committee.

Policy Statement

In response to recent questions regarding the type of water quality-based effluent limitations that are most appropriate for National Pollutant Discharge Elimination System (NPDES) storm water permits, the Environmental Protection Agency (EPA) is adopting an interim permitting approach for regulating wet weather storm water discharges. Due to the nature of storm water discharges, and the typical lack of information on which to base numeric water qualitybased effluent limitations (expressed as concentration and mass), EPA will use an interim permitting approach for NPDES storm water permits. The interim permitting approach uses best management practices (BMPs) in first-round storm water permits, and expanded or bettertailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. In cases where adequate information exists to develop more specific conditions or

limitations to meet water quality standards, these conditions or limitations are to be incorporated into storm water permits, as necessary and appropriate. This interim permitting approach is not intended to affect those storm water permits that already include appropriately derived numeric water quality-based effluent limitations. Since the policy only applies to water quality-based effluent limitations, it is not intended to affect technology-based limitations, such as those based on effluent guidelines or the permit writer's best professional judgement, that are incorporated into storm water permits.
Each storm water permit should include coordinated and costeffective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits. Such a monitoring program may include, ambient monitoring, receiving water assessment, discharge monitoring (as needed), or a combination of monitoring procedures designed to gather necessary information. This interim permitting approach applies only to EPA, however, EPA also encourages authorized States and Tribes to adopt similar policies for storm water permits. This interim permitting approach provides time, where necessary, to more fully assess the range of issues and possible options for the control of storm water discharges for the protection of water quality. This interim permitting approach may be modified as a result of the ongoing Urban Wet Weather Flows Federal Advisory Committee policy dialogue on this subject.

DATES: The policy was signed by the Assistant Administrator for Water on August 1, 1996.

FOR FURTHER INFORMATION: If you have questions about the police, please contact, Bill Swietlik, Storm Water Phase I Matrix Manager, Office of Wastewater Management, at (202) 260-9529 or William Hall, Urban Wet Weather Flows Matrix Manager, Office of Wastewater Management, at (202) 260-1458, or by Internet: hall.william@epamail.epa.gov.

Dated: August 19, 1996.
Fred Lindsey,
Acting Director, Office of Wastewater Management, Designated Federal Official.
[FR Doc. 96-21671 Filed 8-23-96; 8:45 am] BILLING CODE 6560-50-P

STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER No. 90-079

NPDES NO. CA0061654 (CI 6948)

WASTE DISCHARGE REQUIREMENTS STORMWATER/URBAN RUNOFF DISCHARGE for LOS ANGELES COUNTY and CO-PERMITTEES

The California Regional Water Quality Control Board, Los Angeles, (Regional Board) finds :

1. The County of Los Angeles, in cooperation with the following cities : Agoura Hills, Beverly Hills, Culver City, El Segundo, Hermosa Beach, Inglewood, Los Angeles, Manhattan Beach, Rancho Palos Verdes, Redondo Beach, Rolling Hills Estates, Rolling Hills, Santa Monica, Torrance, West Hollywood, and Westlake Village, has submitted a report of waste discharge (NPDES permit application) dated March 15, 1990 for issuance of waste discharge requirements for the County of Los Angeles and other cities tributary to Los Angeles County (excluding Antelope Valley) under the National Pollutant Discharge Elimination System (NPDES Permit No. CA0061654).

2. The discharges consist of surface runoff generated from various land uses in all the hydrologic drainage basins which discharge into water courses flowing into water bodies in Los Angeles County. The quality of these discharges varies considerably and is affected by land use, basin hydrology and geology, season, and the frequency and duration of storm events. The constituents of concern and significance in these discharges are: total and fecal coliform and enterococci bacteria, total suspended solids, biochemical oxygen demand, oil and grease, heavy metals, nutrients, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, pesticides and herbicides, and petroleum hydrocarbons.

3. The objective of this permit is to develop a timely, comprehensive, and cost-effective stormwater pollution control program to minimize pollutants in urban runoff/stormwater discharges to water bodies in Los Angeles County.

4. Due to the complexity and networking of drainage facilities within and tributary to Los Angeles County, the county and adjacent areas discharging storm water into Los Angeles County are divided and prioritized into five drainage basins for the implementation of the permit. The owners/operators of all facilities impacting stormwater quality will be ultimately a party to these waste discharge requirements. The County of Los Angeles together with the cities identified above, the initial parties filing for the system-wide permit, are 'Permittees', with the County of Los Angeles as the 'Principal Permittee' and the rest as 'Co-Permittees'. All other cities and recognized entities such as Caltrans, college/university campuses, hospitals, parks, agricultural areas, real estate developments and waste disposal facilities identified in this Order, are designated 'Co-Participants'. A 'Co-Participant' will be a 'Co-Permittee' upon becoming an active party to the permit.

   Attachments 1 and 2 show, respectively, the list of cities and a partial list of entities designated as Co-Participants for this permit. The list of entities will be revised as necessary.

5. The County of Los Angeles, as the 'Principal Permittee', will obtain the cooperation of 'Co-Participants' to become 'Co-Permittees'. The Regional Board has the discretion and authority to require non-cooperating cities and/or entities to become 'Co-Permittees' or obtain individual stormwater discharge permits, pursuant to 40 CFR 122.26 (a).

6. Los Angeles County as the 'Principal Permittee' is the permit coordinator responsible for general administration of this Order, and coordinating cooperation by 'Co-Permittees', including but not limited to the implementation of local self-monitoring programs and Best Management Practices, and the preparation and submittal of reports required by this Order.

7. Los Angeles County obtains its authority to :

   - control pollutants in stormwater discharge
   - prohibit illegal discharges and control spills
   - require compliance and carry out inspections

of drainage facilities in the County of Los Angeles from the Los Angeles County Flood Control Act and various county ordinances which address industrial wastes and waste discharges within the unincorporated areas of Los Angeles County and contract cities. 'Co-Permittees' with the status of incorporated cities have various forms of legal authority in place, such as charters, State Code provisions for General Law cities, city ordinances and applicable portions of Municipal Codes and the State Water Code, to regulate stormwater/urban runoff discharges.

8. The division and prioritization of Los Angeles County and adjacent areas into five drainage basins for program implementation are based on hydrological characteristics of the watersheds, perceived importance and beneficial uses of water bodies, and the existence of an adequate infrastructure for program implementation. The five drainage basins are :

I : Santa Monica Bay Drainage Basin

II : Upstream Los Angeles River Drainage Basin, to and including Sycamore Canyon Channel (San Fernando Valley);

III : Upper San Gabriel River (San Gabriel Valley) Drainage Basin.

IV : Lower Los Angeles River Drainage Basin

V : Lower San Gabriel River Drainage Basin; and Santa Clarita Valley Basin.

Attachment 3 shows a map of Los Angeles County with the boundary delineations of the five drainage basins.

Attachment 4 shows Co-Participant cities in Los Angeles County (and their respective populations).

[Note: Detailed maps of the Los Angeles County storm drain system with boundary delineations of drainage basins are available for review at the Regional Board Office.]

9. A number of studies on stormwater/urban runoff pollution in the permit areas has been conducted by agencies such as the City of Los Angeles, the Southern California Coastal Water Research Project and the Southern California Association of Governments. These studies indicate stormwater/urban runoff contributes significantly to the deterioration of the quality of water bodies in Los Angeles County.

The University of California at Los Angeles, under the sponsorship of the Santa Monica Bay Restoration Project, is currently compiling and summarizing data and information on stormwater/urban runoff discharges for the Santa Monica Bay watershed.

10. The Los Angeles County Department of Public Works has an active surface water quality monitoring program in the permit area, comprising twenty-eight monitoring stations located at principal storm drains and water conservation facilities. The Surface Water Quality Monitoring Program comprises the collection and analysis of dry weather water samples for general minerals, pesticides, total petroleum hydrocarbons, heavy metals and bacteria (total and fecal coliform, KF streptococci and enterococci). Volatile organic constituents are tested semi-annually at selected stations. Stormwater runoff is monitored three to four times annually at twenty-one stations for minerals, pesticides, heavy metals (total and dissolved), bacteria, total and organic suspended solids, oil and grease, biochemical oxygen demand, total organic carbon and volatile organics.

11. The Los Angeles County Department of Public Works and some cities have on-going activities that reduce stormwater/urban runoff pollutant loads. These activities include periodic catch-basin cleaning and street sweeping, public information on proper disposal of household hazardous waste, and emergency responses to reports of illegal dumping, illicit disposal, illegal connections, and industrial waste spills. The Los Angeles County Department of Public Works also participates and coordinates action with local, State, and Federal agencies responding to spills and illegal dumping reports that threaten surface waters.

12. The Regional Board currently regulates industrial process and point source non-process wastewater and stormwater discharges to storm drain systems through NPDES permits. Point source discharges including stormwater will continue to be regulated by the Regional Board. An information system will be developed and maintained to update pollutant loadings to designated

drainage facilities and water bodies from permitted point source discharges.

13. The State Water Resources Control Board (State Board) adopted a Water Quality Control Policy for the Enclosed Bays and Estuaries of California on May 16, 1974. The policy provides that the discharge of industrial process waters to enclosed bays and estuaries shall be prohibited. Storm water and urban runoff are not considered industrial process waters for the purpose of that policy.

14. The State Board adopted a revised Water Quality Control Plan for Ocean waters of California (Ocean Plan) on March 22, 1990, which amended the Plan adopted on September 22, 1988. The Plan contains water quality objectives for the coastal waters of California.

15. The Regional Board adopted a revised Water Quality Control Plan for the Los Angeles River Basin (Basin Plan) on November 27, 1978. The Basin Plan incorporates the Ocean Plan, and contains water quality objectives for the basin, including the beneficial uses of water bodies.

16. The beneficial uses of water bodies in Los Angeles County and their tributary streams include contact water recreation, non-contact water recreation, wildlife habitat, preservation of rare and endangered species, marine habitat, estuarine habitat, fish migration, fish spawning, industrial service and process supply, agricultural water supply, shellfish harvesting, navigation, commercial and sport fishing, and groundwater recharge.

17. Section 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act of 1972 to require the Environmental Protection Agency (EPA) to establish regulations for stormwater/urban runoff discharge under the National Pollutant Discharge Elimination System (NPDES).

18. The Federal Clean Water Act allows EPA to delegate its NPDES permitting authority to States with an approved environmental regulatory program. The State of California is one of the delegated States. The Porter-Cologne Act (State Water Code) authorizes the State Board, through its Regional Boards, to regulate and control the discharge of pollutants into waters of the state and tributaries thereto.

19. Although Water Code Section 13263 (a) requires that waste discharge requirements issued by Regional Boards shall include provisions to implement water quality based objectives, numerical water quality standards

are not provided in this Order. Information is not available to establish appropriate numerical limits, and determine locations where permittees shall be made accountable. The requirements in this Order will provide the necessary information while concurrently achieving reductions in pollutant loads to water bodies from stormwater/urban runoff discharges. Numerical water quality objectives will be developed by Board staff for consideration in the permit renewal process and utilized for the evaluation of Best Management Practices.

20. Due to the significance of the Los Angeles County Stormwater/Urban Runoff Program, the Regional Board, in recognition of the need for public involvement and participation in the development and implementation of an effective program will conduct at a minimum an annual workshop, prior to approving plans submitted by Permittees, to solicit comments and to inform the public of the progress of the program. Comments presented will be referred to Los Angeles County for response.

21. Stormwater/urban runoff discharges to drainage facilities that cross County boundaries and Regional Board jurisdictions, and which are regulated under NPDES permits, are the regulatory responsibility of those agencies issuing the permits.

22. The issuance of waste discharge requirements for this discharge is exempt from the provisions of the California Environmental Quality Act (CEQA); Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Water Code Section 13389.

The Board has notified the Permittees and interested agencies and persons of its intent to issue waste discharge requirements for this discharge and has provided them with an opportunity to submit their written views and recommendations.

The Board, in a public hearing, heard and considered all comments pertaining to the discharge and to the tentative requirements.

This Order shall serve as a National Pollutant Discharge Elimination System permit pursuant to Section 402 of the Federal Clean Water Act, or amendments thereto, and shall take effect at the end of ten days from the date of its adoption provided the Regional Administrator, EPA, has no objections.

IT IS HEREBY ORDERED that the Permittees, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act as amended and regulations and guidelines adopted thereunder, shall comply with the following:

1.0 COMPLIANCE

1.1 The Permittees and Co-Permittees shall comply with the requirements contained in this Order according to the following schedule:

	DRAINAGE BASIN	STARTING DATE FOR COMPLIANCE WITH REQUIREMENTS
I.	Santa Monica Bay	July 1, 1990
II.	Upper Los Angeles River (San Fernando Valley)	July 1, 1992
III.	Upper San Gabriel River (San Gabriel Valley)	July 1, 1992
IV.	Lower Los Angeles River	July 1, 1993
V.	Lower San Gabriel River and Santa Clarita Valley	July 1, 1993

2.0 REQUIREMENTS - YEAR 1

2.1 For each Drainage Basin, prepare and submit to the Regional Board within 12 months of the starting date for compliance, according to the schedule under 1.1:

2.1.1 Water quality data and flow data from 1980 to the present to facilitate identification of sources of pollutants present in discharges from the prioritized drainage basin. "Drainage areas" in the drainage basin are to be reported and the "drainage areas" associated with each drainage basin clearly identified.

For purposes of stormwater/urban runoff, a "drainage area" is defined as a subdivision of a drainage basin which is unique in land use patterns, and pollutant characteristics and loadings.

2.1.2 The 90th percentile value for the water quality parameters, (i) Total Suspended Solids (TSS), and (ii) Oil and Grease, from the data set of all wet weather samples collected from 1980 to the present. These data will be used to establish guidance for early action control of stormwater pollution.

The 90th percentile for a given water quality parameter is defined as the concentration value exceeded in ten percent of the samples of the reference data set.

2.1.3 Additional information of a qualitative nature that would contribute to isolating and identifying sources of problems. Such information should include but not be limited to visual observations of factors exacerbating stormwater contamination, principal land use classifications and Standard Industrial Code (SIC) categories of facilities in "drainage areas", and a description of soils, dumps, landfills, waste disposal sites and Resource Conservation and Recovery Act (RCRA) facilities associated with each area.

2.1.4 Monthly precipitation data from rain gauge stations, relevant to the drainage basin, for the years 1980 to the present, and an estimate of the area of impervious surfaces (including paved areas and building roofs) within each "drainage area".

2.1.5 Documentation of existing procedures to detect and address illegal discharges and illicit disposal practices.

2.1.6 Documentation of existing practices and improvement plans to control pollutants in stormwater/urban runoff from construction sites.

2.1.7 Documentation of existing stormwater/urban runoff management practices and existing Best Management Practices (BMPs) for the control of pollutants in discharges from residential, commercial and industrial areas.

For purposes of this permit, a Best Management Practice is defined as a stormwater quality management practice that has been demonstrated to reduce stormwater/urban runoff constituents of concern in studies in the United States and elsewhere, or a stormwater/urban runoff quality management practice that can significantly control stormwater/urban runoff pollution.

2.1.8 Plan with schedule of implementation, for approval by the Executive Officer, of early action BMPs.

For purposes of this permit, an early action BMP is defined as an existing stormwater/urban runoff quality management practice that is optimized to the maximum extent practicable (MEP) in efficiency for the control of stormwater runoff pollution, such as improving the frequency of storm drain catchment basin cleaning or the stricter enforcement of existing regulations, or a BMP that is not specific to stormwater/urban runoff constituents or "drainage area" in its constituent removal capacity and can be applied on a system-wide basis, such as public outreach and educational programs.

For purposes of this permit, maximum extent practicable means to the maximum extent possible, taking into account equitable considerations of synergistic, additive and competing factors, including but not limited to gravity of the problem, fiscal feasibility, public health risks, societal concern, and social benefits.

The Principal-Permittee, in the submittal of plans and schedules to the Executive Officer, shall demonstrate that public input has been obtained.

For purposes of this permit, public input is demonstrated by, (i) disseminating the notice of availability of plans for review and comment, to the public at large, environmental groups, Federal, State and local officials and other interested parties, and (ii) addressing concerns expressed by the public.

The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plan on approval by the Executive Officer.

2.1.9 A workplan for the development of a stormwater/urban runoff monitoring program, for approval by the Executive Officer, to include but not be limited to the following information :

- listing of constituents and parameters to be monitored and the rationale for their choice.
- listing of monitoring locations and the rationale for their choice.
- listing of sampling methodology of choice and frequency of sampling for both wet weather and dry weather flow.
- supplementary information that influences the design of the monitoring plan.

The Principal-Permittee, in the submittal of the workplan to the Executive Officer, shall demonstrate that public input has been obtained.

2.1.10 Documentation that each Permittee, individually and/or jointly, through the establishment of a joint powers authority or a stormwater utility, possesses adequate legal authority to operate and manage stormwater/urban runoff quality management programs, and/or plans to obtain the necessary legal authority to regulate illegal discharges and illicit disposal practices into storm drains, and to prosecute violators.

3.0 REQUIREMENTS - YEAR 2

3.1 For each Drainage Basin, prepare and submit to the Regional Board, for approval by the Executive Officer, within 24 months of the starting date of compliance, according to the schedule under 1.1:

3.1.1 A monitoring program based on the approved workplan. This program shall be designed to:

- o detect accurately the constituents and parameters of concern, in discharges indicated in the workplan, and to identify their possible sources.
- o identify illegal dischargers and/or locations of illicit disposal practices.

Monitoring reports for this program shall be submitted according to the format and frequency to be approved by the Executive Officer.

3.1.2 Plan with schedule of implementation for additional BMPs, judged appropriate for each city or drainage basin, to control pollutants from residential, commercial and industrial sites to the maximum extent practicable.

Both structural and non-structural BMP measures are to be evaluated at the MEP standard. Examples of non-structural measures include catch basin cleaning, street sweeping and public education, while controls such as detention/retention basins, first flush diversions, grassy swales and porous pavements are examples of structural measures.

3.1.3 Plan with schedule of implementation of procedures to detect and eliminate illegal discharges and illicit disposal practices.

3.1.4 Plan with schedule of implementation of measures to control pollutants in surface runoff from construction sites.

The Principal Permittee, in the submittal of plans and schedules (items 3.1.2, 3.1.3, and 3.1.4) to the Executive Officer shall demonstrate that public input has been obtained. The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plans on approval by the Executive Officer.

3.2 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs.

3.3 Evidence of all requisite legal authority to regulate illegal discharges and illicit disposal practices to drainage facilities, and to prosecute violators.

4.0 REQUIREMENTS - YEAR 3

4.1 For each Drainage Basin, submit to the Regional Board, within 36 months of the starting date of compliance, according to the schedule under 1.1, the following:

4.1.1 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs and additional BMPs.

4.1.2 Evidence of implementation and progress of procedures to detect and eliminate illegal discharges and eliminate illicit disposal practices.

4.1.3 Evidence of implementation and progress of measures to control pollutants in surface runoff from construction sites.

5.0 EXPIRATION AND RENEWAL

5.1 This Order expires on June 18, 1995.

5.2 The Permittees shall file a report of waste discharge (ROWD), not later than 180 days before the expiration date, as application for reissuance of waste discharge requirements. This report of waste discharge shall include but not be limited to the following:

5.2.1 Summary of the results of the monitoring program.

5.2.2 Summary of BMPs implemented and evaluations of their effectiveness.

5.2.3 Summary of procedures implemented to detect illegal discharges and illicit disposal practices and an evaluation of their effectiveness.

5.2.4 Summary of measures implemented to control pollutants in surface runoff from construction sites and an evaluation of their effectiveness.

5.2.5 Evaluation of the need for additional BMPs, source control, and/or structural control measures.

5.2.6 Proposed plan of stormwater/urban runoff quality management activities that will be undertaken during the term of the next permit.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on June 18, 1990.

ROBERT P. GHIRELLI, D.Env.
Executive Officer

ATTACHMENT 1

LIST OF CO-PARTICIPANT CITIES

Agoura Hills
Arcadia
Avalon
Baldwin Park
Bellflower
Beverly Hills
Burbank
Cerritos
Commerce
Covina
Culver City
Downey
El Monte
Gardena
Glendora
Hawthorne
Hidden Hills
Industry
Irwindale
La Habra Heights
La Mirada
La Verne
Lawndale
Long Beach
Lynwood
Maywood
Montebello
Norwalk
Palos Verdes Estates
Pasadena
Pomona
Redondo Beach
Rolling Hills Estates
San Dimas
San Gabriel
Santa Clarita
Santa Monica
Signal Hill
South Gate
Temple City
Torrance
Walnut
West Hollywood
Whittier

Alhambra
Artesia
Azusa
Bell
Bell Gardens
Bradbury
Carson
Claremont
Compton
Cudahy
Diamond Bar
Duarte
El Segundo
Glendale
Hawaiian Gardens
Hermosa Beach
Huntington Park
Inglewood
La Canada Flintridge
Lakewood
La Puente
Lancaster
Lomita
Los Angeles
Manhattan Beach
Monrovia
Monterey Park
Palmdale
Paramount
Pico Rivera
Rancho Palos Verdes
Rolling Hills
Rosemead
San Fernando
San Marino
Santa Fe Springs
Sierra Madre
South El Monte
South Pasadena
Thousand Oaks
Vernon
West Covina
Westlake Village

ATTACHMENT 2

LIST OF ENTITIES (PARTIAL LIST)

Caltrans
Army Corps of Engineers
Railroad Rights of Way
Federal Hospitals

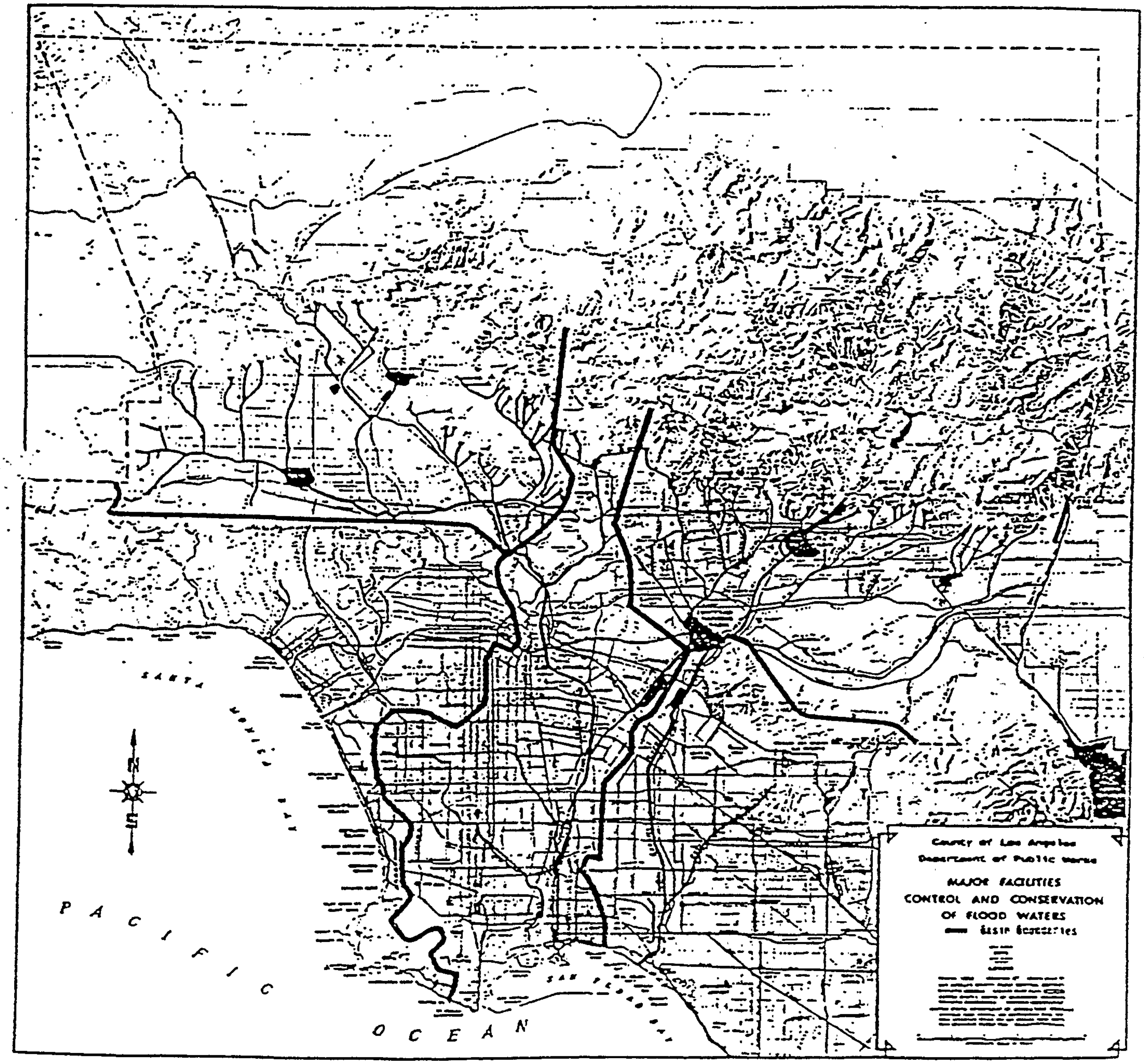
The State University System
University of California Campuses
National Forest Service
Federal Military Facilities

[This list will be updated during the permit process to indicate actual identity of agencies and entities.]

CA0061654

ATTACHMENT 3

DELINEATIONS OF DRAINAGE BASIN BOUNDARIES FOR LOS ANGELES COUNTY



ATTACHMENT 4

CITIES (AND POPULATIONS) TRIBUTARY TO DRAINAGE BASINS

Santa Monica Bay

Agoura Hills	19,000	Rancho Palos Verdes	46,000
Beverly Hills	34,000	Redondo Beach	64,700
Culver City	40,950	Rolling Hills	2,090
El Segundo	15,750	Rolling Hills Estates	7,875
Hermosa Beach	19,750	Santa Monica	96,500
Inglewood	102,300	Thousand Oaks	104,400
Los Angeles	3,400,500	Torrance	142,200
Manhattan Beach	35,300	West Hollywood	38,400
Westlake Village	8,025	Palos Verdes Estates	15,000

Upper Los Angeles River

Burbank	93,800	Glendale	166,100
Hidden Hills	1,950	Los Angeles	3,310,057
San Fernando	20,700		

Upper San Gabriel River

Alhambra	74,900	Arcadia	49,100
Azusa	38,250	Baldwin Park	63,300
Bradbury	930	Claremont	36,550
Covina	43,250	Diamond Bar	74,120
Duarte	21,350	El Monte	95,400
Glendora	47,400	Industry	370
Irwindale	1,230	La Canada Flintridge	20,800
La Habra Heights	5,450	La Puente	33,550
La Verne	30,500	Monrovia	34,000
Montebello	58,200	Monterey Park	64,600
Pasadena	132,200	Pomona	119,000
Rosemead	47,700	San Dimas	32,500
San Gabriel	34,900	San Marino	13,800
Sierra Madre	11,250	South El Monte	18,700
South Pasadena	24,500	Temple City	31,900
Walnut	26,400	West Covina	94,200

(CONTINUED)

Lower Los Angeles River

Alhambra	74,900	Bell	28,250
Bel Gardens	38,300	Carson	88,800
Commerce	11,700	Compton	93,000
Cudahy	20,700	Downey	86,800
El Segundo	15,750	Gardena	50,900
Glendale	166,100	Hawthorne	67,400
Huntington Park	51,200	Inglewood	102,300
La Canada Flintridge	20,800	Lakewood	76,500
Lawndale	27,300	Lomita	20,300
Los Angeles	3,400,500	Lynwood	53,700
Maywood	24,650	Montebello	58,200
Monterey Park	64,600	Palos Verdes Estates	15,000
Paramount	44,450	Pasadena	132,200
Pico Rivera	57,300	Rancho Palos Verdes	46,000
Redondo Beach	64,700	Rolling Hills	2,090
Rolling Hills Estates	7,875	Signal Hill	8,150
South Gate	79,200	South Pasadena	24,500
Torrance	142,200	Vernon	80

Lower San Gabriel River

Artesia	14,950	Bellflower	60,900
Cerritos	58,400	Downey	86,800
Hawaiian Gardens	12,350	La Habra Heights	5,450
Lakewood	76,500	La Mirada	42,600
Long Beach	419,800	Norwalk	90,800
Paramount	44,450	Pico Rivera	57,300
Santa Clarita	115,700	Santa Fe Springs	16,400
Signal Hill	8,150	Whittier	74,100

Population estimates are taken from Report 89 E-1 published by the State of California Department of Finance.

The cities of Avalon (Pop: 2,490), Lancaster (Pop: 82,200), and Palmdale (Pop: 45,850) which are within Los Angeles County are not part of this permit.

To Paula Vitale	From Bruce Fujimoto
Co.	Co.
Dept.	Phone #
Fax #	Fax #

JAN - 9 1991

OFFICE OF GENERAL COUNSEL

MEMORANDUM

SUBJECT: Compliance with Water Quality Standards in NPDES Permits Issued To Municipal Separate Storm Sewer Systems

FROM: E. Donald Elliott [signature]
Assistant Administrator and
General Counsel (LE-130)

TO: Nancy J. Marvel
Regional Counsel
Region IX

In your memorandum of August 9, 1990, you have asked for our views on the following two issues:

ISSUES

1) Must NPDES permits for municipal separate storm sewer systems ("MS4s") issued under Section 402(p)(3)(B) of the Clean Water Act (CWA) include requirements necessary to achieve water quality standards (WQS), as generally required by Section 301(b)(1)(C) for all NPDES permits?

2) If permits issued to MS4s must comply with WQS, by what date must the permit ensure compliance?

SHORT ANSWERS

1) The better reading of Sections 402(p)(3)(B) and 301(b)(1)(C) is that all permits for MS4s must include any requirements necessary to achieve compliance with WQS.

2) Sections 402(p)(4)(A) and (p)(4)(B) give "large" and "medium" MS4s three years to comply with permit conditions from the date of permit issuance. This three year compliance date also applies to WQS-based permit requirements.

DISCUSSION

1. Statutory Background

Section 402(a)(1) requires that all NPDES permits comply with the applicable provisions of section 301. This includes compliance with appropriate technology-based standards and effluent limits (sections 301(b)(1)(B), 301(b)(2)). Permits must include "any more stringent limitation" necessary to meet WQS. Section 301(b)(1)(C). In addition, Section 401 requires that any applicant for a federal permit (including NPDES permits issued by EPA) must provide the permitting agency a certification from the State in which the discharge originates that the discharge will comply with the State's WQS.

As part of the 1987 amendments to the Clean Water Act, Congress added Section 402(p) to the Act, related to storm water discharges. Congress exempted some storm water discharges from the requirement to obtain an NPDES permit until after October 1, 1992. Section 402(p)(1). For certain specific categories of storm water discharges, this permit "moratorium" is not in effect, including discharges "associated with industrial activity," discharges from large and medium municipal separate storm sewer systems (i.e., systems serving a population over 250,000 or systems serving a population between 100,000 and 250,000, respectively). Section 402(p)(2).

For industrial and municipal storm water discharges, EPA was instructed to promulgate new regulations specifying permit application requirements. Congress mandated EPA to issue permits no later than February 4, 1991 (for industrial and large municipal discharges) or February 4, 1993 (for medium municipal discharges). Section 402(p)(4). These permits shall provide for compliance "as expeditiously as practicable, but in no event later than 3 years after the date of issuance of such permit." Id.

Section 402(p) also specified the levels of control to be incorporated into storm water permits. Permits for discharges associated with industrial activity are to require compliance with all applicable provisions of Sections 301 and 402 of the CWA, i.e., all technology-based and water quality-based requirements. Section 402(p)(3)(A). By contrast, permits for discharges from municipal separate storm sewers "shall require controls to reduce the discharge of pollutants to the maximum extent practicable" ("MEP"). Section 402(p)(3)(B)(iii).

2. Analysis

A. WQ-based Requirements in Municipal Storm Water Permits

The relationship of Section 402(p)(3)(B)(iii) to Section 301(b)(1)(C) is not clear, either on the face of the statute or in legislative history. Section 402(p)(3) is clearly intended to draw a distinction between the requirements on industrial and municipal storm water discharges. Section 402(p)(3)(A) states that industrial discharges shall comply with the applicable provisions of section 301, i.e., BAT/BCT technology-based requirements as well as any more stringent WQ-based requirements pursuant to 301(b)(1)(C). In the next sub-paragraph, Congress requires municipalities to control storm water to the MEP standard; no mention is made of section 301. The juxtaposition of (p)(3)(A) and (p)(3)(B) gives rise to the argument that Congress may have intended to waive all section 301 requirements for municipal discharges in favor of the MEP standard. On the other hand, one could read (p)(3)(B)(iii) as modifying only technology-based requirements for municipal storm water (i.e., MEP substitutes for BAT/BCT); any WQ-based requirements would still be necessary in a municipal permit, even if those requirements are more stringent than "practicable." The legislative history of Section 402(p) provides no guidance as to how Congress intended the MEP standard to operate.

Where Congressional intent behind a statutory provision is ambiguous in light of the language or legislative history, the Agency charged with administering that statute may adopt any reasonable interpretation consistent with the goals and purposes of the statute. Chevron, U.S.A. v. NRDC, 467 U.S. 837 (1984). Therefore, EPA has a large degree of discretion to choose how it will interpret the applicability of WQS to municipal storm water discharges. The only interpretation by EPA to date, contained in its proposed rulemaking, has been that WQS would continue to apply to permits for municipal storm water discharges. See, e.g., 53 Fed. Reg. 49,457 (Dec. 7, 1988) (priorities for controls in municipal storm water management programs will be developed to ensure achievement of water quality standards and the CWA).[1] There has been no intervening interpretation expressed by EPA on this issue. It is the opinion of the Office of General Counsel that the interpretation adopted by the Agency in the proposal is a reasonable one, for the following reasons.

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[1] EPA's intent to apply WQS to municipal storm water discharges can also be inferred by the fact that the 1988 proposal did not propose to alter 40 CFR 122.44(d), which provides that all NPDES permits must contain water quality-based requirements more stringent than technology-based requirements, where necessary to achieve WQS.

First, to support the opposite reading (i.e., that WQ-based requirements do not apply to municipal storm water permits), one would have to assert that Congress implicitly waived section 301(b)(1)(C) requirements for municipal storm water. One would further have to assume that Congress impliedly exempted municipal storm water permits from the Section 401 certification requirements. Implied repeals of statutory provisions are generally disfavored. Morton v. Mancari, 417 U.S. 535, 549 (1974). A court generally will find a statute impliedly repealed only if the later enacted provision is in "irreconcilable conflict" with the earlier provision. Kremer v. Chemical Construction Corp., 456 U.S. 461, 468 (1982) (citations omitted). In this case, the statutory provisions are not in irreconcilable conflict; rather, as discussed above, one may read Section 301(b)(1)(C) as requiring "any more stringent limitation" necessary to meet a WQS in every NPDES permit, including permits for discharges from municipal separate storm sewers which are subject to the MEP standard. Such a reading would harmonize the two provisions and give effect to the policy behind Sections 301(b)(1)(C) and 401, i.e., to ensure that WQS are met regardless of practical considerations (such as the availability of treatment technology or the "practicability" of MS4 permit requirements).

To read Section 402(p)(3)(B) as overriding 301(b)(1)(C) requirements would also cause a conflict between Section 402(p) and the general focus of the provisions in the 1987 Amendments, many of which reflect a Congressional desire to improve compliance with the WQ-based requirements of the Act. The amendments to/additions of sections 303(c)(2)(B), 304(l), 319, 320, 402(o) all reflect Congressional concern with the improvement of water quality through the NPDES and other CWA programs. It would be particularly difficult to argue that the storm water provisions, a major part of the 1987 Amendments, were intended to create an exemption from the general rule regarding WQ-based requirements without an explicit acknowledgment of that result. We think the approach taken in the proposed rule is preferable.

B. Compliance Date for WQ-Based Limits in Municipal Storm Water Permits

In contrast to the issue of whether WQ-based requirements apply at all to MS4s, Congress had indeed spoken to the compliance date issue. Section 402(p)(4) requires compliance with all permit conditions no later than three years from the date of issuance. In light of the express language, we believe the Agency may reasonably interpret the three-year compliance provisions in Section 402(p)(4) to apply to all permit conditions, including those imposed under 301(b)(1)(C).[2]

There are arguments which support the reasonableness of this interpretation. First, EPA has issued few, if any storm water permits to MS4s to date. Many of these systems will face NPDES permit conditions for the first time, and I understand immediate compliance for these systems is likely to be unrealistic. The compliance date in Section 402(p)(4) apparently reflects a Congressional realization of that reality. Second, EPA has already construed another very similar provision of the 1987 Amendments in the same manner. Section 304(l) establishes an identical three-year compliance date for achieving water quality standards in Individual Control Strategies issued under that section. EPA has interpreted that provision, while not repealing Section 301(b)(1)(C), to allow for three-year compliance with new effluent limits established to meet WQS on 304(l)-identified streams. 54 Fed. Reg. 23,889 (Jun. 2, 1989). Given that 304(l) deals directly with WQ-based standards and permit requirements, a consistent interpretation with respect to 402(p)(3) and (p)(4) (which, as we have seen, is silent on the role of WQ-based requirements for MS4s) is certainly reasonable.[3]

If you have any questions regarding this memorandum, please contact Randy Hill of my staff, FTS 382-7700.

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[2]. There may be some municipal separate storm sewer systems which are unable to meet even the three-year compliance date in their permits. The Agency retains the discretion to issue an administrative order fixing a schedule for compliance if compliance is not achieved in that three-year period.

[3] The decision of the Administrator in the Star-Kist permit appeal does not affect this analysis. Indeed, the decision itself supports the reading that compliance schedules under Section 304(l) (and, by extension, schedules under Section 402(p)(4)) are unaffected by the holding in that decision. Cf. Order on Petition for Reconsideration, In the Matter of Star-Kist Caribe, Inc., NPDES Appeal No. 88-5, (Apr. 17, 1990), at 6 n.5 (because decision does not prevent all post-1977 compliance schedules, arguments regarding 304(l) are not pertinent); (order stayed Sept. 4 1990).

State of California

Memorandum

To : Jesse M. Diaz, Chief
Division of Water Quality and
Water Rights

Date: [illegible]

Craig M. Wilson
Chief Counsel
OFFICE OF THE CHIEF COUNSEL

From : STATE WATER RESOURCES CONTROL BOARD

Subject: ENFORCEMENT OF GENERAL INDUSTRIAL STORM WATER PERMIT

ISSUE

You have asked whether municipalities subject to storm water permits for municipal separate storm sewer systems may be authorized, or required, to enforce the general permit which will regulate discharges of storm water associated with industrial activities.

CONCLUSION

Enforcement of all NPDES permits, including the general storm water permit, is left to the State Board and the Regional Boards, and to EPA. Municipalities are entitled to bring citizen's suits to enforce NPDES permits where the state and EPA fail to act, but they may not be forced to do so. Municipalities could also enact and enforce their own permit programs.

DISCUSSION

The federal Clean Water Act authorizes EPA to issue NPDES permits to regulate discharges of pollutants into waters of the United States. Clean Water Act Section 402. The Clean Water Act also spells out enforcement actions which EPA may take, including issuance of fines. Clean Water Act Section 309. States are also authorized to establish permit programs, which may be approved by EPA. Clean Water Act Section 402. One of the requirements for approval is that the state has adequate authority to abate violations of permits, including penalties. Clean Water Act Section 402. In California, the State Board and

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the Regional Boards are granted authority to implement the NPDES program. Water Code Section 13370 and following. They are required to ensure compliance will all applicable provisions of the federal act. Water Code Section 13377. The Water Code includes penalty provisions similar to the federal law. Water Code Section 13385.

Thus, the federal law, as supplemented by state law, sets forth a detailed system of enforcement by state and federal authorities. There is no provision in these statutory provisions for direct enforcement of NPDES permits by another governmental agency, such as the municipalities which operate municipal separate storm sewers. (Municipalities may, of course, through their own legal authority, establish conditions on the discharge of storm waters associated with industrial activities within their jurisdictions.)

Municipalities are entitled to bring citizens suits for violation of NPDES permits pursuant to Clean Water Act Section 505. However, these suits may only be brought after EPA and the State are given 60 days' notice that the suit will be commenced. See Section 505. If EPA or the state commences enforcement action within that 60-day period, the citizen suit is barred. Also, citizens suits are limited to ongoing and prospective violations, while EPA and the state may issue fines for wholly past violations. Gwaltney of Smithfield, Ltd. v. Chesapeake Bay Foundation (1987) 484 U.S. 49. Thus, the citizens suit is meant only to supplement, and not to supplant, action by EPA and the state. Gwaltney, supra.

Thus, municipalities cannot step into the shoes of the State Board and the Regional Board and take over the NPDES permit enforcement responsibilities. They do not have the same authority to take enforcement actions, and this might affect the state's ability to show that it can ensure compliance with the Act. Further, it would not be appropriate for the State Board to require the municipalities to file citizens suits to enforce the industrial general permit. A preliminary step to filing such a suit would be a demonstration that the state was unwilling to commence enforcement action, and the municipality would be constrained in the actions it could take.

As was mentioned above, the Regional Boards may, as conditions of the municipalities' own permits, require the municipalities to take actions to reduce pollutants in discharges of storm water associated with industrial activities. These actions may include enforcement actions pursuant to the municipalities' police powers, including ordinances, fines and permits. From the requirements in EPA's regulations, it is clear that municipalities are expected to take a strong regulatory role in controlling industrial discharges, but this may not be done through direct enforcement of the industries' NPDES permit.

United States
Environmental Protection
Agency

Office Of Water
(EN-336)

EPA 833-F-93-002B
July 1993

EPA

NPDES Storm Water Program

Question And Answer Document Volume 2

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NPDES
Storm Water Program

Question and Answer Document

Volume II

EPA

U.S. Environmental Protection Agency
Office of Wastewater Enforcement and Compliance
Permits Division
401 M Street, SW
Washington, DC 20460

July 1993

municipal separate storm sewer systems were due on May 17, 1993 and November 16, 1992, respectively, this results in permit issuance by November 16, 1993 for large municipalities and by May 17, 1994 for medium municipalities.

87. **How is EPA incorporating 1990 census data into the storm water program?**

A. Most of the municipalities that meet the definition of either a large or medium MS4 based on the results of the 1990 Census have already begun to seek an NPDES permit. Headquarters is working with the Regions and States to determine the best way to incorporate the remaining municipal entities into the program.

88. **How does EPA envision the relationship between large and medium MS4 operators and NPDES permitting authorities in terms of addressing industrial storm water discharges to MS4s?**

A. EPA envisions a partnership between NPDES permitting authorities and operators of large and medium municipal separate storm sewer systems in controlling pollutants in storm water discharges associated with industrial activity through MS4s. In addition, NPDES storm water permits provide a basis for enforcement actions directly against the owner or operator of the storm water discharge associated with industrial activity.

A second NPDES permit will be issued to the operator of the large and medium MS4. This permit will establish the responsibilities of the municipal operators in controlling pollutants from storm water associated with industrial activity which discharges through their municipal system. Under this approach, municipal operators will be able to:

- Assist EPA in identifying priority storm water discharges associated with industrial activity through their system;
- Assist EPA in reviewing and evaluating storm water pollution prevention plans that industrial facilities are required to develop; and
- Assist EPA in compliance efforts regarding storm water discharges associated with industrial activity to their municipal system.

A more complete description of this policy is provided in the August 16, 1991 Federal Register (56 FR 40973).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

December, 1993

In Reply
Refer to: W-5-1

MEMORANDUM

SUBJECT: Role of Municipalities in the Implementation of State General NPDES Permits for Storm Water Associated with Industrial Activity

FROM: Eugene Bromley EB
EPA, Region 9 (W-5-1)

TO: Maryann Jones, Storm Water Section
California State Water Resources Control Board

This is in response to your request at the last Urban Runoff Task Force meeting for a justification for asking municipalities to assist the State and EPA in the implementation of the storm water program for industrial sources. You had requested this review pursuant to the development of the State storm water compliance strategy which describes the roles of the various parties involved in the storm water program. You had noted that some municipalities have been reluctant to assist the State in activities such as inspections, monitoring and review of SWPPPs for industrial facilities.

EPA's final permit application regulations of November 19, 1990 (55 Fed. Reg. 47990) set forth the permit application requirements for industries and municipalities and also discuss the implementation of the program over the longer term. These regulations envision a cooperative effort on the part of the NPDES permitting authority and permitted municipalities in the implementation of the industrial storm water program (55 Fed. Reg. 47997). The storm water permit application regulations at 40 CFR 122.26(d)(2)(iv)(C) also specifically require that municipalities develop and implement controls on industrial sources which discharge into the municipal separate storm sewer system (MS4). The permit application must include:

"description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit application determines are contributing a substantial pollutant loading to the municipal storm sewer system."

The regulations are 40 CFR 122.26(d)(2)(iv)(C)(1) also require that the municipality:

"identify priorities and procedures for inspections and establishing and implementing control measures for such discharges"

and include

a monitoring program for storm water discharges associated with industrial activity identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit . . .

(40 CFR 122.26(d)(2)(iv)(C)(2)).

EPA's Part 2 permit application guidance manual (EPA 833-B-92-002, which has already been provided to the State Board) suggests four specific activities to be undertaken by a municipality to assist NPDES permitting authorities with the implementation of the industrial storm water program. These recommendations are found on page 6-17 in Attachment 1 (excerpted from the EPA guidance manual). These recommendations are similar to the activities which will be implemented in accordance with agreements between the San Francisco Bay Regional Board and Santa Clara and Alameda Counties. The guidance manual also notes that municipalities are ultimately responsible for the discharges from their MS4s and thus it is in the best interests of a municipality to assist in the control of pollutants in storm water from industrial sources which is discharged into the MS4.

The State/municipal partnership is also discussed in the preamble to EPA's recent multi-sector general permit (58 Fed. Reg. 61157, Attachment 2). This discussion generally reiterates and supports the above discussion regarding the role of municipalities in assisting the State with the industrial storm water permit.

For the above reasons, we would recommend that the State compliance strategy ask that municipalities provide some assistance to the State with the implementation of the industrial storm water program. However, the strategy should provide flexibility with regards to the extent and timing of the municipal involvement. Factors such as municipal resources, the number and nature of industrial facilities in a given area, and the presence or absence of water quality impairments would be factors to consider in setting the requirements at the local level.

For the most part, the draft State compliance strategy (version of October 19, 1993) is already consistent with the above recommendations. Page 5 indicates that municipalities must address industrial storm water discharges, including those subject to the State's general permit. In addition, while the strategy (page 10) indicates that municipalities will "focus" on compliance with local ordinances, this would not exclude activities in support of the State. We suggest that the strategy indicate that municipalities should indeed focus on compliance with local requirements but also engage, as resources allow, in the types of activities discussed in the attachments in support of the State. The strategy should also indicate that while the State would focus on compliance with the general permit, the State would also bring to the attention of a municipality any observed non-compliance with local ordinances which may include special requirements beyond those of the general permit.

These above suggested additional activities by the State and municipalities should not constitute an excessive burden for either since pollution prevention is the basic intent of both the local ordinances and the State general permit. Review by a municipality of an industrial facility for compliance with the State's general permit is simultaneously a useful means for a municipality to evaluate the facility from the perspective of the local program and ensure that appropriate controls are implemented for significant sources of pollutants. Awareness of special local requirements by State inspectors would also enhance the effectiveness of the overall program.

Attachments

Characterization data should also be evaluated. Applicants should analyze quantitative data from representative outfalls to establish a monitoring and control program.

An integral part of this requirement is the adequacy of the applicant's legal authority. If a municipality believes that a discharge of storm water associated with industrial activity violates the industrial facility's NPDES permit limits, but the municipality does not have authority over the discharge, the municipality should contact the NPDES permitting authority for appropriate action. Examples of possible actions by the NPDES permitting authority are:

- For a facility that already has a NPDES individual permit, the permit may be reopened and further controls imposed;
- For a facility covered by a NPDES general permit, an individual site-specific permit application may be required; or
- For a facility not covered by a NPDES storm water permit, a permit may be required.

The municipality is ultimately responsible for discharges from their MS4. Consequently, the proposed storm water management program should describe how the municipality will help EPA and authorized NPDES States:

- Identify priority industries discharging to their systems;
- Review and evaluate storm water pollution prevention plans and other procedures that industrial facilities must develop under general or individual permits;
- Establish and implement BMPs to reduce pollutants from these industrial facilities (or require industry to implement them); and
- Inspect and monitor industrial facilities to verify that the industries discharging storm water to the municipal systems are in compliance with their NPDES storm water permit, if required.

6.3.3.1 Identifying Priorities

Proposed management programs must clearly identify priority industrial facilities.

> §122.26(d)(2)(iv)(C)(1). [The applicant must] identify priorities and procedures for inspections and establishing and implementing control measures for such discharges.

This section discusses how applicants might identify priority facilities. Section 6.3.3.2 discusses how municipalities might develop procedures for inspections and implementation of control measures.

At a minimum, priority facilities include:

- Operating and closed municipal landfills;
- Hazardous waste treatment, disposal or recovery facilities; and
- Facilities subject to SARA Title III.

Municipalities must identify these and other priority industrial facilities and describe the criteria used to identify them. For example, information from the Toxics Release Inventory is one source a municipality could use to identify industrial facilities subject to SARA Title III. Other sources may include CWA Section 205 or 208 use-attainability studies, other studies that indicate a site-specific beneficial use impairment immediately downstream of a storm water outfall, or records of industrial pretreatment programs or other permit programs that identify facilities that may be the source of a use impairment or

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TABLE 4.—ADVANCED BMP ALTERNATIVES

Prevention	Containment	Mitigation		Waste disposal
		Cleanup	Treatment	
Monitoring	Secondary containment	Physical	Liquid-solids separation.	Landfill.
Nondestructive	Flow diversion to secondary containment.	Mechanical	Volatilization	Land treatment.
Labeling	Vapor control	Chemical	Coagulation/precipitation.	Reclamation.
Covering	Dust control		Neutralization	Discharge to surface water.
Pneumatic and vacuum conveying	Sealing		Ion exchange	Deep well injection.
Vehicle positioning			Chemical oxidation	Discharge to POTW.
Dry cleanup			Biological treatment	Offsite disposal.
			Thermal oxidation	

3. Traditional Storm Water Management Practices

In some situations, traditional storm water management practices such as grass swales, catch basin design and maintenance, infiltration devices, unlined retention or detention basins, water reuse, and oil and grit separators can be applied to an industrial setting. However, care must be taken to evaluate the potential of many of these traditional devices for ground water contamination. In some cases, it is appropriate to limit traditional storm water management practices to those areas of the drainage system that generate storm water discharges with relatively low levels of pollutants (e.g., many rooftops, parking lots, etc.). At facilities located in northern areas of the country, snow removal activities may play an important role in a storm water management program. In addition, other types of controls such as spill prevention measures can be considered to prevent catastrophic events that can lead to surface or ground water contamination.

4. Diversion of Discharge to Sewage Treatment Plant

Where storm water discharges contain significant amounts of pollutants that can be removed by a sewage treatment plant, the storm water discharge can be discharged to the sanitary sewage system. Such diversions must be coordinated with the operators of the sewage treatment plant and the collection system to avoid worsening problems with either combined sewer overflows (CSOs), basement flooding or wet weather operation of the treatment plant. Where CSO discharges, flooding or plant operation problems can result, onsite storage followed by a controlled release during dry weather conditions may be considered.

5. End-of-Pipe Treatment

End-of-pipe treatment requirements are typically imposed through numeric effluent limitations, which provide the discharger with flexibility to design the most cost effective type of treatment for the given facility.

At many types of industrial facilities, it may be appropriate to collect and treat the runoff from targeted areas of the facility. This approach was taken with 10 industrial categories with national effluent guideline limitations for storm water discharges. There are several basic similarities among the national effluent guideline limitations for storm water discharges:

- To meet the numeric effluent limitation, most, if not all, facilities must collect and temporarily store onsite runoff from targeted areas of the plant.
- The effluent guideline limitations do not apply to discharges whenever rainfall events, either chronic or catastrophic, cause an overflow of storage devices designed, constructed, and operated to contain a design storm. The 10-year, 24-hour storm, or the 25-year, 24-hour storm commonly are used as the design storm in the effluent guideline limitations.
- Most technology-based treatment standards are based on relatively simple technologies such as settling of solids, neutralization, and drum filtration. Potential ground water impacts should also be considered by operators when designing storage devices.

V. The Federal/Municipal Partnership: The Role of Municipal Operators of Large and Medium Municipal Separate Storm Sewer Systems

A key issue in developing a workable regulatory program for controlling pollutants in storm water discharges associated with industrial activity is the proper use and coordination of limited regulatory resources. This is especially important when addressing the appropriate role of municipal operators of large and medium municipal separate storm sewer systems in the control of pollutants in storm water associated with industrial activity which discharge through municipal separate storm sewer systems.

Several key policy factors arise when considering the appropriate strategy for regulating storm water discharges associated with industrial activity through municipal separate storm sewer systems. These factors include the following:

- The role and responsibilities of municipalities to control pollutants from nonmunicipal facilities which are discharged through a storm sewer owned or operated by the municipality.
- The large number of storm water discharges through municipal systems (the Agency anticipates that the majority of storm water discharges associated with industrial activity from many industrial classes discharge through municipal separate storm sewer systems).
- The ability of municipalities to recognize and represent local concerns and considerations.
- The ability of municipal operators to assist EPA and authorized NPDES States in identifying local priorities for controlling storm water discharges associated with industrial activity through specific municipal systems.
- The ability of municipal operators to assist EPA and authorized NPDES States to oversee effectively the development of appropriate site-specific controls for storm water discharges associated with industrial activity through municipal systems and to effectively require compliance with such controls.
- The authorities provided by the CWA (including those provided to the public) to review information developed

under the NPDES program and to enforce NPDES permits.

• The requirements of the CWA to develop and implement the NPDES permit program.

On November 16, 1990 (55 FR 47990), EPA promulgated a permitting scheme where controls for storm water discharges associated with industrial activity through large and medium municipal separate storm sewer systems may be addressed by two permits issued in a coordinated manner. This complementary permit approach envisions cooperative efforts by the permit issuing agency and municipal operators of large and medium municipal separate storm sewer systems to develop programs that will result in controls on pollutants in storm water discharges associated with industrial activity which discharge through municipal systems.

Under the complementary permit approach, storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems are required to obtain permit coverage. Permits for these discharges will establish requirements (such as controls or monitoring) for industrial operators of the discharge into the municipal system. In addition, these permits provide a basis for enforcement actions directly against the owner or operator of storm water discharges associated with industrial activity.

A second permit, issued to the operator of the large or medium municipal separate storm sewer, establishes the responsibilities of the municipal operators in controlling pollutants from storm water associated with industrial activity which discharges through their system. The framework for permits for discharges from large and medium municipal separate storm sewer systems has been developed to establish the responsibilities of the municipal operator to control pollutants discharged through these municipal systems. At the heart of the permit program for discharges from municipal separate storm sewer systems serving a population of 100,000 or more are requirements that municipal applicants develop and implement municipal storm water management programs. The municipal storm water management programs that will be incorporated into NPDES permits for discharges from municipal separate storm sewer systems will generally address (in addition to other possible requirements) the following three major components:

• Reducing pollutants in storm water discharges from municipal landfills; hazardous waste treatment, storage and disposal facilities; facilities subject to the Emergency Planning and Community Right-to-Know Act (EPCRA), section 313; and other priority industrial facilities through municipal separate storm sewers.

• Reducing pollutants in construction site runoff through municipal separate storm sewers.

• Identifying and controlling non-storm water discharges to municipal separate storm sewer systems.

These components of a municipal program can initiate the role of the municipality in assisting EPA and authorized NPDES States in implementing controls to reduce pollutants in storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems. Municipal programs to reduce pollutants in industrial site runoff and construction site runoff through municipal separate storm sewer systems specifically will address municipal responsibilities in controlling pollutants from industrial facilities. In addition, programs to identify and control non-storm water discharges to municipal separate storm sewer systems will in many cases focus on industrial areas because these areas often have a high potential for illicit connections, spills or improper dumping.

Consistent with the final permit application regulations published on November 16, 1990, (55 FR 47990), the proposed general permit accompanying this fact sheet have been developed to assist in establishing a cooperative approach between EPA and municipal operators of large and medium municipal separate storm sewer systems for controlling pollutants from storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems. These requirements will be coordinated with requirements in permits for discharges from large and medium municipal separate storm sewer systems. Major features of the proposed general permit that establish the framework for this cooperative approach include:

• Operators of storm water discharges associated with industrial activity which discharge through a large or medium municipal separate storm sewer system may be required to submit a copy of the notice of intent to the municipal operators of large or medium municipal system receiving the discharge.

• Requirements to monitor and reduce pollutants in discharges will be established for storm water discharges associated with industrial activity which discharge through large and medium municipal separate storm sewer systems (as well as other storm water discharges associated with industrial activity). Any records, reports, or information obtained by the Director as part of the permit implementation process, including site-specific storm water pollution prevention programs that are developed pursuant to the proposed general permit, are available to municipalities under section 308(b) of the CWA. This will assist municipalities in reviewing the adequacy of such requirements and developing priorities among industrial storm water sources.

• Industrial permittees with discharges through large and medium municipal systems may be required to submit discharge monitoring reports to municipal operators of these systems (as well as to the permitting issuing agency) or other monitoring results as required by the operator of the municipal separate storm sewer to assist the municipal operator in identifying priorities.

These permit conditions, along with appropriate conditions in permits for discharges from large and medium municipal separate storm sewer systems, will allow municipal operators of these systems to assist EPA in:

• Identifying priority storm water discharges associated with industrial activity to their system

• Reviewing and evaluating storm water pollution prevention plans

• Compliance efforts regarding storm water discharges associated with industrial activity to their municipal systems.

VI. Summary of Common Permit Conditions

The following section describes the permit conditions common to discharges from all the industrial activities covered by today's permit. These conditions reflect the baseline permit requirements established for most regulated industries in EPA's General Permits for Storm Water Discharges Associated with Industrial Activity (57 FR 41344–41356 September 9, 1992, and 57 FR 44438–44470 September 25, 1992). Permit requirements which vary from industry to industry are discussed in part VIII of this fact sheet.

A. Notification Requirement

General permits for storm water discharges associated with industrial

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FAX TRANSMISSION

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

DATE: 3/12 **PAGES (inclu..ing cover sheet):** 7

TO: Name: Carlos Urrunaga

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FROM: Name: Eugene Bromley

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NOTE:

Memorandum: "Role of municipalities in implementation of State general NPDES permits for Storm Water Associated with Industrial Activity"

R0008394

State of California

'ɘmorandum

To : Clayton Roche
Deputy Attorney General
Office of the Attorney General
455 Golden Gate Avenue, Suite 6200
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Date: OCT 5 1994

William R. Attwater
Chief Counsel

From : OFFICE OF THE CHIEF COUNSEL
STATE WATER RESOURCES CONTROL BOARD
901 P Street Sacramento, CA 95814
Mail Code G-8

Subject: ATTORNEY GENERAL OPINION NO. 94-814

This memorandum addresses issues raised in Senator Mike Thompson's request for an opinion of the Attorney General on the following question: May the Vallejo Sanitation and Flood Control District adopt ordinances and regulations prohibiting pollution of the district's storm waters, with enforcement by administrative fines, penalties, and criminal sanctions? As will be explained, the ultimate issue of the authority of the Vallejo Sanitation and Flood Control District (District) is not an issue on which I would like to provide a legal opinion, but I believe it is important that the Attorney General understand the context of this issue in preparing an opinion. Therefore, I will present background information on the relevant regulatory requirements of the storm water program.

The 1987 amendments to the federal Clean Water Act require that national pollutant discharge elimination system (NPDES) permits be issued for discharges from municipal separate storm sewer systems (MS4's) serving a population over 100,000.[1] Section 402(p); 33 U.S.C. Section 1342(p). The federal Environmental Protection Agency (EPA) adopted implementing regulations in 40 CFR Section 122.26. The

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[1] *The Clean Water Act regulates both "large" MS4's, serving populations of 250,000 or more, and "medium" MS4's, serving populations of 100,000 to 250,000. Clean Water Act Section 402(p)(2)(C) and (D). The storm sewer system for Vallejo is designated as a medium MS4.*

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regulations require that MS4's which are regulated pursuant to NPDES permits must show adequate legal authority to carry out the programs necessary to regulate pollutants in storm water runoff. See, 40 CFR Sections 122.26(d)(1)(ii) and 122.26(d)(2)(i). In general, these requirements consist of the ability to control through ordinance, enforcement orders, or similar means, the contribution of pollutants to the municipal storm sewers by residents and businesses throughout the service area. Thus, in order to comply with the federal regulations, a MS4 must have adequate legal authority to regulate discharges of pollutants into the municipal sewer system. The NPDES permit, itself, will be issued by the San Francisco Bay Regional Water Quality Control Board (RWQCB).

The EPA regulations indicate that MS4's may be owned or operated by a variety of public agencies, including:

> "[A] State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity ...." 40 CFR Section 122.26(b)(8)(i).

The storm sewer system is also broadly defined, to include "roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains". 40 CFR Section 122.26(b)(8).

In light of the broad definitions of municipal storm sewer systems and because the permitting requirements are based on population areas, most municipal storm water permits have been issued to a number of co-permittees in a geographical area, including cities, counties, state agencies (such as CalTrans), and flood control districts. For example, one permit was issued for the Los Angeles area which includes 94 cities, the County, and various special districts.

Issuing permits to co-permittees accomplishes the goal of insuring that all of the storm sewer system is covered by the permit, and that those entities with the legal authority to oversee implementation of the permit's requirements are placed in a position of responsibility. In adopting its regulations, EPA acknowledged the role of co-permittees in assuring compliance with the regulations and the permit terms. There are a number of references to these issues in the Preamble to the regulations. Volume 55, Federal Register pages 47990 and following (November 16, 1990). For example, EPA states that its broad definitions of large and medium storm sewer systems are meant to address comments including the need for permittees to have legal authority and control over land use, and the need for flood control districts to be addressed as a system or part of a system. Vol. 55, Fed.Reg. at p. 48039. EPA discusses in detail its decision to allow co-permittees including cities, counties, and flood control districts to:

> "[R]esolve the problems associated with permittees not having adequate land use controls, the legal authority to implement controls, and the ownership of the conveyances." *Id.*, at p. 48041.

EPA specifically addresses the difficulty which would be encountered if the only permittee was a flood control district without adequate land use or legal authority to assure compliance:

> "... flood control districts, which may have no land use authority in incorporated cities, will be co-permittees with the city which does possess land use authority. EPA envisions that permit conditions for these systems will be written to establish duties that are commensurate with the legal authorities of a co-permittee." *Id.*

My purpose in reviewing this background is to demonstrate that while the issue of whether the Vallejo Sanitation and Flood Control District has authority to adopt ordinances and regulations prohibiting pollution of the district's storm waters, with enforcement by administrative fines, penalties, and criminal sanctions is not one which I am prepared to answer, since I am not familiar with the District's enabling statutes, the federal requirements apply jointly to all MS4's in the Vallejo geographic area. This includes, at a minimum, the City of Vallejo which clearly does have adequate land use and legal authority. In adopting a permit for storm water discharges from Vallejo, the RWQCB will need to ensure that the permittees or co-permittees which are named have the authority required under the federal regulations. While the District may prefer not to have any co-permittees listed on the permit, that would only be acceptable if in fact it alone does have adequate authority to ensure compliance with the permit.

If you have any questions regarding this matter, please contact Betsy Miller Jennings of my staff at (916) 657-2421 or CALNET 8-437-2421.

cc: Tom Mumley
RWQCB, San Francisco Bay Regional Board
2101 Webster Street, Suite 500
Santa Rosa, CA 95403

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State of California

Memorandum

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To Carlos Urrunaga	From Fujimoto
Co.	Co.
Dept.	Phone #
Fax #	Fax #

To : Bruce Fujimoto
Division of Water Quality

Elizabeth M Jennings

Elizabeth Miller Jennings Oct 3, 1995
Senior Staff Counsel

From : OFFICE OF THE CHIEF COUNSEL
STATE WATER RESOURCES CONTROL BOARD
901 P Street, Sacramento, CA 95814
Mail Code G-8

Subject: MUNICIPAL STORM WATER PERMITS: COMPLIANCE WITH WATER QUALITY OBJECTIVES

ISSUE

Must storm water permits for municipal separate storm sewer systems (MS4s) include requirements necessary to achieve water quality objectives?

CONCLUSION

Storm water permits issued to MS4s must include requirements necessary to achieve water quality objectives.

DISCUSSION

Section 301 of the Clean Water Act prohibits the discharge of any pollutant unless pursuant to a National Pollutant Discharge Elimination System (NPDES) permit. Section 301 also requires compliance with effluent limitations necessary to achieve compliance with technology-based standards (e.g., best practicable control technology currently available or secondary treatment). Finally, Section 301 requires compliance with any more stringent effluent limitation which are necessary to protect water quality standards.

Section 402(p) of the Clean Water Act includes a technology-based standard for storm water permits issued to MS4s. Such permits must require:

> "controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods ...."

Section 402(p) does not discuss water quality-based standards. A question is therefore raised whether permits issued to MS4s

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must include only effluent limitations to meet the technology-based standard of "maximum extent practicable" (MEP), or whether they must also include water quality-based effluent limitations.

This question has already been answered by the SWRCB in Order No.WQ 91-03. The answer is that permits issued to MS4s must include effluent limitations which will achieve the MEP standard, and will also achieve compliance with water quality objectives. The SWRCB stated:

> We therefore conclude that permits for municipal separate storm sewer systems issued pursuant to Clean Water Act Section 402(p) must contain effluent limitations based on water quality standards. Order No. WQ 91-03, at slip op. 36.

The specific language in effluent limitations or other permit conditions is left to the discretion of the agency issuing the permit. Thus, for storm water permits for MS4s, it is appropriate to include "best management practices" (BMPs) instead of numeric effluent limitations. See, Order No. WQ 91-03, at slip op. 37-38. These BMPs may be adequate as both technology-based limitations and water quality-based limitations. *Id.* Section 301(b)(1)(C) of the Clean Water Act broadly requires compliance with "any more stringent limitation, including those necessary to meet water quality standards". The legal requirements for determining effluent limitations in permits are listed in 40 Code of Federal Regulations (CFR) Section 122.44. The SWRCB interpreted these provisions in Order No. WQ 91-03, and concluded permits for MS4s may include BMPs as effluent limitations.

In Order No. WQ 91-04, the SWRCB considered a storm water permit issued to a MS4 that included BMPs as effluent limitations, and did not specifically require compliance with water quality objectives. The SWRCB stated that even where a permit does not specifically reference violation of water quality standards, it should be read "so as to require the implementation of practices which will achieve compliance with applicable standards". Slip op. at 15.

In conclusion, the SWRCB has determined storm water permits for MS4s must include requirements necessary to achieve compliance with both MEP and water quality standards. The SWRCB has allowed RWQCBs to determine the specific requirements to place in permits. The SWRCB has approved permits for MS4s which include BMPs rather than numeric effluent limitations. The SWRCB has also approved a permit that did not specifically prohibit violation of water quality objectives. The permit was approved because it contained BMPs adequate to meet water quality objectives.

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

RESPONSES TO COMMENTS RECEIVED* ON THE DECEMBER 18, 1995 DRAFT NPDES PERMIT FOR MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES WITHIN THE COUNTY OF LOS ANGELES

See also responses to legal comments by the Regional Board Counsel (in the memorandum dated April 17, 1996).

* By February 6, 1996

I. FINDINGS

Commenter	Comment	Discussion	Action
Agoura Hills, Long Beach, EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Culver City, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier, Bellflower, El Segundo	The findings do not represent statements of fact or there is no evidence to show why the findings are made. Findings should not repeat what is in the Order. Should not be self serving or biased. Should be limited to those relevant to storm water quality enhancement. Statements about enforcement actions taken as a result of the current permit should not be included.	State Administrative Procedures manual provides guidance on information to be included in findings such as addressing water quality control plans and water quality objectives; identifying existing requirements and any enforcement actions and amendments thereto.	Findings have been revised to include statements of fact and show headings and categories to facilitate identification of information within the Findings section.
Western States Petroleum Assoc.	Include a list of references in the Findings.		References have been included in the Findings section.

II. RECEIVING WATER LIMITATIONS

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
Receiving Water Limitations			
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Los Angeles County Los Angeles Long Beach	Compliance with receiving water limits is unachievable. Compliance should be measured based on implementation of programs. The Receiving Water Limits language creates significant liability. The city suggests that the standard be reasonable further progress towards reducing pollutants during the permit term and not attainment of water quality standards. The draft permit contains two sets of standards which appear to be in conflict. One based on objectives and standards in plans and the other based on implementation requirements in the draft permit. The existing RWL language will expose each city to a violation of the narrative limits and the permit conditions immediately	The fundamental objective of the Clean Water Act is to protect, maintain or restore existing or potential beneficial uses of receiving waters as evaluated in 1972. Narrative criteria were developed to achieve this goal and are considered necessary by the USEPA to meet the statutory requirements of Clean Water Act (CWA) Section 303(c)(2)(A). These are to be applied to all NPDES permits including those for storm water discharges.	The Receiving Water Limitations language has been revised such that Permittees are not in violation of the permit if they are actively engaged in implementing permit requirements in a satisfactory manner.

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EAC, Agoura Hills, Alhambra, Azusa, Baldwin Park, Covina, Claremont, Commerce, Culver City, Downey, El Segundo, Glendale, Glendora, Hermosa Beach, LaVerne, Los Angeles, Lakewood, Lomita, Long Beach, Industry, San Marino, Sierra Madre, San Marino, Signal Hill, So. El Monte, So. Gate, Torrance, Valencia, West Covina, Whittier Heal the Bay Valencia Company	Permittees are not given the opportunity to implement their MS4 program and progress to meet clean water objectives. Instead, they would have to study almost immediately the cause of violations. The present language implies that municipalities are in non-compliance even when they are implementing the program in a timely manner, but are unable to eliminate violation of narrative standards. The permit should state that compliance is determined not from specific water quality objectives, but from functional equivalency measured by timely and effective implementation of the permit provisions. Water quality standards in statewide plans may be met by the implementation of BMPs. Delete language from the Order.	It is generally accepted that implementation of the requirements of the storm water permit constitutes functional equivalence to compliance with water quality standards. Both the USEPA and the State Water Resources Control Board have stated that BMPs are adequate effluent limitations for MS4 storm water discharges to achieve compliance with water quality standards.	See action above.

III. PROGRAM REQUIREMENTS FOR PROGRAM MANAGEMENT

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTIONS
Principal Permittee			
Hermosa Beach	To place all Principal Permittee requirements in a single section will help to reduce confusion by individual permittees.	The Order contains tables at the beginning of each major section which provides a summary of requirements and shows who needs to implement what and when.	No action suggested
BIA	What moneys will the Principal Permittee use to fund and provide personnel for the development and updating of the CSWMP and the six WMAPs? What is the projected cost of these activities?	The County of Los Angeles has agreed to these activities. The projected cost has not been made available by the County of Los Angeles.	No action suggested
Calabasas	Water quality monitoring implementation should be a county responsibility.	The commenter appears to believe that the burden for monitoring has shifted to individual Permittees. The County's responsibilities include the majority of monitoring requirements.	The permit has been revised to state that the Principal Permittee shall conduct countywide storm water monitoring as one of its responsibilities.
Heal the Bay	The phrase "With the guidance of EAC" throughout the Permit implies that the EAC has control over the implementation of the permit. If the EAC has no legal responsibility, then the role is advisory only.	Please see the Regional Board Counsel's legal memorandum dated April 17, 1996, comment no. 1.	The structure of the EAC and WMCs is presented in the Findings. Reference to the responsibilities of the EAC has been removed.
La Verne	Appointment of a chair to the Watershed Management Committees (WMC) is unnecessary. The county convenes and conducts the meetings. The WMC may select a chair if it determines it to be necessary.	The intent is to have an effective WMC. Also please see the Regional Board Counsel's legal memorandum dated April 17, 1996, comment no. 1.	The permit revision states that the WMC will choose a chair and secretary, and that Los Angeles County will assume these roles until the WMC chooses.

COMMENTERS	COMMENTS	DISCUSSION	ACTIONS
Permittees			
El Segundo, La Verne, Long Beach, LACDPW, Agoura Hills	Few agencies can or will appoint a staff member with the delegated authority required under this permit to sit on the WMC. Many of the issues to be raised are budgetary or policy-related which will require city council or board action. This provision reflects a limited understanding of local government processes and should be stricken from the permit. Incorrectly requires the delegation of authority from a City official to staff.	The Permit requires that a representative be appointed to the WMC with authority to make decisions for the Permittee agency. The intent is to have a workable WMC. The Permittee representative who attends the WMC and/or the EAC meetings should provide input to the development of any program requirements and update their governing Boards as the CSWMP and WMAPs are being developed and implemented.	The statement has been changed to a 'technically knowledgeable representative'.
Long Beach	This section on internal Permittee coordination should be deleted. How the Permittee coordinates and implements this program within its agency should not be specified in this permit.	Some Permittees state that it is easier to gain cooperation from other City departments if it is clear in the Permit that departments within the Permittee's purview must work cooperatively.	No change suggested.
Bell Gardens, Torrance	It is suggested that program requirements be limited to practices which are assured of some degree of success	Program components were included based on MS4 requirements statewide and elsewhere in the nation. Evidence exists that they are effective.	No change suggested.
El Segundo, City of LA	By what authority may a Permittee be required to "jointly prepare" a WMAP? Jointly with whom? Is a Permittee liable for errors of other joint preparers?	Permittees in a Watershed Management Area have the joint responsibility with other Watershed Permittees to prepare the WMAP as part of the renewal application (2001). An individual Permittee is only responsible for its own actions or inactions, and not that or those of any other Permittee(s).	No change suggested.

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Heal the Bay	Section does not specifically state that the Permittee is responsible for the implementation of the requirements of the Order as soon as the Order is adopted	Permittees may falsely believe that they have nothing to do until the CSWMP is complete. Permittees are required to implement existing storm water BMPs.	Language has been included to state that Permittees are required to implement components by specified dates.
External Agency Coordination			
Bellflower, El Segundo	Electronic bulletin boards are outdated technology. The Board should make the information available on the Internet.	Not all Permittees have a comparable level of access to electronic information. The Regional Water Quality Control Board is currently updating the information services available within the office. The additions include internet capabilities.	Permit language has been changed to state that information will be available from the Regional Board via the electronic bulletin board or other available methods.
LACDPW, Santa Clarita	The US Army Corp of Engineers and State Parks, and US Forest Service should be added to list of cooperating agencies for external coordination.	The list provided in the Permit was not intended to be all inclusive.	The suggested entities have been added to the list.

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Executive Advisory Committee			
Agoura Hills, Alhambra, Azusa, Baldwin Park, Beverly Hills, Bradbury, Carson,Cerritos, Claremont, Commerce, Covina, Culver City, EAC, Downey, Glendale, Glendora, Heal the Bay, Hermosa Beach, Industry, Inglewood, Irwindale, La Verne, Lomita, Los Angeles City, LACDPW, Lakewood, Lomita, Long Beach, Norwalk, Palos Verdes Estates,Pico Rivera, San Marino, Santa Clarita, Santa Fe Springs, Sierra Madre, Signal Hill, S El Monte, S Gate, Torrance, Vernon, West Covina, West Hollywood, Westlake Village, Whittier	The membership of the EAC should be left to the permittees and not dictated by Regional Board staff. There should be no non voting members on the EAC. The EAC should be limited to public agency personnel. The concern for public input at the EAC level is unwarranted (or unnecessary). The public will be allowed to input during the public comment periods.	It is suggested that Permittees include members of the public including business and environmental representatives during the development and implementation of the CSWMP and WMAPs. (40 CFR 122.26(D)(2)(iv) requires that a storm water management program "include a comprehensive planning process which involves public participation...") Please see the Regional Board Counsel's legal memorandum dated April 17, 1996, comment no. 1.	Reference to the make-up, participation and responsibilities of the EAC has been deleted from the Section. The Findings briefly describes the structure of the EAC as originally proposed in the application.
BIA, Heal the Bay, Senator Hayden,	The Regional Board representative, member of the public, and two industry representatives are presently designated as non-voting members of the EAC. These members should be able to vote. The public member should be an environmental community representative.		
Agoura Hills, Alhambra, Carson, Claremont, Commerce, Culver City, EAC, Glendora, Heal the Bay, Hermosa Beach, La Verne, Lomita, Palos Verdes Estates, Torrance, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	The makeup of the EAC in the December Permit deviates significantly from the current selection process. Permittees suggest that the selection process be returned to the WMC for election of the most qualified persons for the positions as members of the EAC.		
La Verne	The Regional Board should have no authority to appoint persons to the WMCs. This section should note that selection and participation on the EAC by permittees other than the county and City of los Angeles is voluntary.	Participation on the EAC is voluntary. References to specific makeup of EAC and WMCs and processes has been eliminated.	
Santa Monica	The WMC representative to the EAC should be based on WMC consensus, defaulting to the city with the largest population if necessary.		

R0008409

Calabasas and Malibu Creek Permittees	Two representatives from each watershed area should serve on the EAC. One of whom must be an elected official from a Permittee city.	An elected official on the EAC would be beneficial to policy making. However, the support is not shared by all.	No change suggested.
La Verne Bellflower, La Verne, Beverly Hills, Bradbury, Carson, Diamond Bar, Hermosa Beach, Norwalk, Rolling Hills, West Hollywood, Westlake Village	How may the EAC guide conflict resolution among Permittees and advise the County on its liaison responsibilities to the Regional Board. The EAC cannot coordinate the implementation of pilot projects because it is beyond the means of the EAC. Suggest striking it from the Permit. The EAC doesn't have the ability or legal authority to compile information for submittal to the Regional Board. Suggest striking it from the Permit.	Regional Board Counsel's legal memorandum, dated April 17, 1996, addresses the issue. See Response No. 1.	The Regional Board's Counsel prepared and sent a response.
Watershed Management Committees			
La Verne	Appointment of a chair to the Watershed Management Committees (WMC) is unnecessary. The county convenes and conducts the meetings. The WMC may select a chair if it determines it to be necessary. What issues will the WMC be voting upon?	The intent is to have an effective WMC. The issues to be voted upon by the Permittees on the WMCs may include EAC representation, modifications to CSWMP, WMAP components, and recommendations to the EAC, among other issues.	The permit revision states that the WMC will choose a chair and secretary, and that Los Angeles County may assume these roles if none volunteer.
La Verne	Who pays to circulate the draft annual report? If the WMC, how will it be apportioned and administered?	The County of Los Angeles will circulate the draft annual report among the WMCs and EAC.	No change suggested.
Beverly Hills, Bradbury, Carson, Diamond Bar, Hermosa Beach, Norwalk, Rolling Hills, West Hollywood, Westlake Village	WMC should have no legal requirements. WMC should not be held responsible for any Permit requirements.	Please see the Regional Board Counsel's legal memorandum dated April 17, 1996, comment no. 1.	No change suggested.

R0008410

La Verne	Why and what resources is the county expected to provide permittees with populations under 100,000?	Smaller cities had previously noted that they wanted to be on the EAC but had limited resources to do a competent job. The resources to be provided were dependent on specific needs, and would be determined by the County of Los Angeles. The resources anticipated were limited to coordination of meetings, not financial disbursements.	No change suggested.
Heal the Bay, Santa Monica	Permit should clearly require preparation of WMAP according to clear and specific criteria that include monitoring and evaluation as factors that feed back into plan revisions. WMAPs should be developed with consideration of how to enhance degraded beneficial uses and/or protect existing beneficial uses within a watershed as designated in Basin Plan and 303(d) listing. Permit needs to specify who has legal requirement to develop the WMAPs. Add submission deadlines for the WMAPs.	The basic criteria to be followed for the WMAP, are those developed for the CSWMP, with the appropriate modifications for the watershed. Specificity is sometimes seen as limiting flexibility. Submission deadlines will be added in the revision to the draft.	The permit revision states that the WMAP is to be developed as part of the renewal application in 2001. This will be after the completion of the CSWMP.

R0008411

Torrance	Is there enough evidence regarding the effectiveness of pollution control efforts that the Permittee will be able to make an informed decision? Will the Regional Board be providing the information to the Permittees?	There is sufficient information available nationally to research potential BMPs and make good decisions. Clean Water Act Section 402(p) states that Permittees are required to reduce pollutants in storm water to the maximum extent practicable. Regional Board staff will continue to share valuable BMP and storm water management program information with the Permittees.	No change required.

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTIONS
Fiscal Resources			
Alhambra, Azusa, Bellflower, EAC, Carson, Commerce, Culver City, Downey, El Segundo, Glendale, Glendora, Hermosa Beach, Industry, Inglewood, Lakewood, La Verne, Lomita, Long Beach, Monterey Park, San Marino, Whittier, West Covina, Hermosa Beach, Southgate, Signal Hill, South El Monte, Sierra Madre	The budget requirements are excessive and too detailed. A simple reporting requirement should be used. Permit demonstrates lack of understanding of budgeting process.	The budget summary should be sufficient to provide information on storm water program implementation, as required under 40 CFR 122.26(d)(2)(vi).	Permit language has been revised to require a budget summary that follows the Principal Permittees' budget summary format.
Claremont	What is the purpose of providing financial information? The permittees are already overburden with unfunded mandates and ever shrinking financial resources.		
La Verne			
Heal The Bay	Budget summary is overly detailed and may prove very difficult to provide.		

Program Substitution			
City of LA Bellflower, El Segundo, La Verne	The Program Substitution requirements are too burdensome. Demonstrating "technical feasibility" or "implementation outweighs the pollution control benefits" is a subjective decision and open to interpretation.	The CSWMP and the WMAPs development process, and this Order will identify BMPs for implementation. Flexibility is provided to Permittees to replace a specific BMPs if they propose better or equally effective alternatives.	Subtitle heading has been changed to BMP or Requirement Substitution.
Heal the Bay, Santa Monica Bay Keeper	Determinations regrading program substitution could be purely subjective, or worse yet, become political. Support section that allows BMP substitution flexibility, not BMP elimination.	The Executive Officer is vested with the authority to approve the alternative if the enumerated conditions can be met.	The Order includes language regarding the replacement of a BMP or requirement within the Substitution section.
Administrative Review			
BIA, Baldwin Park, Bellflower, Bell Gardens, Burke Williams, Claremont, Culver City, EAC, El Segundo, Glendale, Glendora, Heal the Bay, Hermosa Beach, La Verne, Pico Rivera, Rosemead, San Dimas, San Marino, Santa Fe Springs, Torrance, West Covina	Any determination made by the Executive Officer should be subject to appeal to the Regional Board.	The Administrative Review Provision is an informal process to facilitate dispute resolution between the Regional Board and Permittees. This is not required under federal or state law but is included as a courtesy to Permittees. For additional discussion, please refer to the April 17, 1996, Regional Board Counsel's legal memo, Response nos. 2, 3, and 4.	No action suggested.
Bellflower	The review period for all submittals to the Regional Board should be a maximum of 60 days. The 120 day review period could lead the Permittee to expend a substantial effort on a program that may turn out not to be acceptable.	The time period allowed for review by the Regional Board, is a commitment by the Regional Board, while not required by current law, to review and respond to Permittees' submittals.	No changes suggested.
Public Review			

American Oceans Campaign	WMC meetings should be open to the public and the public should have adequate opportunity to review permit submittals.	WMC meetings are presently open to the public.	No changes suggested.
Bay Keeper	All programs including measures of effectiveness must be subject to Public Review.	All program implementation components submitted to the Regional Board are subject to public review and comment.	
BIA	Comments submitted by the public within the 45 days comment period must be provided to the Board prior to Board action.	All comments submitted by the public are made part of the administrative record for consideration by the Regional Board	

IV. ILLICIT CONNECTIONS / DISCHARGES

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
Illicit Connections			
Azusa, W. Covina	Illicit connections remain a costly requirement. Uncertain merit.	This component was required under Order 90-079. "Illicit connections can result ... in dangers to public health; ...can create severe wide-spread contamination problems" (Final rule - 55 FR 222, 48056)	No change suggested.
Agoura Hills	Cities have no control over federal and state land parcels. Who has regulatory control?	Finding 20 in December draft recognizes cities' non jurisdiction in such cases. The Regional Board in such circumstances may issue separate NPDES permits with sufficient evidence.	The Discharge Prohibition Section has been revised to exclude, "Discharges originating from federal, state or other facilities which the Permittee is preempted from regulating".
Alhambra, Culver City, Lomita, Torrance	Differentiate illicit connections, illicit discharges, and illegal disposal.	Illicit connection is the structural plumbing to the MS4. Illicit discharges are unauthorized releases to the MS4. Illegal disposal is a term used by the USEPA to connotate improper disposal of oil, toxic materials, etc. The term is not used in the draft but the practice is included under illicit discharges to avoid confusion.	Terms are defined in glossary

R0008415

LA County Paramount NRDC Santa Clarita, Vernon NRDC	Allow 8 months from permit adoption for model development for illicit connections and discharges. Each city to submit implementation schedule 4 months from the Executive Officer's approval. Begin implementation of program by June 15, 1997. Develop model by July 15, 1996. Begin implementation by Jan 15, 1997. Adjust begin implementation date to factor budget process, permit delays. City modifications to model must be justified and approved by the Executive Officer.	This component was required under Order 90-079. It might be feasible to develop and implement sooner.	Requirements have been revised to a allow 8 months from permit adoption for model development. Cities are given 4 months from model approval by the Regional Board's Executive Officer to begin implementation.
LA Co La Verne Bellflower, El Segundo, La Verne	Inspection schedule is city specific and should not be part of the model. Inspection of illicit connection should be left to the city. Prioritization of problem areas should be left to the city.	Schedule will be made part of a city's program and not the model. The draft stated, 'Methods to prioritize' to be developed as part of the countywide model. Each city still determines its own priorities.	The reference to an implementation schedule with the countywide model has been deleted in the revision.
Vernon	Who will follow up on illicit connections?	The owners/operators of the MS4 system. Interagency agreements are encouraged in 'Program Management: Legal Authority' to facilitate the process.	No action suggested
W. Covina	GIS is a costly expense.	The draft did not require a GIS. However, it is a useful tool to map and track the drainage system.	No action suggested
Santa Clarita	Illicit connections includes physical transfer to other natural and constructed drainage systems.	An illicit connection is an unauthorized structural plumbing to the MS4 which may include constructed drainage systems and natural drainage systems.	No action suggested

R0008416

Long Beach	Clearly state the minimum requirements for the program to eliminate illicit connections and discharges.	The minimum requirements are described in the Order under Illicit Connections. Additional guidance is found in the USEPA guidance document, *'Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems, USEPA Document No/600/R-92/238'*	No action suggested
Illicit Discharges			
El Segundo	Standard enforcement procedures unnecessary since city specific.	Standard enforcement procedures in the model promote countywide consistency. However, the extent of use will still be city specific.	No action suggested
LA County NRDC	Allow 8 months from permit adoption for model development. Each city to submit implementation schedule 4 months from the Executive Officer's approval. Develop model by July 15, 1996. Begin implementation by Jan 15, 1997. City modifications to model must be justified and approved by the Executive Officer.	This component was required under Order 90-079. It might be feasible to develop and implement sooner. See NRDC's comment below.	Requirements have been revised to allow 8 months from permit adoption for model development. Cities are given 4 months from model approval by the Executive Officer to begin implementation.
LA County	Separate surveillance program not cost effective. Delete. Field staff education program sufficient.	USEPA regulations require, "procedures to conduct on-going field screening to investigate portions ... with a reasonable potential of containing illicit discharges" (Final Rule 55 FR 222, 48071). Education of employees may be insufficient.	No action suggested
Other Prohibited Activities			

R0008417

Inglewood Los Angeles NRDC	Date to prohibit by legal authority is too soon. Date to prohibit should be 120 days from effective date of Permit. Propose 3 months from permit adoption to obtain authority to prohibit.	July 1996 may be too soon.	This Section has been merged with the Legal Authority subsection. The Permittee is given 120 days from adoption of the permit to demonstrate legal authority to prohibit.
Western States Petroleum Association (WSPA)	Mere presence of leaves in storm water discharge must not be deemed a violation	The legal prohibition is on disposal of leaves as the language suggests and not mere presence. Disposal is an affirmative action.	No action suggested.
Southern Cal Rock Products	Indicate that concrete trucks may be washed out on construction sites but must avoid discharge to storm drains.	Language can be clarified.	The permit language has been revised.
Torrance	Why are concrete trucks singled out when there are other significant sources?	USEPA regulations include a "requirement to effectively prohibit non-storm water discharges to the MS4" (Final Rule 55 FR 222, 48055). Other significant sources of pollutants must also be addressed when identified.	No action suggested
Industry	Exclude wash-down of impervious surfaces. Necessary for proper adhesion during asphalt pavement resurfacing.	Wash down from asphalt paving may contain PAHs....Non-storm water discharges to the MS4 from such activities must be 'effectively prohibited'.	No action suggested
Long Beach.	This subsection may be duplicative with 'Legal Authority'. Specific prohibitions are not supported by evidence.	The specific prohibitions are activities that contribute pollutants to storm water. The specificity of the listed activities may serve as a direct educational tool for the public to draw attention to these practices that contaminate storm water.	This subsection has been deleted, and the requirements integrated with the 'Legal Authority' subsection.

Non Storm Water Discharges			
Alhambra, Culver City, Commerce, Hermosa Beach, Lakewood, Lomita, Beverly Hills, Bradbury, Carson, Diamond Bar, Hermosa Beach, Norwalk, Rolling Hills, West Hollywood, Westlake Village Long Beach NRDC	Non storm water exemptions should correspond with federal list. Exemptions should be consistent with other Regional Boards. Qualify exemption for residential swimming pool discharges to exclude filter back wash.	USEPA regulations require municipalities to address 19 categories of non-storm water only where such discharges are identified by cities as sources of pollutants to receiving waters (Final Rule, 55 FR 222, 48071). The Regional Board currently requires NPDES permit coverage for 4/19 (non-residential swimming pool discharges, groundwater dewatering, hydrostatic testing [water line flushing and potable water sources]). There is no easy way to determine if groundwater discharges are uncontaminated without conducting periodic sampling in an area with a history of regional groundwater contamination such as in LA county. Consistency will be maintained to the extent necessary. However, Regional situations may warrant some deviation.	The non-storm water exemptions has been revised to include 17 out of 19 types listed in federal regulations, with the exception of groundwater infiltration (which must be covered by a state general permit) and street wash water. Sidewalk washing was consisdered but for consistency purposes, only those specifically named in the USEPA regulations were included.
Claremont, EAC, El Segundo, Glendora, LA County, La Verne, Santa Fe Springs, WSPA, West Covina	Exempt commercial roof drains.	Roof drain discharges by their nature are storm water and need no special exemption as they are covered by this permit. Roof drain discharges that are non-storm water on the other hand must be 'effectively prohibited' since they are not conditionally exempted under federal law.	We have deleted references to roof drainage in this subsection.
MWD, Long Beach	Exempt potable water sources	The Regional Board requires NPDES general permit coverage for discharges from hydrostatic test waters (includes potable water sources). Potable water sources are proposed to be covered under a public utilities general NPDES permit to be issued by the State Board.	Potable water sources have been included under the 'Conditionally Exempt' category.

Santa Monica	Recommend dechlorination before water line flushing.	Requirements are stated in the Regional Board's NPDES general permit for hydrostatic testing (includes water-line flushing). The State Board's proposed general NPDES permit for public utilities will do the same.	Water line flushing has been included under the 'Conditionally Exempt' category.
Industry, MWD, Santa Fe Springs Vernon Bellflower, El Segundo, La Verne Calabasas Heal the Bay Los Angeles NRDC	Exempt fire hydrant testing; building wash downs; flow testing of new asphalt paving, curbs and gutters. Exempt fire sprinklers testing. Exempt saw cutting, grinding, emergency flares. Exempt hydraulic cleaning, sand blasting. What are inductive traffic loops? Allow cities to select the most appropriate methods of controlling the discharges through planning Future non storm water category exceptions must be subject to public review. Language is proposed	Federal regulations do not list these non-storm water discharges as types that municipalities are 'exempt' form addressing.	Revised language provides Permittees one year to develop and submit a list of non-storm water discharges not in the federal list and with recommended effective prohibition methods to minimize pollutant discharge and adverse impacts on receiving waters.
Alhambra, Bellflower, El Segundo, La Verne	Indicate other non storm water discharges permitted by the State are exempt.	'Discharge Prohibitions' section makes this statement.	A subsection introduction has been included to state, 'non-storm water discharges in compliance with a separate NPDES or WDR permit or granted a discharge exemption by the Executive Officer or the Regional Board or the State Board are not prohibited under this Order'.

Los Angeles, Santa Clarita Long Beach, Torrance, Ahmanson La Verne	Conditionally exempt street washing and side walk washing. What is the basis for the Executive Officer's determination for designating street washing and side walk washing? Are the city or residents prohibited from street and side walk washing?	Street washing is listed as a conditional exempted category under federal regulations, side walk washing is not. Both types of discharges under certain circumstances may transport toxic pollutants, as well as pathogenic bacteria and virus. The potential prohibition is on activity that causes a discharge to the MS4, not the activity itself. The city of Los Angeles is expected to conduct a study of pollutants in and methods to 'effectively prohibit' street washing and side walk washing discharges	The revision provides one year for Permittees to come up with a strategy to address street wash water and sidewalk washing as a source of pollutants to the MS4.
BIA	Only the Regional Board should be able to determine the condition necessary to exclude coverage of non storm water in the 'Conditionally Exempted Discharges' category. Neither the Executive Officer nor cities may establish the conditions.	Federal regulations state that 19 enumerated non-storm water discharges need not be prohibited unless municipalities identify these as source of pollutants to the MS4	No action suggested.

Public Reporting			
Long Beach	List minimum requirements.	Can consider enumerating minimum requirements.	Suggested requirements for Public Reporting have been added to the revision.
LA County Paramount	Develop standard program 8 months from permit adoption Cities submit a schedule to implement 4 months after the Executive Officer approval. Develop standard program by July 15, 1997. Cities implement by October 15, 1997.	This component was developed under Order 90-079. It might be feasible to develop and implement sooner.	Requirements have been revised to a allow 8 months from permit adoption for model development. Cities are given 4 months from model approval by the Regional Board's Executive Officer to begin implementation.
La Verne	Define 'Reportable Quantity'.	The term is defined in federal regulations and the glossary.	Term is defined in the glossary.

R0008422

V. INDUSTRIAL/COMMERCIAL SOURCES

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
Identification of Sources			
Hermosa Beach, Sierra Madre, Signal Hill, So El Monte, South Gate, Los Angeles Irwindale, Long Beach, Palos Verdes Estates	Some cities already have a database in a specific format. Information requested is excessive. SIC and location are sufficient.	Cities are encouraged to work with LA Co. to ensure that its format is compatible with those of the cities. Federal regulations and guidance require municipalities to identify the locations of industrial facilities which discharge storm water, and provide an inventory of pollutant sources organized by watershed. NPDES program status will be provided by the Regional Board.	The requirements are restricted to very basic information, (1) Facility name; (2)Site address; (3)Watershed; (4) Applicable SIC Code(s); and (5) NPDES storm water permit coverage status, if applicable.
Carson, La Verne, Vernon, El Segundo	Unfunded mandate. Eliminate whole section or limit to data collection on industrial commercial sources.	Federal regulations require cities to "...identify priorities and procedures for inspections and ...control measures" for storm water discharges from industrial activity and commercial areas (Final Rule 55 FR 222, 48070 and 48071).	The section has been eliminated and integrated with the Public Information/ Public Participation Section to emphasize focus on educational outreach.
Santa Clarita, Vernon	Implementation dates are too soon.	The implementation have been revised.	The permit had been revised to provide the Principal Permittee with 6 months from permit adoption to develop the database format and Permittees 6 months from permit adoption to collect the database information for their areas. The Principal Permittee is given 16 months from permit adoption to compile the database.
NRDC	Criteria for selection of additional facilities should not include number but rather total impervious area or area exposed.	Number of facilities is a reasonable albeit less direct measure of potential significance.	No action suggested

LA Co.	Only those facilities requiring site visits should be included in the database.	A limited number of categories of other facilities identified as significant potential contributors by the USEPA under Phase II may be reasonably included. The option remains with the Permittees.	The revision requires, at a minimum, site visit facilities to be included in the database.
BIA	How were potentially regulated facilities notified?	Finding 34 in the December draft states staff held meetings with affected interests and sought written comments on drafts of the permit. Additionally, the mailing list for this Order includes associations, utilities, school districts and universities, federal and state facilities, and the LA chamber. The Chamber has agreed to distribute the Order to its business membership.	No action suggested
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	How were priorities established to target certain types of facilities?	Facilities listed in the site education visits requirement include those that were selected by the USEPA to be part of the Phase 1 program, those listed under CZARA guidelines as sources of urban storm water pollutants, dominant Phase II potential sources of pollutants in storm water, and those most frequently given citations for violating local ordinances in the City of Los Angeles in a limited survey.	The list of facilities under the site educational visits has been limited to Phase 1 facilities, gas stations, other automotive service, and restaurants. The WMC may identify other significant potential sources at a later date on the basis of watershed conditions and characteristics.
Prioritization of Sources			

R0008424

Glendale, Hermosa Beach, Signal Hill, Sierra Madre, So El Monte, So Gate LA Co., Irwindale, Heal the Bay, Palos Verdes Estates EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Prioritization is not feasible because of changing demands on personnel. Delete section. Not a solid procedure or serves no purpose because of specificity of facilities to visit. Delete section. Prioritization for site visits are unclear.	Prioritization may not be necessary because of the specificity of site visits.	This sub-section has been deleted in the revision.
Source Control Measures			
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Clarify level of treatment acceptable for discharge of wash-waters.	The level of treatment acceptable would be methods that meet BAT/ BCT standards for the industry, or effluent standards established for the type of pollutants in the discharge, such as oil and grease, heavy metals, MBAS, pH, TSS.	This requirement has been integrated with the Legal Authority sub-section.
Covina, Long Beach Glendale, Industry, Paramount, Sierra Madre, Signal Hill, So El Monte, Hermosa Beach	Prohibitions are too detailed to include in an ordinance, or exceed CWA requirements. Prohibition date too soon. BMPs list deadline is too soon	Can reconsider prohibition date. The BMPs list will be developed by LA Co. in consultation with the Permittees.	This requirement has been integrated with the Legal Authority sub-section. The revision gives the Permittees 120 days from the date of adoption of the Order to demonstrate legal authority to control the activity.
LA County	BMP lists for only facility categories that require site visits.	Can include a statement to clarify that lists are to be developed for only those categories of facilities that require site visits.	The revision states that BMPs will be developed "for use by Permittees for each industrial/commercial SIC group requiring educational site visits".

Industry, So Cal Rock Products, Southern Cal Contractors La Verne, BIA	Requirement to cover all hazardous materials and not perform vehicle maintenance to eliminate exposure to storm water is unreasonable. Define 'susceptible or exposed to storm water'	There is no specific requirement to cover materials, only that potential exposure to storm water be eliminated. The language requires storage away from areas that may come in contact with storm water, and repair in areas which are not exposed. Language can be revised to allow for repair in exposed areas but where fluids can be contained, so that there is no discharge to the MS4. The phrase means areas or activities that may potentially come in contact with storm water.	This requirement has been integrated with the Legal Authority subsection.
NRDC	Add swimming pool backwash to list of prohibited wash water discharges.	Can consider adding a prohibition on swimming filter backwash.	Language has been added to the Legal Authority subsection to prohibit filter backwash from swimming pool discharges.
WSPA, BIA	Similar public agency activities are not held to the same standard of performance.	The requirements in the permit are intended to hold public agency activities to the same level of performance as private sector for similar activities	Any apparent inconsistencies between similar public agency and private sector activities have been corrected in the revision including public construction activities and public parking lots.
Source Inspection			

R0008426

Irwindale, Inglewood, Vernon Inglewood, Agoura Hills, Azusa, Manhattan Beach, La Verne, Long Beach Heal the Bay, La Mirada, LA Co Senator Hayden, NRDC, Tree People	More time is needed to develop, implement program and inspect so many facilities. Inspections are an unreasonable burden and should be performed by other agencies, or funds must be provided. Only educational site visits should be required for Phase 1 facilities and others. Do not change the emphasis and frequency of visits in the section.	Facilities inspection programs were to be developed under Order 90-079. The scope of the inspections has been reduced to educational site visits.	The permit revision establishes frequencies for the educational site visits spread over the five year term, with a minimum of two site visits in the life of this Order. The frequencies give the Permittees a reasonable period of time to initiate the program from the date of adoption of the permit.
Sierra Madre, Signal Hill, So El Monte, So Gate	Who enforces at State permitted facilities?	The Regional Board will enforce the provisions of the State permit at such facilities. The USEPA envisions a partnership between municipalities and the state in overseeing compliance with the state storm water permit. Enforcement of local agency requirements at such sites is with the Permittee.	The Regional Board sent a letter to the State Board to pursue the possibility of sharing permit fees with local agencies to streamline facility site visits, and support local agency lead.
EAC, Baldwin Park, Bell Gardens, Claremont, Commerce, Covina, Downey, Glendale, Glendora, La Verne, Lakewood, Lomita, Long Beach, San Marino, Santa Fe Springs, West Covina,Whittier, El Segundo	Phase 1 facilities and others permitted by the State should be excluded from inspections.	Federal regulations state that municipalities must assist USEPA and NPDES states and implement a program to " i. identify priority industries; ii. review and evaluate SWPPPs and other procedures that industrial facilities develop ...; iii. establish and implement BMPs to reduce pollutants from industrial sites (or require industry to implement them)"(Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges... EPA 833-B-92-002, Section 6, p 6-17)	The permit has been revised to state that Permittees are to discuss applicable storm water requirements, distribute educational materials, identify facilities that have not submitted an NOI or do not have a SWPPP on site, and follow-up where deemed appropriate.

EAC, Baldwin Park, Bell Gardens, Claremont, Commerce, Covina, Downey, Glendora, Lakewood, Lomita, San Marino, Santa Fe Springs, West Covina,Whittier, El Segundo	Allow for implementation of 'Public Outreach/Public Participation before the inspection program.	EPA's Final Rule did not encourage sequencing of storm water program elements. EPA stated that to implement Section 402(p)(3) of the CWA, comprehensive storm water management programs which address a number of major sources of pollutants to the system are necessary".(55 FR 222, 48052).	The section has been eliminated and integrated with the Public Information/ Public Participation Section to emphasize focus on educational outreach.
EAC, Downey, Lakewood, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Delete the Enhanced Inspection Program	Can consider elimination of this requirement. Use of the enhanced inspection program in the draft Order was left to the discretion of individual municipalities. A Storm Water Inspection Handbook has been developed under State sponsorship. Municipalities may use the handbook to augment the emphasis of the site visit program, on a as needed basis. See *California Industrial/ Commercial Stormwater Inspection Handbook for Municipal Agencies*, Alameda Countywide Clean Water Program, 1996.	This has been eliminated.
WSPA	Why is industrial waste permit used as a criterion to increase site visit frequency?	Facilities with a local agency industrial waste permit are often visited annually as part of the local agency program. This may provide multiple opportunities for educational contact. However, the Regional Board is sensitive to the observation that this action may constitute a compliance penalty.	The frequency requirement to visit facilities that also have a local agency industrial waste permit has been reduced to once every 24 months.

WSPA	Who establishes the site visit baseline?	A countywide model for the scope of site visits and BMP lists will be developed by the Principal Permittee in consultation with the EAC, industry and the environmental community. Each municipality will implement the model or a modified version.	The permit has been revised to provide the Principal Permittee 10 months from permit adoption to develop a BMP checklist for use by Permittees after approval by the Regional Board Executive Officer.
Covina	What are categories (i) - (xi)? What is GISP?	These categories are Phase I industrial facilities and are enumerated in federal regulations. GISP is the acronym for General Industrial Storm Water Permit issued by the State for Phase I facilities.	A definition is included in the glossary to describe facilities in Phase 1 categories (i) - (xi).
Long Beach	Gas stations are arbitrarily chosen.	The USEPA's Phase II evaluation identified automotive service facilities (including gas stations) as having among the highest potential to contribute heavy metals and toxic organic chemicals to storm water discharges to the MS4. Similarly CZARA guidelines identified gas stations as a category of commercial activity that is required to implement BMPs for urban storm water pollution. Partly in response to this designation, the industry has been proactive and has developed recommended BMPs.	The permit has been revised to provide for the development of checklists for use by Permittees. The recommended BMPs developed by the industry can serve as a basis for the checklist for gas stations.

VI. DEVELOPMENT PLANNING / CONSTRUCTION

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
Prioritization of Development Projects			
Los Angeles Long Beach Building Industry Association (BIA) American Oceans Campaign, NRDC, Tree People NRDC, Heal the Bay California Coastal Commission Heal the Bay	Prioritization criteria ignores storm water impacts associated with proposed development Arbitrary criteria for prioritization is excessive and unwarranted. Prioritization criteria overly expansive in range in covering development / redevelopment projects. The value of a redevelopment project is irrelevant as a trigger criterion. Redefine criteria to state that 40,000 sq ft is High Priority, 10,000-40,000 Priority, and <10,000 Limited Priority. 25 percent slope or greater should be under 'High Priority' as negotiated. All projects in Areas of Special Biological Significance should be made High Priority. Projects requiring "grading permits" should be Priority Projects.	Federal guidelines state that, "All construction sites regardless of size must be addressed by the municipality" (USEPA Document No. EPA 833-B-92-002, p 6-11.) The prioritization criteria were selected to establish bottom line criteria for cities to review potential water quality impacts during development and redevelopment. Controlling storm water pollutants at the onset of land development has been identified as a cost effective approach to storm water pollution management.	The criteria for prioritization have been generalized to state "Priority Projects are development and redevelopment projects which the Building Official (or equivalent municipal authority) determines may have a potential significant effect on storm water quality. "
NRDC, Heal the Bay	Include special requirements for development projects with > 25 (15) parking spaces.	The criteria for determination may be generalized to provide some flexibility.	No action suggested.

R0008430

Azusa, Long Beach, La Verne, Whittier	The distinction between significant and non-significant impact is the 5 Ac threshold.	In the municipal program, "all construction sites regardless of size must be addressed" (USEPA Document No. EPA 833-B-92-002, p 6-11). In addition, the Federal 9th Circuit Court of Appeals invalidated the 5 Ac threshold as arbitrary and capricious for NPDES storm water coverage (NRDC v, EPA, 1991). The rule was remanded to EPA for reconsideration.	The criteria for prioritization have been generalized to state "Priority Projects are development and redevelopment projects which the Building Official (or equivalent municipal authority) determines may have a potential significant effect on storm water quality. "
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Clarify responsibility and discretion of Public Works Director on Limited Priority projects.	The municipal authority is given the discretion to develop a checklist for potentially significant effect. To promote countywide consistency, it is intended that criteria will be developed by some consensus.	Permit language has been revised to state projects that a "Building Official (or equivalent municipal authority) determines will not have a potential significant impact on storm water quality."
Countywide Guidelines			
Pico Rivera, Santa Clarita	Maintaining existing runoff rate or reducing peak runoff rates do not improve water quality.	"Sediment runoff rates from construction sites are typically 10-20 times greater than agricultural lands, and 1,000-2,000 times those of forest lands.... Runoff from construction sites also can include other pollutants [such as] fertilizer, pesticides, petroleum derivatives, construction chemicals, and solid wastes." (USEPA Document No. EPA 833-B-92-002, p 6-12).	This requirement has been dropped in the permit revision.

R0008431

Industry	Guidelines are inconsistent with basic erosion control practices. Current city practices require 12% landscaping per parcel developed.	Preamble to the EPA's Final Rule states, that, "municipal permit management programs may not rely exclusively on [existing] erosion or sediment control laws for implementing that portion of management programs that address discharges from construction sites, unless such laws implement NPDES permit program requirements" (55 FR 222, 48052). Current inconsistencies may need to be reviewed in light of water quality concerns.	Permit language under 'Planning Control Measures' has been generalized in the revision to allow the city some flexibility.
SMBRP Heal the Bay	Clarify if permit requires the development and implementation of Watershed Management Area Plans (WMAPs). Indicate who has the legal requirement to develop WMAPs and include deadlines.	The WMAP in the draft Order was left for a particular watershed to develop as a permit application for 2001. The countywide program remains the default program. The entity legally required to develop the WMAPs was not specified. The responsibility lies with the Permittees in each WMC.	The revision states that the Principal Permittee with the Permittees shall develop a WMAP as a permit application for 2001.
Planning Process			
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Separate the Planning and Construction section and components.	This is a format preference issue. Federal regulations for municipal requirements for construction activity include; site planning, BMPs, inspection/ enforcement priorities, and training which are all included in one subsection (40 CFR 122.26(d)(2)(iv)(D)).	The format has been simplified in the revision.
La Verne	LA County should follow some democratic process in the development of countywide plans to protect the interests of cities.	This is a subject for discussion in the EAC. The Regional Board staff encourages a cooperative partnership.	No action suggested.
Planning Control Measures			

NRDC, Tree People	Include provision to evaluate retrofit of existing developments with treatment controls, which appeared in the May 1995 partial draft.	Retrofit of existing developments is a costly undertaking, and may be justified only if persistent water quality problems are identified. It may be an appropriate consideration in the development of the WMAP.	No action suggested.
NRDC	Require a narrative plan with a description of how BMPs were selected for High Priority and Priority projects.	A narrative plan is required only for High Priority Projects. For Priority Projects, a check list of construction BMPs with a brief explanation can be included.	The revision states that LA County will develop "standard plans and guidelines... for the following development categories: i) a 100+ home subdivision, ii) a 10-home subdivision, iii) a 100,000+ square-foot commercial development, iv) an automotive repair shop; v) a retail gasoline outlet, vi) a restaurant, and vii) a hillside-located single-family dwelling."
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Correlate types of projects to pollutants of concern	Pollutants of concern for the various watersheds are identified in the Water Quality Assessment Report prepared by the Regional Board. However, the list may not be complete because of limited sampling events and data-gaps.	No action suggested.

Ahmanson	Where is the reference to parking lots in the Clean Water Act?	Several studies have demonstrated that parking lots may be significant sources of pollutants such as heavy metals, and petroleum derivatives. The preamble to the EPA Final Rule states that, "The ..NPDES State has the authority to require a permit by designating storm water discharges such as those from parking lots..." (55 FR 222, 48010). Requiring that pollution from parking lots be addressed through the municipal program is a reasonable alternative as opposed to requiring permits.	No action suggested.
BIA Ahmanson EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Vernon	Regional Board should ensure that the burden to reduce pollution is equitably distributed among all entities that contribute to NPS pollution. Unlawfully targets new development to improve existing conditions. Regional post construction structural BMPs should be implemented only when water quality problems are identified Post development runoff requirement is not achievable. Post construction BMPs listed are not applicable to most developments.	The draft Order equitably distributes the responsibility of reducing pollutants in storm water discharges to the maximum extent practicable by requiring that illicit discharges; storm water from industrial areas; storm water from commercial areas; and storm water from residential areas be controlled. Reference to specific post-construction BMPs can be deleted.	Reference to specific post-construction BMPs has been deleted in the revision.

R0008434

Long Beach, Whittier NRDC California Coastal Commission Los Angeles	Requirement to prepare Mitigation plans for High Priority and Priority projects is unreasonable and excessive. Require a narrative plan with a description of how BMPs were selected for High Priority and Priority projects. Include specific standards for storm water control, e.g., 25 yr; 2 yr 24 hr, etc. BMPs required in plan must be standardized and implementable.	An Urban Storm Water Mitigation Plan is required for High Priority Projects. Most cities already require such projects to submit a plan before issuing grading/ building permits. Storm water considerations can be integrated into the plan, to streamline municipal requirements. A narrative of BMP choice can be included. For Priority Projects, a check list of construction BMPs with a brief explanation of BMP selection can be included. Requirements, checklists, appropriate BMPs and design standards may be developed jointly with BIA and environmental interests.	The permit has been revised to state that Urban Storm Water Mitigation Plans are required for priority projects.
Identification of Construction Sites			
Los Angeles Long Beach, Whittier Los Angeles, El Segundo, La Verne, Whittier	Incorporation of prioritization data would require substantial modification to the current data system Database listing is excessive and unreasonable Delete requirement to focus on development of BMPs	Federal regulations and guidance require municipalities to identify the locations of industrial activity, including construction sites, which discharge storm water, and provide an inventory of pollutant sources organized by watershed. NPDES program status will be provided by the Regional Board.	This requirement has been deleted.
Bellflower, El Segundo, Long Beach, Whittier	Information on the State permit coverage of construction sites must be provided by the Regional Board.	The Regional Board will make available to cities information on who has obtained coverage under the state storm water permit, as part of External Agency Coordination.	No change suggested.

Los Angeles LA County	Define 'Project Erodibility' Project Erodibility determination time consuming.	The term in the draft Order was used to indicate if a construction project was situated on a slope with grade of 25 % or more.	The terms and criteria have been deleted in the revision.
Source Inspection			
Alhambra, Culver City, Commerce, Lomita	Staff has not responded to ambiguous issues on inspections and legal authority.	Regional Board Counsel in a memo dated April 17, 1996, responded to legal questions on inspections and municipal authority raised by cities.	The Regional Board Counsel's memo was prepared in response to legal issues raised.
Azusa, Long Beach, La Verne, Whittier West Covina NRDC Los Angeles	Construction sites greater than 5 Ac. should be inspected by the State. Cities should not be required to inspect smaller sites that have a lesser impact. The distinction between significant and non-significant impact is the 5 Ac threshold. Cities should not be responsible for large construction sites. Verify NOI is submitted and SWPPP prepared for construction sites 5 Ac or more and deny building/grading permits if none. Change from inspection program to education site visits.	Federal regulations state that the municipal program for construction sites should include a "description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of construction activity" (40 CFR 122.26(d)(2)(iv)(D)(3)). EPA also states that the role of large and medium municipalities includes to "Assist EPA [and the NPDES state] in reviewing and evaluating storm water pollution prevention plans that industrial facilities [including construction activity] are required to develop under the general permit" (56 FR 159, 40973).	The permit revision states that no grading permit for developments with disturbed areas five acres or greater will be issued unless the applicant can show that 1) a Notice of Intent (NOI) to comply with the State Construction Activity Storm Water Permit has been filed and 2) a Storm Water Pollution Prevention Plan (SWPPP) has been prepared.

VII. PUBLIC AGENCY ACTIVITIES

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
General			
LA County NRDC	Suggest that Principal Permittee be given 16 months to develop model, and that each permittee submit a schedule for implementation of the model 4 months after EO approval Time allowed for development of model program by the Principal Permittee and implementation by permittees is too long.	A revised timeline to allow the Principal Permittee to develop model and for Permittees to begin implementation will be included in the revision.	16 months are provided to develop a model and each permittee submits a schedule for implementation of the model 4 months after EO approval of model.
LA County	The County cannot agree to an evaluation of public agency activities by all permittees. It will conduct a limited and focussed assessment.	A limited and focussed assessment that includes participation by other Permittees will be sufficient.	The Principal Permittee in consultation with the Permittees will evaluate public agency activities jointly.
Long Beach	What is the reason for requiring public agency activities to reduce storm water pollutants?	Federal regulations require that municipalities develop programs to control storm water pollution from specified municipal activities that have a high potential for contaminating storm water. See 40 CFR 122.26 (d)(2) (iv) (3) - 122.26 (d)(2) (iv)(7).	No action necessary.
Los Angeles	Requirements cannot be met during emergency situations involving essential public services. Recognize such situations in the permit.	Language will be included in the revision to recognize exceptions to meeting public agency requirements during emergencies.	The Order requires that the model Public Agency program include an "emergency" element.

Heal the Bay Valencia Co, BIA, NRDC	Reinsert the requirement terms "shall" and "will" consistent with the September 1995 partial draft. Hold municipal activities to a standard equivalent to the private sector. Why is there a separate section for public construction activities?	Alternative language will be included in the revision to be consistent with the intent of the Order to hold the public sector to an equivalent level of performance. A separate sub-section for public construction activities is included to promote permit streamlining. Each Permittee has the option to seek coverage under this permit for public construction activities presently covered by a separate state general permit, it they develop a program to implement SWPPPs and other general permit requirements.	This has been revised to reflect the comments.
Sewage Systems			
Calabasas Vernon	Exempt cities who contract with sanitation districts from any requirements to develop and implement procedures for sewage system operations. What are the responsibilities of the sanitation districts, who are not permittees to this Order.	Most sanitation districts are not a party to this permit. However, Permittees do contract or have similar agreements with sanitation districts to provide sewage treatment services in their areas. A condition to manage sewage systems within the Permittees area consistent with sewage systems BMPs may be included in the agreements for services. The sanitation districts must comply with their NPDES Permit conditions.	No change necessary.
NRDC	Add requirement to develop "procedures to close beaches if necessary..."	Language to develop include beach closure procedures will be added to the revision.	This is included under Sewage Systems Operations.

Public Construction			
LA County	The county will not coordinate other Permittees' compliance with the general construction activities storm water permit. Modify language.	Language will be revised to allow each Permittee to develop a standard procedure if it chooses to be covered for public construction activities under this permit rather than the state general permit.	This has been incorporated.
La Verne Santa Clarita Calabasas	Clarify purpose of this sub-section. What is the responsibility of the permittee in a public construction project. Allow self-monitoring by permittees. Extend the requirements of this sub-section to all sites identified in the Section 'Development Planning/ Construction', not just to sites 5 acres or more.	The requirements in this sub-section extend to all public construction projects that meet the criteria in the Development Planning/ Construction section. The Permittee is expected to implement a program to ensure that public construction projects meet the same design and BMP standards required of private projects. The 5 acre or greater threshold is to offer alternative coverage under this permit for public construction projects presently covered under the state construction activity general permit.	No action necessary.
Vehicle Maintenance			
LA County	Clarify the 'ten or more vehicles ' used to qualify fleet vehicle maintenance. Is it per day, number of service bays, etc.	The language will be revised to state 'ten or more vehicles per day'.	Ten or more vehicles per day is the standard. Included in Order.
Los Angeles	Requirement to conduct vehicle washing in specially equipped areas will be costly. Alternative language is proposed.	Language will be revised to allow control to the maximum extent practicable of discharges from vehicle washing areas.	The Order allows flexibility for vehicle and equipment washing.

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Parks/ Recreation Facilities			
Santa Clarita	Clarify 'preferred use' as applied to pesticides, herbicides, and fertilizers.	Language will be modified to state, "selective and environmentally responsible use".	Order revised to incorporate comment.
Santa Clarita	Why does the discharge of municipal swimming pool waters need a separate NPDES permit?	Swimming pool discharges at times contain residual chlorine which are toxic to aquatic life. Municipal swimming pool discharges as a matter of past Regional Board policy have been required to obtain an individual permit. Swimming pool discharges are allowed under this permit if Permittees implement BMPs to reduce chlorine to acceptable levels before it reaches receiving waters. Filter back-wash should be discharged to the sanitary sewer (with the sewer agency's approval).	Revisions to the Order incorporate discussion.
Storm Drain Operation and Maintenance			
La Verne	Eliminate requirement to investigate the feasibility of dry weather flow diversion.	Dry-weather flow diversions may be appropriate in certain circumstances, such as consistently polluted dry flows. In these situations, diversion to the sanitary may be the most cost efficient method to protect public health.	No change.
Covina	Provide reasons to record the quantity of catch basin waste collected.	The quantification of catch-basin wastes can provide an estimate of the amount of waste that has been prevented from reaching the water-courses and beaches. It is a substitute measure of program implementation and effectiveness. It can help identify areas of high accumulation which can become candidates to focus BMPs.	No action suggested.

Streets and Roads			
Southern California Contractors Association	Requirements for municipal streets and road maintenance are less restrictive than those imposed on private businesses.	The intent is to hold public agency activities to the same level of performance as private sector activities.	The discussion and comment have been incorporated into the Order.
Flood Control			
LA County	Integrate the Flood control subsection with Storm Drain Maintenance because of their similarity.	The two subsections will be integrated in the revision.	Comment has been incorporated into the Order.
Parking Facilities			
Carson Vernon Building Industry Association	Requirement to clean Permittee owned parking lots with 25 or more parking spaces will be costly if it will involve steam cleaning. How are Permittees expected to enforce the requirements on parking lots? Why is the requirement for Permittee owned parking lots greater than a requirement to remove debris on non-permittee owned	Several studies indicate that parking lots with urban vehicular traffic produce significant quantities of storm water pollutants. Permittee owned parking lots are required to periodically clean to reduce the potential for contamination of storm water. No reference is made to 'steam cleaning' as the only acceptable method of reducing this potential. Permittees are expected to include periodic cleaning activities in their program for permittee owned parking lots.	No change.

Public Industrial Activities			
Santa Monica	Support allowing municipalities to cover their industrial facilities under this permit. Also include non-storm water utility discharges to the MS4.	Permittees may seek coverage under this permit for their facilities presently covered under the state general industrial permit, if they develop a program to notify, implement SWPPPs, and meet other requirements. Non-storm water discharges to the MS4, including those from public utilities, may be allowed under this permit provided adequate BMPs have been developed and are implemented. See the 'Illicit Connections/ Discharges: Non-storm Water Discharges'.	No action.

VIII. PROGRAM REQUIREMENTS FOR PUBLIC INFORMATION AND PARTICIPATION

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTIONS
Public Information and Participation			
Downey, Paramount, West Covina EAC, BIA, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	The public education section of the permit is very important and should be implemented prior to the implementation of the other requirements in the permit. Public education and the development of Storm Water Management Plans do not include public participation.	Public education is one of several BMPs to necessary to reduce storm water pollution. However, a comprehensive storm water management plan will include several parallel efforts to control storm water pollution. Public participation and input during public education program development is very important to its success. Permittees are encouraged to seek public input in developing the public education component.	No change suggested.
Alhambra, Bellflower, Lomita, San Marino, Whittier, Long Beach, Manhattan Beach	The RWQCB has no authority to compel cities to contribute a "fair share" (which is not defined), to a public education program that is to be developed in the future by the Principal Permittee.	A fair share simply referred to participation in the development of the Public Education Program. Language will be modified to indicate participation.	Language has been changed to "expected to work collaboratively"
Los Angeles, Bellflower, El Segundo, La Verne, Hermosa Beach, Sierra Madre, Signal Hill, South El Monte, South Gate, Bellflower Heal the Bay	What type of "analysis" of residents and businesses is the City to conduct to identify outreach goals and target audiences? How detailed must it be? The second objective of the PIPP program should be to measurably change the behavior of target audiences by encouraging those audiences to implement appropriate solutions.	The "analysis" intended is an objective survey by the municipality to identify opportunities for public education. The City and County of Los Angeles have already undertaken elaborate surveys. The other Permittees may need to only build on this information.	Have eliminated the term "analysis." The suggested modification of the second objective will be made.

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Long Beach, Los Angeles	Immediate Outreach. Is this section part of the SWMP or the CSWMP? What if a Permittee has an established educational program for some of the program requirements specified? Must the Permittee change their program to fit the CSWMP?	This is a requirement of the Order and components of the CSWMP, and the WMAPs. The established educational program for a specific requirement, if it covers the essential purpose of the requirement, may be sufficient. However, the Permittee must develop or co-develop and implement any requirements not met by the current educational program in place.	No change suggested.
Calabasas	Permit should include curriculum materials and training for teachers.	Permittees who work well with their school districts, are encouraged to consider the suggestion. Others have commented that they have no control over school districts.	The Order encourages the acquisition and distribution of classroom materials to educators.
Covina Vernon Bellflower, El Segundo	The County should be responsible to produce or acquire a video for presentation, not the Permittees. Smaller cities should solely be responsible for distributing educational materials within its respective jurisdiction. Audio Materials should be done Countywide and not necessarily be each Permittee.	Each city is required to have educational materials available for its residents and businesses. The materials may, however, be developed in any manner that is cost-effective as determined by Permittees. Permittees may work-out the desired partnership with the County to acquire educational materials..	No change suggested.

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IX. MONITORING

COMMENTING AGENCIES	COMMENTS	DISCUSSION	ACTION
Critical Sources Monitoring			
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Los Angeles County Los Angeles Long Beach	An arbitrary number of critical sources has been selected for monitoring by permittees without justifying need. The critical sources/ BMP evaluation should not be restricted to only structural BMPs. Language should be revised to consider all appropriate BMPs. The regulating agency should be primarily responsible for evaluating critical sources (industrial/commercial sources and BMP effectiveness). Eliminate the requirement as proposed. The requirement to monitor five additional critical sources in addition to those to be conducted by the principal permittee is excessive and unwarranted.	Federal regulations require all MS4 permittees to "monitor and collect quantitative data on storm water pollutants in MS4 discharges" [122.26(d)(2)(iii)]. In addition, permittees must also "develop a monitoring program for storm water discharges from industrial sites" [122.26(d)(2)(iv)(C)(2)], and "estimate reductions in pollutant loads as a result of program implementation" [122.26(d)(2)(v)] The federal regulations require each municipality with a population of 100, 000 or greater to implement all monitoring components. While the permit requires LA County to implement the majority of the monitoring components, it appears reasonable to require the other 86 permittees to undertake at least one special/ pilot project per watershed (for a total of six) to assess or mitigate storm water, non storm water pollution, program effectiveness, or any other assessment of the objectives of the storm water program. Any appropriate BMP may be evaluated as part of the special/ pilot project.	This sub-section in the permit has been eliminated at Permittees request.

SMBRP Heal the Bay	Clarify the criteria to be considered when implementing specific critical sources monitoring projects. Criteria for selecting critical sources projects should include annual reports submitted by Phase 1 industries to the Regional Board	The general objective of the critical sources/ BMP monitoring is to identify sources of pollutants of concern and develop cost effective methods to minimize storm water/ non storm water pollution. For watershed special projects, it was expected that permittees would utilize criteria that consider the conditions in the watershed when deciding on the special project.	This sub-section in the permit has been eliminated at Permittees request.
General Comments			
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier South Gate, Signal Hill, So. El Monte, Sierra Madre, Hermosa Beach SMBRP	There appears to be no relationship between the monitoring program and the storm water management program in the Order. Permittees should be given the discretion to implement a comprehensive monitoring strategy. Ensure that the proposed monitoring program is linked to WMAP implementation	The storm water management program is expected to draw on information gathered through the monitoring program to make improvements or emphasize implementation efforts. The WMAP can serve as the plan that incorporates such changes. However, the WMAP will be developed only after the CSWMP is completed, a period likely to take 4 years. The current monitoring program in large part was designed by experts brought together by LA County and NRDC. It is comprehensive and when implemented will measure the propensity of types of land use to generate pollutants of concern, monitor long term trends in storm water pollutant loads, evaluate specific activities and practices to mitigate storm water pollutants, and assess impacts on the receiving waters.	The permit revision provides for modifications and amendments to be made to the monitoring program after approval by the Executive Officer, annually.

Los Angeles County	The County cannot agree to summarize and interpret data from all surface water monitoring programs in the county area. This task is the responsibility of the Regional Board.	The statement in the permit was in error and will be corrected. The intent is to describe methods used to collect, analyze, and interpret storm water data in LA county.	The statement has been corrected, and the Monitoring Plan subsection appropriately modified.
Heal the Bay, SMBRP Technical Advisory Committee	The constituent monitoring list from the County's current monitoring program should be included. In addition, add diazinon, chlorpyrifos, diuron, malathion, simazine, total DDT, total PCBs. VOCs which provide little useful information may be eliminated. Also indicate standard analytical methods. Require sampling of all four mass emission sites over the five year permit term. Sampling for just two years is insufficient to establish long term trends.	The constituent monitoring list with standard analytical methods to be used can be included as an appendix. The pesticides and PCB can be added to the list of constituents, if the cost to the monitoring program is modest or can be offset by removing other constituents. Long term trends cannot be established in two years. Mass emission stations will be required to continue sampling through the permit term, but with fewer station events after the first two year period.	The constituent monitoring list with analytical methods has been added to the Appendix. Suggested constituents have been added to the list of pollutants of concern. VOCs monitoring has been made optional. The monitoring at mass emission stations has been revised to require continuation once initiated, although the number of station events after the first year of monitoring has been reduced.
Natural Resources Defense Council	Include dates for public review and Executive Officer approval of monitoring program task submittals.	Appropriate dates will be included in the revision.	Appropriate dates have been included for submittal of monitoring program tasks, and Executive Officer's approval.
The Valencia Company	The monitoring program should identify the impacts of storm water on receiving waters to establish the need for structural BMPs	The proposed comprehensive monitoring program will evaluate the impact on receiving waters.	No action suggested.

Claremont, Long Beach, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Pollutants of concern are not identified in the Order.	Pollutants of concern are to be identified as a requyirement of the monitoring program that the Principal Permittee will be implementing. Pollutants of concern can be found in the Findings of the Order and in the Water Quality Assessment (WQA) completed by Regional Board staff. This "WQA" is available from the Regional Board Planning Unit.	The Order requires that an objective of the monitoring program is to identify pollutants of concern.
Santa Clarita	Clarify the role of Santa Clarita in monitoring activities in the Santa Clara River WMA.	The exact nature of participation in the comprehensive monitoring activities should be worked out between the two municipalities in this watershed. It was expected that the city would perform a pilot project/special study to assess or mitigate storm water, non storm water pollution, program effectiveness, or any other assessment of the objectives of the storm water program. This could have also been done in cooperation with the Ventura County Storm Water Program Permittees., who represent the lower part of the watershed.	The pilot project/special study section in the permit has been eliminated at Permittees request.

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X. PROGRAM REQUIREMENTS FOR PROGRAM EVALUATION AND REPORTING

Commenting Agencies	Comments	Discussion	Actions
Alhambra, Bellflower, Carson, EAC, Commerce, El Segundo, Culver City, Lakewood, Lomita, Long Beach, San Marino, Whittier	Reporting required to show compliance with the Order is too excessive.	Reporting requirements have been reduced from semi-annual reports to annual reports. Permittees are being required to submit sufficient information so that progress with the requirements of this Order can be determined by the regulating agency.	The Reporting requirements in this section have been consolidated to provide Permittees time and flexibility to demonstrate compliance.
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier, Long Beach	Limit annual report to summary information.	It is not meant that each BMP shall be implemented to the MEP. This is a common misuse of the term Maximum Extent Practicable. MEP refers to a storm water management program as a whole and not for individual BMPs.	
EAC, Downey, Glendale, Irwindale, La Mirada, La Verne, Palos Verdes Estates, Santa Fe Springs, West Covina	MEP standard cannot be achieved. It is to burdensome to show that a BMP has been implemented to the MEP.	Maximum Extent Practicable is the standard for implementation of storm water management programs, taken as a whole, to reduce pollutants in discharges to the maximum extent practicable. It is the maximum extent possible taking into account equitable consideration and competing facts, including, but not limited to: the gravity of the problem, public health risk, societal concern, environmental benefits, pollutant removal effectiveness, regulatory compliance, public acceptance, implementability, cost and technical feasibility. MEP refers to storm water management programs as a whole and not for individual BMPs.	The glossary includes the term Maximum Extent Practicable.
Long Beach	We understood all elements of the Order were to be implemented to the maximum extent practicable, not just selected elements. This phrase is frequently neglected.	Permittees are expected, under Section 402(p) of the Clean Water Act, to demonstrate that the Permittees storm water programs are reducing pollutants in storm water to the Maximum Extent Practicable.	

Bell Gardens, Carson, Covina, Downey, EAC, El Segundo, Glendale, Irwindale, La Mirada, La Verne, Long Beach, Palos Verdes Estates, Pico Rivera, Rosemead, Santa Clarita, Santa Fe Springs, Torrance, West Covina	Dates for compliance too soon. Consider suggestion that program implementation be predicated on a given number of months after Permit adoption. Also allow for delays in approval by the Executive Officer..		The Order reflects the comments received.
Bell Gardens, Carson, Covina, Downey, EAC, El Segundo, Glendale, Irwindale, La Mirada, La Verne, Long Beach, Palos Verdes Estates, Pico Rivera, Rosemead, Santa Clarita, Santa Fe Springs, Torrance, West Covina LA County	Pilot projects are not possible for each BMP. Watershed BMPs require greater effectiveness scrutiny than county-wide BMPs.	Pilot projects are recommended to demonstrate effectiveness of watershed BMPs prior to a full scale implementation. There is no intent to increase the scrutiny for watershed BMPs, unless they are presented as a substitution to a countywide program.	These requirements have been eliminated at Permittees' requests.
Carson, EAC, City of LA, County of LA, La Verne, West Covina, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Calabasas and Malibu Creek Cities	Performance standards should be deleted entirely or not included until the next permit is adopted (2001). Performance standards should be approved by City Councils first.	Performance standards are intended to be self-suggested goals for the countywide program or a watershed. Such standards may be useful to demonstrate compliance with the MEP standard.	The permit has been revised to provide Performance Standards will be developed for the next Permit in 2001 at Permittees request.

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XI. GENERAL COMMENTS

Commenter	Comment	Discussion	Action
EAC, Alhambra, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Culver City, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Downey, La Mirada, La Verne, Manhattan Beach, Long Beach Calabasas	Permit is too long, complex, ambiguous, contradictory, and poorly structured. Recommend hiring a consultant to format and finalize permit. A summary of Principal Permittee and Permittees Requirements with due dates should be created. Need an index for the Order.	The December 18, 1995 draft was sent to cities to provide an early opportunity for input on the permit. Many aspects of the permit were not finalized.	The Order has been reviewed for structure and is now in a format that is more consistent and readable than the December 18, 1995 version. The Order contains tables at the beginning of each major section which provide a summary of requirements and show who needs to implement what and when. Additionally, a table of contents has been included for easy identification.
Building Industry Association, Santa Monica	Supports watershed management approach		No action necessary.
Culver City, Long Beach, La Mirada	Board's intent is not reflected in the Order language. Goals/objectives are not adequately addressed in the Order.	The objective of the program is to reduce pollutants in storm water discharges to the maximum extent practicable.	This is identified at the beginning of Part 2 of the Order.
EAC, Azusa, Claremont Culver City, Downey, Glendale, Glendora, La Mirada, La Verne, Palos Verdes Estates, Torrance, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Downey, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Palos Verdes Estates, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, Torrance, West Covina, West Hollywood, Westlake Village, Whittier State Senator Tom Hayden, California Coastal Commission, American Oceans Campaign, Santa Monica Bay Keeper, Natural Resources Defense Council	Deadlines/compliance dates are unrealistic. Compliance dates too soon. Lacks understanding of local government decision making and budgeting process. Compliance dates are too long considering there are requirements from the first permit adopted in June 1990.	The compliance dates within the December 18, 1995 draft were put in for comment purposes.	The due dates have been changed and are based upon the date of adoption of this Order. Acknowledging that some requirements were required under the first Order, some requirements are more specific now as compared to the first Order.

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Assemblymember Sheil Kuehl, Heal the Bay, American Oceans Campaign, Santa Monica, Malibu Western States Petroleum Association	Strongly endorse the draft Order. Strongly support implementation of appropriate BMPs at retail gasoline outlets to reduce pollutants to the MEP.		No action necessary.
EAC, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	The certification signature by a principal executive officer or ranking elected official required as part of standard provisions is not practical.	This is a federal requirement under 40 CFR 122.22(b) for reports or other information required by a permit.	No action necessary.
American Oceans Campaign, Santa Monica Bay Keeper, Natural Resources Defense Council, Valencia Company, Building Industry Association,	Public input should be gained prior to amending any requirements under this Order.	This is identified in Section I.H of this Order.	No action necessary.
Alhambra, Azusa, Beverly Hills, Bradbury, Calabasas, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Los Angeles, Manhattan Beach, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, Torrance, West Covina, West Hollywood, Westlake Village, Whittier, Claremont, Commerce, La Verne	Expand Glossary of terms. Include acronyms.		The glossary has been expanded. Additionally many acronyms have been included.
Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Long Beach, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier, EAC, La Mirada	The CSWMP and WMAPs are not specifically defined. There are unknown requirements to be imposed in the future if not stated clearly in the Order.	It is imperative that each Permittee play a proactive role in the development of the programs required under this Order. See Regional Board Counsel's memorandum , comment no. 5.	The CSWMP and WMAPs are explained in the General Requirements section of Part 2 of the Order and in the glossary.

EAC, Building Industry Association, Commerce, Long Beach, Bellflower, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier Long Beach	Comment period inadequate considering length of permit. Another draft should be generated before tentative permit. Regional Board staff has not been responsive to questions/comments in early drafts of the permit.	Review periods for this Order have surpassed 60 days and will exceed 100 days when complete. Federal law requires only a 45 day review period for such Orders. In total, over 17 months will have passed from the time that the earliest draft circulated for comments (February 14, 1995) and the date that the tentative Order goes before the Regional Board for consideration (July 15, 1996). All drafts have been available to the Permittees at any given time. Although it may be desirable to provide additional review time, Any more beyond the one 45-day comment period cannot be provided and still meet the July 15, 1996 target for adoption. Other major metropolitan areas (Sacramento, Orange County, and San Francisco Bay) have already adopted a municipal storm water permit. The revised tentative is responsive to the comments received and reflects many discussions and input from multiple agencies. Regional Board staff has carefully considered comments received in preparing the tentative permit. The December 18, 1995 draft is the first complete permit draft distributed. Regional Board staff have made every effort to be fully responsive.	No action. No action recommended.
La Verne	The Principal Permittee is charged with developing permit requirements which must be implemented by the Permittees. Will Permittees be forced to comply with Principal Permittee developed programs for which their involvement may be limited or for which they do not agree?		Language throughout the Order requires that the Principal Permittee in consultation with the Permittees develop identified programs. Permittees have the ability to make appropriate local modifications when implementing the model programs

Commerce	Regional Board staff has not been forthcoming in responding to questions from Permittees regarding gray areas of the Permit.	Regional Board staff have made every effort to clarify the language used within the Order and to eliminate any gray areas.	No action.
Claremont, Long Beach, Azusa, Beverly Hills, Bradbury, Carson, Cerritos, Commerce, Diamond Bar, Baldwin Park, Bell Gardens, Claremont, Covina, Glendale, Glendora, Hermosa Beach, Industry, Lomita, LACDPW, Norwalk, Pico Rivera, Rolling Hills, Rosemead, San Dimas, San Marino, Santa Clarita, Santa Fe Springs, West Covina, West Hollywood, Westlake Village, Whittier	Pollutants of concern are not identified in the Order.	Pollutants of concern will be better identified, as a requirement of the monitoring program that the Principal Permittee will be implementing. Pollutants of concern can be found in the Findings of the Order and in the Water Quality Assessment (WQA) completed by Regional Board staff. This "WQA" is available from the Regional Board Planning Unit.	The Order identifies pollutants of concern within the Findings.
Bellflower, Downey, El Segundo, Long Beach	Regional Board should consider the new USEPA document "Nonpoint Source Program and Grants Guidance for fiscal Year 1997"	This document was reviewed by Regional Board staff. The comments by the Permittees are well taken. The document provides non-point source program direction. The NPDES program is a point-source program. The document is used by our Planning Unit staff for contracts and planning purposes. Regional Board staff among different units work on separate but similar programs and projects which may affect the Permittees under this Order. Regional Board staff will confer among each other as much as practicable to achieve greater effeciveness and efficiency and attempt to eliminate any overlap.	No action necessary.

State of California

Memorandum

: Catherine Tyrrell
Assistant Executive Officer
Los Angeles RWQCB

Date: APR 17 1996

Jorge A. León

Jorge A. León
Senior Staff Counsel

From : OFFICE OF THE CHIEF COUNSEL
STATE WATER RESOURCES CONTROL BOARD
901 P Street, Sacramento, CA 95814
Mail Code G-8

Subject: LEGAL ISSUES RAISED IN DRAFT STORM WATER WDR/NPDES PERMIT FOR LOS ANGELES COUNTY ET AL.

You have asked that I respond to legal issues raised in comments submitted by the principal permittee, copermittees, and interested parties during the development of the current draft of Waste Discharge Requirements/NPDES Permit (permit) for Los Angeles County and the copermittee cities.

As background to the storm water permitting process, the federal Clean Water Act (CWA or Act) provides that the U.S. EPA Administrator, or States with delegated authority, shall issue National Pollutant Discharge Elimination System (NPDES) permits to control discharge of pollutants into surface waters. California is a delegated state for NPDES purposes. Section 402(p) (33 USC § 1342) requires that storm water discharges be addressed through the NPDES permitting process. Section 402(p) provisions applicable to municipal permits read as follows:

> "Municipal discharge. Permits for discharges from municipal storm sewers . . . .
>
> "(i) may be issued on a system- or jurisdiction-wide basis;
>
> "(ii) shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers; and
>
> "(iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other

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provisions as the Administrator or the State determines appropriate for the control of such pollutants." (§ 402(p)(2)(B).)

The language of Section 402(p) is notably brief and provides a great deal of discretion to the U.S. EPA Administrator and to delegated states. To assist the states and affected parties in interpreting the CWA's provisions, the U.S. EPA issued regulations in 1990 that implement and interpret Section 402(p). They are found at 40 CFR Part 122.26. Along with the regulations, the U.S. EPA released a "Final Rule" that contains its responses to comments received during the rulemaking, and in large measure, illuminates the U.S. EPA's interpretation of the CWA requirements. Later, the U.S. EPA published its "Guidance Manual For the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems", which contains further guidance.

Below, I have paraphrased the comment that raises each legal issue, followed by my response.

1. *Under the terms of the current draft, the Executive Advisory Committee (EAC) could be held legally responsible for compliance with the provisions of the permit. The Regional Board has no authority to require an EAC nor can it dictate the composition of the EAC.*

As I understand it, the EAC provisions of the permit were included in a response to a proposal contained in the permit application submitted by Los Angeles County on behalf of the copermittees, and, to facilitate administration of the permit, given the complexities involved in obtaining the involvement of 86 copermittee cities. It is evident that for the permit to be successfully implemented, some form of leadership among the copermittees is necessary. In this connection, I note that 40 CFR 122.26(d)(2)(iv) requires "where necessary, intergovernmental coordination" in developing and implementing a storm water management program. Recognizing the absence of any specific requirement for an EAC, the provision was contemplated as a voluntary effort to further the success of the permit implementation.

Turning to the liability issue, the previous draft provided that the EAC would implement certain permit requirements. The current (December 18, 1995) draft is revised to clarify that the EAC provides direction to the County and the cities, who are the actual dischargers under the permit. The dischargers remain responsible for implementation of the permit requirements. The EAC members themselves, in their role as members of the EAC, are neither permittees nor dischargers. As such, they cannot personally or as a group be required to do anything under the permit. The legal responsibility for implementation of the permit requirements remains with the County and the cities.

On the issue of the Regional Board's authority, if there remains opposition to the EAC provisions, I recommend that staff delete all requirements regarding the EAC and, instead, expand the Findings to discuss the EAC proposals provided by the dischargers themselves. In that way, we memorialize the fact that the dischargers suggested the approach and mention a leadership mechanism while deleting any objectionable mandatory requirements. The permittee and the copermittee thus assume all responsibility for appropriate implementation of the permit.

2. *The Administrative Review provisions regarding issuance of a Notice of Intent to Meet and Confer violate the permittee's due process rights in that the city is not afforded notice and an opportunity to be heard.*

These provisions were drafted to create an informal dispute resolution process for the benefit of the cities. The Administrative Review provisions constitute a voluntary mechanism intended to resolve compliance issues in an informal manner prior to commencement of formal enforcement. "Due Process" applies only to State action that would deprive the subject of property or other rights. Since the Administrative Review process precedes (and ultimately seeks to replace) formal enforcement actions, there is no loss of property or other rights and, thus, there can be no loss of due process rights. To the extent that the comment seeks an additional level of notice and opportunity to be heard, I would recommend against it, since to do so would defeat the purposes of informal resolution.

Additionally, the analysis above regarding the EAC is also pertinent to the Administrative Review component of the permit. That is, the relevant provisions in the draft permit were developed to facilitate administration of the permit, although staff recognizes that there is no specific authority to require inclusion of such provisions. If voluntarily accepted by the dischargers, it can be included for the purpose of promoting effective communication regarding compliance with the permit, and to avoid enforcement actions. Removal of these provisions would remove an apparently desirable dispute resolution mechanism preceding enforcement action. However, if there remain objections to the provisions, as with the EAC, I recommend deletion.

3. *The NRDC and other entities should be required to participate in the Administrative Review process to resolve differences and be bound by the results.*

To the extent that the NRDC and other nondischarging observers agree to be so bound, they are free to negotiate a document memorializing that agreement with the dischargers. However, the Regional Board does not possess any authority over nondischarging entities. The Regional Board's authority in issuing the permit is limited to controlling the conduct of dischargers which affects water quality. It does not extend to the conduct of nondischargers. Indeed, the CWA provides certain rights to citizens, including the right to file a citizen's suit challenging the failure to properly implement CWA provisions. Adoption of the proposed comment would infringe on that right. Thus, the Regional Board may not require that the NRDC or others participate in or be bound by the Administrative Review process.

4. *Final determinations made by the Executive Officer during the Administrative Review process should be subject to appeal to the Regional Board.*

Under Water Code Section 13263(e), all final determinations made by the Executive Officer involving waste discharge requirements are subject to review by the Regional Board. Non-final decisions are not reviewable because it would create duplication and impede final resolution of issues. A provision can be added to the Administrative Review section to satisfy the comment, to the effect "Final determinations made by the Executive Officer at the conclusion of the Administrative Review process are subject to review by Regional Board pursuant to Water Code Section 13263(e)."

5. *The draft permit exceeds State and Federal requirements for storm water programs. Programs required under the permit should be limited to those required under the Clean Water Act.*

By its express terms (Section 402(p)), the Act requires that the municipalities implement controls to reduce the discharge of pollutants in storm water to the maximum extent practicable (MEP) and must not exceed water quality standards. The State's obligation is to interpret this provision to give effect to the purposes of the Act. The programs required under the permit are consistent with this mandate. The permit contemplates programs that will reduce the discharge of pollutants to the maximum extent practicable. Rather than exceeding the CWA requirements, the permit provisions describe storm water program components that minimally fulfill the CWA mandate.

For example, another comment states, "The Clean Water Act does not regulate 'parking lot pollution'".

The U.S. EPA states in the Final Rule as follows:

> "The Administrator or NPDES State has the authority under section 402(p)(2)(E) of the amended CWA to require a permit prior to October 1, 1992, by designating storm water discharges such as those from parking lots that are significant contributors of pollutants or contribute to a water quality standard violation." (Federal Register, Vol. 55, p. 48010.)

Studies demonstrate that parking lot storm water discharges are significant sources of pollutants. See Pitt et al., Urban Storm Water Toxic Pollution, Assessment, Sources, V. 67, pp. 260-275; Western States Petroleum Association and American Petroleum Institute, Results of Retail Gas Outlet & Commercial Parking Lot Storm Water Runoff Study (Geomatrix Consultants), 1994. Since the Act does not exempt a source that is a significant contributor of pollutants, it is appropriate to address parking lot pollution in the municipal storm water permit.

6. *Who determines what is the "maximum extent practicable?"*

It is up to the principal permittee and the copermittees initially to propose actions that implement best management practices to reduce pollution to the MEP. It is the Regional Board's responsibility, however, to evaluate the proposed programs using appropriate guidance. Neither the CWA nor the U.S. EPA has defined MEP. However, the issue has been analyzed in some detail in a memorandum prepared by Elizabeth Miller Jennings, Senior Staff Counsel, Office of Chief Counsel, State Water Resources Control Board, dated February 11, 1993 (copies of which can be provided on request). The following excerpt provides the factors that we need to consider in determining MEP:

> "Although MEP is not defined by the federal regulations, use of this manual in selecting BMPs should assist municipalities in achieving MEP. In selecting BMPs which will achieve MEP, it is important to remember that municipalities will be responsible to reduce the discharge of pollutants in

storm water to the maximum extent practicable. This means choosing effective BMPs, and rejecting applicable BMPs only where other effective BMPs will serve the same purpose, the BMPs would not be technically feasible, or the cost would be prohibitive. The following factors may be useful to consider:

"1. Effectiveness: Will the BMP address a pollutant of concern?

"2. Regulatory Compliance: Is the BMP in compliance with storm water regulations as well as other environmental regulations?

"3. Public acceptance: Does the BMP have public support?

"4. Cost: Will the cost of implementing the BMP have a reasonable relationship to the pollution control benefits to be achieved?

"5. Technical Feasibility: Is the BMP technically feasible considering soils, geography, water resources, etc.?

"After selecting a menu of BMPs, it is of course the responsibility of the discharger to insure that all BMPs are implemented."

The Regional Board's role is to review BMPs suggested by the municipalities and determine MEP using the above guidance and the court's decision in NRDC et al. v. California Department of Transportation Federal District Court, Central District of California (1994). The court stated that a permittee must evaluate and implement BMPs except where (1) other effective BMPs will achieve greater or substantially similar pollution control benefits; (2) the BMP is not technically feasible; or (3) the cost of BMP implementation greatly outweighs the pollution control benefits.

7. *The draft permit unjustifiably imposes an unnecessary burden by requiring that the cities conduct inspections of industrial/commercial facilities and to determine whether an NOI has been submitted to the State Board, whether a SWPPP is available on-site, and to notify the Regional Board staff of noncompliance with these and any other requirements as determined appropriate by the permittee.*

The U.S. EPA has provided guidance on this issue. Its language in the Final Rule (Federal Register, Vol. 55, p. 48056) indicates that it contemplates that the cities will arrange for inspections as necessary to assure success of the storm water programs:

> "Today's rule also requires the municipal storm sewer permittee to describe a program to address industrial discharges that are covered under the municipal storm sewer permit. Today's rule requires the municipal applicant to identify such discharges . . . , provide a description of a program to monitor pollutants in runoff from certain industrial facilities that discharge to the municipal separate storm sewer system, identify priorities and procedures for inspections, and establish and implement control measures for such discharges. Should a municipality suspect that an individual discharger is discharging pollutants in storm water above acceptable limits, and the owner/operator of the system has no authority over the discharge, the municipality should contact the NPDES permitting authority for appropriate action."

Furthermore, the federal regulations, at 40 CFR 122.26(d)(2)(i)(F) require that municipalities demonstrate legal authority to:

> "Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm water sewer."

The inclusion of this requirement in the regulations supports the conclusion that it was the U.S. EPA's intent to require the municipalities to carry out those inspections. The provisions of the permit regarding inspections are drafted in an attempt to make the cities' increased role as manageable as possible. They are drafted to allow the cities to meet their obligation to inspect facilities for compliance with permit requirements as part of the inspection and enforcement process which the permittees are already required to implement pursuant to guidelines issued pursuant to CWA Section 402(p) and any other inspection programs that they may undertake. Inspection staff can comply with the permit requirements by making additional observations at facilities that are inspected, take additional notes and share appropriate information with the Regional Board staff. There may be room for negotiating the specific types of facilities which must be inspected and the inspection frequencies, but it is clear that the CWA contemplates some level of inspection by the copermittees.

8. *City and County inspectors will need an administrative inspection warrant to gain access to private property to inspect facilities. The cities would have to embark upon the burdensome process of obtaining an administrative warrant to enter such properties. The permit requirement that cities inspect nonpermitted facilities exceeds CWA requirements.*

As noted above, the CWA and the implementing regulations found at 40 CFR 122.26 must be interpreted in a manner to carry out the purposes of the Act. As noted above, the U.S. EPA's guidance on the matter makes it clear that the CWA and the federal regulations seek to impose an inspection responsibility on the permittees. 40 CFR 122.26 (d)(2)(i)(F) expressly requires that the permittees demonstrate or obtain the authority to conduct inspections. To the extent that cities do not presently possess authority to inspect, they will obtain such authority in compliance with this regulation.

Generally, the County and cities should presently possess authority to enforce and ensure compliance with their various permits, such as for construction and business. The County and cities should be able to rely on that authority to gain access to private property in the majority of cases to assure compliance with the storm water permit requirements. In the much smaller number of cases, where the inspectors are unable to gain consensual entry to premises, they may have no right of entry without a warrant. The process involves drafting the warrant documents, obtaining a judge's signature, providing advance notice of execution of the warrant, and, if met with resistance, enlisting cooperation of the local police to gain access for inspection purposes. Certainly, this will create an additional burden for those cases where consensual access is not available, and, while there is no accurate way to predict the proportion of consensual versus nonconsensual cases, it is possible that over time, the process could become routinized, resistance to such inspections reduced and, therefore, the burden to obtain warrants, reduced.

9. *The federal regulations provide that certain identified discharges are to be addressed only when the municipality identifies the discharges as a source of pollution. The permit proposes to prohibit certain activities that have not been so identified by the municipalities. The permit's exemptions should mirror the federal regulations.*

The federal regulations promulgated pursuant to CWA Section 402(p) require permittees to "effectively prohibit" all non-storm water discharges to the MS4 except those that have been issued a separate NPDES permit. However, the regulations treat a discreet list of nineteen categories separately. As to these, the municipal permittees need not prohibit their discharge unless they are identified as a source of pollutants. (40 CFR § 122.26(d)(2)(iv)(B)(1).) The December 18, 1995 draft permit includes the nineteen exempt categories in two separate groups: "Exempted Discharges" and "Conditionally Exempted Discharges." The latter group includes additional categories of non-storm water discharges not listed as such by the U.S. EPA, but which the municipalities requested be exempt.

The Regional Board requires separate NPDES permit coverage for ground water discharges and hydrostatic testing (this includes waterline flushing and potable water sources) because of region-specific contamination concerns. In addition, the Regional Board has historically required that public/municipal swimming pool discharges be covered by a separate NPDES permit.[1]

In order to avoid a conflict with these Regional Board policies, I recommend that the draft permit follow the federal list of non-storm water exemptions, except for three categories: (1) uncontaminated ground water; (2) discharges from potable water sources; (3) water line flushing; and (4) dechlorinated public/municipal swimming pools discharges. The Regional Board may consider adopting a policy in the future, as appropriate, to resolve any conflicts in this area.

Regarding additional categories that permittees requested be exempted but are not in the U.S. EPA's list of nineteen, these may be handled under the draft permit's "Procedures for Exemption." In order to be considered, permittees must demonstrate that strategies for minimizing pollutant discharges have been developed, or show that the non-storm water discharge is not a potential source of pollutants to the MS4.

10. *The legal authority requirements should apply to the primary operator of the MS4 and the principal permittee (the County), rather than the copermittee cities.*

40 CFR Part 122.26 (d)(2)(i) requires a demonstration that the applicant can operate pursuant to legal authority established

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[1] *Section 402(p) requires that facilities already under permit shall remain covered under a separate NPDES permit.*

by statute, ordinance, or series of contracts which authorizes or enables the applicant at a minimum to:

> "(A) Control through ordinance, permit, contract, order, or similar means, the contribution of pollutants to the municipal storm water sewer by storm water discharges associated with industrial activity and the quality of storm water discharges from sites of industrial activity;
>
> "(B) Prohibit through ordinance, order, or similar means, illicit discharges to the municipal separate storm sewer;
>
> "(C) Control through ordinance, order, or similar means, the discharge to a municipal separate sewer of spills, dumping or disposal or materials other than storm water;
>
> "(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;
>
> "(E) Require compliance with conditions in ordinances, permits, contracts, or orders; and
>
> "(F) Carry out all inspection, surveillance, and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer."

The U.S. EPA's Guidance Document provides assistance on the issue whether the County alone can be required to provide the legal authority demonstration:

> "When two or more municipalities submit a joint application, each coapplicant must demonstrate that it individually possesses adequate legal authority over the entire municipal system it operates or owns. A coapplicant need not fulfill every component of legal authority specified in the regulations, as long as the combined legal authority of all coapplicants satisfies the regulatory criteria for every segment of the MS4 (including authority over sources that discharge to the MS4) . . . .

"Coapplicants also may use interjurisdictional agreements to show adequate legal authority and to ensure planning, coordination, and the sharing of the resource burden of permit compliance. When more than one entity is submitting an application for a MS4 (either as coapplicants or as individual applicants for different parts of a system), the role of each party must be well defined. Each applicant or coapplicant must show the ability to fulfill its responsibilities, including legal authority for the separate storm sewers it owns or operates." (Section 3.2.3)

This guidance makes clear that the cities and the County must coordinate with each other to assure that there is the necessary legal authority either in the County or in the cities, or through some combination of authority, to control the discharge of pollutants in all parts of the municipal separate storm sewer system.

11. *The legal authority requirements are unclear.*

In summary, the copermittees must demonstrate to the Regional Board that they possess the legal authority to implement the required actions provided in 40 CFR 122.26(d)(2)(i)(A)-(F). Subject to the Response to Comment No. 10, above, each permittee's municipal attorney should provide a statement that he/she has reviewed the city's ordinances and has determined that they provide the necessary authority. If the permittee does not currently have an effective ordinance(s) that provides the required authority, it must provide a schedule setting forth when it will adopt or amend its ordinances to provide the necessary authority.

Once each permittee has so demonstrated, it is required to enforce those ordinances to the extent required to effectively control discharges to and from those portions of the MS4 over which it has jurisdiction, as required by the permit.

12. *No city attorney will be able to certify that the city possesses legal authority to implement the permit because the permit requires inspections that may infringe on the rights of private parties.*

The current draft eliminates the requirement that the city attorney "certify" legal authority. Regarding authority to implement the permit, the comment confuses two separate issues. The permit requires compliance with the legal authority requirements as provided at 40 CFR Part 122.26(d)(2)(i)(A)-(F). This requirement can be met simply by providing information about the ordinance that provides the stated authority, or a schedule in which such ordinance will be adopted. That is all that a city attorney needs to consider. The issue regarding inspections is an entirely separate matter and it does not need to delay compliance with the straightforward legal authority requirements. Specifically, the issue regarding inspections is whether the permit requirements themselves regarding inspections are appropriate. That issue is treated in responses to Comments 3 and 4, above.

13. *The stated goals of the Countywide Guidelines would unrealistically and unlawfully target new development to improve existing conditions, rather than preventing water pollution by storm water discharges.*

The current draft has been modified to clarify that the requirement is to preserve--rather than create--existing beneficial uses. To the extent that the comment suggests that the permit applies disproportionately to existing facilities and new development, requiring the latter to take on greater responsibility for control of storm water pollution, a review of the permit shows this to be unfounded. Many more of the permit's requirements apply to existing residential, commercial, and industrial facilities.

14. *The Regional Board does not have authority to adopt watershed management plans that effectively preempt local land use control.*

CWA Section 402(p) provides that municipal storm water permits, "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices . . . ." As interpreted and implemented in the federal regulations, 40 CFR 122.26(d)(2)(iv)(D) requires:

> "A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system, which shall include: [1] A description of procedures for site planning which incorporate consideration of potential water quality impacts."

Municipalities are authorized under their planning authority to control land use decisions. The above regulation clearly contemplates that municipalities exercise their planning power in such a manner that considers potential water quality impacts. Pursuant to these directives, the permit requires consideration of watershed planning elements to control pollution from affected sources.

The permit requires actions consistent with existing law, including those concerning local land use control, and should not be read as preempting those laws. The intent has been to facilitate, to the extent allowed by law, smooth implementation of applicable provisions of the CWA and to ensure consistency with the Coastal Zone Act Reauthorization Amendments (CZARA). Under CZARA, management measures have been prescribed by the U.S. EPA and National Oceanic and Atmospheric Administration (NOAA) applicable to construction activity regardless of land size.

15. *Provisions of the permit dictate the manner in which the dischargers are to comply with its requirements, in violation of Water Code Section 13360.*

Water Code Section 13360 clearly provides a restriction on the ability of the Regional Boards to dictate the manner of compliance with State requirements. However, Water Code Section 13377 provides that, notwithstanding Section 13360, the Regional Boards shall issue waste discharge requirements which apply and ensure compliance with all applicable provisions of the CWA. Inasmuch as the permit seeks to implement CWA requirements, it does not violate Section 13360 for the Regional Board to include specified programs that must be implemented by the municipalities in order to carry out CWA requirements. This is made all the more necessary by the elimination of numerical limits from the permit. Reliance on BMPs requires specification of those programs that are relied upon to reduce pollution.

16. *The decision-making authority of a city rests with its city council, and it cannot be delegated, except within narrowly prescribed limits, to a representative on the WMC.*

As I understand it, the intent of the permit is to assure representation by city staff of sufficiently high level to accomplish implementation of programs within narrow time limits, and avoid wasted time. Further discussion should identify the appropriate staff, or the extent of permissible delegation, and if none is available, other acceptable mechanisms for the WMC to achieve its objectives, including procedures that would allow the representatives to take issues back to their respective city councils for approval.

17. *The BMP substitution provisions unlawfully delegate to the Executive Officer authority to prescribe permit requirements.*

The provisions were put into the draft permit in order to allow the cities a streamlined means of allowing for BMP substitution. If an acceptable provision cannot be drafted along the lines described below, it should be deleted. BMP changes would thus be taken to the Board for approval.

The current draft provides that the Executive Officer approve modifications only where he/she finds that the proposed change will (1) achieve greater or substantially similar reduction in storm water pollutants, and (2) be implemented within a similar period of time. These criteria are sufficiently detailed to constitute an appropriate authorization to the Executive Officer.

18. *The cities have no legal authority to control discharges on federal and certain other facilities within the cities' jurisdiction.*

The permit may properly require only control of discharges <u>to the extent allowed by law</u>. The provisions of the permit are not intended to, and legally cannot, expand the cities' authority over such facilities as federal properties. The appropriate permit language should be clarified to exclude obligations by the cities over federal properties located within its boundaries, state-owned properties, state parks, and state universities.

19. *The Permit constitutes rulemaking subject to the APA.*

The essence of the argument appears to be that, because the Regional Board staff has relied upon studies, guidance manuals, reports, portions of other permits, and staff input to produce the draft permit, and those underlying documents have not been subjected to scrutiny under the APA, the permit itself constitutes rulemaking subject to the APA. I do not agree.

Government Code Section 15375 defines a "permit" as:

> "[A]ny license, certificate, registration, permit, or any other form of authorization required by a state agency to engage in a particular activity or act."

The draft storm water waste discharge requirements for Los Angeles County constitute a permit within the meaning of the Government Code. Permits issued pursuant to Water Code Section 13262 or 13377 are not subject to the APA. (Government Code § 11352.) The fundamental distinction between permit issuance and rulemaking is that the former is a quasi-judicial process involving a specific discharger or group of dischargers based upon facts unique to the discharger or group, while the latter is a quasi-legislative exercise aimed at regulating the public in general, based upon general facts.

By definition, permit issuance involves the identification and imposition of applicable standards to allow the permittee or permittees to discharge storm water. That is what the draft permit seeks to accomplish. The fact that the draft permit makes use of materials not previously subjected to the APA does not, as the comment suggests, impose upon any group, any perceived requirements in those materials and documents. That would be rulemaking, subject to the APA. None of the arguments raised by the commenters affect the essential difference between rulemaking and permit issuance.

Furthermore, the process for adoption of the permit provides safeguards not unlike the APA's procedural requirements. Both provide for notice, opportunity to comment, response requirements, and hearing before the Board. The process provides for airing of all comments to provisions in the permit by those subject to permit and by other interested parties. The commenters' invitation to embark upon a rulemaking process in order to adopt the permit should be declined as it would unavoidably confuse the distinction between rulemaking and permit issuance. Moreover, the Regional Boards have not historically engaged in rulemaking under the APA. That function has been performed exclusively by the State Board in its discretion. To require each Regional Board to engage in separate rulemaking actions to support their storm water permits is not only time- and resource-intensive, but creates the undesirable potential for conflicting results.

20. *Reimbursement for State Mandates. The permit will require numerous programs which the cities will have to fund. To the extent the storm water permit requirements constitute federal requirements, the State may not properly shift the cost of those programs to the cities, without providing a funding mechanism.*

Section 6 of Article XIII B of the California Constitution requires the state to reimburse local government for the costs of complying with any new program or higher level of service mandated by either the Legislature or any state agency. In developing this storm water permit, the Regional Board is implementing provisions of the CWA and applicable regulations, which are federal laws. The SWRCB has previously determined that in several circumstances, Regional Board orders are exempt from the requirement for reimbursement. Among the reasons is that the orders implement federal and not state law. See <u>The</u>

City of San Bernardino (1991) Order No. WQ 91-08. As noted in other responses to comments, the permit requirements are intended to require the minimal programs and activities necessary to carry out the intent of the CWA, which is to assure reduction to the maximum extent practicable the discharge of pollutants in storm water. The Regional Board has not relied upon its discretion under State law to implement more stringent requirements than those set forth under the CWA.

21. *The information gathering requirements (developing a computer database, obtaining information from permittees, conducting inspections, preparing reports) exceed the CWA and federal regs, and are in violation of 44 U.S.C. Sections 3501, et seq. (Paperwork Reduction Act) and would require hiring additional staff.*

The current draft reduces the reporting frequencies and the detail of required reporting. The aspects of this comment concerning obtaining information from permittees and the need to hire more staff is addressed in the comment/response dealing with inspections. As to the manner of report submittal, the Regional Board may request that reports be submitted in a particular format, including electronic.

The Paperwork Reduction Act (PRA) applies to collection and use of information by federal agencies, not state agencies. 44 U.S.C. Section 3502(1). Even if it were applicable to collection and use of information by state agencies, the reporting requirements do not violate the PRA so long as the required reports are "necessary for the proper performance of the functions of the agency." 44 U.S.C. § 3508. Clearly, the reporting requirements are necessary to assure compliance with the permit.

22. *The County has no authority to require a city to cease discharges that occur in the city but enter county-operated storm water conveyances. Who is liable for cleanup costs?*

This is the kind of issue that should be resolved among the County and the cities themselves, as copermittees pursuant to interagency agreement authority. The cities among each other, and the County and the cities should consider entering into memoranda of understanding to apportion their respective responsibilities in such cases.

23. *Regarding Section II.B., the cities should not be required to assume any responsibility for cleanup if the owner/operator does not address a problem.*

The EPA's guidance indicates that the cities have responsibility for assuring that owner/operators do not cause illegal storm water discharges. It follows that the cities have responsibility to assure that owner/operators who cause pollution will address pollution problems they have caused through enforcement actions. The cities assume cleanup responsibility under their obligation to assure prevention of discharges of pollutants into storm water channels. Otherwise, that responsibility is illusory.

24. *The permit improperly seeks to shift responsibility for control of* *<u>Industrial/Commercial</u>* *sources of pollution to the cities.*

The permit places responsibility for control of these sources at the same place that the U.S. EPA places the responsibility: with the municipalities. The US EPA notes in the Preamble to the Storm Water Regulations that municipalities are in the best place to enforce compliance with storm water discharge requirements.

> "Because storm water from industrial facilities may be a major contributor of pollutants to MS4s, municipalities are obligated to develop controls for storm water discharges associated with industrial activity through their system in their storm water management program . . . . The CWA provides that permits for municipal separate storm sewers shall require municipalities to reduce pollutants to the maximum extent practicable. Permits issued to municipalities for discharges from municipal separate storm sewers will reflect terms, specified controls, and programs that achieve that goal."

Federal Register, Volume 55, Number 222, p. 48000. Again, at p. 48006, the U.S. EPA stated:

> "Municipal operators of large and medium municipal separate storm sewer systems are responsible for obtaining system-wide or area permits for their system's discharges. These permits are expected to require that controls be placed on storm water discharges associated with industrial activity which discharge through the municipal system."

It is clear from these passages that the U.S. EPA interprets the CWA as requiring control of industrial/commercial discharges by the municipalities. The draft permit is consistent with the EPA's interpretation.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
IOS ANGELES REGION
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(213) 266-7500
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July 30, 1996

Dear Permittee Contact Persons:

WASTE DISCHARGE REQUIREMENTS AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES IN THE COUNTY OF LOS ANGELES (ORDER No. 96-054, NPDES No. CAS614001)

Attached is the adopted Los Angeles County Municipal NPDES Permit for discharges of storm water and urban runoff in the County of Los Angeles.

Pursuant to Division 7 of the California Water Code, this Regional Board, following a public hearing held on July 15, 1996, considered the tentative requirements, and adopted Order No. 96-054 (copy attached). This Order also serves as the National Pollutant Discharge Elimination System (NPDES) permit under the federal Clean Water Act. It will take effect on July 31, 1996, and expire on July 30, 2001.

When submitting programs and/or reports to the Regional Board pursuant to the provisions of Order No. 96-054, please include a reference to **"Compliance File No. 6948" and address them to the attention of the Technical Support Unit** to assure that the programs/reports are directed to the appropriate staff and file.

This Regional Board is committed to sharing information with the Permittees as much as possible. Attached is a list of sources of information and references to assist in implementing storm water management programs in Los Angeles County. Additionally, I have directed my staff to provide useful information to the Permittees as it becomes available. If at any time a Permittee has questions or desires further information, I encourage you to contact Carlos Urrunaga, the staff person assigned to this Permit.

If you have any additional questions, please do not hesitate to contact any of my staff: Carlos Urrunaga at (213) 266-7598, Xavier Swamikannu at (213) 266-7592, or Winnie Jesena at (213) 266-7594.

Sincerely,

Robert P. Ghirelli

for CATHERINE TYRRELL
Assistant Executive Officer

Enclosures as stated

cc: City Mayors - Enclosures: USEPA letter and list of Storm Water Information Resources only.

STORM WATER INFORMATION RESOURCES

The following is a list of references and bulletins which MS4 Permittees may find useful for storm water program implementation. Arrangements may be made to copy documents at the Regional Board Office when a contact phone number or address is not listed.

SWQTF Meeting Minutes. California Storm Water Quality Task Force. Proceedings from bimonthly meetings on developments in municipal storm water management in California. Mailed for a nominal annual charge. Contact Bob Hale, Chairman, at (510) 670-5543.

Non-point Source News-Notes. Terrene Institute, 4 Herbert Street, Alexandria, VA 22305. An occasional USEPA funded free bulletin on the control of non-point sources of water pollution in U.S. states. Write to Terrene Institute to be placed on mailing list. All issues may also be accessed through the Internet at http://www.epa.gov.OWOW/NPS/npsie.html.

Watershed Protection Techniques. Silver Spring, MD. A quarterly bulletin on urban watershed restoration and protection measures from around the U.S. For subscription information, please call the Center for Watershed Protection at (301) 589-1890.

Stormwater Resource Guide. California Storm Water Quality Task Force (1994). A comprehensive list of existing educational outreach materials related to storm water quality management in California. Contact Chuck Ellis at the City of Los Angeles at (213) 847-5206.

Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems. A User's Guide, USEPA Document No. EPA/600/R-92/238 (1992). Guidance manual developed by the USEPA for municipalities for investigation of non-storm water entries into storm drainage systems.

Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems. USEPA, Document No. EPA 833-B-92-002 (1992). Guidance manual developed by the USEPA to provide technical support to MS4 programs for storm water discharges on regulatory requirements and BMPs.

Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties.. California Regional Water Quality Control Board, Los Angeles Region (1994). The Regional Board document on policies and standards to preserve and enhance water quality and protect beneficial uses of water resources in the Los Angeles Region. Call (213) 266-7579 to purchase a color-reproduction copy at a price of $45.

California Storm Water Best Management Practice Handbooks. California Storm Water Quality Task Force, Sacramento, CA (1992). Technical manuals that provide guidance on BMPs published in three volumes - Municipal, Industrial, and Construction. Available for a nominal cost from Blue Print Service at (510) 444-6771.

California Industrial/Commercial Stormwater Inspection Program Handbook. Alameda Countywide Clean Water Program (1996). Handbook prepared with USEPA funding to assist California municipalities in developing and implementing industrial and commercial facilities site-visit/inspection programs. Available for a nominal cost from Blue Print Service at (510) 444-6771.

Fundamentals of Urban Storm Water Management. Terrene Institute (1994). Manual prepared with USEPA funds which provides comprehensive technical information on storm water quality management and in-depth discussion of institutional issues.

07/29/96

STATE OF CALIFORNIA—ENVIRONMENTAL PROTECTION AGENCY PETE WILSON, *Governor*

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
. ANGELES REGION
CENTRE PLAZA DRIVE
MONTEREY PARK, CA 91754-2156
(213) 266-7500
FAX: (213) 266-7600

July 31, 1996

Dear Interested Parties:

WASTE DISCHARGE REQUIREMENTS AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES IN THE COUNTY OF LOS ANGELES (ORDER No. 96-054, NPDES No. CAS614001)

Pursuant to Division 7 of the California Water Code, this Regional Board, following a public hearing held on July 15, 1996, considered the tentative requirements and adopted Order No. 96-054. This Order also serves as the National Pollutant Discharge Elimination System (NPDES) permit under the federal Clean Water Act. It will take effect on July 31, 1996, and expire on July 30, 2001.

To minimize copying and postage costs, we are sending Order No. 96-054 only to the Permittee contact persons and to those who participated in the Permit deliberations. In order to receive a copy of the adopted and signed permit, please circle the information which best applies and return the enclosed postcard. For those who do not wish to receive a copy of the adopted and signed permit, you may simply write "96-054" in the blank "Order No. 96-XXX" at the top of the revised tentative permit dated July 5, 1996, in your possession. Changes made to the revised tentative and adopted by the Regional Board are listed on the attached change sheet. The revised tentative accompanied by the change sheet are equivalent to the adopted permit.

If you would like to continue receiving information regarding the permit and its implementation, please circle the information which best applies and return the enclosed postcard. Otherwise, we may delete your name from the mailing list.

If you have any questions, please do not hesitate to contact Carlos Urrunaga at (213) 266-7598.

Sincerely,

WINNIE D. JESENA, P.E.
Chief, Los Angeles County Coastal
Surface Water Unit

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

In Reply
Refer To: W-5-1

JUL 18 1996

Robert Ghirelli
Executive Officer
California Regional Water Quality Control Board
Los Angeles Region
101 Centre Plaza Drive
Monterey Park, CA 91754-2156

Dear Dr. Ghirelli:

The purpose of this letter is to formally endorse the action by the Los Angeles RWQCB on July 15, 1996, in adopting the storm water permit for Los Angeles County and its co-permittees (NPDES permit No. CAS614001).

Aside from certain minor changes which were made at the July 15, 1996 hearing, the permit which was adopted is the same as the permit which was distributed for review on July 5, 1996. On July 12, 1996, we provided the Los Angeles RWQCB with a letter approving the version of July 5, 1996. We have also reviewed the minor changes which were made and concluded that the changes do not affect our previous determinations regarding the permit.

Therefore, by this letter, we are providing formal notification to the Los Angeles RWQCB of our approval of the storm water permit for Los Angeles County and co-permittees which was adopted on July 15, 1996. Should you have any questions regarding this matter, please call me at (415) 744-2001 or refer your staff to Eugene Bromley of the Permits Issuance Section at (415) 744-1906.

Sincerely yours,

Catherine Kuhlman

Catherine Kuhlman, Chief
Permits and Compliance Branch
Water Management Division

Printed on Recycled Paper

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER NO. 96-054
(NPDES NO. CAS614001)

WASTE DISCHARGE REQUIREMENTS FOR MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES WITHIN THE COUNTY OF LOS ANGELES

Table of Contents

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER NO. 96-054
NPDES NO. CAS614001 (CI 6948)

WASTE DISCHARGE REQUIREMENTS
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES
WITHIN THE COUNTY OF LOS ANGELES

Findings

The California Regional Water Quality Control Board, Los Angeles Region (hereinafter referred to as the Regional Board), finds:

Existing Permit and Report of Waste Discharge

1. The County of Los Angeles and 85 incorporated cities within the County of Los Angeles (see Attachment A, List of Permittees), hereinafter referred to as Permittees, discharge or contribute to discharges of storm water and urban runoff from municipal separate storm sewer systems (MS4s), also called storm drain systems, and water courses within the County of Los Angeles into receiving waters of the Los Angeles Basin under countywide waste discharge requirements contained in Order No. 90-079 adopted by this Regional Board on June 18, 1990. That Order also serves as a National Pollutant Discharge Elimination System (NPDES) permit (CA0061654).

2. On December 21, 1994, the Permittees submitted a Report of Waste Discharge (ROWD) as an application for re-issuance of waste discharge requirements and an NPDES permit.

Nature of Discharges and Sources of Pollutants

3. The discharges consist of surface runoff (non-storm water and storm water) from various land uses in all the hydrologic drainage basins that discharge into water bodies in Los Angeles County. The quality and quantity of these discharges vary considerably and are affected by the hydrology, geology, and land use characteristics of the watersheds; seasonal weather patterns; and frequency and duration of storm events.

4. Studies have shown that storm water runoff from urban and industrial areas typically contains the same general types of pollutants that are often found in wastewater in industrial discharges. Pollutants commonly found in storm water runoff include heavy metals, pesticides, herbicides, and synthetic organic compounds such as fuels, waste oils, solvents, lubricants, and grease. [References: *'Surface Runoff to the Southern California Bight'* and, *'Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1990*

and 1991,' SCCWRP Annual Report 1990-1991 and 1991-1992 (1993); Pitt and Field, *Hazardous and Toxic Wastes Associated with Urban Storm Water Runoff*, In Proceedings of the Sixteenth Annual RREL Hazardous Waste Reduction Symposium, Document No. EPA 600-9-90-037 (1990); *Storm Runoff in Los Angeles and Ventura Counties, Final Report*, California Regional Water Quality Control Board, Los Angeles Region (1988).]

These compounds can have damaging effects on both human health and aquatic ecosystems. In addition to pollutants, the high volumes of storm water discharged from MS4s in areas of rapid urbanization have had significant impacts on aquatic ecosystems due to physical modifications such as bank erosion and widening of channels. [References: *Fundamentals of Urban Storm Water Management,* Terrene Institute and USEPA, (1994); *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems*, USEPA, Document No. EPA 833-B-92-002 (1992).]

5. Water Quality Assessments conducted by the Regional Board identified impairment of a number of water bodies in Los Angeles County. [Reference: *Water Quality Assessment 1996*, Regional Water Quality Control Board, Los Angeles Region (1996).] The beneficial uses of certain water bodies specifically identified in these assessments are either impaired or threatened to be impaired. Pollutants found causing impairment include: heavy metals, coliform, enteric viruses, pesticides, nutrients, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organic solvents, sediments, trash, debris, algae, scum, and odor.

6. An epidemiological study conducted during the summer of 1995 for the Santa Monica Bay Restoration Project (SMBRP) demonstrated that there is an increased risk of acute illnesses caused by swimming near flowing storm drain outlets in Santa Monica Bay. [Reference: *An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay*, SMBRP (1996).]

   Previous investigations conducted for the SMBRP showed pathogens were detected in summer runoff at four storm drain locations. [References: *Pathogens and Indicators in Storm Drains within the Santa Monica Bay Watershed*, SMBRP (1992); *Storm Drains as a Source of Surf Zone Bacterial Indicators and Human Enteric Viruses to Santa Monica Bay*, SMBRP (1991), *An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses from Two Santa Monica Storm Drains*, SMBRP (1990).]

   Possible sources of pathogen contamination include pet and livestock feces, illicit sewer connections to the storm drains, leaking sewer lines, malfunctioning septic systems, and improper waste disposal by recreational vehicles, campers or transients. Additional potential sources of human pathogens in nearshore waters include sewage overflows into storm drains, small boats waste discharges, and bathers themselves.

7. The Regional Board therefore considers storm water/urban runoff discharges to be significant sources of pollutants that may be causing, threatening to cause, or contributing

to the impairment of the water quality and beneficial uses of the receiving water bodies in Los Angeles County, and, as such, need to be regulated.

Coverage and Exemptions

8. The requirements in this Order cover all areas within the boundaries of the cities as well as unincorporated areas in Los Angeles County within the jurisdiction of the Los Angeles Regional Board except the City of Avalon. The Permittees serve a population of about 11.4 million [Reference: *1990 Census of Population and Housing,* Bureau of the Census, U.S. Department of Commerce (1992)] in an area of approximately 3,100 square miles. Attachment B shows the map of the permitted area in Los Angeles County.

9. Federal, state, regional or local entities within the Permittees' boundaries or in jurisdictions outside the County of Los Angeles, and not currently named in this Order, may operate storm drain facilities and/or discharge storm water to storm drains and watercourses covered by this Order. The Permittees may lack legal jurisdiction over these entities under state and federal constitutions. Consequently, the Regional Board recognizes that the Permittees will not be held responsible for such facilities and/or discharges.

   For those entities within the Permittees' boundaries, the Regional Board may consider designating them as Permittees under this Order or issuing separate NPDES permits consistent with this Order. The California Department of Transportation (Caltrans), currently a Co-Permittee to Order No. 90-079, submitted an ROWD on July 3, 1995, for separate waste discharge requirements for its discharges in the County of Los Angeles and the County of Ventura. The waste discharge requirements to be issued to Caltrans will be consistent with this Order.

10. Sources of discharges into receiving waters in the County of Los Angeles but in jurisdictions outside its boundary include the following:

    a. About 34 square miles of unincorporated area in Ventura County drain into Malibu Creek, thence to Santa Monica Bay,

    b. About 9 square miles of the City of Thousand Oaks also drain into Malibu Creek, thence to Santa Monica Bay, and

    c. About 86 square miles of area in Orange County drain into Coyote Creek, thence into the San Gabriel River Watershed in the County of Los Angeles.

    The Regional Board will insure that storm water management programs for the areas in Ventura County and the City of Thousand Oaks that drain into Santa Monica Bay are consistent with the requirements of this Order. The Regional Board will coordinate with the Santa Ana Regional Board so that storm water management programs for the areas in Orange County that drain into Coyote Creek are consistent with the requirements of this

Order.

11. The City of Santa Clarita and some unincorporated areas of Los Angeles County drain into the Santa Clara River Watershed, a portion of which is located in Ventura County. Discharges of municipal storm water in Ventura County are regulated under NPDES permit CAS063339 (Order No. 94-082). Successful management of the entire watershed needs coordination among the City of Santa Clarita, the County of Los Angeles, and Ventura County in developing and implementing the storm water management plan for the watershed.

12. Certain pollutants present in storm water and/or urban runoff may be contributed by activities which the Permittees cannot control. Examples of such pollutants and their respective sources are: polycyclic aromatic hydrocarbons which are products of internal combustion engine operation, nitrates from atmospheric deposition, lead from fuels, copper from brake pad wear, zinc from tire wear, and natural-occurring minerals from local geology. However, Permittees can implement measures to minimize entry of these pollutants into storm water.

<u>Bases of Waste Discharge Requirements</u>

<u>Federal Statutes and Regulations</u>

13. Section 402(p) of the federal Clean Water Act (CWA), as amended by the Water Quality Act of 1987, requires NPDES permits for storm water discharges from MS4s to waters of the United States. Section 402(p)(3)(B) requires that permits for MS4s: ..... "(i) may be issued on a system- or jurisdiction-wide basis; (ii) shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers; and (iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants."

14. On November 16, 1990, pursuant to Section 402(p) of the CWA, the USEPA promulgated 40 Code of Federal Regulations (CFR) Part 122.26 which established requirements for storm water discharges under the NPDES program. The regulations recognize that certain categories of non-storm water discharges may not be prohibited if they have been determined not to be significant sources of pollutants.

15. Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) requires coastal states with approved coastal zone management programs to address non-point pollution impacting or threatening coastal water quality. As required by CZARA, USEPA issued *Guidance Specifying Management Measures For Sources of Non-point Pollution In Coastal Waters*, Document No. EPA-840-B-92-002 (1993). The guidance focuses on five major categories of non-point sources that impair or threaten coastal waters

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nationally: (a) agricultural runoff; (b) silvicultural runoff; (c) urban runoff (including developing and developed areas); (d) marinas and recreational boating; and (e) hydromodification. This Order includes management measures for pollution from urban runoff. Thus, it provides the functional equivalence for compliance with CZARA in this area.

State Statutes and Permits

16. To facilitate compliance with federal regulations, in 1992 the State Water Resources Control Board (State Board) issued two statewide general NPDES permits: one for storm water from industrial sites [NPDES No. CAS000001, General Industrial Activities Storm Water Permit (GIASP)] and the other for storm water from construction sites [NPDES No. CAS000002, General Construction Activity Storm Water Permit (GCASP)]. "Industrial Activities," as defined in 40 CFR § 122.26(b)(14)(i) through (xi), and construction activities with a disturbed area of five acres or more are required to obtain individual NPDES permits for storm water discharges, or be covered by these statewide general permits by completing and filing a Notice of Intent with the State Board.

17. California Water Code (CWC) Section 13263(a) requires that waste discharge requirements issued by Regional Boards shall implement any relevant water quality control plans that have been adopted; shall take into consideration the beneficial uses to be protected and the water quality objectives reasonably required for that purpose; other waste discharges; and, the need to prevent nuisance.

Regional Board Water Quality Control Plans and Policies

18. The Regional Board adopted an updated Water Quality Control Plan (Basin Plan) for the Los Angeles Region on June 13, 1994, *'Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*, (1994). 'The Basin Plan, which is incorporated in this Order by reference, specifies the beneficial uses of receiving waters and contains both narrative and numerical water quality objectives for the receiving waters in the County of Los Angeles.

19. This Regional Board has implemented a Watershed Management Approach to address water quality protection in the region. The objective of the Watershed Management Approach is to provide a comprehensive and integrated strategy towards water resource protection, enhancement, and restoration while balancing economic and environmental impacts within a hydrologically defined drainage basin or watershed. It emphasizes cooperative relationships between regulatory agencies, the regulated community, environmental groups, and other stakeholders in the watershed to achieve the greatest environmental improvements with the resources available.

20. To implement the Watershed Management Approach, as well as facilitate compliance with this Order, the County of Los Angeles is divided into six Watershed Management Areas (WMAs) as follows:

a. Malibu Creek and Rural Santa Monica Bay WMA
b. Ballona Creek and Urban Santa Monica Bay WMA
c. Los Angeles River WMA
d. San Gabriel River WMA
e. Dominguez Channel/Los Angeles Harbor WMA
f. Santa Clara River WMA

Attachment A, shows the list of Permittees under each Watershed Management Area.

Other Bases

21. The SMBRP developed a Bay Restoration Plan to serve as a blueprint for Santa Monica Bay's recovery, '*The Santa Monica Bay Restoration Plan*, SMBRP (1994).' The Plan recommends actions that the Regional Board should integrate into the storm water permit and provides guidance to the Regional Board for the development of a strong, environmentally sound storm water program.

22. The Regional Board is the enforcing authority in the Los Angeles region for the two statewide general permits, described in Finding 16, which regulate discharges from industrial facilities and construction sites, and all NPDES storm water and non-storm water permits issued by the Regional Board. These industrial and construction sites are also regulated under local laws and regulations.

23. The ROWD submitted by the Permittees includes:

    a. Summary of Best Management Practices (BMP) implemented;
    b. Storm water management plans for the six WMAs;
    c. Countywide evaluation of existing storm water quality data; and
    d. Monitoring Program.

    The ROWD served as partial basis for the development of the Storm Water Management Program (SWMP) requirements of this Order.

24. A USEPA review of activities conducted by the automotive service sector indicates that automotive service facilities present a significant potential for the discharge of pollutants into storm water. [Reference: *Storm Water Discharges Potentially Addressed by Phase II of the NPDES, Report to Congress*, USEPA (1995).]

25. Studies indicate that facilities with paved surfaces subject to frequent motor vehicular traffic (such as parking lots and retail gasoline stations), or facilities which perform vehicle repair, maintenance, or fueling (such as retail gasoline outlets with service bays) are potential sources of pollutants of concern in storm water. [References: Pitt *et al.*, *Urban Storm Water Toxic Pollutants: Assessment, Sources, and Treatability*, Water Environment Res., 67, 260 (1995); *Results of Retail Gas Outlet and Commercial Parking Lot Storm Water*

Runoff Study, Western States Petroleum Association and American Petroleum Institute, (1994); Action Plan Demonstration Project, Demonstration of Gasoline Fueling Station Best Management Practices, Final Report, County of Sacramento (1993).]

Studies also suggest that the implementation of best management practices can reduce storm water pollutants from these types of facilities. [References: *Storm Water Best Management Practices for Retail Gasoline Outlets*, Western States Petroleum Association, (1996); and *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, Document No. EPA 840-B-92-002 (1992).]

26. A review of industrial waste/pretreatment records in Los Angeles County on illicit discharges indicate that automotive service facilities and food service facilities sometimes discharge polluted washwaters to the MS4. The pollutants of concern in such washwaters include food waste, oil and grease, and toxic chemicals. Other storm water/industrial waste programs in California have reported similar observations.

Objectives and Requirements of this Order

27. The objective of this Order is to protect the beneficial uses of receiving waters in Los Angeles County. To meet this objective, this Order requires implementation of BMPs intended to reduce pollutants in storm water and urban runoff such that ultimately their discharge will neither cause violations of water quality objectives nor create conditions of nuisance in receiving waters.

28. The Regional Board recognizes the challenges unique to regulating storm water discharges through municipal storm sewer systems, including intermittent and variable nature of discharges, difficulties in monitoring, and limited physical control over the discharge, and that it will require adequate time to implement and evaluate the effectiveness of best management practices required in this Order and to determine whether they will adequately protect the receiving water.

29. This Order designates the County of Los Angeles as the Principal Permittee. The Principal Permittee will coordinate and facilitate activities necessary to comply with the requirements of this Order, but is not responsible for insuring compliance of any individual permittee.

30. Each Permittee is only responsible for the implementation of the appropriate storm water management program developed pursuant to the requirements of this Order, and not for the implementation of the provisions applicable to the Principal Permittee or other Permittees. A Permittee is required to comply only with the requirements of this Order applicable to discharges which originate from places within its boundaries over which it has authority to enforce the requirements of this Order.

31. In the ROWD, the Permittees proposed the formation of a countywide Executive Advisory Committee (EAC), and a Watershed Management Committee (WMC) for each of the WMAs.

The EAC and the six WMCs are now functional.

The EAC's main role is to facilitate programs within each watershed and to enhance consistency among all of the programs. Similar to the Principal Permittee, the EAC is not responsible for insuring compliance of any individual permittee with the requirements of this Order.

The WMCs, as required in this Order, will provide the leadership framework to facilitate development of the Watershed Management Area Plans and foster cooperation among Permittees.

32. The USEPA issued a guidance manual for submittal of a Part II application for MS4s. [Reference: *Guidance Manual for the Preparation of Part of the NPDES Applications for Discharges from Municipal Separate Storm Sewer Systems*, EPA Document No. 833-B-92-002 (1992).] The manual describes the components of a municipal storm water program that will meet the requirements of 40 CFR Part 122.26.

33. The SWMP required in this Order builds upon the foundation established in Order No. 90-079, consists of the components recommended in the USEPA guidance manual, and was developed with the cooperation of representatives from the regulated community and environmental groups. The SWMP includes requirements with compliance dates to provide specificity and certainty of expectations. It also includes provisions that promote customized initiatives, both on a countywide and watershed basis, in developing and implementing cost-effective measures to minimize discharge of pollutants to the receiving water. The various components of the SWMP, taken as a whole rather than individually, are expected to reduce pollutants in storm water and urban runoff to the maximum extent practicable.

34. The main focus of the SWMP is pollution prevention through education, public outreach, planning, and implementation of BMPs. Successful implementation of the provisions of the SWMP will require cooperation and coordination of all public agencies in each Permittees' organization, among Permittees, and the regulated community. To minimize cost, the Permittees are encouraged to utilize their existing organizational framework to implement the various activities required in this Order.

35. As required in Order No. 90-079 and pursuant to 40 CFR Part 122.26(d)(2)(i), this Order requires Permittees to demonstrate that they possess the legal authority to implement and enforce the storm water programs within their respective jurisdictions. If Permittees decide that the legal authority will be through ordinances, Permittees are encouraged to develop a model ordinance to minimize cost and promote countywide consistency.

The Permittees are encouraged to enter into interagency or interjurisdictional agreements or other means to control the discharge of pollutants from one portion of the MS4 to another portion of the MS4.

36. Order 90-079 required the development and implementation of BMPs to minimize pollutants in storm water. In 1993, the Regional Board approved 13 baseline BMPs to facilitate the implementation of countywide minimum requirements, encourage countywide consistency, and provide a minimum measure of progress. These BMPs were selected from Permittees' MS4 programs. Twelve of these 13 BMPs have been incorporated into this Order: a) catch basin labeling; b) public illicit discharges reporting; c) construction storm water ordinance; d) public education and outreach; e) catch basin cleanout; f) roadside trash receptacles; g) street sweeping; h) proper disposal of litter, lawn clippings, pet feces; i) removal of dirt, rubbish and debris at homes and businesses; j) oil, glass, and plastics recycling; k) proper disposal of household hazardous wastes; and l) proper water use and conservation. The thirteenth BMP (inspections of vehicle repair shops, vehicle body shops, vehicle parts and accessories, gasoline stations, and restaurants) has been changed to educational site visits.

37. Each Permittee owns and operates facilities within its jurisdiction that may impact storm water quality. Each Permittee, under this Order is required to implement BMPs to reduce pollutant discharges from these activities and/or facilities.

38. This Order provides the flexibility for the Permittees to petition the Regional Board Executive Officer to substitute a BMP or requirement under the SWMP with an alternative BMP, if they can provide information and documentation on the effectiveness of the alternative, equal to or greater than the prescribed BMP in meeting the objectives of this Order.

39. This order contemplates that the Permittees are responsible for considering potential stormwater impacts when making planning decisions. However, neither this order nor any of its requirements are intended to restrict or control local land use decision-making authority.

Others

40. The Regional Board will provide the Principal Permittee with an updated list of NPDES permits on a quarterly basis through the Regional Board's electronic bulletin board which may be accessed at (213) 266-7663, or other available methods, for use by each Permittee to identify permitted sources of active non-storm water discharges into the MS4.

41. This action to adopt and issue waste discharge requirements and a NPDES permit is exempt from the provisions of the California Environmental Quality Act; Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Section 13389 of the California Water Code.

Public Process

42. The Regional Board will notify interested agencies and interested persons of the availability of reports, plans, and/or schedules of implementation submitted pursuant to the requirements of this Order. The Regional Board will consider comments prior to taking any

action on the submitted documents as provided for in this Order.

43. This Order may be modified or alternatively revoked or reissued prior to its expiration date, in accordance with the procedural requirements of the federal NPDES program, and the California Water Code and Title 23 of the California Code of Regulations for the issuance of waste discharge requirements.

44. The Regional Board staff solicited comments on early drafts of this Order from Permittees, interested agencies, and interested persons. In addition, Regional Board staff met with representatives from Permittees, business associations, environmental groups, and other interested persons to discuss permit requirements and attempt to resolve critical issues. Regional Board staff also solicited feedback from the SMBRP Oversight Committee on early drafts of the Order, attended Permittee watershed meetings, made presentations to government officials, and conducted and/or participated in public workshops to hear concerns.

The Regional Board has notified Permittees, interested agencies, and interested persons of its intent to prescribe waste discharge requirements and an MS4 NPDES permit for storm water discharges, and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.

The Board, in a public hearing, heard and considered all comments pertaining to the tentative waste discharge requirements. This order shall serve as a National Pollutant Discharge Elimination System (NPDES) Permit pursuant to Section 402 of the federal Clean Water Act, or amendments thereto, and shall take effect at the end of 15 days from the date of its adoption, provided the Regional Administrator of the U.S. Environmental Protection Agency, Region IX, has no objections.

Requirements

IT IS HEREBY ORDERED that the County of Los Angeles and the Cities of Agoura Hills, Alhambra, Arcadia, Artesia, Azusa, Baldwin Park, Bell, Bellflower, Bell Gardens, Beverly Hills, Bradbury, Burbank, Calabasas, Carson, Cerritos, Claremont, Commerce, Compton, Covina, Cudahy, Culver City, Diamond Bar, Downey, Duarte, El Monte, El Segundo, Gardena, Glendale, Glendora, Hawaiian Gardens, Hawthorne, Hermosa Beach, Hidden Hills, Huntington Park, Industry, Inglewood, Irwindale, La Cañada Flintridge, La Habra Heights, Lakewood, La Mirada, La Puente, La Verne, Lawndale, Lomita, Long Beach, Los Angeles, Lynwood, Malibu, Manhattan Beach, Maywood, Monrovia, Montebello, Monterey Park, Norwalk, Palos Verdes Estates, Paramount, Pasadena, Pico Rivera, Pomona, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, Rosemead, San Dimas, San Fernando, San Gabriel, San Marino, Santa Clarita, Santa Fe Springs, Santa Monica, Sierra Madre, Signal Hill, South El Monte, South Gate, South Pasadena, Temple City, Torrance, Vernon, Walnut, West Covina, West Hollywood, Westlake Village, and Whittier, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act, as amended, and regulations and guidelines adopted thereunder, shall comply with the following for the areas within their boundaries and subject to their regulatory jurisdiction, in the County of Los Angeles.

Part 1. DISCHARGE PROHIBITIONS AND RECEIVING WATER LIMITATIONS

I. Discharge Prohibition

Each Permittee shall, within its jurisdiction, effectively prohibit non-storm water discharges into the municipal separate storm sewer system (MS4) and watercourses, except where such discharges are:

A. In compliance with a separate individual or general NPDES permit; or

B. Identified and in compliance with Part 2.II.C (Non-storm Water Discharges), of this Order; or

C. Discharges originating from federal, state or other facilities which the Permittee is pre-empted from regulating.

Compliance with this Order through timely development and implementation of programs described herein shall constitute compliance with this prohibition.

II. Receiving Water Limitations

The water quality objectives and water quality standards applicable to receiving waters in Los Angeles County contained in the Basin Plan, '*Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*, California Regional Water Quality Control Board, Los Angeles Region, Monterey Park (1994),' and amendments thereto, shall serve as receiving water limitations for discharges covered under this Order. It is the purpose of this Order that the discharge of storm water, or non-storm water, from a municipal separate storm sewer system (MS4) for which a Permittee is responsible not cause nuisance, continuing or recurring impairment of beneficial uses, or exceedances of water quality objectives in the receiving waters.

Timely and complete implementation by a Permittee of the storm water management programs prescribed in this Order shall satisfy the requirements of this section and constitute compliance with receiving water limitations. However, if the Integrated Receiving Waters Impact Report required in this Order (Part 2.VII.D.) and/or other available information show that discharges authorized under this Order still cause or contribute to the impairment of the beneficial uses or exceedances of water quality objectives, Permittees, as part of their Report of Waste Discharge for the renewal of this Order, shall submit revised storm water management programs that are watershed-specific and will increase the likelihood of preventing future exceedances of water quality objectives.

Part 2. STORM WATER MANAGEMENT PROGRAM REQUIREMENTS

The objective of the Storm Water Management Program requirements prescribed in this Order is to reduce pollutants in discharges to the maximum extent practicable in order to attain the water quality objective and protect the beneficial uses of receiving waters in Los Angeles County. Each Permittee shall implement within its jurisdiction the Storm Water Management Program requirements of this Order and those of the Countywide Storm Water Management Plan (CSWMP) or Watershed Management Area Plan (WMAP) that will be developed pursuant to this Order.

The CSWMP is the unified plan consisting of programs developed under the Storm Water Management Program Requirements of this Order.

The WMAP is the comprehensive implementation plan for a specific Watershed

Management Area (WMA) based on the requirements of this Order, the CSWMP, and any other applicable actions that address pollutants of concern and other water quality issues unique to that WMA toward the objective of reducing pollutants in discharges to the maximum extent practicable. Upon approval by the Executive Officer, the WMAP will supersede the CSWMP.

If there is any conflict or discrepancy between information in the tables and the narrative provisions of this Order, the narrative provisions prevail.

I. Program Management

Table 1 shows the summary of program management requirements and their corresponding compliance dates.

Table 1
Program Management Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Submit completed CSWMP	I.A.8	✓		Upon completion of development of all programs but not later than July 30, 1999.	Executive Officer
Develop a WMAP for the WMA	I.C.3.d	✓	(through WMCs)	Within 180 days prior to expiration of Order (February 1, 2001) (pending the approval of the CSWMP by Executive Officer)	Executive Officer
Identify additional SIC groups	I.C.3.g		(through WMCs)	Established through WMCs	N/A
Prepare budget summary format	I.D.1	✓		3 (October 30, 1996)	Executive Officer
Submit annual budget summary to Principal Permittee	I.D.2		✓	60 days after budget adoption	Executive Officer
Demonstrate legal authority	I.E.2		✓	120 days (November 28, 1996)	Executive Officer

A. Responsibilities of the Principal Permittee

The County of Los Angeles is hereby designated as the Principal Permittee, and as such shall:

1. Coordinate permit activities among permittees and act as liaison between Permittees and the Regional Board on general permit issues;

2. Provide personnel and fiscal resources for the development and update of the CSWMP and WMAPs and their components;

3. Convene the Watershed Management Committees (WMCs) constituted pursuant to Part 2.I.C upon designation of representatives;

4. Provide technical and administrative support for committees that will be organized to implement this Order;

5. Implement the Countywide Monitoring Program required in this Order;

6. Provide personnel and fiscal resources for the preparation and submittal to the Regional Board of annual reports, and summaries of other reports required under this Order;

7. Comply with the "Responsibilities of the Permittees" in Part 2.I.B; and

8. Submit to the Regional Board the CSWMP upon completion of the development of all programs under the SWMP requirements.

B. <u>Responsibilities of the Permittees</u>

Each Permittee shall, within its geographic jurisdiction:

1. Comply with the requirements of SWMP and CSWMP and their amendments;

2. Coordinate among its internal departments and agencies, as appropriate, to facilitate the implementation of the requirements of this Order applicable to such Permittee in an efficient and cost-effective manner;

3. Participate in the development and, if necessary, the update of the CSWMP;

4. Submit in a timely manner to the Principal Permittee an annual report on its implementation of the SWMP and CSWMP;

5. Appoint a technically knowledgeable representative to the appropriate WMC;

6. Participate in the development of the WMAP for its respective watershed management area through its WMC, and shall implement said WMAP upon approval by the Executive Officer; and

7. Work with other agencies, to the extent necessary, and submit a report to the Executive Officer on recommendations to resolve any conflicts identified between the provisions of this Order and the requirements of

other regulatory agencies, if the Permittee considers it necessary.

C. Watershed Management Committees (WMCs)

1. Each WMC shall be comprised of a voting representative from each Permittee in the WMA.

2. The WMC's chair and secretary shall be chosen by the WMC. In the absence of volunteer Permittee(s) for the positions, the Principal Permittee shall assume those roles until the WMC chooses members of the committee for the positions.

3. Each WMC shall:

   a. Facilitate cooperation and exchange among Permittees;

   b. Establish goals and objectives for the WMA;

   c. Prioritize pollution control efforts considering beneficial use impairment as a basis;

   d. Participate in the development of the WMAP for its respective WMA after the CSWMP is completed;

   e. Assess the effectiveness of, prepare revisions for, and recommend appropriate changes to the CSWMP and the WMAP;

   f. Coordinate and facilitate the submittal of completed reporting forms to the Principal Permittee for report integration, and assist in the preparation of Annual Reports by the Principal Permittee on storm water management activities within the WMA for submittal to the Executive Officer;

   g. Identify, as part of the industrial/commercial Source Identification program, additional SIC industrial/commercial groups selected as priority to be included in the database described in Part 2.V.B.1.a. The following criteria shall be considered in the identification process:

      i. Extent of exposure of the industrial/commercial activity to storm water;

      ii. Types and quality of non-storm water discharges;

      iii. Similarity of industrial/commercial activity to industrial activity regulated under the USEPA Phase 1 facilities;

iv. Types of chemicals and wastes generated that can contaminate storm water;

v. Existence of duplicate regulatory programs with other agencies that emphasize waste management and minimize exposure of the industrial/commercial activity to storm water;

vi. Number of facilities in the WMA;

vii. Professional understanding of the industrial/commercial sector's waste management practices;

viii. Experience of local agency industrial waste inspection programs; and

ix. Any other information that indicates a significant potential for contamination of storm water.

D. <u>Fiscal Resources</u>

1. The Principal Permittee, in consultation with the Permittees, shall prepare a budget summary format not later than October 30, 1996, for use by each Permittee to report resources available to implement the SWMP.

2. Each Permittee shall submit to the Principal Permittee a summary of resources dedicated for storm water program implementation, not later than 60 days after budget adoption by the Permittee's elected local governing body. A Permittee may provide all necessary data in an alternate format which includes the same information unless directed otherwise by the Executive Officer.

E. <u>Legal Authority</u>

1. Pursuant to the time frame established in E.2, each Permittee shall demonstrate that it possesses the legal authority necessary to control discharges to and from those portions of the Municipal Separate Storm Sewer System (MS4) over which it has jurisdiction so as to comply with this Order. This legal authority may be demonstrated by either a single ordinance or a single guidance document containing all the applicable statutes, ordinances, permits, contracts, orders or agreements which govern a Permittee's storm water management activities, as required by 40 CFR 122.26(d)(2)(i).

Each Permittee shall either individually or collectively possess the legal authority to:

a. Control the contribution of pollutants to the MS4 by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity, unless permitted under a separate NPDES permit, through the following prohibitions and requirements:

   i. Prohibit the discharge of untreated wash waters to the MS4 when gas stations, auto repair garages, or other types of automotive service facilities are cleaned;

   ii. Prohibit the discharge of untreated wastewater to the MS4 from mobile auto washing, steam cleaning, mobile carpet cleaning, and other such mobile commercial and industrial operations;

   iii. Prohibit to the maximum extent practicable, discharges to the MS4 from areas where repair of machinery and equipment, including motor vehicles, which are visibly leaking oil, fluid or antifreeze is undertaken;

   iv. Prohibit the discharges of untreated runoff to the MS4 from storage areas of materials containing grease, oil, or other hazardous substances, and uncovered receptacles containing hazardous materials;

   v. Prohibit the discharge of commercial/municipal swimming pool filter backwash to the MS4;

   vi. Prohibit the discharge of untreated runoff from the washing of toxic materials from paved or unpaved areas to the MS4;

   vii. Prohibit or control to the maximum extent practicable washing impervious surfaces in industrial/commercial areas which results in a discharge of untreated runoff to the MS4, unless specifically required by State or local health and safety codes;

   viii. Prohibit the discharge from washing out of concrete trucks to the MS4;

   ix. Require regular sweeping or other equally effective measures to remove debris from industrial/commercial motor vehicle parking lots with more than twenty-five parking spaces that are located in areas potentially exposed to storm water; and,

x. Require the use of BMPs or placement of machinery/ equipment that is to be repaired or maintained such that leaks, spills and other maintenance-related pollutants are not discharged to the MS4;

b. Prohibit illicit discharges and illicit connections to the MS4 and require removal of illicit connections.

c. Control spills, dumping, or disposal of materials, including the following, to the MS4 through the following prohibitions and requirements:

i. Prohibit littering;

ii. Prohibit the disposal of leaves, dirt, or other landscape debris into a storm drain;

iii. Prohibit the discharge to the MS4 of any pesticide, fungicide, or herbicide banned by the USEPA or the California Department of Pesticide Regulation;

iv. Require proper disposal of food wastes;

v. Prohibit the disposal of hazardous wastes into trash containers used for municipal trash disposal so as not to cause a discharge to the MS4; and

vi. Require, in areas exposed to storm water, the use of BMPs and/or removal and lawful disposal of all fuels, chemicals, fuel and chemical wastes, animal wastes, garbage, batteries, and other materials which have potential adverse impacts on water quality.

The above requirements (Part 2.I.E.1.) do not require inspection of private property. Legal authority is necessary, however, so that if the Permittee becomes aware of situations associated with private property that cause obvious discharges of prohibited materials to the MS4 or pose the potential for such discharges, the Permittee has the legal authority to abate such discharges.

2. Each Permittee shall:

Provide to the Principal Permittee for submittal to the Executive Officer, not later than November 28, 1996, copies of ordinances, regulations, and other legal documents establishing legal authority, or in the alternative:

a. A statement by its legal counsel that the Permittee has obtained all necessary legal authority to comply with this Order, referencing that legal authority with specificity; and/or

b. If Part 2.I.E.2.a. is only partially fulfilled, a timely schedule for obtaining adequate legal authority to comply with this Order, enumerating, with specificity, the legal authority that remains to be obtained.

F. Best Management Practice (BMP) or Program Substitution or Elimination

A Permittee may petition the Executive Officer to:

1. Substitute any BMP or program identified in this Order, the CSWMP, or the WMAP, if the Permittee can document that:

   a. The proposed alternative BMP or program will meet or exceed the objective of the original BMP or program in the reduction of storm water pollutants; or

   b. The fiscal burden of the original BMP or program is substantially greater than the proposed alternative, but does not achieve a substantially greater improvement in storm water quality; and,

   c. The proposed alternative BMP or program will be implemented within a similar period of time.

2. Eliminate any BMP or program identified in this Order, the CSWMP, and/or the WMAP, if the Permittee can document that:

   a. The BMP or program is not technically feasible and no substitute is available; or

   b. The cost of implementation outweighs the pollution control benefits; or

   c. The BMP or program is not applicable in the Permittee's jurisdiction.

The Executive Officer may approve or disapprove the petition in accordance with

Part 2.I.G and 2.I.H.

G. Administrative Review

The administrative review process formalizes the procedure for review and acceptance of reports and documents submitted to the Regional Board under this Order. In addition, it provides a method to resolve any differences in compliance expectations between the Regional Board and Permittees, prior to initiating enforcement action.

1. Storm water program documents, including progress reports, guidelines checklists, BMPs, databases, program summaries, and implementation and compliance schedules, developed by the Principal Permittee or a Permittee under the provisions of this Order, shall be submitted to the Executive Officer or the Regional Board, where required for approval. The process is as follows:

   a. For documents that require Executive Officer's approval, the Executive Officer will notify the Principal Permittee and/or Permittee of the results of the review and approval or disapproval within 120 days. If the Executive Officer has not responded within 120 days following submittal, the Permittee shall notify the Regional Board of its intent to implement the program components as submitted. If after 10 days the Executive Officer has not responded, the Permittee will implement the submitted program and the Executive Officer may not make modifications; and,

   b. Documents that require formal Regional Board approval will undergo public review and comment before Board consideration at a public meeting.

2. If the Executive Officer determines that a Permittee's storm water program is insufficient to meet the provisions of this Order, the Executive Officer shall send a "Notice of Intent to Meet and Confer (NIMC)" to the Permittee, with specific information in support of the determination. The NIMC shall include a time frame by which the Permittee must meet with Regional Board staff. The processes are as follows:

   a. The Permittee, upon receipt of a NIMC, shall meet and confer with Regional Board staff to demonstrate that the Permittee's program is sufficient to meet the requirements of this Order; and, if not, seek clarification on the steps to be taken to completely meet the provisions of this Order. The meet and confer period will conclude with either a notice of program sufficiency to the Permittee, or the submittal to and acceptance by the Executive Officer of a written "Storm Water Program Compliance Amendment (SPCA)" which shall include implementation deadlines. The Executive Officer may terminate the meet and confer period after a reasonable period due to a lack of progress on issues and may order submittal of the SPCA by a specified date. Failure to submit an acceptable SPCA by the specified date shall constitute a violation of this Order;

b. The Executive Officer will approve or reject the submitted SPCA or an amended SPCA within 120 days. Rejection of an SPCA by the Executive Officer shall state the reasons for the failure to approve the SPCA. A Permittee that receives a rejection of an SPCA shall have sixty (60) days to remedy the specified deficiency and resubmit the SPCA. If the Executive Officer has not responded within 120 days following submittal of an SPCA, the Permittee shall notify the Executive Officer of its intent to implement the SPCA as submitted. If after 10 days the Executive Officer has not responded, the Permittee will implement the submitted SPCA and the Executive Officer may not make modifications;

c. The Permittee shall comply with the terms of the SPCA. The Permittee shall submit reports to the Executive Officer on progress made under the SPCA. The frequency of progress report submittal shall be quarterly unless otherwise prescribed by the Executive Officer. Failure to comply with the terms and conditions of the SPCA shall constitute a violation of this Order and shall be cause for enforcement action by the Regional Board; and,

d. The Executive Officer shall not take enforcement action against a Permittee until the Executive Officer has notified the Permittee in writing that the Administrative Review Process has been exhausted and that the Executive Officer has determined that a violation exists warranting enforcement.

H. Public Review

1. The Principal Permittee shall maintain a current mailing list of interested parties, organized by WMAs, for distribution of documents that require the Executive Officer's approval. The Executive Officer will provide the Principal Permittee with the initial list of interested parties.

2. The Principal Permittee shall distribute for public comment the initial CSWMP, WMAPs, and other storm water program requirements that are submitted to the Executive Officer or the Regional Board for approval.

Interested parties wishing to have their comments considered prior to Regional Board action on these documents must submit their comments in writing to the Regional Board not later than 45 days after the Principal Permittee has made the document available to the public. The date of public release is also the date of submittal to the Regional Board. This 45-day comment period is part of the 120 day review period for documents submitted for Executive Officer's approval.

II. Illicit Connections and Illicit Discharges

Table 2 on the following page shows the summary of requirements under this section and corresponding compliance dates.

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Table 2
Illicit Connections and Discharges Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Develop model illicit connection elimination program	II.A.1	✓		8 months (March 31, 1997)	Executive Officer
Implement illicit connection elimination program	II.A.2		✓	≤ 36 months (July 30, 1999)	N/A
Develop model illicit discharge elimination program	II.B.1	✓		8 months (March 31, 1997)	Executive Officer
Implement illicit discharge elimination program	II.B.2		✓	≤ 36 months (July 30, 1999)	N/A
Conduct a study of municipal street and municipal sidewalk washing	II.C.3		✓ City of Los Angeles	Within 12 months from Executive Officer date of determination	Executive Officer
Submit BMPs and schedule for implementation	II.C.3		✓ City of Los Angeles	Within 12 months from Executive Officer date of determination	Regional Boar[illegible]
Implement non-storm water management program BMPs	II.C.3		✓	In accordance with RB approved schedule ≤ 36 months (July 30, 1999)	N/A
Develop standard program for public reporting of illicit discharges and illicit disposal practices	II.D.1	✓		8 months (March 31, 1997)	Executive Officer
Implement standard program to facilitate public reporting of illicit discharges and illicit disposal practices	II.D.2		✓	≤ 36 months (July 30, 1999)	N/A
Develop standard program for reporting hazardous substances	II.D.3	✓		8 months (March 31, 1997)	Executive Officer
Implement standard program for reporting hazardous substances	II.D.4		✓	≤ 36 months	N/A

A. Illicit Connections

1. The Principal Permittee, in consultation with the Permittees, shall develop a countywide model program for elimination of illicit connections to the MS4 not later than March 30, 1997. The program shall include, at a minimum:

   a. Standardized storm drain inspection procedures, and illicit connection identification and elimination procedures;

   b. Methods to prioritize potential problem areas, including, but not limited to old commercial/industrial areas, and areas with heavy industry listed under subchapter N of 40 CFR Parts 405 - 471;

   c. Methods to utilize results of field screening activities, and other appropriate information;

   d. Standardized record keeping to document illicit connections; and

   e. Enforcement procedures to terminate illicit connections.

2. Each Permittee, based on the countywide model program, shall develop and implement as appropriate a program to identify and eliminate illicit connections to the maximum extent practicable not later than four (4) months after the commencement of its next fiscal year following approval of the model program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

B. Illicit Discharges

The primary responsibility for cleanup and removal of illicit discharges of pollutants to the MS4 shall be with the owner/operator of the discharging facility or site. Nothing in this Order shall be interpreted to limit or in any way prevent action by a Permittee against the party responsible for the illicit discharge.

1. The Principal Permittee, in consultation with the Permittees, shall develop a countywide model illicit discharges elimination program not later than March 31, 1997. The program shall include, at a minimum:

   a. Standardized enforcement procedures, including administrative and judicial, to eliminate illicit discharges;

b. Standardized procedures for investigation, containment and cleanup of spills, which include a procedure to ensure that sewage treated with disinfection agents will not be discharged into the storm drain system to the extent practicable;

c. Methods to prioritize problem areas of illicit disposal where inspection, cleanup, and enforcement are necessary to prevent the discharge of contaminants;

d. Standardized procedures to educate inspectors, maintenance workers, and other field staff to notice illicit discharges during the course of their daily activities, and report such occurrences;

e. Standardized record keeping system to document illicit discharges; and,

f. Industrial/commercial education and outreach materials to inform businesses about the problem of illicit discharges/dumping and proper discharge/disposal practices.

2. Each Permittee shall, based on the countywide model program, develop and implement, as appropriate, a program to identify and eliminate illicit discharges not later than four (4) months after commencement of its next fiscal year following approval of the model program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval, but in no event shall implementation be later than July 30, 1999.

C. Non-Storm Water Discharges

Non-storm water discharges in compliance with a separate NPDES permit/Waste Discharge Requirements (WDR) or granted a discharge exemption by the Regional Board, the Executive Officer, or the State Water Resources Control Board are not prohibited under this Order.

1. Exempted Discharges

The following non-storm water discharges need not be prohibited:

a. Flows from riparian habitats or wetlands;
b. Diverted stream flows;

c. Springs;
d. Rising ground waters;
e. Uncontaminated groundwater infiltration; and
f. Discharges or flows from emergency fire fighting activities.

The Executive Officer, upon presentation of evidence in accordance with Part 2.II.C.4., may include other categories of non-storm water discharges under this subsection.

2. Conditionally Exempted Discharges

The following non-storm water discharges need not be prohibited. However, if they are identified by either a Permittee or the Executive Officer as being significant sources of pollutants to receiving waters, then appropriate BMPs to minimize the adverse impacts of these sources shall be developed and implemented under the CSWMP or the WMAPs:

a. Landscape irrigation;
b. Water line flushing;
c. Potable water sources provided the discharges are managed in accordance with an approved Industry-wide Standard Pollution Prevention Practices developed by the American Water Works Association, California-Nevada Section, or equivalent document; and in compliance with any requirements established by the Permittee(s);
d. Foundation drains;
e. Footing Drains;
f. Air conditioning condensate;
g. Irrigation water;
h. Lawn watering;
i. Water from crawl space pumps;
j. Dechlorinated swimming pool discharges;
k. Individual residential car washing; and,
l. Street washing (including sidewalk washing).

The Executive Officer, upon presentation of evidence in accordance with Part 2.II.C.4., may include other categories of non-storm water discharges under this subsection.

3. Designated Discharges

Municipal street washing and municipal sidewalk washing discharges have been determined by the Executive Officer to be potential sources of pollutants of concern. The City of Los Angeles will conduct a study to characterize municipal street washing and sidewalk washing, assess the impacts of such activities, and recommend appropriate BMPs to control any adverse impact. The City of Los Angeles will submit its recommendations to the Executive Officer not later than one year from adoption of this Order. A BMP implementation schedule shall be included where appropriate.

The Regional Board will determine within four (4) months of the City of Los Angeles' submittal which BMPs, if any, the Permittees shall implement, and approve any necessary schedule of implementation, provided the implementation date is not later than July 30, 1999.

The Executive Officer, upon presentation of evidence, may include other categories of non-storm water discharges under this subsection.

4. Procedures for Exemption

A Permittee may identify and describe additional categories of non-storm water discharges to be considered by the Executive Officer for exemption from the Discharge Prohibitions. The criteria to be considered for a request for exemption include one or more of the following:

a. Documentation that the discharge is not a significant source of pollutants to receiving waters or does not cause impairment of beneficial uses of receiving waters;

b. Special circumstances that have been defined in which the discharge has been found not to be a significant sources of pollutants to, or does not cause impairment of beneficial uses of receiving waters;

c. Specific BMPs, where determined feasible, that have been identified to reduce pollutants in the discharge to the maximum extent practicable and minimize adverse impacts of such source, with an implementation schedule; or

d. Established procedures to ensure BMP implementation, including an implementation schedule, performance standards, monitoring and record keeping.

The exemption request for additional non-storm water discharges may be submitted, beginning with the first Annual Report. The exemption becomes effective upon approval by the Executive Officer.

D. <u>Public Reporting</u>

1. The Principal Permittee, in consultation with the Permittees, shall develop

a countywide standard program to promote, publicize, and facilitate public reporting of illicit discharges and illicit disposal practices not later than March 31, 1997. The program may include, but not be limited to:

a. A system to receive incoming complaints;

b. A communication network to link Permittees so that action can be coordinated and complaints can be investigated promptly; and

c. A system to notify the complainant of any action taken, if appropriate.

2. Each Permittee shall implement the countywide illicit discharges and illicit disposal reporting program not later than four months after commencement of its next fiscal year following approval of the program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

3. The Principal Permittee, in consultation with the Permittees, shall develop a countywide program not later than March 31, 1997, for reporting incidents of "reportable quantity" of hazardous substances entering the MS4. The incidents shall be reported to the State of California Office of Emergency Services (OES) [current number, (800) 852-7550] and the Federal Hazardous Response Center [current number, (800) 424-8802].

4. Each Permittee shall implement the countywide program for reporting hazardous substances entering the MS4, not later than four months after commencement of its next fiscal year following approval of the program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

III. Development Planning and Construction

A. Development Planning

Table 3 on the following page shows the summary of requirements under this section and corresponding compliance dates.

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Table 3
Development Planning Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Develop a model system for prioritization of development projects	III.A 1.a	✓		18 (January 30, 1998)	Executive Officer
Implement a system for prioritization of development projects	III.A.1.a		✓	≤ 36 months (July 30, 1999)	N/A
Develop list of recommended BMPs for development projects (countywide guidelines)	III.A.1.b	✓		18 (January 30, 1998)	Regional Board
Develop Standard Urban Storm Water Mitigation Plans (SUSMP)	III.A.1.c	✓		6 months after Regional Board approval of countywide guidelines	Executive Officer
Develop and submit a schedule of implementation for a program for planning measures consistent with the Standard Urban Storm Water Mitigation Plan (SUSMP) for priority projects	III.A.2		✓	≤ 36 months (July 30, 1999)	N/A
Develop guidelines for preparing/reviewing CEQA documents	III.A.3.a	✓		18 (January 30, 1998)	Executive Officer
Incorporate CEQA guidelines into internal procedures	III.A.3.a		✓	≤ 36 months (July 30, 1999)	N/A
Include watershed and storm water management consideration into General Plan revisions	III.A.4 3.b		✓	During General Plan revisions	N/A
Develop model program for developers	III.A.4	✓		18 (January 30, 1998)	Executive Officer
Implement developer information program	III.A.4		✓	≤ 36 months (July 30, 1999)	N/A

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1. Countywide Development Planning Guidance

The Principal Permittee, in consultation with the Permittees, shall develop the following development planning guidance materials for use during planning and permitting of all development projects requiring discretionary approval:

a. A model documented system, such as a checklist, for determining priority projects as well as a list of specifically exempt projects not later that January 30, 1998. Priority and exempt projects are defined as follows:

   i. Priority Projects are development and redevelopment projects requiring discretionary approval which the Building Official (or equivalent municipal authority) determines may have a potential significant effect on storm water quality.

   ii. Exempt Projects are development and redevelopment projects which the Building Official (or equivalent municipal authority) determines will not have a potential significant impact on storm water quality.

   The documented system shall consider location of the project with respect to designated environmentally sensitive areas and the slope and erosion potential of the site and surrounding areas.

   Each Permittee shall incorporate a substantially similar system into its procedures not later than six months after commencement of its next fiscal year following approval of the ~~of the~~ documented system by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

b. A list of recommended BMPs not later than January 30, 1998. The list of BMPs shall include:

   i. Site planning practices;
   ii. Post-construction best management practices; and
   iii. Redevelopment and infill practices.

Consideration shall be given to the type of development and the potential for storm water pollution when determining the applicability of BMPs. Cost effectiveness, ease of maintenance, and consistency with other environmental mandates may also be considered.

For developments where increased storm water discharge rates will result in an increase in downstream erosion potential, the list of recommended BMPs shall include those BMPs which can be used to maintain peak runoff rates at pre-development levels to the maximum extent feasible.

The list of recommended BMPs shall be submitted to the Regional Board for approval.

c. Standard Urban Storm Water Mitigation Plans (SUSMPs) and guidelines for their preparation not later than six months after Regional Board approval of the BMPs in Part 2.III.A.1.b. The SUSMPs shall incorporate the appropriate elements of the recommended BMPs list. At the minimum, SUSMPs and guidelines shall be prepared for the following development categories:

i. a 100+ home subdivision;
ii. a 10-home subdivision;
iii. a 100,000+ square-foot commercial development;
iv. an automotive repair shop;
v. a retail gasoline outlet;
vi. a restaurant; and
vii. a hillside-located single-family dwelling.

2. Planning Control Measures

Each Permittee shall develop a program on planning control measures for priority projects (Part 2.III.A.1.a) consistent with the programs developed under Part 2.III.A.1.b. & c.. Each Permittee shall initiate implementation of its program not later than six months after commencement of its next fiscal year following approval of the model Standard Urban Storm Water Mitigation Plans by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be initiated later than July 30, 1999. Each Permittee shall require that the project applicant submit an Urban Storm Water

Mitigation Plan appropriate and applicable to the project, and that the Permittee approve the Plan prior to the issuance of any grading or building permit. The Urban Storm Water Mitigation Plan shall incorporate by detail or reference appropriate post-construction BMPs to:

a. Implement, to the maximum extent practicable, requirements established by appropriate governmental agencies under CEQA, Section 404 of the Clean Water Act, local ordinances and other legal authorities intended to minimize impacts from storm water runoff on the biological integrity of natural drainage systems and water bodies;

b. Maximize, to the maximum extent practicable, the percentage of permeable surfaces to allow more percolation of storm water into the ground;

c. Minimize, to the maximum extent practicable, the amount of storm water directed to impermeable areas and to the MS4;

d. Minimize, to the maximum extent practicable, parking lot pollution through the use of appropriate BMPs such as retention, infiltration, and good housekeeping;

e. Establish reasonable limits on the clearing of vegetation from the project site including, but not limited to, regulation of the length of time during which soil may be exposed and, in certain sensitive cases, the prohibition of bare soil; and

f. Provide for appropriate permanent controls to reduce storm water pollutant load produced by the development site to the maximum extent practicable.

The Permittee may refer applicants to the '*California Storm Water Best Management Practice Handbooks,* California Storm Water Quality Task Force, Sacramento, CA (1992)' and its revisions; the Countywide Storm Water Management Plan; '*USEPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Issued under the Authority of Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990,* Document No. EPA 840 B 92-002 (1993),'; and similar manuals for specific guidance on selecting post-construction BMPs for reducing pollutants in storm water discharges.

3. Planning Process

In order to integrate storm water management considerations into discretionary development projects at the time that they are first proposed to jurisdictions, and to support other provisions of this Order:

a. The Principal Permittee, in consultation with the Permittees, shall develop storm water management guidelines for use in preparing/reviewing CEQA documents, and in linking storm water quality mitigation conditions to local discretionary project approvals not later than January 30, 1998.

   The guidelines shall address the preservation of areas that provide water quality benefits such as riparian corridors and wetlands and shall promote protection of the biological integrity of drainage systems and water bodies.

   Each Permittee shall review the guidelines for the purpose of making appropriate modifications in their internal procedures not later than six months after commencement of its next fiscal year following approval of the program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

b. Each Permittee shall include watershed and storm water management considerations in the appropriate elements of the Permittee's General Plan, whenever said elements are significantly rewritten. Appropriate elements may include the following:

   i. Conservation; and/or
   ii. Open space; and/or
   iii. Land-use; and/or
   iv. Public utilities; and/or
   v. Infrastructure; and/or
   vi. Other appropriate elements.

4. Developer Information Program

The Principal Permittee, in consultation with the Permittees, shall develop a model program not later than January 30, 1998, to inform developers seeking discretionary approvals about:

a. Development and construction storm water management;

b. Maximization of pervious areas and storm water infiltration (where geology and topography permit); and

c. Cost effective storm water pollution control measures.

The program shall provide specific guidance on selecting BMPs to reduce pollutants in storm water discharges from urbanized areas, and include appropriate BMPs, educational materials, and handbooks and guidelines described in Part 2. III.A.3.

Each Permittee shall implement a developer information program consistent with the model program not later than six months after commencement of its next fiscal year following approval of the model by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999. Each Permittee's program shall include information about its legal authorities. Permittees are encouraged to engage in joint efforts in implementing the program.

B. Development Construction

Table 4 on the following page shows the summary of requirements and corresponding compliance dates under this section.

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Table 4
Development Construction Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Develop minimum requirements, recommended BMPs, and design checklists for construction	III.B.1	✓		14 (September 30, 1998)	Regional Board
Develop and implement a program for construction control measures	III.B.2.a		✓	≤ 36 months (July 30, 1999)	N/A
Require applicants to demonstrate coverage under State Construction General Permit prior to issuance of grading permits	III.B.2.b		✓	6 (January 31, 1997)	N/A
Develop a model construction inspection program	III.B.3.a	✓		14 (September 30, 1997)	Executive Officer
Implement a construction inspection program	III.B.3.b		✓	≤ 36 months (July 30, 1999)	N/A

1. Countywide Development Construction Guidance

The Principal Permittee, in consultation with the Permittees and appropriate stakeholder organizations, shall develop not later than September 30, 1998, the following development construction guidance materials for all development project construction activities: minimum recommended requirements, BMPs appropriate for various activities, and checklists for use in design and inspection. The Countywide minimum requirements and recommended BMPs shall:

a. Include erosion and sediment control practices;

b. Address multiple construction activity-related pollutants;

c. Focus on BMPs such as source minimization, education, good housekeeping, good waste management, and good site planning;

d. Target construction areas and activities with the potential to generate significant pollutant loads;

e. Require retention on the site, to the maximum extent practicable, of sediment, construction waste, and other pollutants from construction activity;

f. Require, to the maximum extent practicable, management of excavated soil on site to minimize the amount of sediment that escapes to streets, drainage facilities, or adjoining properties;

g. Require, to the maximum extent practicable, use of structural drainage controls to minimize the escape of sediment and other pollutants from the site.

h. Require, to the maximum extent practicable, containment of runoff from equipment and vehicle washing at construction sites, unless treated to remove sediments and pollutants.

The lists of BMPs shall be submitted to the Regional Board for approval.

2. Construction Control Measures

a. Each Permittee shall develop a regulatory program for construction activities as defined in Part 2.III.A.1.a. consistent with the Countywide Development Construction Guidance not later than six months after commencement of its next fiscal year following approval of the minimum recommended requirements and BMPs in Part 2.III.B.1. by the Regional Board , provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

The Program shall require, prior to the issuance of any building or grading permit, preparation of appropriate wet weather erosion control and storm water pollution prevention plans which include, by detail or reference, all appropriate construction BMPs developed under Part 2.III.B.1.

Priority Project plans must include a narrative discussion of the reasons used for selecting or rejecting BMPs. In lieu of a narrative, the project architect or engineer of record may sign a statement on the plan to the effect: "As the architect/engineer of record, I have selected appropriate BMPs to effectively minimize the negative impacts of this project's construction activities on storm water quality. The project owner and contractor are aware that the selected BMPs must be installed, monitored, and maintained to ensure their effectiveness. The BMPs not selected for implementation are redundant or deemed not applicable to the proposed construction activities."

b. Each Permittee shall implement a procedure not later than January 31, 1997, whereby the Permittee shall not issue a grading permit for developments with disturbed areas of five acres or greater unless the applicant can show that (i) a Notice of Intent (NOI) to comply with the State Construction Activity Storm Water Permit has been filed and (ii) a Storm Water Pollution Prevention Plan (SWPPP) has been prepared.

3. Site Inspection

a. The Principal Permittee, in consultation with the Permittees, shall develop a model construction activity inspection program, which includes checklists, not later than September 30, 1997. The model program shall include but not be limited to:

i. Procedures for construction site inspections;

ii. Procedures to require corrective action be undertaken by contractors at noncomplying sites;

iii. Procedures for enforcement action against noncomplying construction activity; and

iv. Appropriate training for program staff.

b. Each Permittee shall implement a construction activities inspection program based on the model program not later than six months after commencement of its next fiscal year following approval of the model program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999. The program may be integrated with the Permittees regular program of construction inspection for maximum efficiency.

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IV. Public Agency Activities

Table 5 shows the summary of requirements under this section and their corresponding compliance dates.

Table 5
Public Agency Activities Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Evaluate existing public agency activities and develop a model program to reduce storm water impacts	IV.A	✓		16 (December 1, 1997)	Executive Officer
Develop a program to reduce storm water impacts from public agency activities with a schedule for implementation	IV.B		✓	4 months after Executive Officer approval of model ≤ 36 months (July 30, 1999)	N/A

A. Public Agency Model Program

The Principal Permittee, in consultation with the Permittees, shall develop a model program to reduce the impact of public agency activities on storm water quality not later than December 1, 1997. The model program shall include a discussion of the on-going investigation of the feasibility of dry weather flow diversion from the MS4 to municipal waste water treatment plants, where appropriate. The model shall be submitted to the Regional Board for approval.

To minimize costs and avoid duplication of effort, it is encouraged to incorporate and recognize in the model program existing regulations, requirements and plans, such as waste minimization plans, spill prevention control and countermeasures, and business plans.

B. Permittee Public Agency Programs

Each Permittee shall develop and implement a Public Agency Program based on the model program developed by the Principal Permittee not later than four months after commencement of its next fiscal year following approval of the model program by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

C. Program Requirements

Both the model program and the Permittee programs shall at a minimum include, where applicable:

1. Sewage Systems Operations

   a. Procedures to keep sewage spills or leaks from facilities operated by a Permittee from entering the MS4 to the maximum extent practicable;

   b. Procedures to identify, repair, and remediate sanitary sewer blockages, exfiltration, overflow, and wet weather overflows from sanitary sewers operated by a Permittee to the MS4;

   c. Procedures to respond to overflows and investigate complaints;

   d. Procedures to insure that the Permittee is able to investigate any suspected connections or cross connections from the sanitary sewer systems to the MS4; and

   e. Procedures to notify public health agencies with discretionary decision authority on beach closures when there is a threat to public health.

2. Public Construction Activities Management

   a. Storm water management requirements for the design and construction of public facilities consistent with the requirements and time lines specified for private development in Part 2.III.A and III.B. ;

   b. Procedures to seek coverage, as an option, under this Order for construction activity with a disturbed area of five acres or more (Phase 1, 40 CFR 122.26) which is under taken by or on behalf of the Permittee, if the Permittee develops:

i. A process for notifying the Executive Officer of Permittee's construction activity;

ii. A checklist of construction activity BMPs using BAT/BCT criteria for public construction activity;

iii. A procedure to verify implementation of construction activity BMPs;

iv. A requirement to prepare and retain site-specific SWPPPs;

v. A procedure to report annually on the effectiveness of SWPPPs at public construction activity sites, and certify compliance with the requirements in this Order.

3. Vehicle Maintenance/Material Storage Facilities Management

a. Model pollution prevention plan for public vehicle maintenance/material storage facilities which have the potential to discharge pollutants into storm water. A public vehicle maintenance/material storage facility is any Permittee-owned or operated facility or portion thereof that:

i. Conducts industrial activity, operates equipment, handles materials, and provides services similar to Federal Phase 1 facilities;

ii. Performs fleet vehicle maintenance on ten or more vehicles per day including repair, maintenance, washing, and fueling;

iii. Performs maintenance and/or repair of heavy industrial machinery/equipment; and

iv. Stores chemicals, raw materials, or waste materials in quantities that require a hazardous materials business plan or a Spill Prevention, Control, and Counter-measures (SPCC) plan.

b. BMPs to improve site specific pollutant control including but not be limited to:

i. Good housekeeping practices;

ii. Material storage control;

iii. Vehicle leaks and spill control;

iv. Illicit discharge control;

v. Training for employees on proper outdoor loading/unloading of materials;

vi. Vehicle and equipment washing area control;

vii. Regular maintenance of treatment structures such as sumps, oil/water separators, or equivalent; and

viii. Proper waste handling disposal.

4. Landscape and Recreational Facilities Management

a. Procedures for application of pesticides, herbicides, and fertilizers that will include:

i. List of approved pesticides and selective and environmentally responsible uses;

ii. Product and application information;

iii. Application equipment use and maintenance; and

iv. Record keeping.

b. Procedures to minimize storm water pollution by pesticides and fertilizers used for landscape maintenance, including the utilization of Integrated Pest Management (IPM) techniques to the maximum extent practicable;

c. Procedures to prevent the disposal of landscape waste into the MS4;

d. Procedures to encourage retention and planting of native vegetation to reduce water, fertilizer, and pesticide needs;

e. BMPs to reduce exposure of fertilizers and pesticides to storm water during storage, to include as applicable, the following:

i. Storage indoors or under cover on paved surfaces;

ii. Secondary containment;

iii. Reduction in storage and handling of hazardous materials;

iv. Regular inspection of storage areas;

f. Guidelines to schedule irrigation and fertilization to minimize:

i. Chemical application during wet season and to terminate chemical application during storm events; and

ii. Over-watering and nutrients/pesticides entrainment.

g. Procedures to manage discharges of municipal swimming pool water into the MS4, including dechlorination practices, proper disposal of clean-out waters, and piping of filter backwash to the sanitary sewer;

h. BMPs to minimize trash, debris, and other pollutants from entering Permittee-owned recreational water bodies, to include:

i. Routine trash collection along, on, and/or in, water bodies, where feasible; and

ii. Public outreach to educate the public about impacts of illicit disposal.

5. Storm Drain Operation and Management

a. BMPs for Inlet Maintenance to be implemented to the maximum extent practicable, including but not be limited to:

i. Inspection and cleaning of catch basins between May 1 and September 30 of each year;

ii. Additional cleaning of catch basins, as necessary, between October 1 and April 30;

iii. Record keeping of catch basins cleaned; and

iv. Recording of the overall quantity of catch basin waste collected.

b. BMPs for Storm Drain Maintenance to be implemented to the maximum extent practicable, including but not be limited to:

i. Proper disposal of material removed;

ii. Removal of trash and debris from open channel storm drains at least annually between May 1 and September 30 of each year;

iii. Surveillance for debris buildup in open channels during the rainy season.

c. Waste Management program to include:

i. Procedures to identify problem areas of illicit discharge for regular inspection;

ii. Procedures to minimize to the maximum extent practicable the discharge of contaminants during MS4 cleanup to maintain optimum channel capacity; and

iii. A review of current maintenance activities to assure that appropriate storm water BMPs are being utilized.

6. Streets and Roads Maintenance

a. Program to sweep curbed streets at a targeted frequency of:

i. At least monthly; and;

ii. Where feasible, more frequently in areas generating significant refuse.

b. Streets and roads maintenance program including:

i. BMPs for existing saw-cut management and paving practices to include but not be limited to:

aa. Avoidance during wet weather to the extent feasible; and

bb. Material storage away from drainage areas to prevent storm water pollution or other equally effective BMPs.

ii. Good housekeeping practices to insure proper management of any wastes that are generated;

iii. Collection, transport, and disposal of maintenance waste at appropriate disposal facilities in accordance with applicable federal, state, and local laws and regulations;

iv. Management of concrete materials and wastes including but not limited to:

aa. Washout of concrete trucks off- or on-site in designated areas and not into storm drains, open ditches, streets, or catch basins;

bb. Material storage under cover, away from drainage areas or other equally effective BMPs; and

cc. Avoidance of excess mixing of concrete or cement on-site.

v. Employee training to:

aa. Promote a clear understanding of the potential for maintenance activities to pollute storm water; and

bb. Identify and select appropriate BMPs.

7. Parking Facilities Management

Parking Facilities Management Plan to include sweeping or other equally effective measures to remove debris from Permittee-owned parking lots with more than twenty-five parking spaces that are located in areas potentially exposed to storm water.

8. Public Industrial Activities

a. Procedures to seek coverage, as an option, under this Order for Phase I industrial facilities which are owned or operated by a Permittee, if the Permittee develops:

i. A process for notifying the Executive Officer of public industrial facilities owned or operated by the Permittee;

ii. A checklist of BMPs using BAT/BCT criteria for public industrial facilities;

iii. A procedure to verify implementation of industrial facility BMPs;

iv. A requirement to prepare and retain site specific SWPPPs; and

v. A procedure to report annually on the effectiveness of SWPPPs and the results of the facility monitoring programs at public

Phase 1 industrial facilities, and certify compliance with the requirements of this Order.

9. Emergency Procedures

Procedures for addressing emergency repairs of essential public services and infrastructure and responding to natural disasters.

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V. Public Information and Participation

To reach as many Los Angeles County residents as possible, a comprehensive educational outreach approach shall be undertaken under this Order. In recognition of the importance of public education to effective storm water management solutions, this Order calls for immediate Permittee public outreach efforts at a specified minimum level as well as a longer term effort to develop an integrated, comprehensive outreach program. As part of the immediate effort, each Permittee is expected to choose an appropriate combination of outreach tools and activities to raise public awareness of storm water issues and improve water quality in its own individual jurisdiction, with efforts at a prescribed minimum level as described below. As part of the longer term effort, each Permittee is expected to work collaboratively to develop a comprehensive outreach/education program countywide and within its watershed management area.

The objectives of the public education program are: (i) to measurably increase the knowledge of the target audiences regarding the MS4, the impacts of storm water pollution on receiving waters, and potential solutions for the target audiences to implement BMPs to reduce the problems caused; and (ii) to measurably change the behavior of target audiences by encouraging those audiences to implement appropriate solutions.

Table 6 on the following page shows the summary of requirements and corresponding compliance dates under this section.

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Table 6
Public Information and Education Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Have outreach materials available for distribution	V.A.1		✓	8 (March 31, 1997)	N/A
Demonstrate outreach materials are being distributed	V.A.2.a		✓	12 (July 30, 1997)	N/A
Demonstrate appropriate Permittee employees are being trained	V.A.2.b		✓	12 (July 30, 1997)	N/A
Develop industrial/commercial facility database format	V.B.1.a	✓		6 (January 31, 1997)	N/A
Collect information based on database format	V.B.1.b		✓	12 months from WMC designation	N/A
Compile information from Permittees into industrial/commercial site visits	V.B.1.c	✓		22 (June 1, 1998)	N/A
Develop a checklist of BMPs for industrial/commercial site visits	V.B.2	✓		10 (May 30, 1997)	Regional Board
Implement an Industrial/Commercial facility site visit program	V.B.3.a		✓	Upon Regional Board approval of BMP checklist and in accordance with Table 7	N/A
Provide list of facilities visited	V.B.3.c		✓	Quarterly	N/A
Begin use of BMP checklists	V.B.3.b		✓	Upon Regional Board approval	N/A
Develop a 5 year public education strategy	V.C.1	✓		12 (July 30, 1997)	Executive Officer
Implement the strategy	V.C.2		✓	Based upon implementation schedule to be included in the strategy	

A. Immediate Outreach

1. Each Permittee shall, at a minimum, have available for distribution or reference as appropriate, not later than March 31, 1997, the following:

a. Written Material

i. Written materials (minimum of three types) to convey pertinent information to meet program objectives. Examples of written materials include flyers, brochures, door-hangers, newspaper articles, mail-inserts, and newsletters;

ii. Documentation that a reasonable effort was made to list pertinent city phone numbers under the government pages of phone directories. This should be updated as necessary and should include telephone numbers for reporting clogged catch basin inlets and/or illicit discharges/dumping, and a general number for storm water management program information. These phone numbers may be city-specific or countywide;

iii. Training materials for educating appropriate Permittee employees regarding compliance with applicable storm water permits;

iv. An up-to-date listing of contractor and developer storm water management training programs available in the area. This list should be updated annually;

v. An up-to-date checklist and a brochure explaining contractor and developer needs as they relate to Development Planning and Construction (Part 2.III) of this Order for use at a Permittee's planning/permitting counter. They should be updated annually; and

vi. Education materials (a minimum of three types) for targeted business sector audiences for use in site visits as per provisions in Part 2.V.B.2 of this Order.

b. Audio Material

Documentation that a reasonable effort was made by the Principal Permittee or on behalf of the Permittees as a whole to obtain radio broadcast public service announcements to convey information regarding storm water management.

c. Visual Material

A catch basin labeling program, including label installation and maintenance schedules, to educate the public on the ultimate destination of storm drain flows.

2. Each Permittee shall demonstrate by July 30, 1997, that it has undertaken the following activities:

a. Distribution of outreach materials to the general public, or targeted audiences such as schools, community groups, contractors and developers at the appropriate public counters and public events; and,

b. Training of the appropriate Permittee employees (those whose jobs or activities directly affect storm water quality, or those who respond to questions from the public) regarding the requirements of the storm water management program.

B. <u>Industrial/Commercial Educational Program</u>

Each Permittee shall develop an industrial/commercial site visit program. The purpose of such site visits will be solely educational and to provide industrial/commercial facilities with information regarding the Permittee's storm water program, and to provide advice when requested in understanding and complying with the Permittee's storm water regulations. To minimize cost, each Permittee is encouraged to coordinate its site visit program with existing fire, health, industrial wastes and/or other inspection type programs so that the Permittee need not institute new and separate site visit programs. The program shall contain the following components:

1. Identification of Sources

a. The Principal Permittee in consultation with the Permittees shall develop a database format for listing industrial/commercial facilities by four digit SIC Industry Numbers not later than January 31, 1997. This database will serve as a reference resource for the public, business, industry, local government, the Regional Board, and other public agencies on storm water program participation. The initial accuracy of the database will be dependent on the accuracy of electronic and information sources used to establish the database, but the accuracy is expected to improve after Permittees begin to implement the industrial/commercial site visit program. No legal import is to be attributed to the database developed by the Permittees. The database format shall include at a minimum:

i. Facility name;
ii. Site address;
iii. Watershed Management Area;
iv. Applicable SIC code(s); and
v. NPDES storm water permit coverage status, if applicable.

b. Each Permittee shall collect information based on the format developed by the Principal Permittee to identify industrial/commercial facilities within its jurisdiction and submit to the Principal Permittee not later than one year after the Principal Permittee provides the database format to the Permittees or for "iii" below not later than one year after designation of groups by the WMC. The list of facilities shall include, at a minimum:

i. All industrial groups regulated under Phase I of the Federal storm water program (40 CFR 122.26; Phase I Facilities);

ii. Motor vehicle repair shops, motor vehicle body shops, motor vehicle parts and accessories facilities, gas stations, and restaurants; and

iii. Additional SIC industrial/commercial groups identified as priorities by each WMC pursuant to this Order.

c. The Principal Permittee shall compile the information submitted by each Permittee into a database of industrial/commercial facilities not later than June 1, 1998. This database shall include:

i. For each four-digit SIC Industry Number, primary activities that might impact runoff discharges (from national or commercial database sources); and

ii. For each four-digit SIC Industry Number, primary materials that might impact runoff discharges (from national or commercial database).

2. Source Control Measures

The Principal Permittee, in consultation with the Permittees, shall develop a list of specific storm water BMPs for each industrial/commercial SIC group of facilities requiring educational site visits under Part 2.V.B.3. not later than May 30, 1997. The BMPs shall:

a. Address multiple pollutants;

b. Initially focus on pollutant source minimization, education, good housekeeping, and site design alternatives; and

c. Target source areas and activities with the highest potential to generate substantial pollutant loads.

The BMP lists shall be submitted to the Regional Board for approval, after which the Principal Permittees shall distribute them to the Permittees to be incorporated in each Permittee's outreach measures conducted during industrial/commercial site visits.

3. Educational Site Visits

a. Each Permittee shall implement an industrial/commercial educational site visit program according to the following schedule in Table 7, upon Regional Board approval of BMP checklists:

Table 7
Schedule of Educational Site Visits

FACILITIES	SITE VISIT FREQUENCY (No. of Contacts / Time period)
i) Phase I*, [i]-[ix] and [xi] with waste discharge or pretreatment permit	1 / 24 months **
ii) Phase I, [i]-[ix] and [xi] with no waste discharge or pretreatment permit but with GIASP	1 / 24 months**
iii) Phase I, [i]- [ix] with no waste discharge or pretreatment permit, and no GIASP	1 / 24 months**
iv) Phase I [xi] with no GIASP	1 / 5 years***
v) Vehicle repair shops, vehicle body shops, vehicle parts and accessories facilities	1 / 24 months**
vi) Gas stations	1 / 24 months* *
vii) Restaurants	1 / 24 months* *
viii) Facilities selected by WMCs	1 / 36 months

* See Glossary of Terms for definition
** Once in 24 months with a minimum of two site visits during the five-year term of this Order
*** See exception in text below

i. Phase 1 facilities in categories [i] through [ix] and [xi] which have an industrial waste discharge permit or a pretreatment permit, once every twenty-four months;

ii. Phase 1 facilities in categories [i] through [ix] and [xi], which do not have an industrial waste discharge permit or a pretreatment permit but have obtained coverage under the GIASP, once every twenty-four months;

iii. Phase 1 facilities in categories [i] through [ix], which do not have an industrial waste discharge permit, a pretreatment permit or GIASP coverage, once every twenty-four months;

iv. Phase 1 facilities in category [xi] without an industrial waste discharge permit, a pretreatment permit, or GIASP coverage. In lieu of a site visit, contact by phone, mail-out of questionnaire and educational materials, or other similar method to inform the facilities of notice of intent (NOI) requirements and encourage good storm water quality control measures (non-responders to be identified in annual report), once in five years;

v. Vehicle repair shops, vehicle body shops, vehicle parts and accessories (SIC Industry Major Group 75); once every twenty-four months;

vi. Gasoline stations (SIC Industry Number 5541); once every twenty-four months;

vii. Restaurants (SIC Industry Number 5812), once every twenty-four months; and,

viii. Additional SIC industrial/commercial groups identified by the WMC for the watershed in which the Permittee is located, once in thirty-six months, with a maximum limit of 3,000 additional site visits per Permittee during the term of this Order.

b. During the educational site visit, the Permittee shall:

i. Consult with a representative of the facility to explain applicable storm water regulations;

ii. Distribute and discuss applicable BMP and educational materials, including information regarding the codes, regulations, ordinances, and permits applicable to the category of the facility. In the case of

Phase I facilities, notify the facility of specific requirements under the Statewide Industrial General Permit including that such facilities must file an Notice of Intent (NOI) with the State Water Resources Control Board and that a Storm Water Pollution Prevention Plan (SWPPP) must be available on the site; and

iii. Follow-up with facilities, as deemed necessary and appropriate by the Permittee, to provide advice in complying with the Permittee's storm water ordinances, prohibitions, and other legal instruments.

c. Each Permittee shall submit to the Principal Permittee, on a quarterly basis, the lists of visited facilities identified by category. The Principal Permittee shall compile the submitted lists and submit them to the Executive Officer on a quarterly basis.

4. Alternative Programs

A Permittee may petition the Executive Officer to substitute the industrial/commercial educational program with an alternative industrial/commercial educational program that will achieve greater or substantially similar educational goals and which will be implemented within a similar period of time.

C. Five-Year Storm Water Public Education Strategy

A Five-Year Storm Water Public Education Strategy, which elaborates steps for implementing public education programs, shall be developed by the Principal Permittee. The strategy shall: communicate key educational information; develop educational programs for target audiences; utilize various innovative educational tools and incentives for participation; employ effective outreach to the region's multi-ethnic communities; and conduct opinion surveys to assist in evaluating public awareness both before and after implementation of the public education programs.

The Permittees shall endeavor to coordinate public outreach efforts among themselves, with environmental groups, and pertinent public and private agencies.

1. The Principal Permittee, in consultation with Permittees, shall develop not later than July 30, 1997, a Five-Year Countywide Storm Water Education Strategy which addresses education/outreach issues countywide as well as by watershed, including a schedule for implementation. The strategy shall include a full range of outreach tools, from simple brochures to sophisticated media. The strategy shall identify the Permittee's responsibilities for implementation, including specific objectives for changing knowledge and behavior.

The Principal Permittee shall submit the strategy to the Executive Officer for approval. Each Permittee shall implement the strategy not later than four months after commencement of its next fiscal year following approval of the strategy by the Executive Officer, provided, however, that such approval is issued not later than 90 days prior to the commencement of the Permittee's fiscal year. If such approval is given within 90 days of the commencement of a Permittee's fiscal year, such program shall be implemented in the second fiscal year following approval but in no event shall implementation be later than July 30, 1999.

At a minimum, the Five-Year Storm Water Education Strategy shall include actions for:

a. Identification of land uses and activities that have a higher potential for storm water pollution and will include and/or accomplish the following:

   i. Pollutants: The reduction of targeted pollutants of concern in a particular watershed; and

   ii. Activity-specific: Activity-specific outreach programs shall be developed and implemented using written, audio, or visual outreach tools.

   The strategy shall include activity-specific outreach programs that inform residents about the problem of illicit discharges and dumping and shall promote, publicize, and facilitate public reporting of these activities. The program shall also include continuing operation, maintenance, and promotion of the countywide reporting hotline.

b. Emphasis on the importance of pollution prevention for a variety of audiences, including local residents, school-aged children, businesses, and public employees whose job functions and daily lives may impact storm water quality. Efforts will include and/or accomplish the following:

   i. For Residents

      aa. Educate residents on recycling and household hazardous waste disposal options. The program shall provide information on collection services, including locations and schedule; provide outreach materials on source reduction and proper use, storage, and disposal methods for household hazardous wastes; and continue to encourage residents to recycle, e.g., oil, antifreeze, glass, plastics, and batteries.

      bb. Encourage residents to participate in specific storm water outreach programs. Residents shall be informed of and provided with the opportunity to share ideas and comments about the programs. Each Permittee shall demonstrate that a good faith effort has been made to outreach to different communities within the watershed management area or region and to receive feedback from the communities while measuring success of the program.

cc. Educate do-it-yourselfers regarding pollution prevention strategies. Each Permittee shall demonstrate that a good faith effort has been made to outreach to different communities within the watershed management area or region.

dd. Promote public participation through cooperative programs to foster awareness and identification of storm water pollution issues among residents in a watershed. Catch basin labeling and other established sign programs are examples of this type of cooperative effort. Another example for cooperative outreach is an "Adopt-A-" program. Residents can "adopt" highways, storm drains, catch basins, or streams to monitor, restore, and protect them.

ee. Residents shall be encouraged to mow vegetation surrounding their residence rather than disk.

ii. For School Children

School programs shall be developed and implemented wherever possible to include information on MS4s, the difference between sanitary sewers and storm drains, the importance of preventing storm water pollution, and provide illicit discharges/disposal and reporting procedures, source minimization, and general pollution prevention. Acquisition and/or development of classroom materials and their distribution to teachers are encouraged.

iii. For Businesses

aa. An education and outreach program shall be developed and implemented for business activities identified as having greater potential of discharging pollutants into the MS4. This includes sidewalk washing by individual merchants. The program shall encourage employee training on the effectiveness of storm water pollution prevention practices. In addition to written, audio, and visual materials, other possible means of focused outreach may include: conducting workshops, mass mailings, and submitting informational articles to trade/industry magazines. Each Permittee shall provide outreach materials through business license renewal counters and/or make efforts to outreach through professional and business associations or industrial/commercial site visits.

bb. Construction

An education program shall be developed and implemented for construction contractors, owners, builders, and do-it-yourselfers on proper BMP implementation and maintenance, and pollution prevention.

iv. Appropriate Permittee Employees

Permittee employees involved in storm water related activities shall be trained on storm water management and pollution prevention practices. Cooperative efforts among enforcement agencies should be encouraged.

Training programs shall include, but not be limited to, articles in city newsletters, training classes, checklists for field personnel, and interdepartmental forums or committees to the extent the Permittee utilizes any of the foregoing. Materials developed for other audiences may also be used in Permittee employee training programs. Appropriate public agency employees shall be trained in:

aa. Emergency spill cleanup procedures and hotline phone numbers;

bb. Environmentally sensitive alternative products;

cc. Good housekeeping practices; and,

dd. Municipal NPDES and other permitting requirements.

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VI. Monitoring Program

A. Objectives

The overall goal of this monitoring program is to develop and support effective watershed storm water quality management programs towards reduction of pollutants to the maximum extent practicable.

The major specific objectives of program are as follows:

1. To track water quality status, pollutant trends and pollutant loads, and identify pollutants of concern;
2. To monitor and assess pollutant loads from specific land uses and watershed areas;
3. To identify, monitor, and assess significant water quality problems related to storm water discharges within the watershed;
4. To identify sources of pollutants in storm water runoff;
5. To identify and eliminate illicit discharges;
6. To evaluate the effectiveness of management programs, including pollutant reductions achieved by implementation of BMPs; and,
7. To assess the impacts of storm water runoff on receiving waters.

B. Monitoring Program Requirements

The Principal Permittee shall implement the monitoring program described in Attachment C, Monitoring Program Requirements. The summary of the monitoring program requirements and compliance dates are given in Table 8 on the following page.

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Table 8
Monitoring Requirements And Compliance Dates

Requirement	Permit Attachment	Principal Permittee	Permittees	Months from Order Adoption Compliance Date)
Begin re-evaluation of land use monitoring station locations	C.1.a	✓		
Complete re-evaluation of land use monitoring station locations	C.1.a	✓		Upon EO* approval- Sept 1, 1996
Monitor land use stations at prescribed storm event frequency	C.1.c	✓		0
Implement a pilot study monitoring program from one sampler at a land use station to sample storm greater than .1 inches of rainfall	C.1.d	✓		0
Monitor at mass emission stations	C.2.a	✓		0
Submit a report for characterizing critical sources and BMPs	C.3.b	✓		Sept 1, 1996
Conduct a program for characterizing critical sources and BMPs	C.3.b	✓		Upon EO* approval
Install and evaluate BMPs appropriate to the critical sources	C.3.d	✓		Second full rainy season
Re-evaluate progress made by other entities within the state to evaluate critical sources and BMPs	C.3.e	✓		Third full rainy season
Submit a workplan for Loads Assessment model	C.4	✓		18 (January 30, 1998)
Fund a receiving waters study	C.5	✓		
Prepare, retain, and revise a Monitoring Plan	VI.C.1	✓		Submit to the EO* when so requested

* Executive Officer

VII. Program Reporting and Evaluation

Table 9 shows the summary of requirements under this section with corresponding compliance dates.

Table 9
Program Evaluation and Reporting Requirements and Compliance Dates

Requirement	Permit Section	Principal Permittee	Permittees	Months from Effective Date of Order (Compliance Date)	For Approval By
Develop standard Annual Reporting format, including reporting forms	VII.A.1	✓		6	Executive Officer
Submit Annual Report to Regional Board	VII.A.2	✓		Every October 15	N/A
Submit an Annual Monitoring Report	VII.B	✓		Every July 15	N/A
Submit a Program Evaluation Report of 5-Year Strategy	VII.C.1	✓		48 (July 31, 2000)	N/A
Submit Assessment of Effectiveness of CSWMP Components	VII.C.2	✓		48 (July 31, 2000)	N/A
Submit Recommendations for Development of Performance Standards for selected CSWMP Components	VII.C.3	✓		54 (February 1, 2001)	N/A
Submit a Receiving Water Impacts Report	VII.D	✓		48 (July 31, 2000)	N/A
Submit WMAPs	Part 3.VI		✓	To be included with ROWD. (February 1, 2001)	Executive Officer

A. Annual Program Report

1. The Principal Permittee shall, not later than January 31, 1997, develop a standard annual program reporting format for use by Permittees, including reporting forms.

2. The Principal Permittee, in coordination with the Permittees, shall submit an Annual Program Report to the Executive Officer on or before October 15 of each year. The first Annual Report is due October 15, 1997. The Annual Program Report shall comply with 40 CFR §122.42(c) and include, at a minimum:

   a. The implementation status of program tasks contained in this Order, CSWMP, and/or WMAP, as applicable to each Permittee;

   b. The status of, or statement of completion of all components and milestones described in this Order, CSWMP, and/or WMAP, as applicable to each Permittee;

   c. Results of program tasks contained in this Order, CSWMP, and/or WMAP, as applicable to each Permittee;

   d. Program accomplishments and self-assessment of strategy effectiveness (including how the Permittee arrived at new program elements, if any) by each Permittee, organized by Watershed Management Areas, in the areas of (i) Program Management; (ii) Illicit Connections/Discharges; (iii) Development Planning/Construction; (iv) Public Agency Activities; (v) Public Education/Public Participation;

   e. A summary of BMP implementation, Permittee level of effort, and other such measures of achieving storm water program objectives, utilizing uniform information and data collection methodology to support area-to-area, and year-to-year comparisons;

   f. The names, titles, and telephone numbers of personnel responsible for supervising implementation of the program tasks contained in this Order, CSWMP, and/or WMAP, as applicable to each Permittee.

   g. Recommended changes and/or modifications to the programs identified in this Order, CSWMP, and/or WMAP.

B. <u>Annual Monitoring Report</u>

The Principal Permittee shall submit a separate Annual Monitoring Report by July 15 of each year. The first Annual Monitoring Report is due on July 15, 1997. The report shall include status of implementation of the monitoring program, results of the monitoring program and interpretation thereof, and suggested modifications or amendments to the Monitoring Program with relevant justifications.

C. Program Evaluation Report

1. The Principal Permittee, shall, not later than July 31, 2000, complete an analysis of the general success of the Five-Year Storm Water Public Education Strategy and identify its accomplishments. This report shall serve as the basis for the next Five-year Storm Water Public Education Strategy that will be part of the ROWD.

2. The Principal Permittee shall, not later than July 31, 2000, and in consultation with the Permittees, prepare and submit a report on the assessment of the effectiveness of the CSWMP components (except that identified in C.1.).

3. The Principal Permittee shall, not later than February 1, 2001, submit a report on the identification of CSWMP components for which performance standards will be developed and implemented during the next term of the permit. The report shall include a schedule of development of performance standards. The performance standards will indicate the level of implementation necessary to demonstrate that efforts are being made to reduce the discharge of pollutants in storm water to the maximum extent practicable. This report will be an integral part of the ROWD.

D. Integrated Receiving Water Impacts Report

The Principal Permittee shall not later than July 31, 2000, prepare and submit an Integrated Receiving Water Impacts Report. The report shall include, but not be limited to a comprehensive analysis of the results of the different monitoring data (land use, mass emissions, critical source, load assessment, receiving waters, and other pertinent studies available), and feasible environmental indicators. It should also include recommendations on future monitoring requirements, e.g., integration of storm water receiving water monitoring with regional receiving water monitoring, if applicable. This report will be an integral part of the ROWD.

Part 3. STANDARD PROVISIONS

I. The initial storm water management program, as delineated in the CSWMP or WMAPs may need to be modified, revised, or amended periodically to respond to changed conditions and to incorporate more effective approaches to pollutant controls. Minor changes may be made at the direction of the Executive Officer. Minor changes requested by the Permittees shall become effective upon written approval of the Executive Officer. If proposed changes involved a major revision in the overall scope of the program, such changes must be approved by the Regional Board as amendments to this Order.

II. Except as otherwise provided in this Order, all reports or submittals made directly to the Executive Officer or through the Principal Permittee shall be signed under penalty of perjury by the principal executive officer or the ranking elected official of the Permittee or a duly authorized representative if:

A. The authorization is made in writing by a person described above;

B. The authorization specifies either an individual or a position having responsibility for the overall operation of the Permittee's storm water management program, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the Permittee. A duly authorized representative may thus be either a named individual or any individual occupying a named position; and

C. The written authorization is submitted to the Executive Officer.

III. This Order may only be modified, revoked, or reissued, prior to the expiration date, by the Regional Board, in accordance with the procedural requirements of the Water Code and Title 23 of the California Code Regulations for the issuance of waste discharge requirements, and upon prior notice and hearing, to:

A. Address changed conditions identified in the required reports or other sources deemed significant by the Regional Board;

B. Incorporate applicable requirements or statewide water quality control plans adopted by the State Board or amendments to the Basin Plan;

C. Comply with any applicable requirements, guidelines, and/or regulations issued or approved pursuant to CWA Section 402(p); and/or

D. Consider any other federal, or state laws or regulations that became effective after adoption of this Order.

IV. The Permittees shall continue to implement the BMPs and/or programs that were required pursuant to Order No. 90-079 until such time that replacement BMPs/programs are implemented under this Order. Except for the foregoing, enforcement purposes, and applicability to the State of California Department of Transportation (Caltrans), Order No. 90-079 (NPDES Permit No. CA0061654) is hereby superseded and replaced by this Order.

V. The issuance of this Order is not intended to, and does not, absolve any Permittee of liability for conduct which may have constituted a violation of Order 90-079 (CA0061654, CI 6948) adopted by this Regional Board on June 18, 1990, nor is it intended to impose any liability on any Permittee or person for any conduct prior to the effective date of this Order.

VI. This Order expires on July 30, 2001. The Principal Permittee and Permittees must submit complete Reports of Waste Discharge (ROWD) in accordance with Title 23, California Code of Regulations, not later than 180 days in advance of such date as application for reissuance of waste discharge requirements. The ROWD shall include watershed-specific WMAPs.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on July 15, 1996.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER NO. 96-054
(NPDES NO. CAS614001)

ATTACHMENTS
TO
WASTE DISCHARGE REQUIREMENTS
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES
WITHIN THE COUNTY OF LOS ANGELES

ATTACHMENT A
LIST OF PERMITTEES
BY
WATERSHED MANAGEMENT AREAS

Santa Monica Bay

Malibu Creek and Other Rural

Agoura Hills
*Calabasas
Los Angeles County
Malibu
Westlake Village

Ballona Creek and Other Urban

Beverly Hills
Culver City
El Segundo
Hermosa Beach
Los Angeles
' os Angeles County
anhattan Beach
Palos Verdes Estates
Rancho Palos Verdes
Redondo Beach
Rolling Hills
Rolling Hills Estates
*Santa Monica
West Hollywood

Dominguez Channel/ Los Angeles Harbor Drainage

Carson
Gardena
Hawthorne
Inglewood
Lawndale
Lomita
Los Angeles
Los Angeles County
*Torrance

Los Angeles River

Alhambra
Arcadia
Bell
Bell Gardens
Burbank
Commerce
Compton
Cudahy
El Monte
Glendale
Hidden Hills
Huntington Park
La Canada Flintridge
****Long Beach***
Los Angeles
Los Angeles County
Lynwood
Maywood
Montebello
Monterey Park
Paramount
Pasadena
Rosemead
San Fernando
San Gabriel
Sierra Madre
Signal Hill
South Gate
South Pasadena
Temple City
Vernon

San Gabriel River

Artesia
Azusa
Baldwin Park
Bellflower
Bradbury
Cerritos
Claremont
Covina
Diamond Bar
Downey
Duarte
Glendora
Hawaiian Gardens
Industry
Irwindale
La Habra Heights
La Mirada
La Puente
La Verne
Lakewood
****Long Beach***
Los Angeles County
Monrovia
Norwalk
Pomona
Pico Rivera
San Dimas
San Marino
Santa Fe Springs
South El Monte
Walnut
West Covina
Whittier

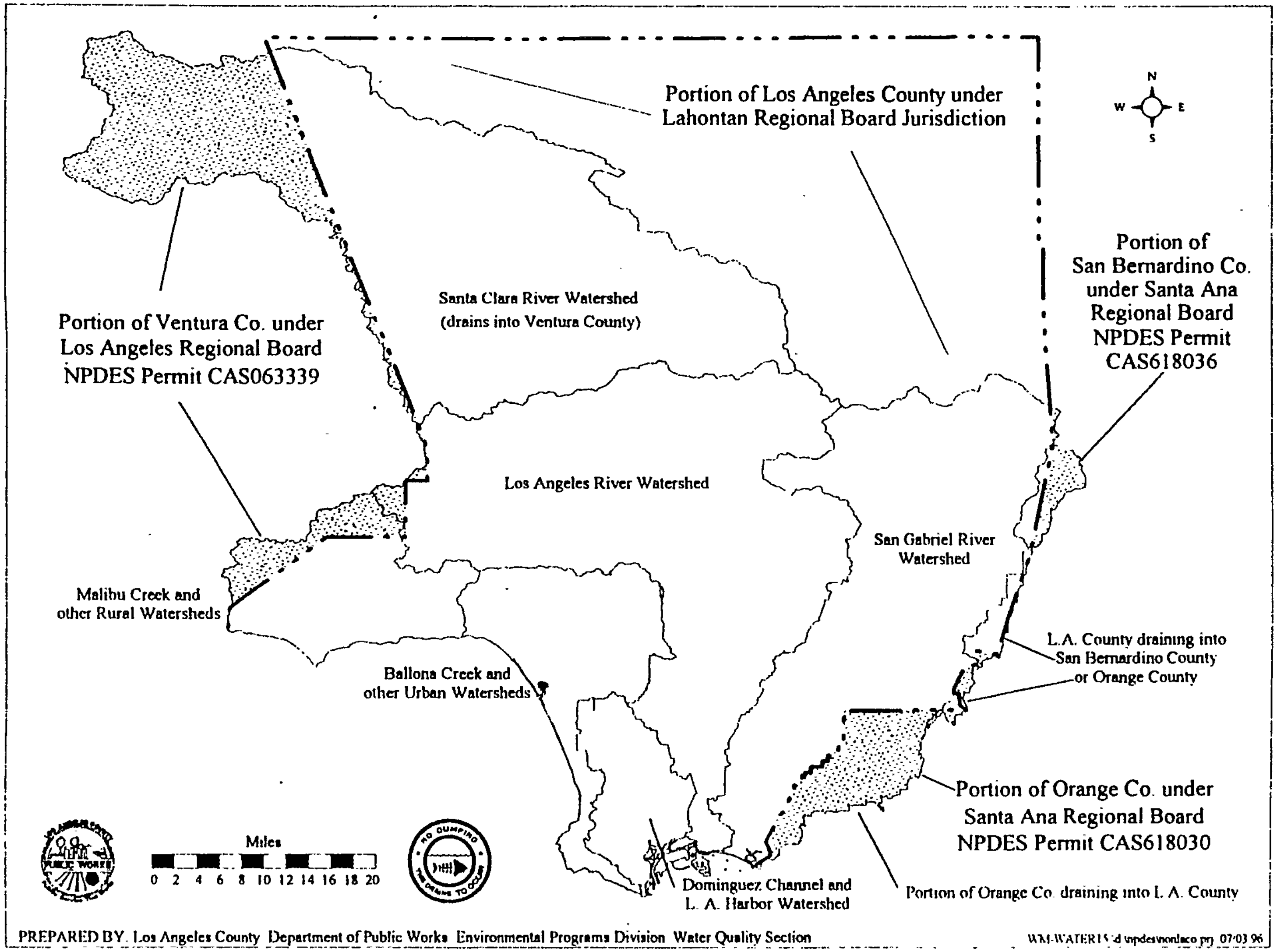
Santa Clara River

Los Angeles County
*Santa Clarita

*Italicized agencies are present in more than one Watershed Management Area. *Indicates City with the largest watershed population other than the County of Los Angeles and the City of Los Angeles.*

ATTACHMENT B

MAP OF LOS ANGELES COUNTY PERMITTED AREA



ATTACHMENT C

MONITORING PROGRAM REQUIREMENTS

A. MONITORING PLAN

The Principal Permittee shall prepare, maintain, and update, if necessary, a monitoring plan which shall include at a minimum, the following:

1. Quality control, quality assurance, data collection, storage and analyses, and detection limits;
2. All sample collection, handling, storage, and analyses in accordance with 40 CFR 136;
3. Location of monitoring stations, constituents, and sampling frequency;
4. Targeted monitoring indicators (e. g., ecosystem, biological diversity, in stream toxicity, habitat, chemical, sediment, stream health) chosen for monitoring;
5. Statistical methods used to design studies, conduct sampling, and interpret data;
6. A description of the role and responsibilities of all the participants in monitoring studies;
7. A description of computer software and modelling programs that will be utilized to assess data, interpret information; and
8. A general description of how data are intended to be utilized for feedback into the storm water management program.

An up-to-date Monitoring Plan shall be submitted to the Executive Officer, when so requested.

B. MONITORING PROGRAM

The following monitoring program is designed to meet the objectives stated under Part 2.VI of this Order:

1. Land Use Station Monitoring

   a. The Principal Permittee shall reevaluate the location of existing monitoring stations (established under Order No. 90-079) reflecting specific land uses ("land use stations") consistent with the cost-benefit methodology described in Attachment C-1. Upon completion of Step 6 of the reevaluation process, but not later than

September 1, 1996, the Principal Permittee shall submit a report to the Executive Officer outlining the steps taken in the reevaluation process, and recommend land use categories to be monitored. Based on results of the reevaluation process, existing land use stations established pursuant to Order 90-079, may be moved to monitor recommended land use categories for monitoring. Existing land use stations under Order 90-079 which do not reflect land use categories recommended for monitoring under the cost-benefit analysis or which are duplicative of other stations will be decommissioned.

b. Upon approval of the report by the Executive Officer, the Principal Permittee shall complete Steps 7-8 of the reevaluation process in Attachment C-1.

c. The Principal Permittee shall monitor land use stations according to the following schedule provided there are sufficient storm events during the season:

Storm Season	Number of Station Events/Storm Season
1996-97	100
1997-98, and thereafter	200

A station event is defined as one sampling event per station.

The land use stations shall be monitored during the term of this Order or until such time that event mean concentrations (EMC) are derived, at the 25% error rate, for the following constituents of concern:

PAHs (total)	Chlordane	Cadmium
Copper	Nickel	Lead
Chromium	Silver	Zinc
Selenium	Mercury	Total Nitrogen
Total Phosphorus	Total Suspended Solids	Diazinon
Chlorpyrifos	Malathion	Simazine
Total DDT	Total PCBs	

The Executive Officer may add or delete constituents of concern. However, for constituents added after the commencement of the second rainy season under the Order, the Principal Permittee need not derive an EMC at an error rate of 25% prior to closing a land use station.

d. All samples for land use station monitoring may be taken with the same type of automatic sampler used under Order 90-079. The samplers shall be set to monitor storms totalling 0.25 inches or greater of rainfall. The constituents to be analyzed are listed in Attachment C-3. The Principal Permittee, for land use sites, may exclude constituents from the list that require grab sampling.

In addition, the Principal Permittee shall, as a pilot study, set one land use sampler to monitor storms from 0.1 inch of rainfall. Based upon an assessment of the following, a decision will be made as to whether to set some or all of the remaining land use samplers to monitor storms totalling 0.1 inches of rainfall or greater: 1) the operational effectiveness of the sampler; 2) the feasibility and effectiveness of sample retrieval and transport; and 3) the ability to reprogram and maintain this setting at other samplers.

e. If a constituent is not detected at the method detection limit (MDL) for its respective test method listed in Attachment C-3 in more than 25 percent of the first ten sampling events or on a rolling basis using ten consecutive sampling events, it will not be further analyzed unless the observed occurrences show high concentrations and are cause for concern. The Principal Permittee will also conduct annual confirmation sampling for non-detected constituents at each station for as long as the station is monitored.

2. Mass Emission Station Monitoring

a. The Principal Permittee shall monitor a total of four mass emission stations. During the 1995-96 storm season, monitoring shall be conducted only at the Ballona Creek and Malibu Creek monitoring stations established under Order 90-079. During the 1996-97 storm season, monitoring shall begin at the San Gabriel River and Los Angeles River (downstream of Wardlow Road) stations. The Principal Permittee shall monitor at the Ballona Creek and Malibu Creek monitoring stations during the 1995-1996 storm season up to ten station events per year including dry weather sampling. Thereafter, monitoring shall be reduced at all stations to a maximum of five events per year. Mass emission station monitoring frequency will be evaluated after the 1998-1999 storm season. However, regardless of the results, monitoring shall not exceed five storm events per station for the 1999-2000 storm season.

b. Samples for mass emission station monitoring shall be taken with the same type of automatic sampler used under Order 90-079, as well as through grab sampling. The samplers shall be set to monitor storms totalling 0.25 inches or greater of rainfall. The constituents to be analyzed for samples taken at mass emission stations are listed in Attachment C-3. The Principal Permittee may elect not to sample Volatile Organic Compounds from the list of constituents for mass emission stations.

c. If a constituent is not detected at the method detection limit for its respective test method listed in Attachment C-3 in more than 25 percent of the first ten sampling events or on a rolling basis using ten consecutive sampling events, it will not be further analyzed unless the observed occurrences show high concentrations and are cause for concern.

d. With the exception of the stations noted in (2)(a) above, monitoring at other mass emission stations installed under Order 90-079 shall be discontinued and the stations decommissioned.

3. Critical Source/Best Management Practice Monitoring

The Principal Permittee shall conduct a program for monitoring critical sources to characterize sources of storm water pollutants and assess effectiveness of BMPs. The program shall be consistent with the following:

a. Selection of Critical Sources: The Principal Permittee will select critical sources for monitoring based on the methodology described in Attachment C-4 (Critical Source/BMP Monitoring). A total of five (5) critical sources will be monitored over six rainy seasons commencing with the 1996-97 rainy season, subject to the provisions of (3)(d) below.

b. Not later than September 1, 1996, the Principal Permittee shall submit a report to the Executive Officer for approval on the critical source selection process and recommend critical sources for evaluation. Upon approval of the report, the Principal Permittee shall proceed to conduct the activities set forth in (3)(c-f).

c. Characterization of Critical Sources: Commencing with the 1996-97 rainy season, the Principal Permittee shall commence the characterization of critical sources. A total of six (6) representative sites of each critical source will be characterized through analysis of runoff. Fewer representative sites may be selected due to distance considerations and/or the unavailability of sufficient source locations willing to participate in the program. A total of at least five (5) storms will be used to characterize the critical source runoff. Samples will be analyzed for those pollutants anticipated to be found in the critical source storm runoff and such analytes will be partitioned, as appropriate, to determine the soluble and suspended fractions.

d. Evaluation of BMPs: In the year after a critical source has been characterized, a BMP or BMPs appropriate to the critical source will be selected and installed at up to half of the critical source examples (the "test sites"). Flow from the remaining source representative sites (the "control sites") will continue to be analyzed. A total of ten (10) targeted storm events will be monitored to assess the effectiveness of the BMPs. If there are insufficient storm events during the year, the evaluation may be continued during the next storm season. The Principal Permittee's monitoring of critical sources and evaluation of BMPs will be concluded by the end of the sixth full rainy season after the adoption of this Order, provided that sufficient number of storms have occurred.

e. Additional Evaluation: After the third full rainy season following the adoption of the Order, the Principal Permittee will reevaluate, the progress made by other public entities in the State to evaluate critical sources and BMPs. If after the evaluation, the Principal Permittee determines that there are either additional critical sources, or BMPs associated with identified significant critical sources which have not been monitored and/or evaluated, the Principal Permittee, subject to the approval of the Executive Officer, will undertake "Additional Monitoring". The Additional Monitoring will consist of monitoring up to three (3) additional critical sources, or evaluate up to an additional three (3) BMP sets, or some combination thereof totalling three. The extent of Additional Monitoring will be dependent on the Principal Permittee's ability to complete the monitoring/evaluation described in(3)(c-d) above; if more time is needed to complete such monitoring, the extent of the Additional Monitoring shall be accordingly reduced.

4. Loads Assessment Model

The Principal Permittee shall, not later than January 15, 1998, submit to the Executive Officer for approval a workplan for performing a loads assessment analysis for each of the six WMAs to determine pollutant loads entering the ocean from receiving waters in the county. The assessment shall be conducted following the third full rainy season after adoption of this Order using the collected monitoring data from the land use and mass emission stations (including data collected from stations monitored under Order No. 90-079) and employing the USEPA simplified model.

5. Receiving Waters Study

The Principal Permittee, in conjunction with other participants that it may choose, will fund a study of receiving waters impacted by storm water described in Attachment C-5, subject to revisions as set forth below in (5)(d). The purpose of the study will be to study the impacts, if any, of storm water/non-storm water discharges on the beneficial uses of Santa Monica Bay and to assist the Permittees in developing storm water management programs. The obligation of the Principal Permittee under this Order with respect to the receiving waters study shall consist of the following:

a. Plume Study: The Principal Permittee will support a plume study to evaluate the dispersion, fate, and transport of storm water pollutants in Ballona Creek and Malibu Creek, through a contribution of up to a maximum of $145,000.

b. Benthic Study: The Principal Permittee will support a study to assess impacts of storm water on the marine benthic community near the mouths of Ballona Creek and Malibu Creek, through a contribution of up to a maximum of $205,000. If it is the consensus of project scientists that a third year of benthic study is advisable to meet the goals of the receiving waters study, the Principal Permittee will contribute up to a maximum of an additional $80,000 for the third year of study.

c. Toxicity Study: The Principal Permittee will support a study to evaluate sediment and water column toxicity in Ballona Creek and Malibu Creek through a contribution of up to a maximum of $118,500. If it is the consensus of the project scientists that a third year of toxicity studies is advisable to meet the goals of the receiving waters study, the Principal Permittee will contribute up to a maximum of $80,500 to fund a third year of study.

d. River Study: The Principal Permittee will take a total of three (two storm weather and one dry weather) water samples at each of the Los Angeles and San Gabriel River mass emission stations during the 1997-98 and 1998-99 seasons. The samples will be subjected to sea urchin fertilization bioassays to evaluate water column toxicity, with the Principal Permittee's out-of-pocket expenses for the study not to exceed $3,600.

e. Project Design: The receiving waters study shall initially contain the elements established in Attachment C-5. However, the scientists conducting the receiving waters study may alter the parameters of the second and (if necessary) the third year of the receiving waters study so as to meet the objectives of the study. Such alterations may include changing of sampling locations, use of different sampling techniques, or other pertinent redirection of resources. The Principal Permittee shall notify the Executive Officer of any revisions to the second and (if necessary) third years of the receiving waters study for review and approval.

f. Study Reports: The Principal Permittee shall require the project scientists conducting the study to prepare an annual report covering study activities of the previous year, and any interim/final assessments. Such reports shall be submitted by the Principal Permittee to the Executive Officer with the Annual Monitoring Report.

g. Principal Permittee Responsibilities: The commitments of the Principal Permittee toward performance of a receiving waters study are: providing funding, and submittal of progress and final reports.

ATTACHMENT C-1

LAND USE SITE SELECTION PROCESS OUTLINE

Step 1

The Principal Permittee will take the Southern California Association of Governments ("SCAG") categories listed below as an initial list of land use categories. The Principal Permittee will use its best efforts to obtain overlays (or similar information) for use in the land use selection process. However, these overlays or information must be usable County-wide in the SCAG database and the Principal Permittee shall not be required to look for or use overlays or information which cannot be so used. The Principal Permittee also shall not be required to create overlays. Some of these categories may not be important (very small area represented in study area, and/or known very low EMC or runoff mass). The initial number of categories will be reduced at this step.

For each remaining category, the Principal Permittee will identify eight (8) representative locations. The eight (8) locations in each category would be relatively small areas, such as a square block for residential areas, a single school or church, a few blocks of strip commercial, etc. These sites would be selected, where possible, over a wide geographical area of the study area to include a range of topographical characteristics such as distance from ocean, etc.

Step 2

In this step, the Principal Permittee should perform a site survey of ground conditions. For each of the eight (8) locations identified for each category, the Principal Permittee will collect information, to the extent such information is available, including: type of roof connections, type of drainage, age of development, housing density, type of landscaping, condition of pavement, soils, and existing storm water control practices.

These are simple field surveys that can be completed by a team of two people at the rate of about 5-6 (maximum) locations a day, depending on navigation problems, traffic delays, and the proximity of the sites. Several photographs should be made of each site and archived with the field sheets for future reference.

Step 3

In this step, currently available and usable aerial photographs taken in the past five years are used to measure the percent impervious area associated with rooftops, streets, driveways, sidewalks, parking areas, storage areas, decks and sheds, swimming pools, alleyways, and other paved areas. Photographic prints for each of the homogeneous neighborhoods examined on the ground in step 2 are needed. The actual measurements require about an hour per site.

Step 4

In this step, the Principal Permittee will compile the information collected in the previous steps and use it to determine which land use categories should be monitored. This refinement step will result in a final list of categories to be examined, based on the actual measured values.

Some of the sites selected for field measurement may actually belong in another category and would be reassigned to that category before the data were evaluated. In addition, development characteristics and areas of important elements may indicate greater variability within an initial category than between other categories in the same land use. If there is no other reason to suspect differences that would affect drainage quality or quantity, these areas could be combined to reduce the total number of individual land use categories used in subsequent evaluations.

On the basis of Step 2 and Step 3, the Principal Permittee will measure the percent of directly connected impervious area for each of the eight neighborhoods surveyed. The Principal Permittee will then compare the percent of impervious area using simple non-parametric statistics to see how differences within a single land use category compare with differences between land use categories. Based on this analysis, the Principal Permittee will aggregate or subdivide land use categories as appropriate. Subdivisions of land use categories shall correspond to those in the SCAG database.

Step 5

Next, the Principal Permittee will rank the selected land use categories according to their predominance and pollutant generation. As part of its analysis, the Principal Permittee will perform a marginal cost/benefit analysis as to which land use categories should be monitored.

For each land use category the following will be estimated based on existing data: drainage area, runoff quantity and an EMC value for each of four indicator pollutants (preliminarily, copper, pyrene, total suspended solids and diazinon). The product of runoff quantity and EMC is the estimated total annual pollutant loading associated with each land use category and indicator pollutant. These sums are then ranked, from the largest to the lowest, and an accumulated percentage contribution is then produced for each pollutant. These accumulated percentage values are plotted against the number of land use categories. The graph will be relatively steep initially and then level off as it approaches 100%. A marginal cost-benefit analysis can then be used to select the number of land uses that should be monitored, which will take into account all four of the indicator pollutants.

The list of County-wide land use categories to be evaluated in Step 5 will be reviewed for each of the six watersheds in the Permit area. If there is a land use category in an individual watershed which may be feasibly monitored and is in the top five land uses in terms of total area in the watershed and is otherwise an important contributor of constituents of concern, but which would not be monitored based on the County-wide marginal cost-benefit analysis, up to two such land uses shall be monitored after the first year of the monitoring program, subject to the station event cap.

Step 6

The Principal Permittee will take the top ranked land uses and if the total number of categories exceed ten, select ten monitoring sites for monitoring the first year. All of the remaining top-ranked land uses will need to be monitored in future years, subject to the station event cap. In selecting those sites for initial monitoring, the Principal Permittee should look for homogeneous areas that are self-contained in a drainage area. In addition, monitoring locations will need to be selected along storm drains that are able to accommodate the sampling equipment, have sampling access, no safety problems, etc.

Step 7

Next, the monitoring stations are installed. The monitoring equipment will include automatic water samplers and, if surcharging flow problems are anticipated, flow sensors measuring velocity and depth of flow. The samples collected at the automatic samplers should all be flow-weighted composites, requiring only one sample to be analyzed per event at each monitoring station. Each sampler site will need to be visited periodically to ensure that everything is ready to sample.

Step 8

The Principal Permittee will continue down the list of priority land use categories and install additional monitoring stations in subsequent years. At some point, the marginal benefit from monitoring an additional land use category will not be sufficient to justify the cost, as determined from the marginal cost-benefit analysis in step 5, and no additional sites will need to be installed. The land use sampling program will end when sufficient storms have been sampled to obtain the desired error level in the EMC values for the constituents of concern.

ATTACHMENT C-2

SCAG LAND USE CLASSIFICATIONS

1. Single Family Residential
    - High Density
    - Low Density
2. Multi-Family Residential
3. Mobile Homes and Trailer Parks
4. Mixed Residential
5. Rural Residential
6. General Office Use
7. Retail Stores and Commercial Services
8. Other Commercial
9. Public Facilities
10. Special Use Facilities
11. Educational Institutions
12. Military Installations
13. Light Industrial
14. Heavy Industrial
15. (Mineral) Extraction
16. Wholesaling and Warehousing
17. Transportation
18. Communication Facilities
19. Utility Facilities
20. Maintenance Yards
21. Mixed Transportation
22. Mixed Transportation and Utility
23. Mixed Commercial and Industrial
24. Mixed Urban
25. Under Construction
26. Golf Courses
27. Local Parks and Recreation
28. Regional Parks and Recreation
29. Cemeteries
30. Wildlife Preserves and Sanctuaries
31. Specimen Gardens and Arboreta
32. Beach Parks
33. Other Open Space and Recreation
34. Urban Vacant
35. Irrigated Cropland and Improved Pasture Land
36. Non-Irrigated Cropland and Improved Pasture Land
37. Orchards and Vineyards
38. Nurseries
39. Dairy and Intensive Livestock, and Associated Facilities
40. Poultry Operations
41. Other Agriculture
42. Horse Ranches
43. Vacant Undifferentiated
44. Abandoned Orchards and Vineyards
45. Vacant with Limited Improvements

ATTACHMENT C-3

LIST OF CONSTITUENTS IN MONITORING PROGRAM AND ASSOCIATED DETECTION LIMITS

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Conventional Pollutants		(mg/L)
Oil and Grease	413.2	1
Total Phenols	420.1	0.1
Cyanide	335.2	0.01
pH	150.1	0 - 14
Temperature		None
Dissolved Oxygen	---	Sensitivity to 5 mg/L
Bacteria		
Total Coliform	9221B	<20mpn/100ml
Fecal Coliform	9221B	<20mpn/100ml
Fecal Streptococcus	9221B	<20mpn/100ml
General		(mg/L)
Dissolved Phosphorus	300	0.05
Total Phosphorus	300	0.05
Turbidity	180.1	0.1NTU
Total Suspended Solids	160.2	2
Total Dissolved Solids	160.1	2
Volatile Suspended Solids	160.4	2
Total Organic Carbon	415.1	1
Total Petroleum Hydrocarbon	418.1	1
Biochemical Oxygen Demand	405.1	2
Chemical Oxygen Demand	410.4	20-900
Total Ammonia-Nitrogen	350.2	0.1
Total Kjeldahl Nitrogen	351.2	0.1
Nitrate-Nitrite	4110	0.1
Alkalinity	310.1	2
Specific Conductance	120.1	1umho/cm
Total Hardness	130.2	2
MBAS	425.1	<0.5
Chloride	4110	2
Fluoride	4110	0.1
Sulfate	4110	2

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Metals (Total and Soluble)		(µg/L)
Aluminum	202.1	100
Antimony	204.2	10
Arsenic	206.2	10
Barium	208.2	100
Beryllium	210.2	5
Boron	212.3	250
Cadmium	213.2	10
Calcium	215.2	200
Chromium	218.2	10
Copper	219.2	10
Hex. Chromium	7196	<10
Iron	236.2	100
Lead	239.2	10
Magnesium	242.1	200
Manganese	243.2	30
Mercury	245.1	1
Nickel	249.2	10
Potassium	258.1	100
Selenium	270.2	5
Silver	272.2	10
Sodium	273.1	50
Thallium	279.2	10
Zinc	289.2	50
Semivolatile Organic Compounds		(µg/L)
Acids	8250	
Benzoic Acid	8250	<5
Benzyl Alcohol	8250	<5
2-Chlorophenol	8250	<2
2, 4-Dichlorophenol	8250	<2
2, 6-Dichlorophenol	8250	<2
4-Dimetylphenol	8250	<2
4, 6-Dinitro-2-metylphenol	8250	<3
2,4-Dinitrophenol	8250	<3
2-Methylphenol	8250	<3
4-Methylphenol	8250	<3
2-Nitrophenol	8250	<3
4-Nitrophenol	8250	<3
4-Chloro-3-methylphenol	8250	<3
Pentachlorophenol	8250	<2
Phenol	8250	<1

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Acids (continued)	8250	(µg/L)
2,3,4,6-Tetrachlorophenol	8250	<1
2,4,5-Trichlorophenol	8250	<1
2,4,6-Trichlorophenol	8250	<1
Base/Neutral	8250	
Acenapthene	8250	<0.5
Acenapthylene	8250	<0.5
Acetophenone-	8250	<3
Aniline	8250	<3
Anthracene	8250	<0.5
4-Aminobiphenyl	8250	<3
Benzidine	8250	<3
Benzo(a)anthracene	8250	<1
4-Chloroaniline	8250	<1
1-Chloronapthalene	8250	<1
p-Dimethylaminoazobenzene	8250	<3
7,12-Dimethylbenz(a)-anthracene	8250	<1
a-,a-Dimethylphenethylamine	8250	<3
Benzo(a)pyrene	8250	<1
Benzo(b)flouranthene	8250	<1
Benzo(k)flouranthene	8250	<1
Chlordane	8250	<1
Bis(2-chloroethoxy)methane	8250	<1
Bis(2-chlorisopropyl)ether	8250	<1
Bis(2-chloroethyl)ether	8250	<1
Bis(2-ethylhexyl)phtalate	8250	<3
4-Bromophenyl phenyl ether	8250	<1
Butyl benzyl phthalate	8250	<3
2-Chloronapthalene	8250	<1
4-Chlorophenyl phenyl ether	8250	<1
Chrysene	8250	<1
Dibenz(a,j)acridine	8250	<3
Dibenz(a,h)anthracene	8250	<1
1, 3-Dichlorobenzene	8250	<0.5
1, 4-Dichlorobenzene	8250	<0.5
1, 2-Dichlorobenzene	8250	<0.5
3, 3-Dichlorobenzidine	8250	<3
Diethylphthalate	8250	<0.5
Dimethylphthalate	8250	<0.5
Di-*n*-butylphthalate	8250	<3
2,4-Dinitrotoluene	8250	<0.5
2, 6-Dinitrotoluene	8250	<0.5

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Base/Neutral (continued)	8250	(µg/L)
Diphenylamine	8250	<3
1, 2-Diphenylhydrazine	8250	<3
Di-n-octylphtalate	8250	<3
Ethyl methanesulfonate	8250	<3
Fluoranthene	8250	<1
Fluorene	8250	<1
Hexachlorobenzene	8250	<0.5
Hexachlorobutadiene	8250	<1
Hexachlorocyclopentadiene	8250	<3
Hexachloroethane	8250	<1
Indeno(1, 2, 3-cd)pyrene	8250	<1
Isophorone	8250	<0.5
3-Methylcholanthrene	8250	<3
Methyl methanesulfonate	8250	<3
Napthalene	8250	<0.5
1-Napthylamine	8250	<3
2-Napthylamine	8250	<3
2-Nitroaniline	8250	<3
3-Nitroaniline	8250	<3
4-Nitroaniline	8250	<3
Nitrobenzene	8250	<0.5
N-Nitroso-di-n-butylamine	8250	<3
N-Nitrosodimethylamine	8250	<3
N-Nitrosodiphenylamine	8250	<3
N-Nitroso-di-N-propylamine	8250	<1
N-Nitrosopiperidine	8250	<3
Pentachlorobenzene	8250	<3
Phenacitin	8250	<3
Phenanthrene	8250	<0.5
2-Picoline	8250	<3
Pronamide	8250	<5
Pyrene	8250	<0.5
5-Tetrachlorobenzene	8250	<3
1, 2, 4,-Trichlorobenzene	8250	<0.5
Pesticides	608	µg/L
Aldrin	608	0.05
alpha-BHC	608	0.05
beta-BHC	608	0.05
delta-BHC	608	0.05
gamma-BHC (Lindane)	608	0.05
Carbofuran	531.1	<5

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CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Pesticides (continued)	8250	(µg/L)
Chlordane	608	0.05
4, 4'-DDD	608	<0.1
4, 4'-DDE	608	<0.1
4, 4'-DDT	608	<0.1
Benzaton	515.1	<2
Dieldrin	608	<0.1
Endosulfan I	608	<0.1
Endosulfan II	608	<0.1
Endosulfan sulfate	608	<0.1
Endrin	608	<0.1
Endrin aldehyde	608	<0.1
Glyphosate	547	<.5
Heptachlor	608	0.05
Heptachlor epoxide	608	0.05
Methoxychlor	608	<0.5
Toxaphene	608	<1.0
2,4-D	515.1	<.02
2,4,5-TP-SILVEX	515.1	<0.2
Polychlorinated Biphenyls	608	(µg/l)
Aroclor-1016	608	<1
Aroclor-1221	608	<1
Aroclor-1232	608	<1
Aroclor-1242	608	<1
Aroclor-1248	608	<1
Aroclor-1254	608	<1
Aroclor-1260	608	<1
Herbicides		(µg/L)
*Diazinon		
*Chlorpyrifos		
*Diuron		
*Malathion		
*Prometryn	507	
*Atrazine	507	
Simazine	507	<2
*Cyanazine	507	
Molinate	507	<.01
Thiobencarb	507	<.1

* Method or Detection Limits to be determined

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Volatile Organic Compounds (VOCs)	8240A	(µg/L)
Acetonitrile	8240A	10.0
Acrolein	8240A	10.0
Acrylonitrile	8240A	0.5
Benzene	8240A	0.5
Bromoform	8240A	0.5
2-Butanone	8240A	10.0
Carbon Disulfide	8240A	10.0
Carbon Tetrachloride	8240A	0.5
Chlorobenzene	8240A	0.5
Chlorodibronmethane	8240A	0.5
Chloroethane	8240A	0.5
2-Chloroethyl vinyl ether	8240A	1.0
Chloroform	8240A	0.5
Dibromomethane	8240A	0.5
1,2-Dibromo-3Chloropropane	8240A	<.01
1, 4-Dichloro-2-butene	8240A	10.0
Dichlorobromomethane	8240A	0.5
Dichlorodifluoromethane	8240A	0.5
1, 1-Dichloroethane	8240A	0.5
1, 2-Dichloroethane	8240A	0.5
1, 1-Dichloroethene	8240A	0.5
trans-1, 2-Dichloroethene	8240A	0.5
1, 2-Dichloropropane	8240A	0.5
cis-1, 3-Dichloropropene	840A	0.5
trans-1, 3-Dichloropropene	8240A	0.5
Ethanol	8240A	10.0
Ethylbenzene	8240A	1.0
Ethylene Dibromide	8240A	<.01
Ethylene Oxide	8240A	10.0
Ethyl Metcrylate	8240A	0.5
2-Hexanone	8240A	5.0
Iodomethane	8240A	0.5
Methyl Bromide	8240A	5.0
Methyl Chloride	8240A	5.0
Methylene Chloride	8240A	1.0
4-Methyl-2-pentanone	8240A	5.0
Styrene	8240A	0.5
1, 1, 2,2-Tetrachloroethane	8240A	0.5
Tetrachloroethane	8240	0.5
Toluene	8240A	1.0
Trichlorofluoromethane	8240A	1.0
1, 2,3-Trichloropropane	8240A	0.5
Trichloroethene	8240A	0.5

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CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
VOCs (continued)	8240A	(µg/L)
1, 1, 1-Trichloroethane	8240A	1.0
1, 1,2-Trichloroethane	8240A	1.0
1,1,2-Trichloro- 1,2,2 trifluoroethane	8240A	<.5
Vinyl acetate	8240A	5.0
Vinyl chloride	8240A	0.5
Xylene (Total)	8240A	0.5

ATTACHMENT C-4

CRITICAL SOURCE/ BMP MONITORING

Selection of Initial Critical Sources to be Studied: The selection of initial critical sources will be made using the following steps:

Step 1: The Principal Permittee first will develop an initial list of candidate critical sources, including industrial and commercial sources that are regulated under the state's General Permit and those which are not.

Step 2: The Principal Permittee next will develop a list of criteria for prioritizing the candidate critical sources developed pursuant to Step 1, including the following: number and/or total area associated with each critical source; runoff pollutants associated with each source; the impact of non stormwater discharges associated with each source; whether or not the source is regulated under the General Permit; and, ease of implementation of monitoring and BMPs.

Step 3: The Principal Permittee next will prioritize the candidate critical sources based on the selection criteria develop under Step 2.

Step 4: The Principal Permittee next will conduct a literature review and contact other state municipal stormwater programs to identify what critical sources have been (or are planned in the next five years) to be studied elsewhere. Where studies have been conducted or are planned to be conducted elsewhere, such studies will be reviewed to assess whether the hydrologic conditions in the study area are representative of those in Los Angeles County, the quality of the study, and any conclusions from studies already conducted. This evaluation will be coordinated with the State Stormwater Quality Task Force.

Step 5: The Principal Permittee next will take the list developed in Step 3 and refine and finalize it based upon the review conducted pursuant to Step 4.

Selection of Additional Critical Sources/BMPs: The selection of additional critical sources or BMPs for monitoring following the third rainy season from the adoption of this Order will follow the steps noted above, except that BMPs be evaluated in addition to critical sources.

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ATTACHMENT C-5

RECEIVING WATERS STUDY

A receiving waters study will be a joint effort among the University of Southern California, the University of California at Santa Barbara and the Southern California Coastal Water Research Project ("SCCWRP"). In addition, the study will be done in cooperation with an ongoing toxicity study by investigators at UCLA. Co-funding, either direct or in terms of vessel support, will be provided by the federal government through the Sea Grant program, and by the City of Los Angeles through SCCWRP. It must be noted that while the Principal Permittee is committed to funding a receiving waters study, the scope of that study will be affected by the availability of non-Principal Permittee funding sources, as discussed below. The Principal Permittee's commitment is limited to the provision of funds.

A. Outline of Study: The receiving waters study includes a plume study to determine the dispersion of stormwater runoff and associated sediment, a study of the benthic environment near two principal storm drains, Malibu and Ballona Creeks, and an assessment of the toxicity of storm drain waters and affected sediments near Malibu and Ballona Creeks. The plume study will be carried out by the USC Sea Grant program. The benthic and toxicity studies will be carried out by SCCWRP. All of these studies will be carried out over two storm seasons, with the third year used for analysis of the data obtained in the previous years. If it is the consensus of the project scientists that a third year of research is appropriate for the benthic and toxicity studies, such study shall be carried out. Each element of these studies is outlined below.

1. Plume Study: The plume study will be conducted over two storm seasons to, at a minimum, accomplish the following:

- Map the spatial and temporal structure of the runoff plumes from Ballona and Malibu Creeks as they flow into Santa Monica Bay following strong winter storms.
- Examine the interaction between the runoff plume and ocean processes as they affect the advection, dispersion, and mixing of the plume.
- Evaluate the impact of storm runoff plumes on beneficial uses of the coastal ocean.
- Characterize the optical properties of the suspended particulate material ("SPM") and dissolved organic material ("DOM") associated with runoff sources.
- Examine the effects of DOM and SPM on the water column optics and the distribution of nutrient concentrations, as the same may affect phytoplankton productivity.
- Assist in establishing appropriate locations for benthic study stations.

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2. Benthic Study: The benthic study will measure the following parameters:

- Water quality (dissolved oxygen, salinity, density, temperature, light transmissivity and pH).
- Sediment grain size, sediment organic concentrations and sediment contaminant concentrations.
- The structure of the benthic invertebrate community.

The benthic study will employ the same methods used in studies of dry weather impacts in river discharge areas carried out by SCCWRP in 1994 and 1995 in the entire Southern California Bight.

3. Toxicity Study: The toxicity study will involve the following proposed annual elements:
Water Column Toxicity

- 30 sea urchin fertilization bioassays taken during two storm and one dry weather event off each of Ballona and Malibu Creeks (including reference sites).
- 3 Phase I TIE tests on up to 3 samples showing toxicity in the sea urchin fertilization bioassays

Sediment Toxicity

- Amphipod survival bioassays of sediment samples from 10 stations (including reference sites) will be taken 2 times (1 storm and 1 dry weather period) in Year 1.
- Amphipod survival bioassays of sediment samples from 10 stations (including reference sites) will be taken 2 times (1 storm and 1 dry weather period) in Year 2.
- Sea urchin growth bioassays will be conducted for chronic toxicity in sediment samples from 6 stations, plus 1 reference site, with the locations to be determined by project scientists based on existing data and best scientific judgment. Biological effects only (survival, growth, sediment avoidance) will be measured for all sites in Year 2.
- Chemical analysis of sea urchin growth test tissue samples (gonad) will be conducted for organics and metals. Duplicate samples from 4 stations (including one reference) will be analyzed in Year 2.
- Phase I TIE tests using sea urchin fertilization of interstitial water from up to 4 stations identified to be toxic in amphipod survival bioassays (4 samples total) will be conducted in Year 2.
- Additional interstitial water testing intended to coordinate with the UCLA study

noted below may also be carried out.

B. Project Flexibility: The exact parameters of Year 2 (and Year 3, if necessary) testing will be determined through a review by the project scientists of the results of Year 1 and Year 2 testing. Thus, the steps outlined above may be modified following the reviews.

C. Coordination with UCLA Toxicity Study: UCLA researchers are involved in an ongoing Santa Monica Bay Restoration Project study of the toxicity of stormwater runoff in Ballona and Malibu Creeks. The receiving waters study shall be coordinated, to the extent possible, with the UCLA study to maximize the utility of information obtained by both studies.

D. Los Angeles and San Gabriel River Study: In addition, the Principal Permittee will take a total of three (two storm weather and one dry weather) water samples taken at each of the Los Angeles and San Gabriel River mass emission stations during each of the first two years that those stations are monitored. The samples will be analyzed using the sea urchin fertilization bioassay, with the bioassay costs not to exceed $3,600.

ATTACHMENT D

GLOSSARY OF TERMS

40 CFR: Title 40 of the Code of Federal Regulations, which is the codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.

Adverse Impact: A detrimental effect upon water quality or beneficial uses caused by a discharge or loading of a pollutant or pollutants. See also "Impact".

Authorized Discharge: Any discharge that is authorized pursuant to an NPDES permit or meets the conditions set forth in this Order.

Basin Plan: Refers to the Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties, adopted by the Regional Board on June 13, 1994 and subsequent amendments.

Beneficial Uses: Existing or potential uses of receiving waters in the permit area as designated by the Regional Board in the Basin Plan.

BAT/BCT Criteria: Treatment-based standards for reducing the discharge of pollutants, as defined in 40 CFR subchapter N, for specific categories of industrial facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards. Effluent limitations have been defined in 40 CFR for the reduction of toxic pollutants using Best Available Technology Economically Achievable (BAT) and for the reduction of conventional pollutants using Best Conventional Pollutant Control Technology (BCT).

BMP: See Best Management Practice

Best Management Practice (BMP): Activities, practices, facilities, and/or procedures that when implemented to their maximum efficiency will prevent or reduce pollutants in discharges. Examples of BMPs may include public education and outreach, proper planning of development projects, proper clean out of catch basin inlets, and proper sludge or waste handling and disposal, among others.

Bioaccumulate: The build up of a substance in the tissues of an organism to a higher concentration than in the surrounding environment, generally as a result of the organism's ingestion and internal storage of the substance over time.

Biostimulatory: An agent, action, or condition that arouses, elicits or accelerates physiological or organic activity. For example, the introduction of excessive nutrients to an aquatic system has a biostimulatory effect which manifests itself as excessive growth of algae in the aquatic systems. As the algae decomposes, dissolved oxygen in the water column is depleted, potentially leading to excessively low dissolved oxygen levels which can lead to suffocation of aquatic life, i.e., fish kills.

CFR: See Code of Federal Regulations.

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CRWQCB: The California Regional Water Quality Control Board, Los Angeles Region. See also Regional Board.

CSWMP: See Countywide Storm Water Management Plan

California Storm Water Best Management Practice Handbooks: The technical manuals prepared under direction of the Storm Water Quality Task Force, representing California members of the American Public Works Association (APWA). Comprising three volumes—Municipal, Industrial, and Construction—they provide guidance for selecting BMPs to reduce pollutants in storm water discharges. These manuals are currently available from Blue Print Service, 1700 Jefferson Street, Oakland, CA 94612, (510) 444-6771 or Fax (510) 444-1262.

Clean Water Act (CWA): The Federal Water Pollution Control Act enacted in 1972 by Public Law 92-500 and amended by the Water Quality Act of 1987. The Clean Water Act prohibits the discharge of pollutants to Waters of the United States unless said discharge is in accordance with an NPDES permit. The 1987 amendments include guidelines for regulating municipal, industrial, and construction storm water discharges under the NPDES program.

Code of Federal Regulations: A codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government.

Construction Activity: Clearing, grading, or excavation that results in soil disturbance. Construction activity does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of the facility, nor does it include emergency construction activities required to immediately protect public health and safety.

Control: To minimize, reduce or eliminate by technological, legal, contractual or other means, the discharge of pollutants from an activity or activities.

Countywide Storm Water Management Plan (CSWMP): A single comprehensive plan for implementation of the requirements of this Order that are applicable to all Permittees and all Watershed Management Areas. The CSWMP is a storm water management implementation plan for the entire drainage area within the jurisdiction of the Permittees under this Order. The Countywide Storm Water Management Plan will be developed as a single document by the Principal Permittee, with assistance and participation from the Permittees, according to the schedule prescribed in the permit. The CSWMP shall be used as a tool to develop a watershed specific Watershed Management Area Plan (WMAP).

Dechlorinated Swimming Pool Discharges: Means swimming pool discharges which have no measurable chlorine and do not contain any detergents, wastes, or additional chemicals not typically found in swimming pool water. The term swimming pool discharges does not include swimming pool filter backwash.

Discharge: Any release, spill, leak, pump, flow, escape, dumping, or disposal of any liquid, semi-solid or solid substance.

Disposal: Affirmative act in the placement of wastes or other materials to be thrown out or thrown away.

Disturbed Area: Means that area altered as a result of clearing, grading, and/or excavation of earth.

Do-it-yourselfers: Means any person or persons who repair or maintain their own vehicle(s) and/or home(s).

Effectively Prohibit: Means prohibit through legal authority or control through requirements, conditions, or other limitation. Control may include best management practices.

Effectiveness: A direct or indirect measure or indicator of how well a program, plan, or best management practice achieves its intended purpose. Measures or indicators of effectiveness include, but are not limited to, detailed accounting of program accomplishments, funds expended, staff hours utilized, field surveys, amount of pollutants reduced, biosurveys, and quantitative data from water quality and sediment sampling.

Erosion: The wearing away of land surface primarily by wind or water. Erosion occurs naturally as a result of weather or runoff but can be intensified by clearing, grading, or excavation of the land surface.

Executive Advisory Committee (EAC): A committee composed of representatives of the County of Los Angeles, the City of Los Angeles, and the six Watershed Management Areas.

Executive Officer: The Executive Officer of the California Regional Water Quality Control Board, Los Angeles Region, or an authorized representative.

Food Distribution Industry: Establishments primarily engaged in the warehousing and storage of perishable goods under refrigeration described by SIC 4222, and establishments primarily engaged in retail selling of food for home preparation and consumption described by SIC Major Group 54.

Food Service Industry: Establishments primarily engaged in the retail sale of prepared food and drinks for on-premise consumption or immediate consumption described by SIC 5812

GCASP: See General Construction Activity Storm Water Discharge Permit.

GIASP: See General Industrial Activity Storm Water Discharge Permit.

General Construction Activity Storm Water Discharge Permit (GCASP). The NPDES permit adopted by the State Water Resources Control Board which authorizes the discharge of storm water under certain conditions.

General Industrial Activity Storm Water Discharge Permit (GIASP). The NPDES permit adopted by the State Water Resources Control Board which authorizes the discharge of storm water under certain conditions.

Good Housekeeping Practice: A common practice related to the storage, use, or cleanup of materials, performed in a manner that minimizes the discharge of pollutants. Examples include purchasing only the quantity of materials to be used at a given time, use of alternative and less harmful products, cleaning up spills and leaks, and storing materials in a manner that will contain any leaks or spills.

Hazardous Material: Any material defined as hazardous by Chapter 6.95 of the California Health and Safety Code.

Hazardous Substance: Any substance designated pursuant to 40 CFR 302. This also includes unlisted hazardous substances which is a solid waste, as defined in 40 CFR 261.2, which is not excluded from regulation as a hazardous waste under 40 CFR 261.4(b), is a hazardous substance under section 101(14) of the CWA if it exhibits any of the characteristics identified in 40 CFR 261.20 through 261.24. Examples of hazardous substances include any substance or chemical product for which one or more of the following applies:

- A material safety data sheet (MSDS) is required
- The substance is listed as radioactive by the Nuclear Regulatory Commission
- The substance is listed as hazardous by the U.S. Department of Transportation
- The material is listed in Labor Code §6382(b).

Hazardous Waste: Means a 'Hazardous Substance' or 'Hazardous Material' which is to be discharged, discarded, recycled, or processed.

IPM: See Integrated Pest Management.

Illicit Connection: Any human-made conveyance that is connected to the storm drain system without a permit, excluding roof-drains and other similar type connections. Examples include channels, pipelines, conduits, inlets, or outlets that are connected directly to the storm drain system.

Illicit Discharge: Any discharge to the storm drain system that is prohibited under local, state or federal statutes, ordinances, codes or regulations. This includes all non-storm water discharges except discharges pursuant to an NPDES permit and discharges that are exempted or conditionally exempted in accordance with Section II of this Order.

Illicit Disposal: Any disposal, either intentionally or unintentionally, of material(s) or waste(s) that can pollute storm water or urban runoff.

Impact: Any actual or potential effect caused either directly or indirectly by the discharge of pollutants.

Impervious Surface: Surface that prevents or significantly reduces the entry of water into the underlying soil, resulting in runoff from the surface in greater quantities and/or at an increased rate when compared to natural conditions prior to development. Examples of places that commonly exhibit impervious surfaces include parking lots, driveways, roadways, storage areas, and rooftops. The imperviousness of these areas commonly results from paving, compacted gravel, compacted earth, and oiled earth.

In Consultation With: Means that the Principal Permittee and Permittees work cooperatively towards the development of programs.

Industrial Activity: The term "industrial activity" is defined in 40 CFR 122.26(b)(14) and refers to 11 categories of activities required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharges associated with "industrial activity" as required by 40 CFR 122.26(c). See Phase I Facilities.

Industrial/Commercial Facility: Any facility involved and/or used in either the production, manufacture, storage, transportation, distribution, exchange or sale of goods and/or commodities, and any facility involved and/or used in providing professional and non-professional services. This category of facility includes, but is not limited to, any facility defined by the Standard Industrial Classifications (SIC). Facility ownership (federal, state, municipal, private) and profit motive of the facility are not factors in this definition.

Integrated Pest Management (IPM): Pest management practice that considers the whole ecosystem when determining potential pest control strategies. IPM emphasizes use of a hierarchy of controls, with a preference for mechanical controls (e.g., mowing) and biological controls (e.g., beneficial insects, pheromones) before chemical controls (e.g., pesticides).

Jurisdiction: Means the geographic area within the Permittee's boundaries that are required under this Order to be under the Permittee's regulatory control. The term is not intended to include facilities which the Permittee is preempted or otherwise precluded from regulating, such as federal and state facilities, school districts, and similar governmental (non-municipally owned or operated) entities.

Legal Authority: The ability of a Permittee to impose and enforce statutes, ordinances, and regulations to require control of pollutant sources and regulate the discharge of pollutants to the storm drain system, and to enter into interagency agreements, contracts, and memorandums of understanding. These powers are granted to the Permittees by the Constitution of the State of California and the General Laws of the State (for General Law Cities/Counties) or individual constitutions (for Charter Cities/Counties). These powers are promulgated by the Permittee through their municipal codes, ordinances, and statutes duly adopted by their governing body.

MS4: See Municipal Separate Storm Sewer System

Maximum Extent Practicable (MEP): The standard for implementation of storm water management programs to reduce pollutants in storm water. MEP refers to storm water management programs taken as a whole. It is the maximum extent possible taking into account equitable consideration and competing facts, including, but not limited to: the gravity of the problem, public health risk, societal concern, environmental benefits, pollutant removal effectiveness, regulatory compliance, public acceptance, implementability, cost and technical feasibility. Section 402(p)(3)(B)(iii) of the Clean Water Act requires that municipal permits "...shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

Municipal Separate Storm Sewer System (MS4): See Storm Drain System.

NPDES: See National Pollutant Discharge Elimination System

National Pollutant Discharge Elimination System: A permit issued by the USEPA, SWRCB, or CRWQCB pursuant to the Clean Water Act that authorizes discharges to waters of the United States and requires the reduction of pollutants in the discharge.

Non-Storm Water Discharge: Any discharge to a municipal storm drain system that is not composed entirely of storm water.

Notice of Intent to Meet and Confer (NIMC): A letter sent to a Permittee or Permittees by the Regional Board Executive Officer as an invitation to discuss the implementation of requirements under this Order and is made when it is suspected that a Permittee or Permittees has/have an insufficient program based upon performance and submittals made under this Order. The NIMC is a part of the Administrative Review section of this Order and provides an opportunity for the Permittee(s) to meet with Regional Board staff to

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clarify any potential misunderstandings prior to, or in lieu of the Regional Board taking enforcement action for "non-compliance".

Nuisance: Anything which meets all of the following requirements: (1) is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property; (2) affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal; (3) occurs during, or as a result of, the treatment or disposal of wastes.

Permittee(s): Any agency named in the NPDES storm water permit as being responsible for permit conditions within its jurisdiction. Permittees to the NPDES storm water permit presently include the County of Los Angeles and the cities of Agoura Hills, Alhambra, Arcadia, Artesia, Azusa, Baldwin Park, Bell, Bellflower, Bell Gardens, Beverly Hills, Bradbury, Burbank, Calabasas, Carson, Cerritos, Claremont, Commerce, Compton, Covina, Cudahy, Culver City, Diamond Bar, Downey, Duarte, El Monte, El Segundo, Gardena, Glendale, Glendora, Hawaiian Gardens, Hawthorne, Hermosa Beach, Hidden Hills, Huntington Park, Industry, Inglewood, Irwindale, La Canada Flintridge, La Habra Heights, Lakewood, La Mirada, La Puente, La Verne, Lawndale, Lomita, Long Beach, Los Angeles, Lynwood, Malibu, Manhattan Beach, Maywood, Monrovia, Montebello, Monterey Park, Norwalk, Palos Verdes Estates, Paramount, Pasadena, Pico Rivera, Pomona, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, Rosemead, San Dimas, San Fernando, San Gabriel, San Marino, Santa Clarita, Santa Fe Springs, Santa Monica, Sierra Madre, Signal Hill, South El Monte, South Gate, South Pasadena, Temple City, Torrance, Vernon, Walnut, West Covina, West Hollywood, Westlake Village, and Whittier.

Pervious: Natural or man-made surfaces that allow the entry of water into the underlying soil, resulting in less runoff from the surface when compared to impervious surfaces. Examples of pervious surfaces include vegetated areas, most undeveloped areas, uncompacted earth surfaces, and lattice type modular pavements.

Phase I Facilities: This term refers to categories of facilities which are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharges associated with "industrial activity" as required by 40 CFR 122.26(c). The term "industrial activity" is defined in 40 CFR 122.26(b)(14) and in general refers to 11 categories of activities. These categories include:

i. FACILITIES SUBJECT TO STORM WATER EFFLUENT LIMITATIONS GUIDELINES, NEW SOURCE PERFORMANCE STANDARDS, OR TOXIC POLLUTANT EFFLUENT STANDARDS (40 CFR SUBCHAPTER N). Currently, categories of facilities subject to storm water effluent limitations guideline are Cement Manufacturing (40 CFR Part 411), Feedlots (40 CFR Part 412), Fertilizer Manufacturing (40 CFR Part 418), Petroleum Refining (40 CFR Part 419), Phosphate Manufacturing (40 CFR Part 422), Steam Electric (40 CFR Part 423), Coal Mining (40 CFR Part 434), Mineral Mining and Processing (40 CFR Part 436), One Mining and Dressing (40 CFR Part 440), and Asphalt Emulsion (40 CFR Part 442). The fact sheet *accompanying this general permit contains additional information pertaining to facilities subject to new source performance* standards or toxic pollutant effluent standards.

ii. MANUFACTURING FACILITIES: Standard Industrial Classifications (SICs) 24 (except 2411 and 2434), 26 (except 265 and 267), 28 (except 283 and 285) 29, 311, 32 (except 323), 33, 3441, and 373.

iii. OIL AND GAS/MINING FACILITIES: SICs 10 through 14 including active or inactive mining operations (except for areas of coal mining operations meeting the definition of a reclamation area under 40 CFR 434.11(1) because of performance bond issued to the facility by the appropriate Surface Mining Control and Reclamation Act (SMCRA) authority has been released, or except for area of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge stormwater contaminated by contact with or that has come into coatct with any overburden, raw material, intermediate products, finished products, by products, or waste products located onthe site of such operations. Inactive mining operations are mined sites that are not being actively mined, but which have an identifiable owner/operator. Inactive mining sites do not include sites where mining claims are being maintained priord disturbances associated with the extraction, beneficiation, or processing of mined material, or sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim.

iv. HAZARDOUS WASTE TREATMENT, STORAGE, OR DISPOSAL FACILITIES: Includes those operating under interim status or a general permit under Subtitle C of the Federal Resource Conservation and Recovery Act (RCRA).

v. LANDFILLS, LAND APPLICATION SITES, AND OPEN DUMPS: Sites that receive or have received industrial waste from any of the facilities covered by this general permit, sites subject to regulation under Subtitle D of RCRA, and sites that have accepted waste from construction activities (construction activities include any clearing, grading, or excavation that results in disturbance of five acres or more).

vi. RECYCLING FACILITIES: SICs 5015 and 5093. These codes include metal scrap yards, battery reclaimers, salvage yards, motor vehicle dismantlers and wreckers, and recycling facilities that are engaged in assembling, breaking up, sorting, and wholesale distribution of scrap and waste material such as bottles, wastepaper, textile wastes, oil waste, etc.

vii. STEAM ELECTRIC POWER GENERATING FACILITIES: Includes any facility that generates steam for electric power through the combustion of coal, oil, wood, etc.

viii. TRANSPORTATION FACILITIES: SICs 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication) or other operations identified herein that are associated with industrial activity.

ix. SEWAGE OR WASTEWATER TREATMENT WORKS: Facilities used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of one million gallons per day or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, oareas that are in compliance with Section 405 of the CWA.

xi. MANUFACTURING FACILITIES WHERE MATERIALS AREEXPOSED TO STORM WATER: SICs 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 3441), 35, 36, 37 (except 373), 38, 39, and 4221-4225.

Note: Category x, Construction activity, is covered by a separate general permit.

Pollutant: Those "pollutants" defined in Section 502(6) of the federal Clean Water Act (33 U.S.C.§1362(6)), or incorporated into California Water Code §13373. Examples of pollutants include, but are not limited to the following:

- Commercial and industrial waste (such as fuels, solvents, detergents, plastic pellets, hazardous substances, fertilizers, pesticides, slag, ash, and sludge);

- Metals such as cadmium, lead, zinc, copper, silver, nickel, chromium, and non-metals such as phosphorus and arsenic;

- Petroleum hydrocarbons (such as fuels, lubricants, surfactants, waste oils, solvents, coolants, and grease);

- Excessive eroded soils, sediment, and particulate materials in amounts which may adversely affect the beneficial use of the receiving waters, flora or fauna of the State;

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▪Animal wastes (such as discharge from confinement facilities, kennels, pens, recreational facilities, stables, and show facilities);

▪Substances having characteristics such as pH less than 6 or greater than 9, or unusual coloration or turbidity, or excessive levels of fecal coliform, or fecal streptococcus, or enterococcus;

The term "Pollutant" shall not include uncontaminated storm water, potable water or reclaimed water generated by a lawfully permitted water treatment facility.

The term "Pollutant" also shall not include any substance identified in this definition, if through compliance with the best management practices available, the discharge of such substance has been eliminated to the maximum extent practicable. In an enforcement action, the burden shall be on the person who is the subject of such action to establish the elimination of the discharge to the maximum extent practicable through compliance with the best management practices available.

Pollutant Loading: The quantity of a pollutant found in storm water and/or non-storm water expressed in mass per unit of time. Pollutant loadings are commonly expressed in units of tons/year or pounds/year.

Pollutants of Concern: Pollutants that exhibit one or more of the following characteristics:

▪Current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water,

▪Elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or

▪The detectable inputs of the pollutant are at a level high enough to be considered potentially toxic to humans and/or flora and fauna.

Pollutants of concern may be different for each receiving water.

For example, Pollutants of concern for the Santa Monica Bay Watershed Management Area include, DDT, PCBs, PAHs, Chlordane, TBT, cadmium, chromium, copper, lead, nickel, silver, zinc, pathogens, TSS (sediment), nutrients, trash and debris, chlorine, oxygen demanding substances, and oil and grease.

Pollution Prevention: Includes any planning, schedules of activities, prohibitions of practices, implementation maintenance procedures, and other management practices, to prevent or reduce pollutants in storm water / urban runoff discharges.

Potable Water Sources: Means flows from drinking water storage, supply and distribution systems including flows from system failures, pressure releases, system maintenance, well development, pump testing, fire hydrant flow testing; and flushing and dewatering of pipes, reservoirs, vaults, and wells.

Principal Permittee: The agency named in the NPDES storm water permit to serve as permit coordinator, responsible for general administration of the permit, and coordinating cooperation by other Permittees, including but not limited to the implementation of local self-monitoring programs and BMPs, and preparation and submittal of reports required by the permit. The Principal Permittee under this Order is the County of Los Angeles.

Proper Disposal: The act of disposing of material(s) in a lawful manner and which ensures the protection of water quality and beneficial uses of receiving waters.

Public Agency Vehicle Maintenance/Material Storage Facility: Any Permittee-owned and/or operated facility that is: used for vehicle or equipment maintenance, repair, washing, or fueling; and/or is required to prepare a hazardous materials business plan.

Regional Board: The Governing Board of the California Regional Water Quality Control Board State agency with primary responsibility for the coordination and control of water quality. This means the California Regional Water Quality Control Board, Los Angeles Region. The Los Angeles Region, is comprised of all basins draining into the Pacific Ocean between the southeasterly boundary, located in the westerly part of Ventura County, of the watershed of Rincon Creek and a line which coincides with the southeasterly boundary of Los Angeles County from the ocean to San Antonio Peak and follows thence the divide between San Gabriel River and Lytle Creek drainage to the divide between Sheep Creek and San Gabriel River drainage.

Reportable Quantity: Means that quantity of a hazardous substance, as set forth in 40 CFR 302, which requires notification pursuant to 40 CFR 302 in event of that quantity release.

Receiving Waters: All surface water bodies within the permit area that are identified in the Basin Plan.

Runoff: Means any runoff including storm water and dry-weather flows from a drainage area that reaches a receiving water body or sub-surface. During dry weather it is typically comprised of many base flow components either contaminated with pollutants or uncontaminated.

SIC: See Standard Industrial Classification.

SPCA: See Storm Water Program Compliance Amendment

SWRCB: State Water Resources Control Board

Secondary Containment: Structures, usually dikes or berms, surrounding tanks or other storage containers to catch spilled or leaked materials to prevent their discharge to the MS4.

Sediment: Organic or inorganic material that is carried by or suspended in water and settles to form deposits in the storm drain system or receiving waters.

Source Minimization: Planning or operational practices that reduce the amount of materials stored at a site.

Standard Industrial Classification (SIC): The statistical classification standard, organized by industry, underlying all establishment-based federal economic statistics. The SIC of a particular industry is determined using the latest Standard Industrial Classification Manual as prepared by the Executive Office of the President, Office of Management and Budget.

Storm Drain System: Streets, gutters, conduits, natural or artificial drains, channels and watercourses, or other facilities that are owned, operated, maintained or controlled by any Permittee and used for the purpose of collecting, storing, transporting, or disposing of storm water.

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Storm Water: Water which originates from atmospheric moisture (rainfall or snowmelt) and that falls onto land, water, or other surfaces.

Storm Water Management Program: This is the sum of all requirements of this Order. This is not be confused with the CSWMP.

Storm Water Pollution Prevention Plan (SWPPP): A plan required by and for which contents are specified in the State of California General Permit for Storm Water Discharges Associated with Industrial Activities, and the General Permit for Storm Water Discharges Associated with Construction Activities. The purpose of the plan is to help identify the sources of pollution that affect the quality of storm water discharges from a site and to describe and ensure the implementation of practices to reduce pollutants in storm water discharges.

Storm Water Program Compliance Amendment (SPCA): The SPCA is a report prepared by a Permittee if directed to by the Regional Board Executive Officer for insufficient submittals made under this Order. The SPCA is a part of the Administrative Review section of this Order and will include additions and enhancements to the jurisdiction's storm water program with enforceable implementation deadlines.

Storm Water Runoff: That part of precipitation (rainfall or snowmelt) which travels via flow across a surface to the storm drain system or receiving waters. Examples of this phenomenon include: the water that flows from a building's roof when it rains (runoff from an impervious surface); the water that flows into streams when snow on the ground begins to melt (runoff from a semi-pervious surface); and the water that flows from a vegetated surface when rainfall is in excess of the rate at which it can infiltrate into the underlying soil (runoff from a pervious surface). When all other factors are equal, runoff increases as the perviousness of a surface decreases.

Storm Water Runoff Mitigation Plan: A plan, to be submitted prior to the submittal of an application for the first planning or building approval for a new development project, that sets forth storm water pollution controls to be incorporated into development projects. The plan shall:

■be designed to reduce the runoff volume from the site and the pollutant load contributed by the site through incorporation of design elements and practices that address each of the following goals:

■maximize, to the extent practicable, the percentage of permeable surfaces in order to allow more percolation,

■minimize, to the extent practicable, the amount of runoff directed to impermeable areas to the storm drain system,

■maximize, to the extent practicable, storm water filtration and storage for reuse through the use of sediment traps, cisterns or other means,

■minimize, to the extent practicable, parking lot pollution through the use of porous materials to allow percolation of storm water, through the installation of appropriate treatment controls, or through other means.

Street Washing: The practice of washing of streets and sidewalks using water or other cleaning fluids.

Toxic Materials: For the purposes of this Order, toxic materials means any material(s) or combination of materials which directly or indirectly cause(s) either acute or chronic toxicity in the water column.

Toxic Pollutant: Those "pollutants", or combinations of pollutants, defined in Section 502(13) or 307(a)(1) of the federal Clean Water Act (33 U.S.C.§1362(13)).

Undesirable Coloration: See "Color" in the Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (page 3-9) June 13, 1994.

USEPA: United States Environmental Protection Agency

Waste Minimization: Operational practices that reduce the amount of waste materials generated. Practices may include recycling and reuse.

Watershed Management Area (WMA): Any one of the six general watershed areas covered by this NPDES storm water permit consisting of the: Malibu Creek and other rural areas discharging to Santa Monica Bay, Santa Clara River, Dominguez Channel/Los Angeles Harbor, San Gabriel River, Los Angeles River, and Ballona Creek and other urban areas discharging to the Santa Monica Bay watersheds.

Watershed Management Area Plan (WMAP): A plan for implementation of permit requirements that is based on the Countywide Storm Water Management Plan (CSWMP) but further addresses specific issues, pollutants of concern, and BMPs that are unique to the specific Watershed Management Area.

Watershed Management Committee (WMC): A committee composed of representatives from each Permittee in a Watershed Management Area. Duties include establishing goals and objectives for the Watershed; prioritizing pollution control efforts; developing a specific Watershed Management Plan; coordinating and facilitating annual reports for the watershed; and facilitating compliance by Permittees in the watershed.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

In Reply
Refer to: WTR-5

MAR 1 7 1998

Walt Pettit
Executive Director
California State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812-0100

Dear Mr. Pettit:

The purpose of this letter is to further clarify our position concerning Order WQ 98-01 adopted by the State Water Resources Control Board on January 22, 1998 in the appeal of Waste Discharge Requirements Order 96-03, NPDES permit No. CAS0108740. This permit authorizes storm water discharges from the municipal separate storm sewer system (MS4) serving the southern portion of Orange County.

As stated in our letter of January 21, 1998, we have concerns regarding the receiving water limitations (RWLs) language which would be included in future California MS4 permits in accordance with Section III of the Order. Our specific concern is with paragraph 2 of the language which only regulates storm water discharges which "cause or substantially (in more than a *de minimis* amount) contribute to a continuing or recurring exceedance" of an applicable water quality standard. We believe that the qualifiers "substantially (in more than a *de minimis* amount)" and "continuing or recurring" are inconsistent with the Clean Water Act (CWA) and its implementing regulations.

NPDES regulations at 40 CFR § 122.44(d)(1)(i) require effluent limitations in permits for "all pollutants or pollutant parameters . . . which the Director determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard . . . ." This requirement applies to all excursions above standards, not just situations where the excursions are "continuing or recurring" and where the permittee causes or contributes "substantially (in more than a *de minimis* amount)" to the excursions, as the Order would provide.

Our letter of January 21, 1998 also noted the RWLs language would unacceptably increase the burden of proof in establishing permit violations. An enforcing agency would have to show that the exceedances were "continuing or recurring" and that if the permittee were only contributing to the exceedances, that the contributions were "more than a *de minimis* amount." NPDES regulations at 40 CFR § 123.27(b)(2) require that the burden of proof for a delegated

State program be no greater than would be required for EPA under the CWA. Since EPA would not have to meet the kinds of threshold requirements that are in the State's RWLs language in order to establish violations of permits which properly implement 40 CFR § 122.44(d)(1)(i), the State's RWLs language would be inconsistent with 40 CFR § 123.27(b)(2).

We would also like to reiterate our disagreement with Conclusion 2 of the Order regarding the consistency of the existing RWLs language in the Orange County permit with the CWA. The RWLs language in the permit requires compliance with water quality standards as required by Section 301(b)(1)(C) of the CWA and 40 CFR § 122.44(d)(1)(i), but then provides that "permittees will not be in violation of this provision" provided they follow up with certain additional actions to address any exceedances of water quality standards which occur. The CWA does not provide for such an exception to compliance with standards.

Our letter of January 21, 1998 also indicated that Region 9 would object to future State MS4 permits which include the RWLs language in the January 22, 1998 Order. As the Regional Boards and State Board move forward in finalizing RWLs in upcoming MS4 permits and permit appeals, EPA is left in the unfortunate position of objecting to future permits until we can ensure water quality standards are adequately implemented in these permits.

Our letter of January 16, 1998 to the State Board included alternative language which we could accept in State MS4 permits. Our alternative is similar to the RWLs language in the January 22, 1998 Order, but without the qualifiers "substantially (in more than a *de minimis* amount)" and "continuing or recurring." We understand the Board may be willing to consider additional proposals for RWLs language despite the apparent nature of the Order as a precedent setting decision.

If have any questions regarding this matter, please call me at (415) 744-1860 or refer your staff to Eugene Bromley of the CWA Standards and Permits Office at (415) 744-1906.

Sincerely,

Alexis Strauss

Alexis Strauss
Acting Director
Water Division

cc: Bruce Fujimoto, State Board
Craig Wilson, State Board
Regional Board Executive Officers
Robert Hale, State Storm Water Quality Task Force
Libby Lucas, Environmental Health Coalition
Jeffrey Joseph, Caltrans

Richard Boon, Orange County
Frances L. McChesney, State Board
Michael Cook, U.S. EPA
Gary Hudiburgh, U.S. EPA

Cal/EPA

Los Angeles Regional Water Quality Control Board

101 Centre Plaza Drive
Monterey Park, CA
91754-2156
(213) 266-7500
FAX (213) 266-7600

Pete Wilson
Governor

May 5, 1998

To: Los Angeles County Municipal Storm Water Permittees

REGIONAL BOARD APPROVAL OF RECOMMENDED BEST MANAGEMENT PRACTICES (NPDES Permit No. CAS614001)

Dear Permittees:

On March 31, 1998, we sent you a copy of the Tentative Board Resolution approving the recommended BMPs for Development Construction and Industrial/Commercial Education (Site Visits) Programs, and for Municipal Sidewalk and Street Washing Activities.

On April 13, 1998, after a public hearing, the Regional Board considered and approved (contained in the attached Resolution No. 98-08) the recommended BMPs for the Industrial/Commercial Education (Site Visits) Program and for the Municipal Sidewalk and Street Washing Activities. The BMPs for Development Construction will be resubmitted for the Board's consideration after the revised Development Construction Model Program has been approved by the Board's Executive Officer.

If you have any questions or need additional information, please call me at (213) 266-7593 or Dr. Xavier Swamikannu at (213) 266-7592.

Sincerely,

WINNIE D. JESENA, P.E.
Chief, Los Angeles Coastal
Watershed Unit

Attachments as stated

R0008584

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

Resolution No. 98-08

APPROVING BEST MANAGEMENT PRACTICES FOR MUNICIPAL STORM WATER AND URBAN RUNOFF MANAGEMENT PROGRAMS IN LOS ANGELES COUNTY

(NPDES NO. CAS614001)

WHEREAS, THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION FINDS:

1. Pursuant to the requirements of Order No. 96-054, Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges Within the County of Los Angeles (Permit), the Principal Permittee, in consultation with Permittees, has developed a model program for Industrial/Commercial Education. This program must include Best Management Practices (BMPs) to control/minimize the discharge of pollutants to receiving waters.

2. The Permit required the City of Los Angeles to conduct a study on pollutants entering storm drains from street and sidewalk washing operation by: (i) characterizing municipal street washing and sidewalk washing; (ii) assessing the impacts of such activities; and (iii) recommending appropriate BMPs to control any adverse impact. Accordingly, the City of Los Angeles has completed and submitted a final report entitled *A Study of Pollutants Entering Storm Drains from Street and Sidewalk Washing Operations in Los Angeles, California* that includes recommended BMPs for said activities.

3. The Permit also requires that the BMPs be approved by the Regional Board before the Permittees incorporate them into their regulatory programs.

4. The BMPs have been evaluated and are considered appropriate for the respective program/activity.

THEREFORE BE IT RESOLVED THAT:

1. The Best Management Practices contained in the following Attachments are approved:

   a. Attachment 1 -- Industrial/Commercial Program (Site Visit); and

   b. Attachment 2 -- Sidewalk and Street Washing.

2. Permittees consider these BMPs in their regulatory programs in accordance with the provisions of Order No. 96-054.

I, Dennis Dickerson, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on April 13, 1998.

DENNIS A. DICKERSON
Executive Officer

Resolution No. 98-08

BMP List Index

Table 1 is an index to all BMP lists and their SIC codes.

Table 1 *Index of BMP Lists for Industrial/Commercial Facilities*		
Attachment 1		
Page Section	*SIC Codes (exceptions in parentheses)*	*Industry Types*
A	24 (2434)	Timber Products Facilities
B	26	Paper and Allied Products Mfg Facilities
C	28 (283)	Chemicals and Allied Products Mfg Facilities
D	29	Asphalt Paving and Roofing Materials Manufacturers and Lubricant Manufacturers
E	32	Glass, Clay, Concrete, and Gypsum Product Facilities
F	33	Primary Metals Facilities
G	10	Metal Mining Facilities
H	12	Coal Mines and Coal Mining-Related Facilities
I	13	Oil & Gas Extraction Facilities
J	14	Mineral Mining and Processing Facilities
K	4953	Hazardous Waste Treatment, Storage or Disposal Facilities
L	4953	Landfills and Land Application Sites
M	5015	Automobile Salvage Yards
N	5093	Scrap & Waste Recycling
O	4911	Steam Electric Power Generating Facilities
P	40 41 42 43 5171	Vehicle and Equipment Maintenance Areas at Land Transportation Facilities
Q	44	Vehicle and Equipment Maintenance Areas at Water Transportation Facilities
R	373	Ship & Boat Building or Repairing Yards
S	45	Vehicle and Equipment Maintenance and Deicing Areas at Air Transportation Facilities
T	4952	Treatment Works

Page Section Refers to the Best Management Practices List for the Industrial/Commercial Education Site Visit Program (January 5, 1998) 4/13/98

R0008587

Table 1 *Index of BMP Lists for Industrial/Commercial Facilities*		
Attachment 1		
Page Section	***SIC Codes (exceptions in parentheses)***	***Industry Types***
U	20 21	Food and Kindred Products Facilities
V	22 23	Textile Mills, Apparel, and Other Fabric Product Manufacturing Facilities
W	2434 25	Wood and Metal Furniture and Fixture Manufacturing Facilities
X	27	Printing and Publishing Facilities
Y	30 39	Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries
Z	31	Leather Tanning and Finishing Facilities
AA	34	Fabricated Metal Products Industry
AB	35 (357) 37 (373)	Facilities that Manufacture Transportation Equip., Industrial, or Commercial Machinery
AC	357 38 36	Manufacturers of Electronic and Electrical Equipment
Attachment 2		
Page Section	***SIC Codes (exceptions in parentheses)***	***Commercial Types***
AD	5013 5014 7532-7534 7536-7539	Vehicle Service Facilities
AE	5541	Gasoline Stations
AF	5812	Restaurants

Page Section Refers to the Best Management Practices List for the Industrial/Commercial Education Site Visit Program (January 5, 1998)

Resolution No. 98-08

ATTACHMENT 2

Recommended Best Management Practices
for
Municipal Sidewalk and Street Washing Operations

TYPE OF DISCHARGE	RECOMMENDED BMPS
SIDEWALK WASH WATER	1. Remove trash, debris, and free standing oil/grease spills/leaks (use absorbent material, if necessary) from the area before washing; and 2. Use high-pressure, low volume spray washing using only potable water with no cleaning agents at an average usage of 0.006 gallon per square feet of sidewalk area.
STREET/ALLEY WASH WATER FROM AREAS WITH UNSANITARY CONDITIONS*	Collect and divert wash water to the sanitary sewer - publicly-owned treatment works (POTW). Note: POTW approval may be needed.

* This BMP is only to be applied in areas impacted by transient populations. Each Permittee is required to apply this BMP in areas where the congregation of transient populations can reasonably be expected to result in a significant threat to water quality.

4/13/98
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California Regional Water Quality Control Board

Los Angeles Region

Winston H. Hickox
Secretary for
vironmental
rotection

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640
Internet Address: http://www.swrcb.ca.gov/~rwqcb4

Gray Davis
Governor

July 7, 1999

Ray Holland
Director, Department of Public Works
City of Long Beach

Edward Putz
City Engineer, Department of Public Works
City of Long Beach
333 West Ocean Boulevard
Long Beach, CA 90802

CITY OF LONG BEACH MUNICIPAL STORM WATER NPDES PERMIT (BOARD ORDER No. 99-060; NPDES No. CAS004003) – LETTER OF TRANSMITTAL

Dear Messrs. Holland and Putz:

I am pleased to send you the final municipal storm water permit for the City of Long Beach (attached), which was adopted by the Regional Board at its meeting on June 30, 1999, pursuant to Division 7 of the California Water Code. Board Order No. 99-060 serves as permit under the National Pollutant Discharge Elimination System (NPDES) for storm water discharges and urban runoff within the City of Long Beach and expires on June 29, 2004.

The Order requires the City to implement the Long Beach Storm Water Management Program (LBSWMP) and the Long Beach Monitoring Program (LBMP). The first Annual Storm Water Permit Report and Assessment is due on December 1, 2000. The first Annual Monitoring Report is due July 15, 2000.

I would like to note that the U.S. Environmental Protection Agency (Region 9) sent formal notification to the Regional Board of its approval of the permit on July 2, 1999. With this act the conditions precedent to the City seeking a dismissal in court of the Complaint/ Petition are complete. I look forward to the dismissal of the Complaint against the Regional Board.

Once again, I wish to thank you and your staff for their participation and assistance during the development and adoption of the permit for the City. Should you have any questions, please do not hesitate to call me at (213) 576-6605 or Dr. Xavier Swamikannu at (213) 576-6654.

Sincerely

DENNIS A. DICKERSON
Executive Officer

cc: Jorge Leon, State Water Resources Control Board
Marilyn Levin, Office of the State Attorney General
Interested Parties on File

R0008590

California Regional Water Quality Control Board

Los Angeles Region

Order No. 99-060
(NPDES NO. CAS004003)

WASTE DISCHARGE REQUIREMENTS
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES
WITHIN THE CITY OF LONG BEACH

Table of Contents

APPENDICES

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

LOS ANGELES REGION

ORDER NO. 99-060
NPDES NO. CAS004003 (CI 8052)

WASTE DISCHARGE REQUIREMENTS
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES
WITHIN CITY OF LONG BEACH

FINDINGS

The California Regional Water Quality Control Board, Los Angeles Region (hereinafter referred to as the Regional Board), finds:

Permit Background

1. The City of Long Beach, hereinafter referred to as the Permittee, discharges or contributes to discharges of storm water and urban runoff from municipal separate storm sewer systems (MS4s), also called storm drain systems, into receiving waters of the Los Angeles Basin.

2. On March 22, 1999, the Permittee submitted a Report of Waste Discharge (ROWD) as an application for issuance of waste discharge requirements and a National Pollutant Discharge Elimination System (NPDES) permit.

3. Municipal storm water discharges from the Permittee's storm drain systems were regulated under countywide waste discharge requirements contained in Order No. 90-079 and Order No. 96-054 adopted by this Regional Board on June 18, 1990, and July 15, 1996, respectively. These Orders serve as an NPDES permit (CA0061654) for the MS4 in Los Angeles County, which is hereby superseded for the City of Long Beach by Order No. CAS004003.

4. The Report of Waste Discharge (ROWD) submitted by the Permittee consists of:

   a. Statement of Accomplishments and Future Goals;
   b. Long Beach Storm Water Management Program; and
   c. Long Beach Monitoring Program;

5. The Long Beach Storm Water Management Program (LBSWMP) submitted by the Permittee consists of several distinct elements:

    a. Program Management
    b. Geographic Characterization
    c. Public Agency Activities Program
    d. Development Planning/ Construction Program
    e. Illicit Connection/ Illicit Discharges Elimination Program, and
    f. Education / Public Information Program
    g. Annual Reporting Program

6. The Long Beach Monitoring Program submitted by the Permittee consists of:

    a. Mass emissions monitoring
    b. Multi-species toxicity testing
    c. Toxicity identification evaluations
    d. Best management practices effectiveness evaluations
    e. Co-operative monitoring - Los Angeles River
    f. Co-operative monitoring - Los Cerritos Channel

7. The Regional Board has reviewed the ROWD and has determined it to be complete under the reapplication policy for MS4s issued by the USEPA on July 1996. The Regional Board finds that the Permittee's proposed Storm Water Management Program is acceptable at this time and when fully implemented, is expected to be consistent with the statutory standard of Maximum Extent Practicable (MEP).

Nature of Discharges and Sources of Pollutants

8. The discharges from the MS4 consist of surface runoff (non-storm water and storm water) from various land uses in the hydrologic drainage basins within the City. Approximately 44% of the Permittee land area discharges to the Los Angeles River, 7% to the San Gabriel River and the remaining 49% drains directly to Long Beach Harbor and San Pedro Bay. The quality and quantity of these discharges vary considerably and are affected by the hydrology, geology, and land use characteristics of the watersheds; seasonal weather patterns; and frequency and duration of storm events.

9. Municipal storm water monitoring data, not specific to the City of Long Beach, shows that storm water runoff from urban and industrial areas typically contains the same general types of pollutants that are found in industrial and municipal wastewater discharges. Pollutants commonly found in storm water runoff include pathogens, heavy metals, pesticides, herbicides, and synthetic organic compounds such as fuels, waste oils, solvents, lubricants, and grease.

10. In general, the substances that are found in urban storm water runoff can harm human health and aquatic ecosystems. In addition, the high volumes of storm water discharged from MS4s in areas of urbanization can significantly impact aquatic

ecosystems due to physical modifications such as bank erosion and widening of channels

11. Water Quality Assessments conducted by the Regional Board identified impairment or threatened impairment of beneficial uses of water bodies in Long Beach including Alamitos Bay, Los Angeles Estuary, El Dorado Lake, Los Angeles River Reach 1, Los Angeles River Reach 2, San Gabriel River Estuary, San Gabriel River Reach 1, Colorado Lagoon, and Los Cerritos Channel. Coastal shorelines including Alamitos Bay Beaches, Belmont Shore Beach, Bluff Park Beach, and Long Beach Shore were not assessed. Within the City of Long Beach, Los Cerritos Estuary was found to be fully supporting beneficial uses.

12. In general, pollutants found in storm water causing impairment include: pH, heavy metals, pathogenic bacteria, enteric viruses, pesticides, nutrients, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organic solvents, sediments, trash, and debris. Elevated tissue levels and poor survival rates for bio-test species have also been observed during water quality assessments.

Coverage and Exemptions

13. The Permittee serves a population of about 426,000 people in an area of approximately 50 square miles. The requirements in this Order cover all areas within the boundaries of the City of Long Beach except for State and Federal properties. Such entities may operate storm drain facilities and/or discharge storm water to storm drains and watercourses covered by this Order. The Permittee may lack legal jurisdiction over these entities under state and federal constitutions. The Permittee generally will not be held responsible for such facilities and/or discharges. The Regional Board may consider issuing separate MS4 NPDES permits consistent with this Order.

14. Federal, state, regional or local entities within the Permittee's boundaries or in jurisdictions outside the City of Long Beach, may operate storm drain facilities and/or discharge storm water to storm drains and watercourses covered by this order. These entities include but are not limited to the (a) California Department of Transportation; (b) Los Angeles County Sanitation Districts; (c) Metropolitan Transportation Authority (c) United States Postal Service; (d) National Guard; (e) State Universities and Colleges; (f) the Long Beach Unified School District; and (g) Veteran Affairs Medical Center. The Permittee may lack jurisdiction over these state or federal entities under state and federal constitutions. Consequently, the Regional Board recognizes that the Permittee will not be held responsible for such facilities and or discharges.

15. For entities within the Permittee's boundaries, over which the Permittee has no jurisdiction, the Regional Board may consider designating them as a co-permittee or issuing separate NPDES permits consistent with this Order.

16. It is the objective of the Regional Board to ensure through reasonable efforts that storm water management programs for areas within the County of Los Angeles, which drain to the City of Long Beach, complement the requirements of this Order.

Federal Statutes and Regulations Statutes and Regulations

17. Section 402(p) of the federal Clean Water Act (CWA), as amended by the Water Quality Act of 1987, requires NPDES permits for storm water discharges from MS4s to waters of the United States. Section 402(p)(3)(B) requires that permits for MS4s: "(i) may be issued on a system - or jurisdiction-wide basis; (ii) shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers; and (iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants."

18. The USEPA promulgated 40 Code of Federal Regulations (CFR) Part 122.26, on November 16, 1990, pursuant to Section 402(p) of the CWA, which established requirements for storm water discharges under the NPDES program. The regulations recognize that certain categories of non-storm water discharges need not be prohibited if they are determined not to be significant sources of pollutants.

19. Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) requires coastal states with approved coastal zone management programs to address non-point pollution impacting or threatening coastal water quality. The USEPA under CZARA has issued guidance for five major categories of non-point pollution in coastal waters. These are: (a) agricultural runoff; (b) silvicultural runoff; (c) urban runoff (including developing and developed areas); (d) marinas and recreational boating; and (e) hydromodification. The Long Beach Storm Water Management Program (LBSWMP) incorporates management measures for pollution from urban runoff, and thus provides the functional equivalence for compliance with CZARA in this category.

State Statutes and Permits

20. To facilitate compliance with federal regulations, the State Water Resources Control Board (State Board) has issued two statewide general NPDES permits: one for storm water from industrial sites [NPDES No. CAS000001, General Industrial Activities Storm Water Permit (GIASP)] and the other for storm water from construction sites [NPDES No. CAS000002, General Construction Activity Storm Water Permit (GCASP)]. The GCASP was issued on August 20, 1992. The GIASP was reissued on April 17, 1997. Facilities discharging storm water associated with industrial activities and construction projects with a disturbed area of five acres or more are required to obtain individual NPDES permits for storm water discharges, or be covered by these statewide general permits by completing and filing a Notice of Intent (NOI) with the State Water Resources Control Board (State Board). The USEPA guidance contemplates coordination of the state administered programs for industrial and construction activities with the local agency program to reduce pollutants in storm water discharges to the MS4.

21. The State Board on June 17, 1999, adopted through Order No. WQ 99-05, standard receiving water limitations language to be included in all municipal storm water permits issued by the State and Regional Boards.

22. The State Board adopted Resolution No. 68-16 "Maintaining High Quality Water" which established an anti-degradation policy for State and Regional Boards.

23. California Water Code (CWC) Section 13263(a) requires that waste discharge requirements issued by Regional Boards shall implement any relevant water quality control plans that have been adopted; shall take into consideration the beneficial uses to be protected and the water quality objectives reasonably required for that purpose; other waste discharges; and, the need to prevent nuisance.

24. California Water Code Section 13370 *et seq.* requires that waste discharge requirements issued by the Regional Boards comply with provisions of the Federal Clean Water Act and its amendments.

Regional Board Water Quality Control Plans and Policies

25. The Regional Board adopted an updated Water Quality Control Plan (Basin Plan) for the Los Angeles Region on June 13, 1994, *'Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties,* (1994). 'The Basin Plan, which is incorporated in this Order by reference, specifies the beneficial uses of receiving waters and contains both narrative and numerical water quality objectives for the receiving waters in the City of Long Beach.

26. This Regional Board has divided the region into watershed management areas to implement a watershed management approach to water quality protection. The objective of the watershed management approach is to provide a comprehensive and integrated strategy towards water resource protection, enhancement, and restoration while balancing economic and environmental impacts within a hydrologically defined drainage basin or watershed. Portions of the City are situated in the following watershed management areas: (1) Los Angeles River and (2) San Gabriel River.

27. This action to adopt and issue waste discharge requirements and a NPDES permit is exempt from the provisions of the California Environmental Quality Act; Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Section 13389 of the California Water Code.

Public Involvement Process

28. The Regional Board has notified the Permittee, MS4 municipalities, interested agencies, interested persons, and the public of its intent to prescribe waste discharge requirements and an MS4 NPDES permit for storm water discharges, and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.

29. The Board, in a public hearing, heard and considered all comments pertaining to the tentative waste discharge requirements. This order shall serve as a NPDES Permit pursuant to Section 402 of the federal Clean Water Act, or amendments thereto.

30. This permit shall take effect at the end of 10 days from the date of its adoption, provided the Regional Administrator of the U.S. Environmental Protection Agency, Region IX, has no objections.

Requirements

IT IS HEREBY ORDERED that the City of Long Beach, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act, as amended, and regulations and guidelines adopted thereunder, shall comply with the following:

Part 1. RECEIVING WATER LIMITATIONS

A. Discharges from the MS4 that cause or contribute to the violation of water quality standards or water quality objectives are prohibited.

B. Discharges from the MS4 of storm water, or non-storm water, for which a Permittee is responsible shall not cause or contribute to a condition of nuisance.

C. The Permittee shall comply with Part 1 and 2 of the permit through timely implementation of control measures and other actions to reduce pollutants in the discharges in accordance with the LBSWMP and other requirements of this permit including any modifications. The LBSWMP shall be designed to achieve compliance with receiving water limitations. If exceedances of water quality objectives or water quality standards (collectively, water quality standards) persist, notwithstanding implementation of the LBSWMP and other requirements of this permit, the Permittee shall assure compliance with discharge prohibitions and receiving water limitations by complying with the following procedure:

1. Upon a determination by either the Permittee or the Regional Board that discharges are causing or contributing to an exceedance of an applicable water quality standard, the Permittee shall promptly notify and thereafter submit a report to the Regional Board that describes BMPs that are currently being implemented and additional BMPs that will be implemented to prevent or reduce any pollutants that are causing or contributing to the exceedances of water quality standards. This report may be incorporated in the annual update of the LBSWMP unless the Regional Board directs an earlier submittal. The report shall include an implementation

schedule. The Regional Board may require modifications to the Report.

2. Submit any modifications to the report required by the Regional Board within 30 days of notification

3. Within 30 days following the approval of the report, the Permittee shall revise the LBSWMP and monitoring program to incorporate the approved modified BMPs that have been and will be implemented, implementation schedule, and any additional monitoring required

4. Implement the revised LBSWMP and monitoring program according to the approved schedule

So long as the Permittee has complied with the procedures set forth above and is implementing the revised LBSWMP, the Permittee does not have to repeat the same procedure for continuing or recurring exceedances of the same receiving water limitations unless directed by the Regional Board to develop additional BMPs.

Part 2. DISCHARGE PROHIBITIONS

I. Discharge Prohibitions

A. The Permittee shall effectively prohibit non-storm water discharges into the MS4 and watercourses except where such discharges:

1. Are covered by a separate individual or general NPDES permit; or

2. Meet one of the conditions below:

a. Not identified as a source of pollutants:

i. Flows from riparian habitats or wetlands;
ii. Diverted stream flows;
iii. Springs;
iv. Rising ground waters;
v. Uncontaminated groundwater infiltration; and

b. Not Identified as a source of pollutants subject to conditions:

i. Reclaimed and potable landscape irrigation water;
ii. Water line flushing;
iii. Discharges from potable water sources;
iv. Foundation drains;
v. Footing Drains;

vi. Air conditioning condensate;
vii. Water from crawl space pumps
viii. Reclaimed and potable irrigation water;
ix. Reclaimed and potable lawn watering;
x. Dechlorinated swimming pool discharges;
xi. Individual residential car washing; and
xii. Sidewalk washing
xiii. Discharges or flows from emergency fire fighting activities.

If any of the above types of non-storm water discharges (Part 2, I. A.2.b) are determined to be a source of pollutants by the Regional Board Executive Officer, the discharge need not be prohibited if the Permittee implements appropriate BMPs to ensure that the discharge is not a source of pollutants. Notwithstanding the above, the Regional Board Executive Officer may impose the prohibition in consideration of anti-degradation policies.

c. The Regional Board Executive Officer may authorize the discharge of additional types of non-storm water, after consideration of anti-degradation policies, and upon presentation of evidence that the non-storm water discharge is not a source of pollutants. This evidence may include the implementation of BMPs to control pollutants.

3. Discharges originating from federal, state, or other facilities which the Permittee is pre-empted by law from regulating.

Part 3 STORM WATER MANAGEMENT, MONITORING, AND REPORTING

I. Storm Water Management

<u>Conformance with Federal Requirements</u>

The City of Long Beach Storm Water Management Program shall, at a minimum, comply with applicable requirements of 40 CFR 122.26.(d)(2), and implement the LBSWMP consistent with guidance issued by the U.S. EPA for Phase 1 MS4 program implementation [EPA Document No. 833-B-92-002]. The LBSWMP shall be implemented so as to reduce the discharges of pollutants in storm water to the maximum extent practicable. The LBSWMP is described (Table of Contents) in Appendix, pages A-1 through A-6.

A. Requirements

1. The Permittee shall implement in its entirety the LBSWMP adopted with this permit and approved modifications to the LBSWMP made during the term of the permit including those made in accordance with

Part 1. C. of this permit.

2. The Permittee shall implement the following BMPs approved by the Regional Board

   a. Catch-basin stenciling
   b. Trash collection
   c. Street sweeping
   d. Waste-oil recycling
   e. Household hazardous waste collection programs
   f. Water conservation practices
   g. Proper disposal practices for litter, green waste, and pet feces
   h. Public Reporting Program for Illicit Connections/ Discharges
   i. Reporting Program for Hazardous Substances Spill
   j. Procedure to deny grading permits to project applicants not filing a Notice of Intent (NOI) for a State General Construction Activity Storm Water Permit or without a State Storm Water Pollution Prevention Plan (SWPPP), where applicable
   k. Review and approval of Urban Storm Water Mitigation Plans for Priority Development Planning Projects
   l. Review and approval of Local Storm Water Pollution Prevention Plans for Priority Development Construction Projects
   m. Inspection of Development Construction Projects
   n. Information Program for Developers

5. The Permittee shall comply with all provisions of this permit and requirements herein.

B. Modification

1. The Regional Board Executive Officer may approve changes to the LBSWMP either:

   a. Upon petition by the Permittee or interested parties and after providing for and considering public comment, or

   b. As deemed necessary by the Regional Board Executive Officer following notice to the Permittee and after providing for and considering public comment.

2. The Permittee shall modify the LBSWMP, at the direction of the Regional Board Executive Officer, to incorporate applicable regional provisions approved by the Regional Board Executive Officer in plans for watersheds shared by the Permittee with other MS4 programs.

C. Rescission

1. Coverage for the Permittee under Board Order No. 96-054 is hereby

rescinded.

D. Legal Authority

The Permittee shall possess the necessary legal authority established by statute, ordinance, or other means, to prohibit and control the contribution of pollutants to the MS4 from storm water discharges. This shall include legal authority to enforce the following:

1. Prohibit illicit discharges and illicit connections to the MS4 and require removal of illicit connections:

    a. Prohibit the discharge of wash waters to the MS4 when gas stations, auto repair garages, or other types of automotive service facilities are cleaned;

    b. Prohibit the discharge of runoff to the MS4 from mobile auto washing, steam cleaning, mobile carpet cleaning, and other such mobile commercial and industrial operations;

    c. Prohibit the discharges of runoff to the MS4 from areas where repair of machinery and equipment which are visibly leaking oil, fluid or antifreeze is undertaken;

    d. Prohibit the discharge of runoff to the MS4 from storage areas of materials, containing grease, oil, or other hazardous substances, and uncovered receptacles containing hazardous materials;

    e. Prohibit the discharge of commercial/ municipal, chlorinated swimming pool water and filter backwash to the MS4;

    f. Prohibit the discharge of runoff from the washing of toxic materials from paved or unpaved areas to the MS4;

    g. Prohibit washing impervious surfaces in industrial/commercial areas which results in a discharge of runoff to the MS4, unless specifically required by State or local health and safety codes; and

    h. Prohibit the discharge from washing out of concrete trucks to the MS4.

2. Prohibit spills, dumping, or disposal of materials, other than storm water:

    a. Prohibit littering;

    b. Prohibit the disposal of leaves, dirt, or other landscape debris into a storm drain;

c. Prohibit the discharge to the MS4 of any state or federally banned pesticide, fungicide, or herbicide;

d. Prohibit the discharge of food waste into the MS4;

e. Require, in areas exposed to storm water, the use of BMPs and/ or the removal and lawful disposal of all fuels, chemicals, fuel and chemical wastes, animal wastes, garbage, batteries, and other materials which have potential adverse impacts on water quality.

3. Control through interagency agreements the contribution of pollutants from one portion of the MS4 to another portion of the MS4.

4. Require compliance with conditions in ordinances, permits, contracts or orders.

5. Carry out all inspections, surveillance and monitoring procedures necessary to determine compliance and non-compliance with permit conditions including the prohibition on illicit discharges to the MS4;

II. Monitoring

A. Requirements

The City of Long Beach Monitoring Program is described in the Appendix, pages C-1 through C-9.

The City of Long Beach Monitoring Program shall:

1. estimate annual mass emissions of pollutants discharged to surface waters through the MS4;

2. evaluate water column and sediment toxicity in receiving waters;

3. evaluate impact of storm water/ urban runoff on bio-species in receiving waters;

4. determine and prioritize pollutants of concern in storm water;

5. identify pollutant sources on the basis of flow sampling, facility inspections, and ICID investigations; and

6. evaluate BMP effectiveness.

B. Regional Participation

1. The Permittee shall participate with the County of Los Angeles, the City

of Los Angeles, Watershed Management Area (WMA) municipalities, and Southern California Coastal Water Research Project (SCCWRP) to investigate storm water impacts on the Los Angeles River, San Gabriel River, and the Los Cerritos Channel, when conducting its monitoring program.

2. The Executive Officer shall by January 1, 2001, after conferring with the Permittees in each watershed, develop and approve a cost-sharing formula that allocates a fair share for monitoring costs to each watershed participant.

3. The Permittee shall participate with (SCCWRP) in regional storm water studies.

C. Implementation

1. The Permittee shall implement in its entirety the Long Beach Monitoring Program adopted with this permit and approved modifications made during the term of the permit.

D. Modification

1. The Regional Board Executive Officer or the Regional Board, consistent with 40 CFR 122.41, may approve changes to the LB Monitoring Program, after providing the opportunity for public comment, either:

a. By petition of the Permittee or by petition of interested parties after the submittal of the Annual Monitoring Program Report. Such petition shall be filed not later than 60 days after the Annual Monitoring Program Report submittal date, or

b. As deemed necessary by the Regional Board Executive Officer following notice to the Permittee.

III. Program Reporting and Evaluation

A. Reporting

1. The Permittee shall submit an Annual Storm Water Permit Report and Assessment to the Regional Board Executive Officer annually on December 1. The first Annual Storm Water Report and Assessment shall be due on December 1, 2000. The Annual Storm Water Permit Report and Assessment will include the information necessary to assess the Permittee's compliance status relative to this Order, and the effectiveness of implementation of permit requirements on storm water quality.

2. At a minimum the Annual Storm Water Permit Report and Assessment will include the following:

   a. Status of compliance with permit requirements including implementation dates for all time-specific deadlines. If permit deadlines are not met, the Permittee shall report the reasons why the requirement was not met, how the requirements will be met in the future, including projected implementation date;

   b. An assessment of the effectiveness of permit requirements to reduce storm water pollution. This assessment will be based upon the specific record-keeping information requirement in each major section of the permit, monitoring data, and any other data the Permittee has, or is aware of that provides information on permit effectiveness; and

   c. An analysis of the data to identify areas of the City which cause or contribute to exceedances of water quality standards or objectives, the predominate land uses in these areas, and potential sources of pollutants in those areas.

B. Public Information and Participation

1. Description of activities on distributing brochures, community outreach efforts, public communication efforts and, educational programs in schools, including, where appropriate, an estimate of the public and student populations reached; and,

2. Number of industrial and commercial site visits in the past year including the number of businesses the City has identified that have failed to file a Notice of Intent (NOI).

C. Illicit Discharges

1. For each illicit discharge the Permittee must report the reason for the discharge and the action taken to prevent similar discharges from occurring.

D. Illicit Connections

1. Number of illegal connections identified in the past year;

2. Number of illegal connections eliminated in the past year; and,

3. Number and type of enforcement actions, applicable to storm water enforcement, taken in the past year.

E. Development Construction

1. Number of construction projects requiring SWPPPs in the past year

2. Number of inspections in the past year; and,

3. Number and type of enforcement actions, applicable to storm water enforcement, taken at construction sites in the past year.

F. Development Planning

1. Scheduled date of significant rewrite of the Permittee's General Plan;

2. Description of the developer information program and assessment of it's effectiveness; and,

3. Number of development projects for which SUSMPs were completed and the percentage of total development projects approved by the Permittee for which a SUSMP was completed since the permit was adopted and in the past year.

G. Storm Water Management Program Budget

1. Fiscal Resources

a. The Permittee shall prepare annually a storm water budget update on resources dedicated to the storm water program. This budget report shall include an estimated baseline budget (based on 1989 data if available), and annual updates identifying the budget expenditures for the storm water management program. At a minimum the specific categories to be detailed are noted below:

i. Program management
ii. Illicit connections/illicit discharge
iii. Development planning/development construction
iv. Construction inspection activities
v. Public Agency Activities
 - Operations and Maintenance
 - Municipal Street Sweeping
 - Fleet and Public Agency Facilities
 - Landscape and Recreational Facilities
vi. Capital Costs
vii. Public Information and Participation
viii. Monitoring Program
ix. Other

H. Storm Water Monitoring Report

1. The Permittee shall submit a Storm Water Monitoring Report on July 15, 2000 and annually on July 15, thereafter. The report shall include:

   a. Status of implementation of the monitoring program;

   b. Results of the monitoring program; and,

   c. Interpretation of the results include analyses of trends, land-use contributions, and BMP effectiveness.

Part 4 SPECIAL AND STANDARD PROVISIONS

I. Special Provisions

A. General

1. Requirements of the permit will take effect immediately (except where otherwise specifically stated in this permit).

2. Requirements of the LBSWMP shall be implemented no later than December 30, 1999, unless a different implementation date is provided in this Order.

3. The Permittee shall coordinate and participate with those Watershed Management Committees formed pursuant to Board Order No. 96-054 within whose watersheds the City of Long Beach's drainage area lies.

4. The Permittee shall develop for distribution a consolidated document with a municipal code cross-reference matrix and current municipal codes for enforcement of the LBSWMP.

5. The Permittee shall submit a report to the Regional Board Executive Officer by January 1, 2000, on the Permittee's evaluation of the need for a comprehensive storm water ordinance, and, if a comprehensive storm water ordinance is not recommended, present the basis of its determination to not develop such an ordinance.

B. Illicit Connections

1. The Permittee shall eliminate all illicit connections the Permittee becomes aware of through City inspections or public reporting within 6 months after the Permittee gains knowledge of the connection.

2. The Permittee shall inspect at a minimum:

    a. those portions of the storm drain system consisting of storm drain pipes 36 inches in diameter or greater, for illicit connections within 5 years after the permit is adopted;

    b. areas of the MS4 designated as high priority, within 2 years after the permit is adopted, based on priorities identified in the LBSWMP;

    c. open channels within one year after the permit is adopted; and,

    d. storm sewers to identify the presence of conditions that may suggest the presence of illicit connections and, where information is developed that suggests such connections exist, investigate and take necessary actions to eliminate the connection.

3. The Permittee shall maintain a database on illicit connections which includes type of connection, location, evidence of illicit discharge, date of initial inspection, enforcement action taken, date of follow-up inspection, and date of removal.

C. Illicit Discharge

1. For all illicit discharges the Permittee gains knowledge of, the Permittee shall investigate the cause, determine the amount and nature of the discharge, and take appropriate action, including where appropriate, the issuance of an enforcement order, that will result in the immediate cessation of the discharge.

2. All Permittee inspectors and other field workers shall receive training on how to identify and report illicit discharges and the requirements of this Order, within 6 months after the permit is adopted, and through an annual refresher training thereafter.

3. Within 2 years after permit adoption, all Phase I industrial facilities, restaurants and gas stations located within the Permittee's jurisdiction shall receive educational information describing illicit discharges. The information shall include: types of discharges prohibited, how to prevent illegal discharges, what to do in the event of an illegal discharge, and the array of enforcement actions the facility may be subject to, including penalties that can be assessed.

D. Development Planning

1. The Permittee shall develop storm water management guidelines for use in preparing/ reviewing CEQA documents, and in linking storm water quality mitigation conditions to local discretionary project approvals. The Permittee shall make appropriate modifications in their internal planning

procedures not later than December 30, 1999.

2. The Permittee shall include watershed and storm water management considerations in the appropriate elements of the Permittee's General Plan whenever said elements are significantly rewritten. Appropriate elements include but are not limited to conservation, open space, land-use, public utilities and infrastructure.

3. All Permittee employees engaged in development planning shall receive training on the requirements of this Order and BMP implementation within six months after the permit is adopted, and through annual refresher training thereafter.

4. The Permittee shall develop and implement a developer information program no later than six months after the permit is adopted to inform developers seeking project approvals from the City about the impacts of development and construction on storm water, BMPs applicable to development and redevelopment, and the SUSMP requirements. The developer information program must reach developers as early in the planning process as possible.

5. The Permittee shall require that Standard Urban Storm Water Mitigation Plans be prepared for the following new projects:

   a. 10-99 home subdivisions
   b. 100 or more home subdivisions
   c. 100,000 or more square-foot commercial developments
   d. environmentally sensitive areas

6. The SUSMP will incorporate the following requirements:

   a. provisions associated with SUSMPs adopted by the Regional Board;

   b. at a minimum, peak runoff rates can not exceed pre-development levels, for developments where the potential for increased storm water discharge rates can result in an increase in downstream erosion potential; and,

   c. for new developments, 25% of required landscaped areas must be vegetated with xeriscape.

7. The Permittee shall require that source control BMPs identified in Table 5-1 in the LBSWMP and included in the Appendix, pages B-1, be implemented for the following projects:

   a. automotive repair shops
   b. retail gasoline outlet
   c. restaurants

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d. hillside projects

8. After July 1, 2000, all trash containers for restaurants shall be required to be located in covered areas and drainage from surrounding areas must be diverted around the trash container area. The Permittee has the discretion to waive this requirement for internal restaurant renovations.

9. Trash containers sized 1 cubic yard or greater shall be required to have lids.

10. All designated vehicle/ equipment wash areas shall be required to be self-contained, or covered, or equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer.

11. For automotive repair shop and retail gasoline outlet developments, discharge of untreated storm water runoff to the storm drain system from toxic or hazardous material storage areas and repair/ maintenance areas shall be prohibited.

12. For automotive repair shop and retail gasoline outlet developments, discharge of storm water runoff to the storm drain system from fueling areas shall be managed with BMPs in accordance with guidelines in, *Best Management Practice Guide: Retail Gasoline Outlets, California Stormwater Quality Task Force (1997).*

13. For restaurants, equipment and accessory wash areas including areas where floor mats are washed must drain to the sanitary sewer.

E. Development Construction

1. The Permittee shall require, prior to the issuance of any building or grading permit, preparation of storm water pollution prevention plans (SWPPPs) for projects that are not subject to the General Construction permit and meet one of the following criteria:

   a. Will result in soil disturbance of one acre or more in size
   b. Is adjacent to an environmentally sensitive area
   c. Is located in a hillside area

2. The SWPPP shall include the appropriate construction site BMPs selected from the list adopted by the Regional Board on April 22, 1999. In addition, the Permittee shall ensure the following minimum requirements are met at every construction site regardless of size:

   a. Sediments will be retained on the project site using structural drainage controls;

b. No construction-related materials, wastes, spills, or residues shall be discharged from the project site to the streets, drainage facilities, or adjacent properties by wind or runoff;

c. Runoff from equipment and vehicle washing shall be contained at the project site; and,

d. Eliminate, to the maximum extent possible, erosion from slopes and channels by implementing applicable BMPs including:

   i. Limit scheduling of grading during the wet season
   ii. When grading occurs during the wet season, the Permittee will conduct onsite inspections of disturbed areas during rain events exceeding 0.1 inch over a 24 hour period
   iii. Vegetation shall be planted and maintained on slopes
   iv. Cover susceptible slopes

3. Project plans must include a narrative discussion of the rationale used for selecting or rejecting BMPs. The project architect or engineer of record, or authorized qualified designee, must sign a statement on the plan to the effect: "As the architect/engineer of record, I have selected appropriate BMPs to effectively minimize the negative impacts of this project's construction activities on storm water quality. The project owner and contractor are aware that the selected BMPs must be installed, monitored, and maintained to ensure their effectiveness. The BMPs not selected for implementation are redundant or deemed not applicable to the proposed construction activities."

4. The Permittee shall not issue a grading permit for developments with disturbed areas of five acres or greater unless the applicant can show that:

   a. a Notice of Intent (NOI) to comply with the State Construction Activity Storm Water Permit has been filed; and,

   b. a Storm Water Pollution Prevention Plan (SWPPP) has been prepared.

5. The Permittee shall inspect every qualifying site at least once during the rainy season to determine if the minimum requirements listed above are being achieved. For inspected sites which do not meet the minimum requirements or have not adequately implemented SWPPP, the Permittee shall follow-up within 2 weeks of the last inspection to ensure compliance.

6. The Permittee shall provide training on the requirements of the development construction and development planning sections of this permit to all construction inspection staff and other staff directly involved in construction activities. Training should be completed by December 30, 1999, and conducted annually thereafter. All new staff should be trained within six

months after their employment start-date.

F. Permittee Public Agency Activities

1. Requirements under the development planning and development construction sections of this Order shall apply to all applicable public agency development and construction projects.

2. The Permittee shall routinely conduct trash collection along, on and/or in water bodies under its jurisdiction.

3. Catch basin maintenance, under Permittee's jurisdiction, shall include:

   a. All catch basins will be cleaned out and inspected one time between May 1 and September 30 of each year; and,

   b. All catch basins that are at least 40% full of trash and debris between October 1 and April 30, shall be cleaned-out.

4. The Permittee shall develop a database on inlet maintenance, which at a minimum, includes a record of catch basin clean-outs to include: the quantity, predominant types, and likely sources of trash removed.

   a. All open channels will be cleaned at least once between May 1 and September 30 of each year. A database record of the of the amount of trash removed shall be maintained.

5. Curbed streets shall be swept a minimum of twice per month.

6. Street saw-cutting and paving is prohibited during a storm event of 0.25 inches or greater (except during emergency conditions).

7. Discharge of untreated runoff from temporary or permanent street maintenance waste storage areas is prohibited.

8. For vehicle maintenance and repair facilities, the discharge of untreated storm water runoff to the storm drain system from toxic or hazardous material storage areas, fueling areas, and repair/maintenance areas is prohibited.

9. All vehicle/equipment wash areas must be self-contained, or covered, or equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer. This provision does not apply to fire fighting vehicles.

10. Discharge of untreated storm water runoff from any toxic or hazardous material storage areas, including waste storage and handling areas, is prohibited.

11. For new public agency developments 25% of all required landscaping areas must be vegetated with xeriscape vegetation.

12. The routine application of pesticides, herbicides, and fertilizers during the wet season is prohibited. The Permittee's Stormwater Task Force shall develop a protocol for the non-routine application of pesticides, herbicides, and fertilizers.

13. Uncovered parking lots with greater than 25 parking spaces, will be swept at least monthly. By October 1, 2000 the Permittee shall develop and implement an uncovered parking lot washing program.

14. Discharge of liquids from concrete truck washouts into storm drains, open ditches, streets or catch basins is prohibited.

15. The Permittee shall train Permittee employees (whose jobs or activities directly affect storm water quality, or those who respond to questions from the public) regarding the requirements of the storm water management program. This includes maintenance, construction, planning, and inspection personnel.

G. Public Information and Participation

1. Telephone numbers for reporting clogged catch basin inlets, illicit discharges, dumping and general storm water management information will be listed in the government pages of the telephone book.

2. A storm water brochure must be provided with every building permit application. The brochure must include:

   a. A listing of contractor and developer storm water management training programs available in the area. (This list must be updated annually on the Permittee's website address);
   b. A list of all requirements of this order related to development and redevelopment projects; and,
   c. The list of development planning and development construction BMPs.

3. The Permittee shall insure that a minimum of 1.5 million impressions per year are made on the general public about storm water quality via print, local TV access, local radio or other appropriate media (in addition to the schoolchildren and industrial/commercial education outreach required below).

4. The Permittee shall distribute outreach materials to the general public, and targeted audiences such as schools, community groups, contractors and developers, at the appropriate public counters and at public events.

5. The Permittee shall provide the Long Beach Unified School District with materials, including but not limited to, videos, live presentations, brochures,

and other media, necessary to educate a minimum of 50% of all school children (K-12) every two years on storm water pollution. This requirement can be accomplished through cooperative efforts with other agencies.

6. Industrial/ Commercial Educational Program

   a. The Permittee shall implement an industrial/commercial educational site visit program. Site visits will occur once every two years at all Phase I industrial facilities, vehicle repair shops, vehicle body shops, vehicle parts (excluding parts retail stores with no outside storage) and accessory facilities, gas stations, restaurants, and additional industrial/ commercial facilities identified as priorities by the Regional Board Executive Officer or the Permittee. During the educational site visit, the Permittee shall:

      i. Consult with a representative of the facility to explain applicable storm water regulations;

      ii. Distribute and discuss applicable BMP and educational materials, including information regarding the codes, regulations, ordinances, and permits applicable to the category of the facility. Specific BMP brochures shall be developed and distributed for each major type of industry. In the case of Phase I facilities, notify the facility of specific requirements under the Statewide Industrial General Permit including that such facilities must file an Notice of Intent (NOI) with the State Water Resources Control Board and that a Storm Water Pollution Prevention Plan (SWPPP) must be available on the site;

      iii. Conduct a site walk-through, when requested by the owner/operator, to provide consultation on recommended BMPs; and

   b. The Permittee shall provide an annual update of the database of industrial/commercial facilities to Los Angeles County and the Regional Board Executive Officer. The database format shall include at a minimum:

      - Facility name
      - Site Address
      - Watershed Management Area
      - Applicable SIC code(s); and
      - NPDES storm water permit coverage status, if applicable

      i. The list of facilities identified within the Permittee's jurisdiction shall include, at a minimum:

         - All industrial groups regulated under Phase I of the Federal storm water program (40 CFR 122.26; Phase I Facilities);

         - Motor vehicle repair shops, motor vehicles body shops, motor vehicle parts and accessories facilities (excepting those with no outside materials storage), gas stations, and restaurants; and

- Additional SIC industrial/commercial facilities identified as priorities by the Permittee or the Regional Board Executive; and
- Number of facility visitations reported to the Executive Officer a list of visited facilities on an annual basis.

H. Five Year Public Education Strategy

1. The Permittee shall participate in the Five Year Public Education Strategy implemented by the Los Angeles County Department of Public Works pursuant to Board Order No. 96-054 by representation in the of the Los Angeles County Department of Works Educational Sub-committee.

I. Inlet/ Catch-basin Stenciling Program

1. All storm drain inlets and catch basins owned and operated by the Permittee must be stenciled with prohibitive language to discourage illegal dumping. In addition, signs with prohibitive language discouraging illegal dumping must be posted along channels and creeks. The Permittee is responsible for the maintenance of the posted signs. The_Permittee shall maintain storm drain sign legibility.

J. Parking Lot Study

1. The Permittee shall conduct a representative survey of privately-owned parking lots of more than 10 spaces exposed to storm water runoff to determine the amount of pollutants generated by these sources and the measures taken to remove litter by the lot operators. The Permitee shall report the results of this survey by July 15, 2000. The survey shall be accompanied by recommendations necessary to effectively reduce the contribution of storm water pollution constituents from these sources and a plan for their implementation.

K. Total Maximum Daily Loads [40 CFR 130.7]

1. The Permittee shall modify the LBSWMP to comply with waste load allocations developed and approved pursuant to the process for the designation of Total Maximum Daily Loads (TMDLs) for impaired water-bodies.

II. Standard Provisions

A. Public Review

1. All documents submitted to the Regional Board in compliance with the terms and conditions of this Permit shall be made available to members of

the public pursuant to the Freedom of Information Act (5 U.S.C. Section 5.52 (as amended) and the Public Records Act (California Government Code Section 6250 *et seq.*)

2. All documents submitted to the Executive Officer for approval shall be made available to the public for a 30-day period to allow for public comment.

B. Monitoring [40 CFR 122.41(j)]

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity;

2. The Permittee shall retain records of all monitoring information, including all calibration and maintenance monitoring instrumentation, copies of all reports required by this Order, and records of all data used to complete the Report of Waste Discharge and application for this Order, for a period of at least five(5) years from the date of the sample, measurement, report, or application. This period may be extended by request of the Regional Board or EPA at any time and shall be extended during the course of any unresolved litigation regarding this discharge;

3. Records of monitoring information shall include:

   a. The date, exact place, and time of sampling or measurements;

   b. The individual(s) who performed the sampling or measurements;

   c. The date(s) analyses were performed;

   d. The individual(s) who performed the analyses;

   e. The analytical techniques or methods used; and

   f. The results of such analyses;

4. All sampling, sample preservation, and analyses must be conducted according to test procedures under 40 CFR Part 136, unless other test procedures have been specified in this Order; and,

5. All chemical, bacteriological, and bioassay analyses shall be conducted at a laboratory certified for such analyses by an appropriate governmental regulatory agency.

C. Reporting

1. The Annual Storm Water Permit Report and Assessment shall contain the following completed declaration:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted.

Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility, of a fine and imprisonment for knowing violations.

Executed on the ___ day of _________ , 19_,

at ____________________________.

(Signature) ___________________ (Title)________________________"

2. The Annual Monitoring Report shall contain both tabular and graphical summaries of the monitoring data obtained during the previous year. In addition, the Permittee shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with the waste discharge requirements.

3. Monitoring Program Reporting shall be consistent with the following standard requirements where applicable:

   a. The Permittee shall file with the Board technical reports on self monitoring work performed according to the detailed specifications contained in the Monitoring Program as directed by the Executive Officer;

   b. In reporting the monitoring data, the Permittee shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernable. The data shall be summarized to demonstrate compliance with waste discharge requirements and, where applicable, shall include results of receiving water observations;

   c. Each monitoring report must affirm in writing that "all analyses were conducted at a laboratory certified for such analyses by the Department of Health Services or approved by the Executive Officer and in accordance with current EPA guideline procedures or as specified in this Monitoring Program";

   d. Each report shall contain the following completed declaration:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted.

Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility, of a fine and imprisonment for knowing violations.

Executed on the ___ day of ________, 19__,

at _________________________.

(Signature)_______________(Title)_________________";

e. If no flow occurred during the reporting period, the monitoring report shall so state;

f. For any analyses performed for which no procedure is specified in the EPA guidelines or in the monitoring and Reporting Program, the constituent or parameter analyzed and the method or procedure used must be specified in the monitoring report; and

g. The Executive Officer may make modifications to the approved monitoring program as deemed necessary.

D. Duty to Comply [40 CFR 122.41(a)]

1. The Permittee must comply with all of the terms, requirements, and conditions of this order. Any violation of this order constitutes a violation of the Clean Water Act, its regulations and the California Water Code, and is grounds for enforcement action, Order termination, Order revocation and reissuance, denial of an application for reissuance; or a combination thereof.

2. A copy of these waste discharge specifications shall be maintained by the Permittee so as to be available at all times to Permittee employees and members of the public.

3. Any discharge of wastes at any point(s) other than specifically described in this Order is prohibited, and constitutes a violation of the Order.

E. Duty to Mitigate [40 CFR 122.41 9d]

1. The Permittee shall take all reasonable steps to minimize or prevent any

discharge that has a reasonable likelihood of adversely affecting human health or the environment.

F. Inspection and Entry [40CFR 122.41(I)

1. The Regional Board, USEPA, and other authorized representatives shall be allowed:

   a. Entry upon premises where a regulated facility is located or conducted, or where records are kept under conditions of this Order;

   b. Access to copy any records that are kept under the conditions of this Order;

   c. To inspect any facility, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Order; and

   d. To photograph, sample, and monitor for the purpose of assuring compliance with this Order, or as otherwise authorized by the Clean Water Act and the California Water Code.

G. Proper Operation and Maintenance [40 CFR 122.41 (e)]

1. The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control including sludge use and disposal facilities (and related appurtenances) that are installed or used by the Permittee to achieve compliance with this Order. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar system that are installed by a Permittee only when necessary to achieve compliance with the conditions of this Order.

H. Signatory Requirements [40 CFR 122.41]

1. Except as otherwise provided in this Order, all applications, reports, or information submitted to the Regional Board shall be signed by the Director of Public Works or City Engineer under penalty of perjury.

I. Reopener and Modification [40 CFR 122.41(f)]

1. This Order may only be modified, revoked, or reissued, prior to the expiration date, by the Regional Board, in accordance with the procedural requirements of the Water Code and Title 23 of the California Code Regulations for the issuance of waste discharge requirements, and upon prior notice and hearing, to:

a. Address changed conditions or new information identified in the required reports or other sources deemed significant by the Regional Board;
b. Incorporate applicable requirements or statewide water quality control plans adopted by the State Board or amendments to the Basin Plan;
c. Comply with any applicable requirements, guidelines, and/or regulations issued or approved pursuant to CWA Section 402(p); and/or
d. Consider any other federal, or state laws or regulations that became effective after adoption of this Order.

2. After notice and opportunity for a hearing, this Order may be terminated or modified for cause, including, but not limited to:

a. Violation of any term or condition contained in this Order;
b. Obtaining this Order by misrepresentation, or failure to disclose all relevant facts; or
c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

3. This Order may be modified, revoked and reissued, or terminated for cause.

4. The filing of a request by the Permittee for a modification, revocation and re-issuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any condition of this Order.

5. This Order may be modified to make corrections or allowances for changes in the permitted activity listed in this section, without following the procedures at 40 CFR Part 122.25, if processed as a minor modification. Minor modifications may only:

a. Correct typographical errors
b. Require more frequent monitoring or reporting by the Permitee.

J. Severability

1. The provisions of this permit are severable; and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected.

K. Duty to Provide Information [40 CFR 122.41 (h)

1. The Permittee shall furnish, within a reasonable time, any information the Regional Board or US EPA may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this Order. The Permittee shall also furnish to the Regional Board, upon request, copies of records required to be kept by this Order.

L. Twenty-four Hour Reporting

1. The Permittee shall report any noncompliance that may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the Permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the Permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times and, if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

   The following shall be included as information that must be reported within 24 hours under this paragraph:

   a. Any unanticipated bypass release that exceeds any effluent limitation in the Order;

   b. Any condition upset that exceeds any effluent limitation in the Order; or

   c. Violation of a maximum daily discharge limitation for any of the pollutants listed in this Order to be reported within 24 hours.

   The Regional Board may waive the above-required written report on a case-by-case basis.

M. Bypass [40 CFR 122.41(m)]

1. Bypass (the intentional diversion of waste streams from any portion of a treatment facility) is prohibited. The Regional Board may take enforcement action against the Permittee for bypass unless:

   a. Bypass was unavoidable to prevent loss of life, personal injury or severe property damage. (Severe property damage means substantial physical damage to property, damage to the treatment facilities that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.);

   b. There were no feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated waste, or maintenance during normal periods of equipment down time. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass that could occur during normal periods of equipment downtime or preventive maintenance;

c. The Permittee submitted a notice at least ten days in advance of the need for a bypass to the Regional Board; or

d. The Permittee may allow a bypass to occur that does not cause effluent limitations to be exceeded, but only if it is for essential maintenance to assure efficient operation. In such a case, the above bypass conditions are not applicable. The Permittee shall submit notice of an unanticipated bypass as required.

N. Upset [40 CFR 122.41(n)]

1. A Permittee that wishes to establish the affirmative defense of an upset in an action brought for non compliance shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

   a. an upset occurred and that the Permittee can identify the cause(s) of the upset;

   b. the permitted facility was being properly operated by the time of the upset;

   c. the Permittee submitted notice of the upset as required; and

   d. the Permittee complied with any remedial measures required.

No determination made before an action for noncompliance, such as during administrative review of claims that non-compliance was caused by an upset, is final administrative action subject to judicial review.

In any enforcement proceeding, the Permittee seeking to establish the occurrence of an upset has the burden of proof.

O. Property Rights [40 CFR 122.41 (h)]

1. This Order does not convey any property rights of any sort, or any exclusive privilege.

P. Enforcement

Violation of any of the provisions of this NPDES permit or any of the provisions of this Order may subject the violator to any of the penalties described herein, or any combination thereof, at the discretion of the prosecuting authority; except that only one kind of penalty may be applied for each kind of violation.

1. The California Water Code provides that any person who violates a waste discharge requirement or a provision of the California Water Code is subject to civil penalties of up to $5,000 per day, $10,000 per day, or $25,000 per day of

violation, or when the violation involves the discharge of pollutants, is subject to civil penalties of up to $10 per gallon per day or $25 per gallon per day of violation; or some combination thereof, depending on the violation, or upon the combination of violations.

2. The Federal Clean Water Act (CWA) provides that any person who violates a permit condition or any requirement imposed in a pretreatment program implementing sections 301, 302, 306, 307, 308, 318 or 405 of the CWA is subject to a civil penalty not to exceed $25,000 per day of such violation. Any person who willfully or negligently violates permit conditions implementing these sections of the CWA is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or both. Any person who knowingly violates permit conditions implementing these sections of the CWA is subject to a fine of not less than $5,000, or more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or by both.

3. The Clean Water Act provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, or other document submitted or required to be maintained under this Order, or who knowingly falsifies, tampers with, or renders inaccurate any monitoring device or method required to be maintained under this act, shall upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 2 years per violation, or by both.

Q. Need to Halt or Reduce Activity not a Defense [40 CFR 122.41(c)

1. It shall not be a defense for a Permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this Order.

R. Other Information

1. Should the Permittee discover that it failed to submit any relevant facts or that it submitted incorrect information in a report, it shall promptly submit the missing or correct information.

2. The Permittee shall report all instances of non-compliance not otherwise reported at the time monitoring reports are submitted.

3. The Permittee shall mail a copy of each monitoring report to:

INFORMATION TECHNOLOGY
CALIFORNIA REGIONAL WATER QUALITY
CONTROL BOARD - LOS ANGELES REGION
320 W. 4TH STREET, SUITE 200
LOS ANGELES, CA 90013

A copy of the monitoring report shall also be mailed to:

REGIONAL ADMINISTRATOR
ENVIRONMENTAL PROTECTION AGENCY
REGION 9
75 Hawthorne Street
San Francisco, CA 94105

S. Definitions

1. "Construction" means constructing, clearing, grading, or excavation that results in soil disturbance. Construction includes structure tear-down. It does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of facility, nor does it include emergency construction activities required to immediately protect public health and safety.

2. "Development construction projects" are those projects constructed on privately and publicly owned land outside the public street right of way. For projects constructed within the public street right of way, refer to Section 2, Municipal Construction Activities.

3. "Discretionary project" is a project which requires the exercise of judgement or deliberation when the public agency or body decides to approve or disapproves a particular activity, as distinguished from situations where the public agency or body merely has to determine whether there has been conformity with applicable statues, ordinances, or regulations.

4. "Environmentally Sensitive Areas" means an area designated as an Area of Special Biological Significance by the State Water Resources Control Board or an area designated as a significant natural area by the California Resources Agency or an area designated as an area of Ecological Significance by the County of Los Angeles.

5. "Grab sample" is defined as any individual sample collected in a short period of time not exceeding 15 minutes. "Grab samples" shall be collected during normal peak loading conditions for the parameter of interest, which may or may not be during hydraulic peaks. It is used primarily in determining compliance with "daily maximum" limits and the "instantaneous maximum" limits.

6. "Hazardous substance" is a material defined under 40 Code of Federal Regulations (CFR) § 302. These are categorized as either "listed" or "unlisted" hazardous substances. Listed hazardous substances are certain items of solid waste that exhibit characteristics identified in 40 CFR § 261.2 through 261.24. Examples of hazardous substances include any substance or chemical product for which one or more of the following applies:

   - A material safety data sheet (MSDS) is required
   - The substance is listed as radioactive by the Nuclear Regulatory Commission

- The substance is listed as hazardous by the U.S. Department of Transportation
- The material is listed in Labor Code § 6382(b)

The above four categories are described in the California Health and Safety Code, Division 20, Chapter 6.95, Hazardous Materials Release Response Plans and Inventory.

7. "Illicit Connection" is any man-made conveyance that is connected to the storm drain system without a permit or through which prohibited non-storm water flows are discharged, excluding roof-drains and other similar type connections. Examples include channels, pipelines, conduits, inlets, or outlets that are connected directly to the storm drain system.

8. "Illicit Discharge" is any discharge to the storm drain system that is prohibited under local, state, or federal statutes, ordinances, codes, or regulations. The term illicit discharge includes all non storm-water discharges except discharges pursuant to an NPDES permit, discharges that are identified in Part 2 of this order, and discharges authorized by the Regional Board Executive Officer.

9. "Illicit Disposal" is any disposal, either intentionally or unintentionally, of material(s) or waste(s) that can pollute storm water or urban runoff.

10. "Median" of an ordered set of values is the value which the values above and below is an equal number of values, or which is the arithmetic mean of the two middle values, if there is no one middle value.

11. "Ministerial" [approval] describes a government decision involving little or no personal judgement by the public official as to the wisdom or manner of carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgement in reaching a decision. A ministerial action involves the use of fixed standards or objective measurements, and the public official cannot use personal, subjective judgement in deciding whether or how the project should be carried out. [Section 15369 of CEQA Guidelines]

12. "Non-Storm Water Discharge" means discharge other than storm water runoff or snow melt.

13. "Potable water sources" means flows from drinking water storage, supply and distribution systems including flows from system failures, pressure releases, system maintenance, well development, pump testing, fire hydrant flow testing; and flushing and dewatering of pipes, reservoirs, vaults, and wells.

14. "Priority pollutants" are those constituents referred to in 40 CFR 401.15 and listed in the EPA NPDES Application Form 2C, pp. V-3 through V-9.

15. "Sidewalk Washing" means pressure washing of paved pedestrian walkways with only water and properly disposing of all debris collected.

16. "Source Control BMPs" are activities, plans, policies, management practices and maintenance procedures, which are designed to control pollutants from entering the storm drain system.

17. "Square feet" for commercial development means total impermeable area including parking area.

18. "Storm water discharges associated with industrial activity" is defined at 40 CFR § 122.26(b)(14)(i) through (xi), and refers to eleven categories of activities required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharges.

19. "Toxic pollutant" means any pollutant listed as toxic under section 307(a)(1) of the Clean Water Act or under 40 CFR 122, Appendix D.

20. "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with effluent limitations because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper action.

21. "Water Quality Standards and Water Quality Objectives" applicable to the Permittee include those contained in the Los Angeles Regional Water Quality Control Plan (Basin Plan), the California Ocean Plan, the National Toxics Rule, and other state or federally approved surface water quality plans. Such plans are used by the Regional Board to regulate all discharges, including storm water discharges.

22. "Wet Season" means the calendar period beginning October 1 through April 15.

23. "Wet Weather" means a storm event that generates runoff 0.10 inches or more over a 24-hour period.

This Order expires on June 29, 2004. The Permittee must submit a complete Report of Waste Discharge (ROWD) in accordance with Title 23, California Code of Regulations, not later than 180 days in advance of such date as application for reissuance of waste discharge requirements.

I, Dennis A. Dickerson, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on June 30, 1999.

DENNIS A. DICKERSON
Executive Officer

June 30, 1999
Date

APPENDIX A
CITY OF LONG BEACH
STORM WATER MANAGEMENT PROGRAM

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R0008628

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SECTION 6. MANAGEMENT PROGRAM FOR ILLICIT DISCHARGES AND ILLICIT CONNECTIONS (cont'd.)

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APPENDIX B
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TABLE 5-1. SOURCE CONTROL BMPs

SOURCE CONTROL BEST MANAGEMENT PRACTICES	BMP[1]
Non-Storm Water Discharges to Drains	SC1
Vehicle and Equipment Fueling	SWQTF Guide[2]
Vehicle and Equipment Washing and Steam Cleaning	SC3
Vehicle and Equipment Maintenance and Repair	SC4
Outdoor Loading/Unloading of Materials	SC5
Outdoor Container Storage of Liquids	SC6
Outdoor Process Equipment Operations And Maintenance	SC7
utdoor Storage of Raw Materials, Products, and By-Products	SC8
Waste Handling and Disposal	SC9
Contaminated or Erodible Surface Areas	SC10
Building and Grounds Maintenance	SC11
Building Repair, Remodeling, and Construction	SC12
Over-Water Activities	SC13
Employee Training	SC14

[1] Numbers refer to California Best Management Practices Handbook
[2] *Best Management Practice Guide: Retail Gasoline Outlets, California Storm Water Quality Task Force (1997)*

APPENDIX C

STORM WATER MONITORING PROGRAM

CITY OF LONG BEACH

A. Monitoring Plan

The Permittee shall prepare, maintain, and update, if necessary, a monitoring plan which shall include at a minimum, the following:

1. Quality control, quality assurance, data collection, storage and analyses, and detection limits;
2. All sample collection, handling, storage, and analyses in accordance with 40 CFR 136;
3. Location of monitoring stations, constituents, and sampling frequency;
4. Targeted monitoring indicators (e. g., ecosystem, biological diversity, in stream toxicity, habitat, chemical, sediment, stream health) chosen for monitoring;
5. Statistical methods used to design studies, conduct sampling, and interpret data;
6. A description of the role and responsibilities of all the participants in monitoring studies
7. A description of computer software and modeling programs that will be utilized to assess data, interpret information; and
8. A general description of how data are intended to be utilized for feedback into the storm water management program.

An up-to-date Monitoring Plan shall be submitted to the Regional Board Executive Officer, when so requested.

B. Monitoring Program

1. The following monitoring program is designed to meet the objectives as stated in this Order:

   a. Beginning Year 1, the Permitee will monitor and test for mass emissions and toxicity at three representative storm drain sites, utilizing end of pipe outfall testing.

   b. In Year 1, the Permitee will monitor one receiving water body (Alamitos Bay) and conduct water column testing for bacteria and toxicity near the dry-weather diversion storm drain outfall.

   c. In Year 2, the Permitee will monitor one receiving water body (Alamitos Bay) and report on the effectiveness of the dry weather diversion on water quality.

d. Beginning Year 3, the Permittee will monitor and test for mass emissions and toxicity at a site on Los Cerritos Channel

e. In Years 3 through 5, the Permitee proposes to co-fund plume, benthic and toxicity studies, based on "fair share" participation as designated by the Los Angeles Regional Water Quality Control Board (Regional Board) for receiving waters in the Los Angeles River and San Gabriel River watersheds.

g. The Permittee will monitor mass emission stations according to the following schedule provided there are sufficient storm events during the season:

Storm Season	Number of Stations	Number of Events/Storm Season
1999-2000	Three	Two dry-weather, four wet-weather
2000-2001	Three	Two dry-weather, four wet-weather
2001-2004	Four + n	Two dry and four wet-weather + n

n is to be determined by "fair share" allocation in Year 3.

2. Mass Emission Station Monitoring

a. The Permittee shall monitor a total of four mass emission stations: three stations (Dominguez Gap, Bouton Creek and Alamitos Bay) beginning the 1999-2000 monitoring season and the fourth (Los Cerritos Channel) beginning in the Year 2000-2001 monitoring season. Additional monitoring for the Los Angeles River and San Gabriel River watersheds is dependent on "fair share" allocation by the Regional Board. The Permittee will monitor up to six station events per year including dry weather sampling.

b. All samples for mass emissions monitoring may be taken with an automatic sampler or equivalent except for the following constituents: (i) pathogen indicators and (iii) oil and grease. These constituents must be collected as grab samples, unless the Regional Board approves an alternative method after request. The samplers shall be set to monitor storms totaling 0.25 inches or greater of rainfall. The constituents to be analyzed are listed on page C-5 through C-9.

c. If a constituent is not detected at the method detection limit (MDL) for its respective test method listed on pages C-5 though C-9 in more than 75 percent of the first 48 sampling events, it will not be further analyzed unless the observed occurrences show concentrations greater than state water quality standards. The Permittee will also conduct annual confirmation sampling for non-detected constituents at each station for as long as the station is monitored.

3. Receiving Waters Study

a. The Permittee will conduct one receiving water study during the 1999-2000 and 2000-2001 monitoring season to evaluate the effectiveness of dry weather diversion.

b. The Permittee proposes, in Years 3 through 5, in conjunction with other "fair share" participants, to fund a study of receiving waters for Los Angeles River and San Gabriel River watersheds. The purpose of the study will be to study the impacts, if any, of storm water/non-storm water discharges on the beneficial uses of the Los Angeles River/ San Pedro Bay and San Gabriel River. The study may include the following distinct components:

i. Plume Study:

- Map the spatial and temporal structure of the runoff plumes and as it flows into the bay or estuary following strong winter storms.
- Examine the interaction between the runoff plume and ocean processes as they affect the advection, dispersion, and mixing of the plume.
- Evaluate the impact of storm runoff plumes on beneficial uses of the coastal ocean.
- Characterize the optical properties of the suspended particulate material ("SPM") and dissolved organic material ("DOM") associated with runoff sources.
- Examine the effects of DOM and SPM on the water column optics and the distribution of nutrient concentrations, as the same may affect phytoplankton productivity.
- Assist in establishing appropriate locations for benthic study stations.

ii. Benthic Study:

- Water quality (dissolved oxygen, salinity, density, temperature, light transmissivity and pH).
- Sediment grain size, sediment organic concentrations and sediment contaminant concentrations.
- The structure of the benthic invertebrate community.

iii. Water Column Toxicity Study:

- Multiple specie (mysid, sea urchin, ceriodaphnia) bioassays.
- Phase I TIE tests.

iv. Sediment Toxicity Study:

- Amphipod survival bioassays of sediment samples from stations (including reference sites).
- Multi-species bioassays will be conducted for chronic toxicity in sediment samples from sampling stations, plus 1 reference site.

- Chemical analysis of multi-species growth test tissue samples will be conducted for organics and metals.

- Phase I TIE tests using sea urchin fertilization of interstitial water will be conducted for samples from stations identified to be toxic in amphipod survival bioassays.

4. Toxicity Identification Evaluation Procedure

   a. The Permittee will conduct Phase 1 TIE on dry weather samples when two consecutive dry weather samples from the same monitoring station show toxicity.

   b. The Permittee will conduct Phase 1 TIE on wet weather samples when three consecutive wet weather samples from the same monitoring station show toxicity.

   c. The Permittee will, once the cause(s) of toxicity has been determined, discuss separately in the Annual Monitoring Report, the following:

      i. the potential sources of the pollutant(s) causing toxicity,
      ii. proposed special studies to verify the sources(s) of the pollutant(s) causing toxicity
      iii. proposed special studies to identify BMPs to reduce the pollutant(s) causing toxicity
      iv. proposed changes to the LBSWMP to reduce the pollutants causing toxicity, and
      v. follow-up monitoring to demonstrate that toxicity has been removed.

   The Regional Board Executive Officer may direct the Permittee to submit the above report earlier than the scheduled Annual Monitoring Report.

LIST OF CONSTITUENTS IN MONITORING PROGRAM AND ANALYTICAL METHODS

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Conventional Pollutants		(mg/L)
Oil and Grease	1664	
Total Phenols	420.1	
Cyanide	335.2	0.01 mg/L
pH	150.1	0-14 mg/L
Temperature		None
Dissolved Oxygen	---	Sensitivity to 5 mg/L
Bacteria		
Total Coliform	9221 B	<20mpn/1 00ml
Fecal Coliform	9221 B	<20mpn/100ml
Fecal Streptococcus	9221 B	<20mpn/100ml
General		
Dissolved Phosphorus	300	0.05 mg/L
Total Phosphorus	300	0.05 mg/L
Turbidity	180.1	0. 1 NTU
Total Suspended Solids	160.2	2 mg/L
Total Dissolved Solids	160.1	2 mg/L
Volatile Suspended Solids	160.4	2 mg/L
Total Organic Carbon	415.1	1 mg/L
Total Petroleum Hydrocarbon	418.1	1 mg/L
Biochemical Oxygen Demand	405.1	2 mg/L
Chemical Oxygen Demand	410.4	20-900 mg/L
Total Ammonia-Nitrogen	350.2	0.1 mg/L
Total Kjeldahl Nitrogen	351.2	0.1 mg/L
Nitrate-Nitrite	4110	0.1 mg/L
Alkalinity	310.1	2 mg/L
Specific Conductance	120.1	1 umho/cm
Total Hardness	130.2	2 mg/L
MBAS	425.1	<0. 5 mg/L
Chloride	4110	2 mg/L
Fluoride	4110	0.1 mg/L
Sulfate	4110	2 mg/L

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Metals (Total and Soluble)		(ug/L)
Aluminum	202.1	100 ug/L
Arsenic	206.2	10 ug/L
Beryllium	210.2	5 ug/L
Cadmium	213.2	10 ug/L
Chromium	218.2	10 ug/L
Copper	219.2	10 ug/L
Hex. Chromium	7196	<10 ug/L
Iron	236.2	100 ug/L
Lead	239.2	10 ug/L
Mercury	245.1	1 ug/L
Nickel	249.2	10 ug/L
Zinc	289.2	50 ug/L
Base/Neutral Acids		
Benzoic Acid	8250	<5 ug/L
Benzyl Alcohol	8250	<5 ug/L
2-Chlorophenol	8250	<2 ug/L
2, 4-Dichlorophenol	8250	<2 ug/L
2, 6-Dichlorophenol	8250	<2 ug/L
4-Dimetylphenol	8250	<2 ug/L
4, 6-Di n itro-2-mety I	8250	<3 ug/L
2-Methylphenol	8250	<3 ug/L
4-Methylphenol	8250	<3 ug/L
2-Nitrophenol	8250	<3 ug/L
4-Nitrophenol	8250	<3 ug/L
4-Ch loro-3-methy I phenol	8250	<3 ug/L
Pentachlorophenol	8250	<2 ug/L
Phenol	8250	<1 ug/L
2,3,4,6-Tetrachlorophenol	8250	
2,4,5-Trichlorophenol	8250	
2,4,6-Trichlorophenol	8250	
Semivolatile Organic Compounds		
Acenapthene	625	
Acenapthylene	625	
Acetophenone	625	
Aniline	625	
Anthracene	625	
4-Aminobiphenyl	625	
Benzidine	625	
Benzo(a)anthracene	625	
4-Chloroaniline	625	
1-Chloronapthalene	625	
p-Dimethylaminoazobenzene	625	

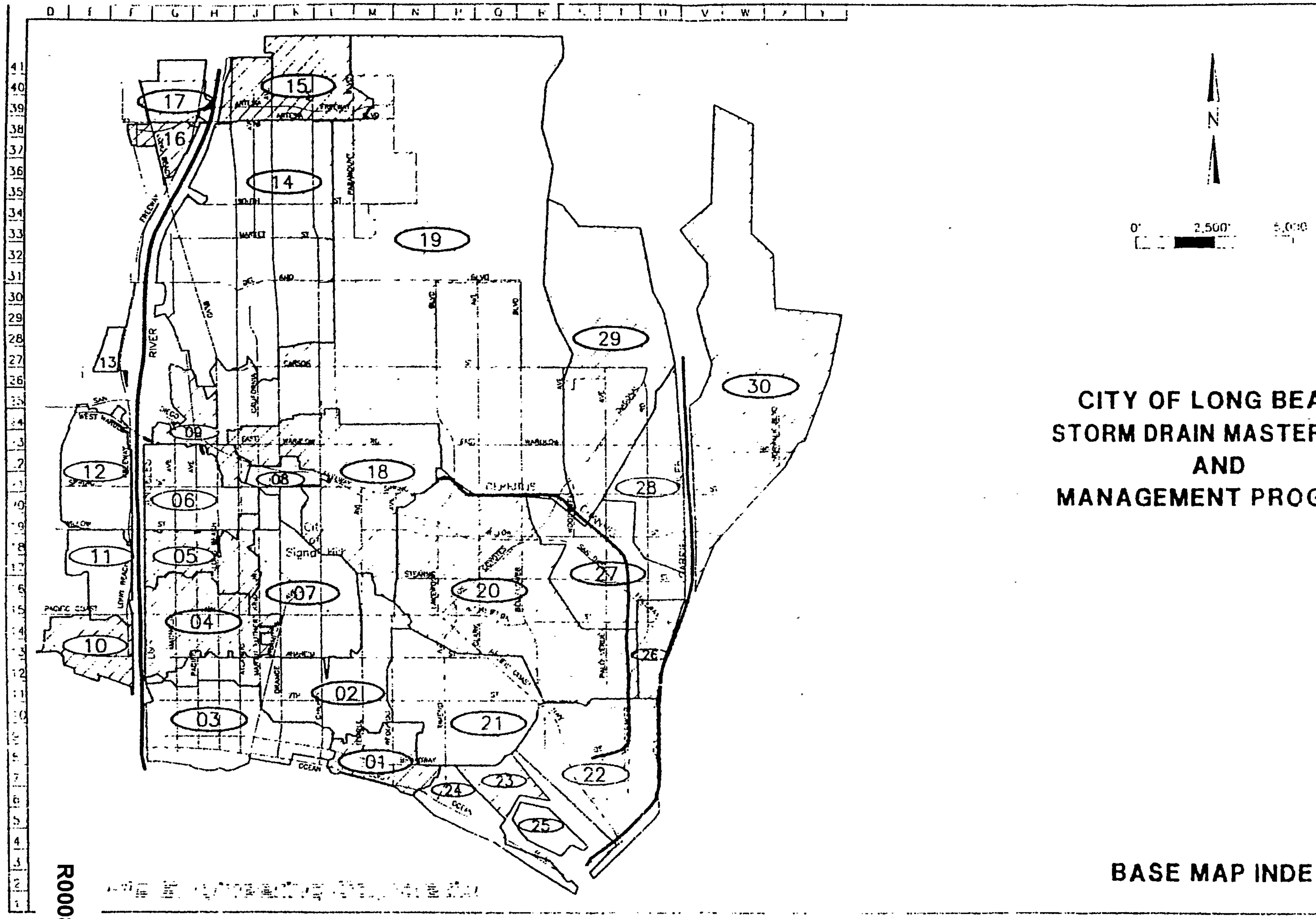
CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Semivolatile Organic Compounds (Continued)		
7,12-Dimethylbenz(a)-anthracene	625	
a-,a-Dimethylphenethylamine	625	
Benzo(a)pyrene	625	
Benzo(b)flouranthene	625	
Benzo(k)flouranthene	625	
Chlordane	625	
Bis(2-chloroethoxy)methane	625	
Bis(2-chlorisopropyl)ether	625	
Bis(2-chloroethyl)ether	625	
Bis(2-ethylhexyl)phthalate	625	
4-Bromophenyl phenyl ether	625	
Butyl benzyl phthalate	625	
2-Chloronapthalene	625	
4-Chlorophenyl phenyl ether	625	
Chrysene	625	
Dibenz(a,j)acridine	625	
Dibenz(a,h)anthracene	625	
1, 3-Dichlorobenzene	625	
1, 4-Dichlorobenzene	625	
1, 2-Dichlorobenzene	625	
3, 3-Dichlorobenzidine	625	
Diethylphthalate	625	
Dimethy lphtha late	625	
Di-n-butylphthalate	625	
2,4-Dinitrotoluene	625	
2, 6-Dinitrotoluene	625	
Diphenylarnine	625	
1, 2-Diphenylhydrazine	625	
Di-n-octylphtalate	625	
Ethyl methanesulfonate	625	
Fluoranthene	625	
Fluorene	625	
Hexachlorobenzene	625	
Hexachlorobutadiene	625	
Hexachlorocyclopentadiene	625	
Hexachloroethane	625	
Indeno(l, 2, 3-cd)pyrene	625	
Isophorone	625	
3-Methylcholanthrene	625	
Methyl methanesulfonate	625	
Napthalene	625	
1–Napthylamine	625	
2-Napthylamine	625	
2-Nitroaniline	625	
3-Nitroaniline	625	
4-Nitroaniline	625	
Nitrobenzene	625	

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Semivolatile Organic Compounds (Continued)		
N-Nitroso-di-n-butylamine	625	
N -N itrosod imethy la mine	625	
N-Nitrosodiphenylamine	625	
N -N itroso-d i-N -propyla mine	625	
N-Nitrosopiperidine	625	
Pentachlorobenzene	625	
Phenacitin	625	
Phenanthrene	625	
2-Picoline	625	
Pronamide	625	
Pyrene	625	
5-Tetrachlorobenzene	625	
1, 2, 4,-Trichlorobenzene	625	
Pesticides		
Aldrin	8080	
alpha-BHC	8080	
beta-BHC	8080	
delta-BHC	8080	
gamma-BHC (Lindane)	8080	
Carbofuran	8080	
Chlordane	8080	
4, 4'-DDD	8080	
4, 4'-DDE	8080	
4, 4'-DDT	8080	
Benzaton	8080	
Dieldrin	8080	
Endosulfan 1	8080	
Endosulfan 11	8080	
Endosulfan sulfate	8080	
Endrin	8080	
Endrin aldehyde	8080	
Glyphosate	8080	
Heptachlor	8080	
Heptachlor epoxide	8080	
Methoxychlor	8080	
Toxaphene	8080	
2,4-D	8080	
2,4,5-TP-SILVEX	8080	
Polychlorinated Biphenyls		
Aroclor-1016		
Aroclor-1221		
Aroclor-1 232		
Aroclor-1242		
Aroclor-1248		

CONSTITUENTS	USEPA METHOD	DETECTION LIMIT
Aroclor-1254		
Aroclor-1260		
Herbicides		
Diazinon	8140	
Chlorpyrifos	8140	
Diuron	8140	
Malathion	8150	
Prometryn	8150	
Atrazine	8150	
Simazine	8150	
Cyanazine	8150	
Molinate	8150	
Thiobencarb	8150	
Methyl tertiary butyl ether (MTBE)	8020	

APPENDIX D

MAPS

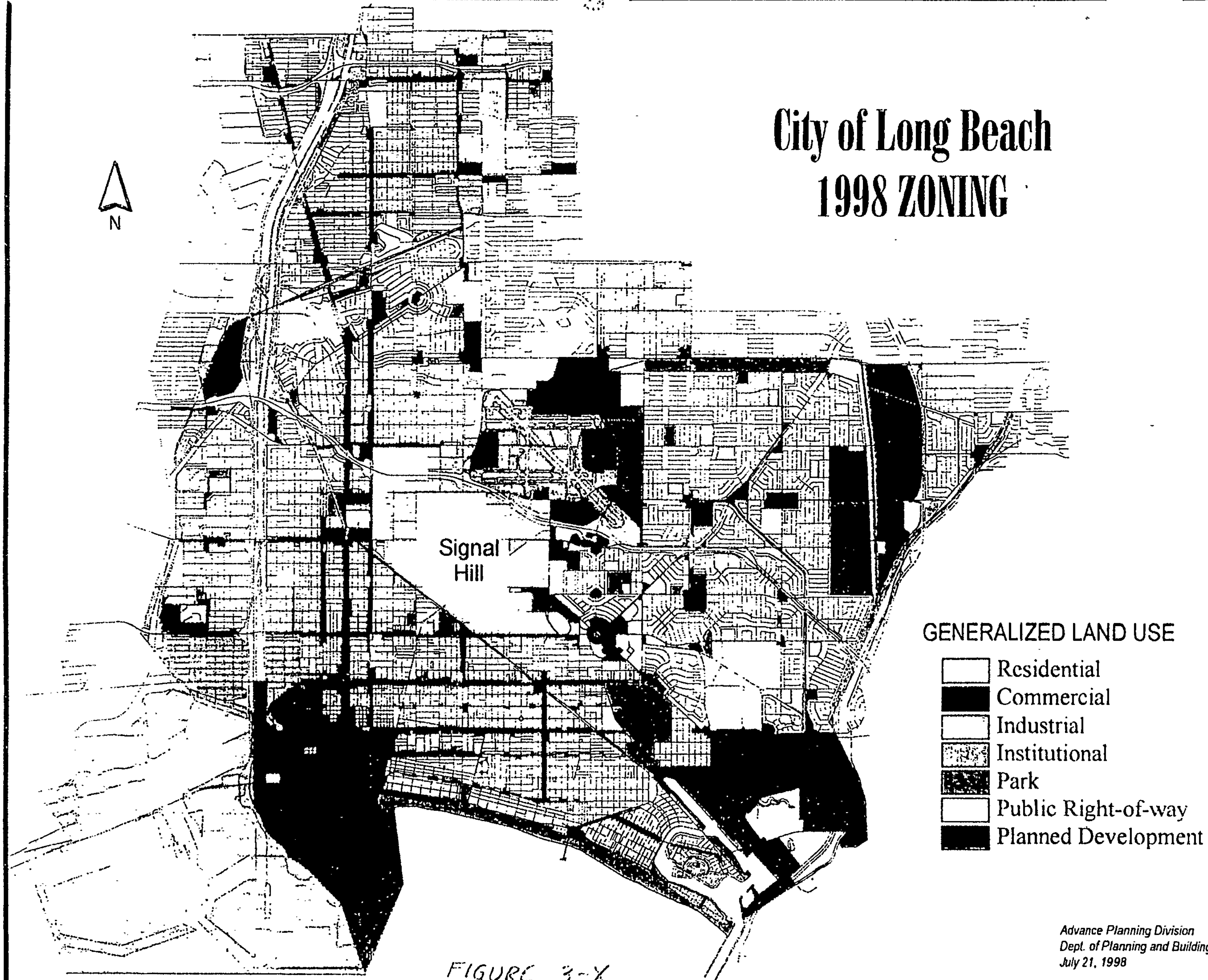


CITY OF LONG BEACH
STORM DRAIN MASTER PLAN
AND
MANAGEMENT PROGRAM

BASE MAP INDEX

R0008645

City of Long Beach
1998 ZONING



Advance Planning Division
Dept. of Planning and Building
July 21, 1998

FIGURE 3-X

3-27

R0008646

ANNOUNCEMENT

NPDES–DEVELOPMENT PLANNING FOR STORMWATER MANAGEMENT

On July 15, 1996, the Regional Water Quality Control Board (RWQCB), Los Angeles Region, adopted Order No. 96-054 ("Permit"). Under the Permit, the County of Los Angeles is designated as the Principal Permittee and the 85 incorporated cities as co-Permittees. In February 2000, the RWQCB adopted a Resolution that established Standard Urban Stormwater Mitigation Plan (SUSMP) criteria for priority projects for the Permittees described in Part A and Part B of the attached table.

The primary objectives are to:

- Effectively prohibit non-stormwater discharges, and
- Reduce the discharge of pollutants from stormwater conveyance systems to the maximum extent practicable

The Los Angeles County Department of Public Works (DPW) is responsible for the implementation of SUSMP requirements in the County unincorporated areas (excluding the Antelope Valley area) and all County-owned facilities. Development and redevelopment projects falling into either Parts A or B of the attached table will be required to obtain SUSMP approvals. Details of facilities and measures that mitigate impacts to water quality must be shown on improvement plans and reviewed as part of those plans.

Information regarding the preparation of SUSMP is available on our website (*link to* SUSMP Plan on www.888CleanLA.com).

SUSMP pertaining to new subdivisions will be reviewed by DPW's Land Development Division. Please call Steve Burger at (626) 458-4943 with any questions (Monday through Thursday).

SUSMP for single-lot developments will be reviewed by DPW's Building and Safety Division. Please contact Mitch Miller at (626) 458-6390 with any questions pertaining to these developments (Monday through Thursday).

In addition, SUSMP for non-residential projects will be reviewed by DPW's Environmental Programs Division. Related questions should be directed to the Industrial Waste Unit of Environmental Programs Division at (626) 458-3517 (Monday through Thursday).

Attachment: SUSMP Project Types, Characteristics and Activities, Parts A and B.

SUSMP Project Types, Characteristics, and Activities
Part A. Type of Proposed Project:
A 10+ home subdivision
A 100,000+ square-foot commercial development[1, 2]
An automotive repair shop (SIC codes 5013, 5014, 5541, 7532-7534, and 7536-7539)[3]
A retail gasoline outlet
A restaurant (SIC code 5812)[4]
A hillside-located single-family dewelling[5]
Parking lots 5,000 square feet or more or with 25 or more parking spaces and potentially exposed to stormwater runoff
Location within or directly adjacent to or discharging directly to an environmentally sensitive area

Part B. Project Characteristics or Activities:
Automotive or Equipment Repair and/or Maintenance
Automotive or Equipment Washing or Cleaning Area(s)
Gas Station or Fuel Dispensing
Outdoor Material or Waste Handling or Storage
Chemical handling and/or storage of petroleum products, paints, solvents, concrete, or hazardous waste?
Outdoor Equipment or Product Fabrication including welding; cutting; sawing; metal fabrication; assembly; application of paints, coatings, or finishes; pre-cast concrete fabrication, etc.
Outdoor Areas for Equipment or Machinery Repair and/or Maintenance
Dry Cleaning Factory
Food Service
Food Processing Plant
Animal Slaughtering
Animal Confinement, Pet Care Facilities, Stables, Kennels, etc.
10 or More Dwelling Units
Hillside Location[5]

[1] "100,000 Square Foot Commercial Development" means any commercial development that creates at least 100,000 square feet of impermeable area, including parking areas.

[2] "Commercial Development" means any development on private land that is not heavy industrial or residential. The category includes, but is not limited to: hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, multi-apartment buildings, car was facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, and public warehouses and other light industrial complexes.

[3] "Automotive Repair Shop" means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

[4] "Restaurant" means a stand-alone facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812).

[5] "Hillside" means property located in an area with known erosivesoil conditions, where the development contemplates grading on any natural slope that is 25 percent or greater.

NATURAL RESOURCES DEFENSE COUNCIL

February 23, 2000

Via Certified Mail (Return Receipt Requested)

Ms. Carol Browner
Administrator
United States Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

Ms. Felicia Marcus
Regional Administrator
United States Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Re: Petition to Correct Deficiencies or Withdraw EPA Approval; Delegated Clean Water Act Authority; Storm Water, Los Angeles Regional Water Quality Control Board (40 C.F.R. § 123.64)

Dear Administrator Browner and Regional Administrator Marcus:

Enclosed please find the Natural Resources Defense Council's formal petition to commence proceedings to withdraw EPA approval of the delegated NPDES storm water program administered by the Los Angeles Regional Water Quality Control Board ("Water Board").

By any objective measure, the Water Board has failed to control storm water and urban runoff in the Los Angeles region, thereby creating what is increasingly recognized as one of the worst runoff pollution problems in the nation. As demonstrated in our petition, the Water Board's failure violates the Clean Water Act, EPA regulations, and the express terms of EPA's NPDES Memorandum of Agreement with the State of California.

By correcting the extreme deficiencies that currently exist in the Water Board's storm water program, there is a great opportunity to improve the environment and reduce public health risks that impact tens of millions of people who use the Santa Monica Bay, San Pedro Bay, the Ventura County coastline, and many adjacent waters. We hope that EPA and the State of California will seize this opportunity to bring this program into compliance with the law, thereby benefiting the more than ten million residents of the

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Suite 250
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323 934-6900
Fax 323 934-1210

www.nrdc.org

71 Stevenson Street
Suite 1825
San Francisco, CA 94105
415 777-0220
Fax 415 495-5996

1200 New York Ave., N.W.
Suite 400
Washington, DC 20005
202 289-6868
Fax 202 289-1060

40 West 20th Street
New York, NY 10011
212 727-2700
Fax 212 727-1773

region and the more than 60 million people who visit area beaches annually.

Should you have any questions, please do not hesitate to contact me at (323) 934-6900.

Sincerely,

David S. Beckman
Senior Attorney

Enclosure

cc: Ms. Alexis Strauss, Director, Water Division, EPA Region IX
Arthur G. Baggett, Jr., Esq., Member, State Water Resources Control Board
Mr. Walt Petitt, Executive Director, State Water Resources Control Board
H. David Nahai, Esq., Chairman, Los Angeles Regional Water Quality Board
Mr. Dennis Dickerson, Executive Officer, Los Angeles RWQCB

DAVID S. BECKMAN, Bar No. 156170
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NATURAL RESOURCES DEFENSE COUNCIL, INC.
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Los Angeles, CA 90048
(323) 934-6900

Counsel for Petitioner
Natural Resources Defense Council

CAROL BROWNER, ADMINISTRATOR
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

In Re Petition of NATURAL RESOURCES DEFENSE COUNCIL for Correction of Legal Deficiencies or Withdrawal of Storm Water Program Administered by Los Angeles Regional Water Quality Control Board	PETITION FOR CORRECTION OF LEGAL DEFICIENCIES OR WITHDRAWAL OF EPA APPROVAL; MEMORANDUM OF POINTS AND AUTHORITIES IN SUPPORT THEREOF [40 C.F.R. §123.64]

Introduction

The Natural Resources Defense Council, Inc., a non-profit environmental organization with over 400,000 members, including 80,000 in California, hereby petitions the Administrator of the United States Environmental Protection Agency to require the immediate correction of legal deficiencies or withdraw EPA approval of the Los Angeles Regional Water Quality Control Board's (hereafter "RWQCB" or "Regional Board") National Pollution Discharge Elimination System Storm Water Permit Program ("Storm Water Program"). 40 C.F.R. § 123.64(b)(1). This petition is brought on the grounds that the State of California, by and through the RWQCB, is not administering the Storm

Water Program in accordance with the provisions of. <u>inter alia</u>, 33 U.S.C. § 1342 and 40 C.F.R. Parts 122 and 123, and that the program meets the criteria for withdrawal of approval as set forth in 40 C.F.R. § 123.63. By any objective measure. the RWQCB's Storm Water Program is wholly inadequate to implement the Clean Water Act or to control polluted urban runoff.

This failure has enormous consequences for the region and its residents. Urban storm water runoff. one of the largest sources of pollution to the coastal and other receiving waters of the nation. is a particularly severe problem in the Los Angeles region. Pollutants conveyed in storm water and urban runoff (collectively referred to herein as "storm water") now constitute the number one source of pollution to Santa Monica Bay and the rest of the region's waterways. Consequently, storm water pollution, which not only harms the environment but has been shown in Los Angeles to cause serious human health impacts, is the most severe water quality problem facing the region. In fact. the severity of the storm water problem in Southern California is such that many experts believe it is the worst problem of its kind in the nation.

However. rather than making storm water a priority during the nearly ten years it has bee.. in charge. the RWQCB has let its storm water permit program fall to such a level that it is completely ineffective and unable to make any significant impact on the problem. While the Board recently has shown signs of shifting its policy stance by adopting strong new development standards. even the best policies are an insufficient response when the regulatory structure to implement them—and other aspects of the program—are entirely missing. In this regard. ***NRDC's Petition demonstrates that the Regional Board inexplicably devotes the least amount of resources to its worst water quality problem: polluted runoff.***

Because of its legal inadequacy and objective ineffectiveness. EPA must withdraw the State's authority. vested in the Regional Board. to oversee the Storm Water Program in Los Angeles unless these deficiencies are corrected within ninety days. 40 C.F.R. § 123.64(b)(8)(iii).

By way of general summary, the major failures of the RWQCB's Storm Water Program include the following:[1]

First. and most fundamentally. the RWQCB has failed to take basic steps consistent with organizing and sustaining an adequate Storm Water Program, starting with the most critical—providing for an adequate level of staffing—through and including the most mundane (yet essential). such as maintaining information. files, and records on its own activities.

Second. the RWQCB has failed to exercise control over the activities required to be regulated under the storm water program. It has failed to issue permits to hundreds, if not thousands. of entities that require them; it has issued a legally defective permit to municipal governments; and it has repeatedly failed to meet deadlines associated with permit implementation.

Third. the RWQCB has failed to inspect and monitor activities subject to the storm water permit program. There are approximately 3,500 active industrial entities in the region subject to the general industrial storm water permit[2] and, by some credible estimates, upwards of 10,000 facilities that should be permitted.[3] Yet. at its current pace. it would take the RWQCB nearly 35 years to perform industrial site inspections at each facility in the region.

Fourth, in part because there have been very few substantive inspections by the RWQCB. the RWQCB has been unable to discover actual permit and other Clean Water Act storm water violations that cause pollution of regional waters. In fact, the vast majority of all formal enforcement actions[4] taken by the RWQCB for storm water violations in the last three years were

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[1] Each of these general claims is substantiated in the sections that follow. These claims, and those contained in the substantive sections of this Petition, *infra*, constitute NRDC's allegations. pursuant to 40 C.F.R. Section 123.63(b)(1).

[2] General Industrial Storm Water Permit Statistics November 1999, at 1 (Los Angeles Regional Water Board 1999).

[3] Heal the Bay, *Omission Accomplished: The Lack of a Los Angeles Regional Water Board Enforcement Program, 1992-1997*, at 21 (January 1999) (citing to UCLA Quarterly Progress Report # 3 to California State Water Resources Control Board, August 15, 1996).

[4] The RWQCB implements a "progressive enforcement approach" to address noncompliance. A "Level I" action is typically a written notice to comply which is sent to the violator. A "Level II" action is typically a second letter to a violator issued by the Executive Officer alerting them to the possibility of more stringent action. It may also include

for failing to submit required forms and information—such as failure to submit an annual report or failure to file an NOI.[5] The RWQCB rarely if ever takes formal enforcement action against entities on the basis of inadequate storm water practices or violations of receiving water objectives. The RWQCB's failure in this regard means that meaningful storm water enforcement action in Southern California is almost entirely the purview of environmental organizations. specifically NRDC and the Santa Monica BayKeeper.

Fifth. as a result of the matters summarized above. the RWQCB has failed to protect and restore regional waters. including world-famous local beaches. riparian habitats. and other coastal resources. as required by the Clean Water Act. In fact. storm water discharges in the region consistently violate the Clean Water Act, a fact which is known to the RWQCB. In the end. the acute toxicity and pathogenic content of regional storm water discharges is the most basic and important proof of this severe problem.

I. Legal Standard

A. The Clean Water Act Sets Standards for Delegated Programs and Provides for EPA Withdrawal of Approval When These Standards are not Satisfied.

The Clean Water Act provides that "[a]ny state [NPDES] permit program under this section shall at all times be in accordance with this section and guidelines promulgated pursuant to this section." 33 U.S.C. § 1341(c)(2). In order to assure that any state program is at all times consistent with the Clean Water Act, the Administrator of EPA may withdraw approval of the program if it does not meet established criteria. The power to withdraw approval of a state permit program is granted to the Administrator by 33 U.S.C. § 1342(c)(3). It provides, in pertinent part:

> Whenever the Administrator determines after public hearing that the State is not administering a program approved under this section in

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a Time Schedule Order. A "Level III" action is "formal" enforcement. specifically the issuance of a Cease and Desist Order or the imposition of Administrative Civil Liability against a violator. *Id* at 7-9.

[5] *See Quarterly Report of Violations and Enforcement Actions*. January 1997 through June 1999 (RWQCB).

> accordance with the requirements of this section, he shall so notify the State and, if appropriate corrective action is not taken within a reasonable time, not to exceed ninety days, the Administrator shall withdraw approval of such program . . . .

The criteria the Administrator is to use in determining whether to withdraw approval of the state permit program are set forth in 40 C.F.R. § 123.63. This part provides that the administrator may withdraw program approval in a number of circumstances, which may be summarized as follows: when the state program fails to exercise control over activities required to be regulated, including <u>failure to issue permits</u>; when there is repeated issuance of <u>permits which do not conform to requirements</u>; when the State's <u>enforcement program fails to comply with requirements</u>; when the State's <u>program fails to adequately inspect and monitor</u> activities subject to regulation.

Further, a state program may be withdrawn where it otherwise fails to comply with the terms of the Memorandum of Agreement ("MOA") under which all state programs are authorized. 40 C.F.R. § 123.63. The Administrator must look to the terms of the MOA to determine whether the State has carried out its duties as set forth in the MOA. In the case of the MOA between U.S. EPA and California, specific Regional Board duties are enumerated, including:

> a. Regulating all discharges subject to the NPDES and pretreatment programs, except those reserved to EPA, in conformance with Federal and State law, regulations, and policy;
>
> b. Maintaining technical expertise, administrative procedures and management control, such that implementation of the NPDES and pretreatment programs consistently conforms to State laws, regulations and policies;
>
> c. Providing technical assistance to the regulated community to encourage voluntary compliance with program requirements;

d. Assuring that no one realizes an economic advantage from noncompliance;

e. Maintaining an adequate file at the appropriate Regional Board Office for each permittee;

f. Comprehensively evaluating and assessing compliance with schedules. effluent limitations. and other conditions in permits:

h. Taking timely and appropriate enforcement actions in accordance with the CWA, applicable federal regulations, and State law: [and]

i. [Conducting] compliance inspections to determine the status of compliance with permit requirements. including sampling and non-sampling inspections.

B. The Clean Water Act Provides Specific Procedures By Which Any Person Can Petition the Administrator to Correct Program Deficiencies or Withdraw Approval.

EPA regulations provide that "the Administrator may order the commencement of withdrawal proceedings on his or her own initiative or in response to a petition from an interested person alleging failure of the State to comply with the requirements of this part . . . ." 40 C.F.R. § 123.64(b)(1). The word, "Person", is broadly defined to include any "individual or organization having an interest in the subject matter of the proceeding."

II. Factual Background: The Regional Board's Failure to Adequately Regulate Storm Water Pollution Has Created the Worst Water Quality Problem in the Region, and One of the Worst Polluted Runoff Problems in the United States.

The ability of the Regional Board to meet its overall obligation to effectively manage and implement the Clean Water Act is inextricably linked with its ability to combat urban runoff and storm water pollution. In simple terms, the goals and the requirements of the Clean Water Act cannot be, and will not be, achieved in Southern California until and unless urban runoff and storm water pollution are effectively regulated.

This direct connection is a result of the predominant role runoff plays in contributing pollutants to receiving waters, degrading many of these waters, and impairing beneficial uses. The sheer volume of polluted runoff; the relative significance of runoff pollution compared to other sources of water pollution; as well as the causes and effects of runoff on human health and the environment are now well-understood in Southern California. These documented facts demonstrate the considerable negative impact on people and the environment that continues today as a result of the Regional Board's inadequate efforts and oversight.

A. <u>Polluted Runoff is the Largest Source of Water Pollution in Los Angeles.</u>

Research has demonstrated that storm water is the largest single source of water pollution in Southern California.[6] As the Southern California Coastal Water Research Project has reported, not only does storm water discharged to Santa Monica Bay contain high quantities of individual pollutants, but it also contains many different pollutants—including those of the greatest concern.[7] These pollutants include a toxic soup of hydrocarbons, pathogens, pesticides, sediment, nutrients and heavy metals. "Urban runoff now represents a larger percentage of the load for pollutants such as zinc, and surpasses loadings from wastewater treatment facilities for pollutants such as lead." *Id.*

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[6] *See, e.g.*, EPA's National Urban Runoff Program (U.S. EPA, 1983); Gersberg, R.M., *Impact of Urban Runoff on Santa Monica Bay and Surrounding Ocean Waters* (1995); *State of the Bay 1998, Executive Summary* (Santa Monica Bay Restoration Project, Mar. 17, 1998) ("*State of the Bay*").

[7] *Santa Monica Bay Restoration Plan* (Santa Monica Bay Restoration Project, August 1994) ("*Bay Plan*") at ES-8; *see, also, id.* at 3-1 ("storm water [and] urban runoff is known to contribute significantly to [12 of the 19] pollutants of concern . . . .").

Indeed, in the past three decades, mass emissions of urban runoff-borne pollutants have increased dramatically in Southern California; this trend has continued during the 1990s, the period in which the Regional Board has been regulating most sources of polluted runoff in the Los Angeles area.[8] In particular, discharges of pollutants such as copper, nickel, nitate, zinc, phosphorous, and ammonia have grown significantly in runoff, while the amount of each pollutant has fallen in wastewater discharged from publicly-owned treatment works. Indeed, the United States Environmental Protection Agency itself recently has recognized that polluted runoff is the leading cause of impairment in the Los Angeles Region. *See Heal the Bay & Santa Monica BayKeeper v. Browner*, Case No. C98-4825 SBA, Amended Consent Decree at 2.

B. Southern California's Polluted Runoff Problem is Among the Worst in the Nation.

The storm water pollution discharged to Southern California's rivers, streams, and ultimately the ocean is not only significant relatively—that is, compared to other local pollutant sources—but also in comparison to storm water discharged in other regions. UCLA researchers have determined that Southern California is impacted by more storm water pollution than "90% of the other urbanized areas in the United States." Stenstrom & Strecker, *Sources of Storm Drain Sources of Contaminants to Santa Monica Bay* (1994) ("Stenstrom & Strecker") at 37; see generally *Los Angeles Times* (September 6, 1999).

1. Polluted Runoff-Related Public Health and Environmental Impacts are Serious and Numerous.

As a general matter, the United States Environmental Protection Agency has observed that storm water pollution and dry weather urban runoff are "increasingly important contributors of use impairment as discharges of industrial process wastewaters and municipal sewage plants

[8] "Changes in Contaminant Inputs to the Coastal Ocean." Southern California Coastal Water Research Project

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come under increased control. . . ." 55 Fed. Reg. 47990, § I (Nov. 11, 1990). Storm water harms coastal waters in part because it contains most, if not all, of the pollutants of greatest concern.[9] In Southern California, research now has demonstrated a variety of serious public health and environmental impacts.

a. Runoff-Related Health Risks at Local Beaches

Perhaps the most significant impact of storm water pollution affects one of the "major recreational beneficial uses of the Bay," swimming.[10] The documented presence of human pathogens in the surf zone of local beaches degrades water quality to such an extent that it is often unsafe for human contact. In fact, due to storm water pollution, many Santa Monica Bay beaches are unsafe for swimming during the rainy season, and many beaches remain unsafe even during dry weather. Because the beaches of Santa Monica Bay attract some 40 to 50 million recreational visits from both residents and tourists each year, the magnitude of this problem is considerable.[11]

These conditions, which are not limited to times when the beaches are officially closed, have been traced directly to urban runoff.[12] A 1995 epidemiological study conducted by the Santa Monica Bay Restoration Project and University of Southern California researchers

(1998).

[9] *The Quality of Our Nation's Water: 1994 Report to Congress* (Washington: U.S. EPA, 1995) at 25.

[10] *Bay Plan* at ES-11.

[11] *Bay Plan* at ES-14 and *Bay Plan Update* (Santa Monica Bay Restoration Project, July, 1997) at 34; *State of the Bay*.

[12] Official Department of Health advisories to avoid ocean contact for 72 hours following a storm are often issued. See *Testing the Waters 1999: A Guide to Water Quality at Vacation Beaches* at 33-34 (147 closures or advisories issued in Los Angeles County during 1998) (NRDC, 1999).

examined the health effects of swimming near storm drain outfalls in Santa Monica Bay.[13] The study found that people who swam directly in front of these storm drains experienced substantially more fevers, chills, ear discharge, vomiting, and similar maladies than those who swam 100 or 400 yards away from the outlets.

b. Runoff-Related Toxicity Impairs Streams and Marine Coastal Environments.

Recent studies indicate that storm water discharge plumes in the Los Angeles area are acutely toxic to marine organisms, and the plumes are detectable miles from discharge points.[14] Because storm water has a freshwater base, it does not mix easily with the ocean's saltwater medium. Consequently, plumes of storm water often remain intact within coastal waters for multiple days. Satellite pictures display enormous plumes of contaminated storm water stretching as far as the Channel Islands, miles off of the Ventura County coastline.[15]

c. Runoff Has Other Demonstrated Negative Impacts in the Marine Environment.

Research focused on Southern California waters also has confirmed additional negative impacts caused by polluted runoff, including impacts related to the growth of marine plants. Recently, researchers have observed phytoplankton blooms known as "red tides" near Malibu Creek and on the boundary of storm water plumes. Storm water inputs stimulate these blooms.[16] In Southern California, researchers also have observed that "high concentrations of . . . particles

[13] Haile, R et al., *An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay* at 6 (Santa Monica: Santa Monica Bay Restoration Project, 1996).

[14] *1996 Annual Report* (Coastal Research Project, 1996).

[15] January 27, 1997 AVHRR Image of Sediment Plume - Santa Barbara Channel.

[16] Bay, Jones, and Schiff, *Study of the Impact of Stormwater Discharge on the Beneficial Uses of Santa Monica Bay*, Executive Summary (SCCWRP, 1999).

in stormwater plumes may have an adverse impact on marine plants by reducing light penetation." *Id.* Storm water plumes reduced the depth at which photosynthesis can occur. and these impacts can occur with even the smallest storms. *Id.*

2. Polluted Runoff Problems Are Increasing in Regional Waters.

Finally. the overall volume of storm water running into coastal waters has increased steadily over the last century.[17] Storm water volume increases with population growth and with urbanization. both of which continue at a rapid pace in Southern California.[18] This fact means that in order to meet requirements to reduce storm water pollution in local waters, the Regional Board must reduce the amount of pollution discharged in absolute terms at a sufficient rate such that additional loadings related to regional growth.do not outstrip reductions made in established urban areas.

III. Legal Argument: The Storm Water Program in Los Angeles Violates Federal Law and Regulations.

The storm water problem is a complex one. and the different areas of the Storm Water Program that are designed to address it. such as outreach assistance to permittees. review of annual permit reports, and industrial site inspections. are interrelated to such an extent that if there is a lapse or a failure in one area of the program. then the other areas of the program will suffer was well. If. for example. inspections are not carried out or are superficial. Clean Water Act violations may never be discovered, and the end result will be more pollution entering the

[17] *Bay Plan Update* (Santa Monica Bay Restoration Project, July. 1997).

[18] This is. in large part. due to the fact that expanding populations modify land uses. replacing natural "sinks" with impervious surfaces. such as roads and buildings. Because rainwater cannot penetrate these surfaces. they create increased runoff. which then flows to the ocean in greater velocities and volumes.

region's waterways. Likewise, if industrial entities that should be permitted are not, the result is not only unregulated discharges of pollution but also the loss of needed permit-related fees that, if collected, would support staff activities and promote program adequacy.

NRDC demonstrates in the sections that follow that the RWQCB's Storm Water Program is not only inadequate in virtually every respect, but that individual programmatic failings are magnified in light of other inadequacies, with the end result being a program that is ineffective. Simply put, the RWQCB's efforts to control the largest source of water pollution in Southern California largely have failed; the program violates 33 U.S.C. §§ 1341 *et seq.* and accompanying regulations.

A. Insufficient Resources and Staffing for the Storm Water Program is the Root Cause of the Program's Illegality and a Fundamental Reason Why EPA Must Withdraw Approval.

When the United States Congress enacted the Clean Water Act, it recognized the fundamental importance of assuring that adequate resources were allotted by States to carry out the Act. Congress stated that:

> The objective of this Act will be met only if the States have vigorous and adequate pollution control programs. . . . [T]here are many states with serious deficiencies in the quality of their program, often caused by a serious inadequacy in the level of funding and manpower.

U.S. Code Cong. and Adm. News at 3685 (P.L. 92-500 §106) (1972).

The concern expressed by Congress, while couched in general terms, provides a perfect description of, and explanation for, the root problem that has hobbled the RWQCB's Storm Water Program: it is severely understaffed and under-funded. The magnitude of this problem becomes evident when (1) the number of legally-required program tasks and elements are considered; (2) the RWQCB's existing storm water staffing levels are compared to those that the

State itself has admitted are required; and (3) existing staffing levels are compared to other RWQCB water quality programs. to which substantially more resources are allotted in many cases. As the analysis below demonstrates. the Storm Water Program is structurally incapable of functioning at current staffing levels—and RWQCB staff know it and have complained about it.

1. A Legally Adequate Storm Water Program Must Have a Number of Separate Elements.

The Clean Water Act regulates two main types of storm water dischargers. and thus there are two main programmatic elements that comprise the storm water program: industrial (which includes construction sites) and municipal. *See* 33 U.S.C. § 1342(p)(3)(A)-(B). Each of these subprograms has many essential tasks which are connected. These tasks include: program development. including developing a storm water work plan and coordinating with other state and federal agencies; public outreach. including responding to general inquiries and conducting presentations and workshops; reviewing permit applications and issuing permits: reviewing annual reports and storm water management plans ("SWPPs"): conducting compliance inspections and monitoring: and initiating and carrying out enforcement actions. See id.; see also 33 U.S.C. § 123.63.

The staff resources necessary to complete these tasks are significant, as SWRCB and RWQCB documents indicate. Consider the following examples:

A single, adequate inspection of an industrial facility takes an average of 12 hours to complete, including drafting reports and related administrative tasks. Hence. to perform one annual inspection of each industrial entity subject to the General Industrial Storm Water Permit alone would take over 25 full-time staff.[19]

The RWQCB must conduct annual report reviews for every active storm water permittee in the region. Each review takes an average of 4 hours.[20] This means that approximately 14,000 hours—or about 8 full-time staff—are required just to perform adequate plan reviews each year.

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[19] Personal communication with Regional Water Board Executive Staff (October 27, 1999).

Oversight and review of pollution reduction plans ("SWPPs")—the basic facility blueprints for storm water compliance—is also an essential task. The RWQCB estimates that at least 2.5 full-time staff would be necessary in order to review SWPPs submitted by industrial facilities.[21]

Municipal inspections are also a critical element of an adequate program. But cities are large, and adequate inspections of each municipal program would take nearly forty hours, when all required tasks are tabulated, according to RWQCB staff. Given the approximately 100 municipal entities subject to the Los Angeles County and the Ventura County municipal storm water permits, it would take nearly 3 full-time staff simply to conduct one annual inspection of each permittee.[22]

2. The State Allots Grossly Insufficient Resources to the Storm Water Program.

Given the number of tasks that Board staff is expected to complete, coupled with the magnitude of the caseload for the region, the State of California recognized that the Los Angeles Regional Water Quality Control Board would need a significant number of dedicated professional staff to carry out the program in a manner that is minimally effective. In 1994 the State undertook a planning exercise to identify the number of full-time staff necessary to carry out the program in the Los Angeles for each of the following five years:[23]

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[20] Personal communication with Regional Water Board Executive Staff (October 27, 1999).

[21] *Work Plan for Storm Water—Industrial Permit Activities* (SWRCB 1994).

[22] Personal communication with Regional Water Board Executive Staff (October 27, 1999).

[23] *Five Year Work-Plan* (State Water Resources Control Board) at Table A-3

Fiscal Year	*Number of Full-time (FY) Staff*
1994-1995:	5.59
1995-1996:	7.74
1996-1997:	13.19
1997-1998:	16.65
1998-1999:	21.37

While these figures show that the State itself calculated that slightly over 21 full-time RWQCB staff would be necessary to implement the Storm Water Program, actual staffing levels have never exceeded 5.59 full-time staff.[24] Stated as a fraction of the staff the State itself claims are necessary. the RWQCB has only one person for every set of tasks that require four people to accomplish. Viewed from a different perspective. it takes the RWQCB staff four years to accomplish the amount of work that should be completed each and every year.

3. According to Assessments Prepared by the State Itself, Virtually Every Aspect of The Storm Water Program is Under-Funded and Inadequate.

The fundamental consequence of the failure to fund the program is that the Storm Water Program operates on a shoestring—and worse. Core elements such as issuance of permits. permit implementation, facility inspections. and enforcement activities all suffer significantly (each of these issues is discussed in following sections below). But these are simply the most noticeable program failures. State documents reveal that almost every task deemed by the State itself to be worthy of inclusion on staffing allocation assessments—such as SWPP review,

[24] Staff Report on Storm Water Discharges Associated Industrial Activities prepared for 12/14/98 Board hearing. at

outreach and education, group monitoring oversight and non-filer investigation—receive either no funding or a small fraction of the minimum funding deemed necessary. *See Los Angeles Regional Board Activities Under the Storm Water Program* (SWRCB, 1997); *see also Watershed Management Initiative Chapter* at 24-26 (Table 1) (listing storm water program elements as "underfunded" or "unfunded"). EPA itself has asserted that the Regional Board's storm water program is "severely underbudgeted." *EPA NPDES Program Implementation Review—Final Report Los Angeles Regional Water Quality Control Board at 29* (EPA, October 1999).

This lack of resources, and its effect on the quality of the storm water program, has not gone unnoticed by RWQCB staff, and consequently, by management. For example, in an e-mail dated March 25, 1998, one storm water staffer commented to Board management on the critical resource problem:

> I was asked many times what we can do to improve the SW program. I think we have to face reality first, recognize it, and then adjust expectations to the reality: if we are not able to receive resources matching the workload, [then] the expectations should be far less than what other regions are doing. Also, send this message out to the public, State Board, US EPA and demand some support.[25]

In another e-mail dated April 8, 1998, RWQCB staff emphasized that the resource limitations have resulted in the deconstruction of the Storm Water Program: "As I see it, we started with a SW [storm water] unit, five years ago, and now we dismantled it to pieces." This staff member concluded by noting that:

> The program does not need fixing—there is no program to start with ... Unless the Stormwater issues are really elevated to an important status level, there is nothing to be fixed. It is only patching work.[26]

2. (Regional Water Board).

[25] Correspondence from Dan Radulescu to Wendy Phillips (March 25, 1998).

[26] Correspondence from Dan Radulescu to Wendy Phillips (April 8, 1998).

4. The Storm Water Program Suffers To a Greater Degree Than Other Regional Board Programs.

Not only are the resources provided to the Storm Water Program insufficient as measured against the level identified as necessary by the State Water Resources Control Board, but the small number of personnel assigned to the Storm Water Program is sharply contrasted with the number of personnel assigned to other programs. For example, the Underground Storage Tank program has 24 full-time staff.[27] The "traditional," point source NPDES program has even more full-time employees assigned to it. *Id.* Yet, with 4 to 5 staff assigned to storm water, the RWQCB is attempting to carry out a program that is arguably far more complex—and and a far more significant cause of water pollution in the region.

5. Conclusion

Given the enormous level of work required by the storm water program and the low level of staff and resources allocated to it, it is clear that the Regional Board is not operating the storm water program at a level that comes close to meeting the requirements imposed by law. This failure to operate the program, and lack of control over the activities covered by it, meets the criteria for withdrawal of approval under 40 C.F.R. § 123.63(a)(2).

B. The Regional Board Has Failed to Exercise Control Over the Activities Required to be Regulated by the Clean Water Act's Storm Water Provisions.

As a condition of EPA approval, the Clean Water Act requires that any state storm water program maintain control over those basic activities that are the subject of regulation under the Act. 40 C.F.R. § 123.63(a)(2)(i); MOA at 6. With respect to the Storm Water Program, these include issuing permits to entities that require them: issuing legally adequate permits; and

[27] *Regional Water Quality Control Board Organizational Chart* (January, 2000).

providing sufficient staff resources to allow for timely implementation of permit requirements (specifically including those permit programs that must be separately approved by the Executive Officer before taking effect). Id.

The Regional Board has failed with respect to each of these requirements.

1. The Regional Board Has Failed to Issue Permits to Thousands of Illegal Dischargers

First, the Regional Board has failed to issue permits to thousands of industrial entities throughout Southern California who are now discharging runoff illegally without a Clean Water Act permit. According to numerous independent studies in the Los Angeles area, the approximately 3,500 facilities now enrolled under general permit coverage are only a fraction of those who are required to comply. In its report, "*Omission Accomplished*," the environmental group Heal the Bay demonstrated that, using conservative assumptions, as many as 10,000 industrial facilities in the Los Angeles region should be, but are not, enrolled under the general industrial storm water permit.[28] Other estimates of the number of facilities operating illegally without a discharge permit are as much as three times higher. While there may be some uncertainty about the number of non-complying facilities, the fact that the Regional Board has to "regulate tens of thousands of facilities" not currently under permit is beyond doubt.[29]

While each facility has a legal duty to comply in the first instance, the Regional Board has the overall responsibility to assure that "all discharges subject to NPDES . . . programs [are regulated] in conformance with Federal and State law, regulations, and policy." MOA at 6. The

[28] Heal the Bay, *Omission Accomplished: The Lack of a Los Angeles Regional Water Board Enforcement Program, 1992-1997*, at 23 (January 1999).

[29] *Fact Sheet, Industrial Storm Water Program, Los Angeles Region*, at 1 (RWQCB, 1998); Correspondence from Dennis Dickerson, RWQCB, to Mike Schulz, Associate Director, EPA Region IX at 9 (November 4, 1998) ("we admit that there are a large number of non-filers within the Region . . . .").

sheer number of facilities operating without a permit, year after year, demonstrates the Regional Board's neglect of its legal obligation. Under these circumstances, EPA's duty to suspend Regional Board authority in light of the RWQCB's failure to "exercise control over activities required to be regulated . . . . including failure to issue permits," could not be more clearly invoked. 40 C.F.R. § 123.63(a)(2)(i).

2. <u>The Regional Board's Most Important Permit Is Legally Flawed.</u>

Second, the Regional Board has failed to assure that its single most important storm water permit, the Los Angeles Municipal Storm Water Permit ("LA Municipal Permit"), meets basic legal mandates and EPA policy. This omission may be related to the fact that the Regional Board has admitted that its permit development activities are "underfunded" and it is able to "deal with only some of [the] issues on the table." *Watershed Management Initiative Chapter* at 24 (Table 1) (RWQCB, 1998).

Specifically, the LA Municipal Permit does not contain legally adequate provisions regarding the obligation of dischargers to meet water quality standards. The LA Municipal Permit provides that discharges will be deemed to be in compliance with water quality standards as long as the permittee has implemented the Permit in a complete and timely manner. *LA Municipal Permit* at 12 ("Receiving Water Limitations").

This provision continues today in force notwithstanding EPA's repeated objection to similar permit language and its issuance of legally adequate, "model" water quality standard provisions in 1999. Significantly, EPA-approved language includes the following absolute prohibition absent from the LA Municipal Permit: "discharges . . . that cause or contribute to the violation of water quality standards or water quality objectives (collectively WQSs) are prohibited." *See, e.g., NPDES Permit for the Santa Margarita Watershed* (Permit No. CA 0108766) at 4 (April 28. 1999); *see also, correspondence from Alexis Strauss, Director Water Division, EPA Region IX to Loretta Barsamian, Executive Officer, San Francisco Regional Water Quality Control Board* (March 17, 1999) (setting forth EPA objections).

By failing to include important permit conditions in its most significant storm water permit, the Regional Board has failed to maintain "technical expertise, administrative procedures and management control such that implementation of the NPDES .. program[] consistently conforms to State laws, regulations and policies." MOA at 6. It has further failed to regulate major dischargers in conformance with applicable laws and policies. Id. On this basis, EPA must withdrawal program approval. 40 C.F.R. § 123.63(a)(4).

3. The Regional Board Has Failed to Effectively Oversee Permit Implementation.

Third, the Regional Board has failed to assure that significant storm water permits, particularly the LA Municipal Permit, are implemented in a timely fashion. Board staff repeatedly failed to exercise management control and oversight sufficient to approve model programs required under the terms of the LA Municipal Permit, thereby substantially delaying implementation of the critical core permit programs designed to reduce runoff pollution.

The LA Municipal Permit included requirements for the subsequent approval of nearly a half dozen model programs to educate the public and control pollutants associated with development and redevelopment, public agency activities, and illicit connections and illegal discharges. See, e.g., *LA Municipal Permit* at 26, 32, 42. The structure of the permit is such that the approval of each model program by the Executive Officer of the RWQCB serves as the "trigger" after which each of the 85 permittees must implement their own individual program. based upon the approved model program. See *LA Municipal Permit* at 26. As such, a failure to approve a model program in a timely fashion has the direct of effect of hamstringing permit implementation.

This is precisely what occurred since July 1996, when the current LA Municipal Permit was adopted by the Regional Board. As the following table demonstrates. RWQCB staff almost immediately lost control of the implementation process, ultimately approving each model program many months (and sometimes years) after applicable permit deadline:

Model Program	*Permit Deadline*[30]	*EO Approval Date*[31]
Public Agency	December 1, 1997	October 21, 1998
Illicit Connection/ Illicit Discharge	March 31, 1997	March 23, 1999
Development Planning		
Program	January 30, 1998	February 11, 1999
BMP List	January 30, 1998	April 22, 1999
SUSMPs	June 30, 1998	January 26, 2000
Development Construction	September 30, 1997	April 22, 1998
Public Education	July 30, 1997	December 1, 1997

[30] *LA Municipal Permit* at 26, 36, 38, 42; *see also Management Report, July '99-September '99* at 12-13 (LARWQCB).

[31] *See* Correspondence from Dennis Dickerson to Interested Parties (February 10, 1999) (IC/ID); *see generally Management Report, July '99-September '99* at 12-13 (RWQCB).

Demonstration of Legal Authority	November 28, 1996	July 5, 1998

According EPA itself, these failures "severely hindered" progress under the storm water permit. *EPA NPDES Program Implementation Review—Final Report Los Angeles Regional Water Quality Control Board at 29* (EPA, October 1999). The delayed approval of these programs underscores that the Regional Board's resource-related inability to oversee implementation of the storm water program extends not only to requirements imposed by federal or state law, but also to those that it designs, such as the model program requirements.

C. <u>The Regional Board Has Failed to Inspect Most Industrial Storm Water Dischargers.</u>

The failure to inspect and monitor storm water dischargers is an enumerated basis for program withdrawal. <u>See</u> 40 C.F.R. § 123.63(a)(3)(iii). This requirement is underscored in the MOA between EPA and the State, which provides specifically that the "Regional Boards shall conduct compliance inspections to determine the status of compliance with permit requirements, including sampling and non-sampling inspections."

Inspection of industrial facilities, construction sites, and municipal entities is a basis for program withdrawal because it is critical to program success. In addition to discovering violations of permits that may be causing pollution to enter waterways illegally, inspections enable Board personnel to meet with facility operators and review permit obligations and measures necessary to prevent pollution. Without an adequate inspection program, it is extremely difficult for RWQCB to determine whether dischargers are complying with permit terms, and thus whether the Storm Water Program is functioning as intended. This is especially true because unlike traditional point sources, who are required to submit detailed monitoring reports regularly, most storm water permittees do not submit similar data.

As discussed below, the Regional Board's storm water inspection program is totally inadequate EPA has identified the need for increased "field presence" by the Regional Board. but given that inspection and program review activities are "under to unfunded," only a "small percent of permitted businesses are inspected." *EPA NPDES Program Implementation Review—Final Report Los Angeles Regional Water Quality Control Board at 29* (EPA. October 1999); *Watershed Management Initiative Chapter* at 24-26 (Table 1) (RWQCB, 1998).

Consequently. the Regional Board staff has conducted only <u>four</u> audits of municipal storm water permittees in Los Angeles County. Furthermore, RWQCB staff annually conduct inspections of only an extremely small percentage of the industrial entities covered under the General Industrial and Construction Permits. Indeed. the Regional Board's failure to inspect industrial facilities is a special factor contributing to storm water pollution in Southern California because this region is the most heavily industrialized in the State of California.[32]

1. <u>The Regional Board's Municipal Storm Water Inspection Program is Virtually Non-Existent</u>.

The State of California's *Storm Water Program Five Year Work Plan* specifies that, beginning in July 1994, "municipal [storm water] programs will be evaluated annually through offsite and onsite audits." *Storm Water Program Five Year Work Plan* at V-9 (State of California. 1994) ("Work Plan"). The Work Plan further specifies the inspection elements required annually for each municipal discharger:

> Onsite audits occur at municipal facilities or sites within the drainage area of a municipality's storm drain system. and consist of interviews of municipal program managers and personnel, review of records, meetings to review offsite-audit

[32] *Watershed Management Initiative Chapter* at 7 (RWQCB. May 15. 1998).

> findings. and inspection of specific projects or actions (e.g.. drop-inlet cleaning. construction-site inspection. control measure effectiveness study) conducted by a municipality. . . . The following activities are included in this task:
>
> (a) Conduct offsite audit:
> (b) Conduct onsite audit;
> (c) Implement appropriate follow-up action.

The requirement of annual inspections is consistent with U.S. EPA mandates, which require an annual inspection of all major dischargers. and at least one inspection every five years for all "minor" discharges. *See State Water Board's Responses to Legislative Analyst's Office Questions* at 6 (October 8. 1998); *Storm Water Five Year Workplan* at VI-15 (SWRCB, 1994) (treating industrial entities as minor storm water dischargers).

Notwithstanding this requirement. RWQCB records show that only four "site visits" to Los Angeles area municipal dischargers (the cities of Pomona. Lynwood. Inglewood. and Santa Monica) and only 17 visits to Ventura County permittees have taken place since 1996. *See L.A. Municipal Storm Water Permit Key Tasks* at 1 (RWQCB 1998): *see also Performance Tracking Reports* (RWQCB, 2000).[33] To put this number in perspective. over a period of three years. the RWQCB should have conducted one annual audit of each of the 95 municipal permittees (for a total of 285 audits). and each audit should have included offsite and onsite components. Even assuming that each of the RWQCB's 21 "site visits" met established requirements (as set forth above). the RWQCB's municipal inspection activity in Los Angeles and Ventura Counties is 7% of the required level.

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[33] Some RWQCB documents state that 3 audits were conducted. *Performance Tracking Reports* (RWQCB. 2000).

2. <u>The Regional Board's Industrial Inspection Program is Totally Inadequate.</u>

As noted. U.S. EPA requires site inspections of major dischargers on an annual basis and all others at least once every five years. Even assuming that each permitted industrial discharger and construction site in the Los Angeles area were considered a "minor" (instead of "major") discharger. the RWQCB must conduct inspections of at least twenty percent of all enrolled entities every year to meet minimum requirements.[34]

Records show that Regional Board staff have not completed anywhere near the minimum required number of inspections. even if it is assumed for the sake of analysis that the most easily achieved standard applies—one inspection per facility every five years. From June 1996 through June 1999. the Regional Board conducted a total of only 858 inspections, which represents approximately 24% of the 3,558 permitted industrial facilities.[35] Hence. the Regional Board's rate of inspection is *at least* three times slower than legally adequate.

Moreover. according to staff, many of these inspections were in response to a Notice of Termination (a submittal that indicates that a facility is closing). Overall, 384 of the reported three-year total of 859 inspections (nearly 45%) were related to facility closure—when polluting activities putatively have ceased. The table below sets forth the minuscule number of *compliance* inspections that the Regional Board claims were conducted at all industrial sites (including construction) in each of the last three full years (for which data is available):

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[34] The State. however. committed in 1994 to conducting an initial inspection visit to every new industrial discharger over a three-year period beginning in 1996. *See Stormwater Program Five Year Workplan* at VI-18 to VI-19 (SWRCB 1994). The RWQCB has failed to meet this program task.

[35] *General Industrial Storm Water Permit Statistics November 1999*, at 1 (RWQCB). *See also List of Industrial Storm Water Permittees*, available at www. swrcb.ca.gov/html/indpmt.html (SWRCB): *See List of Active Construction Storm Water Permittees*, available at www.swrcb.ca.gov/html/cnstrpmt.html (SWRCB). These lists are updated daily. and so total counts vary over time.

Year	*Number of Facilities Inspected*[36]	*Percent of All Enrolled Facilities*
1996-1997	50 facilities	1.4%
1997-1998	123 facilities	3.4%
1998-1999	302 facilities	8%

For fiscal year 1999-2000, Board staff indicated that 454 inspections of industrial facilities are planned, due to a one-time funding increase.[37] Even this level of effort amounts to barely 13% of currently enrolled industrial facilities, still far short of the most lenient inspection rate standard. Moreover, through the end of 1999, Regional Board staff had only conducted 49 inspections, making it all but impossible for them to come anywhere close to their goal.[38]

Yet, even this picture of inadequacy does not fully capture the extent of the problem. According to numerous independent studies in the Los Angeles area, the facilities now enrolled under general permit coverage are only a fraction of those that should be complying but are not. As noted above, as many as 10,000 or more facilities should be enrolled under a general storm water permit; at the RWQCB's average annual rate of inspection it would take the Regional Board nearly 35 years to inspect every ones of these facilities.[39]

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[36] *General Industrial Storm Water Permit Statistics November 1999*, at 1 (Los Angeles Regional Water Board 1999); personal communication with Xavier Swaminkannu (January 2000). NOTE: Throughout this petition, NRDC bases its analysis on data provided pursuant to Public Records Act requests transmitted to the RWQCB, SWRCB, and EPA. NRDC believes that the data provided regarding inspections overstates RWQCB inspection efforts due to poor record-keeping and the lack of a single, consistent data gathering system employed by the RWQCB. In all, NRDC spent over two months attempting to decipher, with the help of RWQCB staff, the precise level of RWQCB inspection activity, and we believe that it is simply impossible to say exactly how many inspections were actually conducted. Nevertheless, we are reporting the data currently available to us. The only error, therefore, that could be introduced into our analysis by the RWQCB's record-keeping would be one that casts RWQCB activities in overly *positive* light. NRDC reserves the right to supplement or revise inspection data based on further discovery.

[37] Personal communication with Regional Water Board Executive Staff, October 27, 1999.

[38] Personal communication with Xavier Swamikannu (January 2000).

[39] Heal the Bay, *Omission Accomplished: The Lack of a Los Angeles Regional Water Board Enforcement Program, 1992-1997*, at 23 (January 1999).

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3. Summary

Given these facts, the criteria for EPA's withdrawal of approval under 40 CFR § 123.63 (a)(3)(iii) and (a)(4) for failure to inspect and monitor activities subject to regulation easily has been met. Not only has the RWQCB failed to inspect the vast majority of facilities under its control, it has wholly failed to implement the terms of the MOA between EPA and the State, an agreement which provides that "the Regional Boards shall conduct compliance inspections to determine the status of compliance with permit requirements, including sampling and non-sampling inspections." MOA at § IV.B.1.

D. The Regional Board Rarely Enforces Storm Water Laws and Regulations.

In order for a law or regulation to achieve its goals, it must induce compliance. Compliance with the law will only result if there is an effective enforcement program to induce it. Accordingly, the failure to act on violations of the Clean Water Act, including non-compliance with permits and other program requirements, is grounds for withdrawal of state programs. 40 C.F.R. § 123.64. Unfortunately, while the RWQCB has increased its enforcement of storm water violations in 1999, overall the storm water enforcement program is still inadequate. The Regional Board itself states that its enforcement program is "underfunded" and, as a result, it is only able to conduct "[m]inimal administrative review and enforcement" and deal with "major non-compliance." *Watershed Management Initiative Chapter* at 24-26 (Table 1) (RWQCB, 1998). As demonstrated below, this "enforcement" program in no way encourages compliance with the law, nor is it consistent with the applicable requirements.

1. Minimum Standards for Enforcement.

When EPA delegated NPDES authority within the Los Angeles area to the State, the Regional Board became the chief enforcement agency for "NPDES permit requirements," including those applicable to storm water dischargers. MOA at 38. The RWQCB is required under the terms of the MOA between EPA and the State to take "timely and appropriate enforcement actions in accordance with the CWA, applicable Federal regulations, and State Law." MOA at 6. Finally, in this respect, the Regional Board must assure "that no one realizes an economic advantage from noncompliance." *Id.*

Pursuant to the MOA, additional enforcement policy is set through California's Administrative Procedures Manual ("APM"). MOA at 2. The APM provides that "*violations of . . . applicable statutory or regulatory requirements should result in a prompt enforcement response against the discharger.*" APM at 5 (italics in original). The APM also provides that any incidence of toxicity should be brought to the attention of the RWQCB for possible enforcement action. *Id.* With respect to failure to obtain permit coverage, the APM states that such a violation is "significant." *Id*

2. <u>The RWQCB Takes Very Few Enforcement Actions Against Storm Water Dischargers.</u>

In all, "[c]ompliance assurance and enforcement outputs in the Storm Water Program are <u>very low</u> relative to the number of regulated facilities." *Compliance Assurance and Enforcement Strategy* (SWRCB, 1998) (emphasis added). This finding is especially true of the Los Angeles RWQCB. During the period from January 1997 through June 1999, despite the over 3,558 enrolled industrial and construction facilities in the region, and the approximately 100 additional municipal dischargers, the RWQCB brought only 37 formal enforcement actions (denoted by the Board as "Level 3" actions) for violations of storm water regulations. *See Quarterly Report of Violations and Enforcement Actions* (January 1997-June 1999).[40]

[40] During preparation of this Petition, Petitioners sought enforcement totals for the second half of 1999. Those

3. Formal Enforcement Action Pursued by the RWQCB Concerns Reporting Requirements and Only Extends to Certain Types of Dischargers.

While the small number of formal enforcement actions taken by the RWQCB indicates that the enforcement program is depressed, even this figure does not capture the degree of inadequacy. As the chart below illustrates, entire sectors of storm water dischargers do not receive any formal enforcement attention at all:

Formal Enforcement by Category and Type, January 1997-June 1999

	Municipal	*Industrial*	*Construction*
Formal Enforcement (discharge/BMP-related):	NONE	NONE	3
Formal Enforcement (reporting-related):	1	33	NONE

As the chart shows, the Regional Board only took 3 formal enforcement actions for the most substantive violations (such as for unlawfully discharging runoff or failure to implement BMPs) during the entire period for all discharger categories combined.[41] The RWQCB took no formal enforcement actions during the period against industrial dischargers for the most substantive violations. Similarly, the RWQCB took one formal enforcement action against municipal dischargers for any type of violation. The RWQCB took only five informal enforcement actions (Level I or Level II) against municipal dischargers. *See Id.* (January 1997-June 1999 Reports).

summaries had not yet been compiled. Pers. Comm Wendy Phillips (January 13, 2000). Note also that of the formal (Level III) enforcement actions brought by the Board for the six years from 1991 through 1997, only two were for violations of storm water permit requirements, of which one was for a violation of an industrial permit, the other being for construction storm water violations. *See Omission Accomplished* at 21 (Heal the Bay, 1998).

[41] These actions were taken against three construction firms: RCS Development Company/Western Pacific Housing (ACL No. 99-007), Beazer Homes Southern California (ACLs 99-012), and Shea Homes (CAO No. 99-008). *See Id.* (April-June 1999).

4. <u>The RWQCB Must Greatly Increase the Level of Enforcement Activity to Stem Violations of the Clean Water Act.</u>

General analyses by the State of California and the RWQCB confirm the impression that the miniscule number of enforcement actions described above is failing to compel compliance with the Clean Water Act.

In a general statewide review, the California Environmental Protection Agency ("California EPA") itself concluded in 1999 that "the number of water quality violations is unacceptably high and that there is a significant gap between the number of enforcement actions needed and the number taken." *Compliance Assurance and Enforcement Initiative* at 9 (SWRCB, September 1999). California EPA further conducted an analysis of 986 violations, representing a five percent sample. It found that:

> the review team determined that these violations should have resulted in a total of 248 enforcement actions, including 167 informal actions and 81 formal actions. Of the needed enforcement, only 68 informal and 8 formal actions were actually taken. . . . Projecting the results . . . indicates that there are approximately 21,000 violations per year . . . .

<u>Id.</u>

Within the Los Angeles Region, the RWQCB staff recently completed one of the first specific studies of non-compliance within the Storm Water Program. Staff examined one sector of industrial storm water permittees, the auto dismantling industry, in order to determine "whether auto salvage yards have complied substantially with the federal storm water regulations for industrial activities." *Storm Water Pollution in the Auto Dismantling Industry: Evaluation of Compliance with the California General Industrial Storm Water Permit* at 2 (Draft, January 2000) ("Compliance Evaluation").

The answer to this question is a resounding "No." As a point of departure, staff noted that compliance of permitted facilities of all types within the industrial storm water segment was "not well characterized." Id. at 5. After conducting document reviews and site visits, the RWQCB's preliminary findings include: (i) "[s]ite inspection revealed BMPs not fully implemented"; (ii) "25% of facility operators did not know what a SWPPP was"; (iii) "[m]ajority of SWPPPs were not site-specific"; and (iv) "enforcement actions on [only] 10% of facilities who failed to submit SWPPP by deadline." Compliance Evaluation at 23.

Further, the vast majority of SWPPPs reviewed by staff were judged to be inadequate or totally missing certain information. *Id.* at 24-25, 27. Monitoring programs were adjudged to be totally inadequate in five of six categories. *Id.* at 26, 28. Not surprisingly, sampling conducted at the facilities within the evaluation showed exceedances "for all constituents (TSS, SC, O&G, Al, Cu, Fe, Pb, and Zn) except for Ph." *Id.* at 40, 45. Concentrations of metals were particularly high. Id.

This evaluation serves to confirm that the RWQCB is not compelling compliance in this industrial segment. Moreover, by implication these findings strongly suggest that the RWQCB is not compelling compliance in any of the other industrial segments subject to the regulation under the industrial storm water permit. In fact, given that the auto dismantling industry has been subject to a prolonged, well-publicized citizen enforcement effort by the Santa Monica BayKeeper, the high levels of non-compliance identified by the RWQCB actually may be statistically lower than in many other industrial segments, who have not been subject to any serious enforcement effort

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5. <u>RWQCB Staff Have Failed to Formally Notify the Board that Storm Water Discharges to Santa Monica Bay and Other Receiving Waters Are Acutely Toxic.</u>

As noted above. the Southern California Coastal Water Research Project has found that storm water discharges in Southern California often are acutely toxic. even when diluted ten to one. These findings. however. never have been formally presented to the RWQCB as a basis for enforcement action, contrary to the express requirements of the Administrative Procedures Manual. APM at 5 ("toxicity").

6. <u>Summary</u>

In all. the RWQCB's enforcement program is inadequate where it exists and. with respect to municipal and industrial dischargers. it remains virtually non-existent. especially when it comes to stopping unlawful discharges and enforcing BMP implementation. As statewide and regional analyses by the State itself show. countless violations of law are not subject to any enforcement. and programmatic compliance. as a consequence, remains spotty at best.

These conditions are precisely those for which withdrawal of EPA approval was designed. *See* 40 CFR § 123.63(a)(3) (withdrawal approval where there has been a failure to act on violations of permits or other program requirements); *see also* MOA at 6 (responsibility of the RWQCB to assure that no one realizes an economic advantage from noncompliance and to take timely and appropriate enforcement actions). EPA must. therefore, withdrawal approval of the Regional Board's Storm Water Program on this enumerated basis/

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F. Continuing Storm Water-Related Violations of the Clean Water Act Demonstrate the Overall Failure of the Storm Water Program and the Need for EPA to Withdraw Approval.

This Petition has demonstrated that the Storm Water Program in the Los Angeles area is inadequate in virtually every respect. In the end, however, one of the most serious indictments of this program is the chemical and biological characteristics of storm water discharges in the region. As demonstrated above, scientific investigations by independent agencies and organizations have established two fundamental facts. First, in Southern California runoff is often acutely toxic in freshwater and marine environments, even when diluted substantially. Second, in Southern California runoff conveys human pathogens to waterways which are heavily used for contact recreation. Studies show that exposure to runoff or these runoff-contaminated waters dramatically increases the incidence of certain illnesses. *See supra* at 6-11.

These conditions are not merely regrettable, they are illegal. The Clean Water Act prohibits the discharge of toxic contaminants in toxic amounts. It further prohibits the discharge of disease-causing microbes and viruses and the impairment of affected beneficial uses, such as swimming in the ocean. In fact, the Act affirmatively requires that beneficial uses of waters—such as habitats for fish or as recreational resources for people—be protected and maintained. *See* 33 U.S.C. § 1251(a); (objective of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters"); 33 U.S.C. § 1251(a)(3) ("it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited"); 40 C.F.R. § 122.44 (probibiting discharges which "cause, have the reasonable potential to cause, or contribute to" a violation of a water quality standard"); *Water Quality Control Plan for the Los Angeles Region*, Chapters 2 and 3 (providing that "all waters shall be maintained free of toxic substances [in toxic concentrations]" and designating recreation as a beneficial use of coastal waters): *California Ocean Plan* (Water Quality Control Plan, Ocean Waters of California) at 2 (bacterial characteristics, water-contact standards) (SWRCB. 1997).

The scientifically-demonstrated attributes of the storm water problem is. in the final analysis. the ultimate "proof in the pudding" of the RWQCB's failure to implement a legally adequate Storm Water Program. The truth is plain: storm water discharges in the region violate the Clean Water Act on a regular, predictable. and ongoing basis. In turn. these indisputable facts show specifically that the RWQCB is. among other things. (1) unlawfully failing to regulate discharges in a manner consistent with state and federal law. (2) unlawfully failing to maintain management control sufficient to assure that storm water discharges meet applicable laws, regulations, and policies, and. most generally. (3) unlawfully failing in its duty to implement the most basic elements of the Clean Water Act. *See* MOA §§ I.C.3 and IV.B.1 (regional board duties).

Under these circumstances. the Administrator must assure that such deficiencies are immediately corrected or the State's authority to oversee the Clean Water Act Storm Water Program in Los Angeles must be revoked.

IV. <u>Conclusion</u>

For all of the reasons set forth above. NRDC respectfully requests that the Administrator commence withdrawal proceedings pursuant to 40 C.F.R. § 123.64(b)(1). Further, each of the aforementioned legal inadequacies must be corrected within ninety days, and a legally adequate storm water program must be implemented in Los Angeles within this period. If this does not occur. the Administrator must withdraw EPA authority from the Los Angeles Storm Water Program. With respect to the specification of the precise characteristics of a legally adequate program. NRDC reserves the right to further brief this issue after further discovery. *See* 40 C.F.R. § 123.64(a)(3)(D) ("Motions"). NRDC further reserves the right to supplement the facts and legal arguments contained herein.

Respectfully Submitted.

Date: February 23, 2000

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Attorneys for PETITIONER NATURAL RESOURCES DEFENSE COUNCIL, INC.

From: BCHALOFS@dep.state.nj.us
To: Multiple recipients of list <stormwater@valley.rtpnc.epa.gov>
Date: 4/3/00 10:02AM
Subject: swimming pools & training -Reply

New Jersey has a General Discharge to Surface Water Permit for swimming poool discharges that acts like a permit-by-rule in that discharges are allowed as long as certain requirements are met, e.g. the water must have sat in the pool for at least 48 hours so that the chlorine has a chance to dissapate. If anyone wants a copy of the permit let me know.

On the Navy presentations I am still confused - is this in addition to the regional traing sessions or are these the regional training?

Barry Chalofsky

CONDITIONS FOR AUTHORIZATION UNDER THE NJPDES DISCHARGE TO SURFACE WATER GENERAL PERMIT FOR SWIMMING POOL DISCHARGES (NJ0128589)

The New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Surface Water (DSW) General Permit for Swimming Pool Discharges authorizes the discharge of water containing de minimis amounts of pollutants as specified below, without the submittal of a NJPDES permit application or request for authorization and without an individual permit or other written notification of authorization from the Department of Environmental Protection (Department), as of the effective date of this general permit. A de minimis discharge of pollutants for purposes of this general permit is defined as water, which complies with all of the conditions, specified in this permit. The entity responsible for the work, which results in a discharge authorized by this permit, is required to certify that the proposed discharge(s) will comply with all of the conditions of this permit. The certifying entity must maintain a copy of this certification on-site and where it is impractical to maintain on-site, must provide a copy to the Clerk of the municipality where this discharge activity will occur or occurs. However, no submittal to the Department is required. Conditions for discharges authorized by this general permit are further specified below. Questions or comments regarding this permit should be directed to Jim Grob of the Division of Water Quality at (609) 292-4860.

PURPOSE AND SCOPE

The New Jersey Water Pollution Control Act (N.J.S.A.58:10A), also known as the state Clean Water Act, requires that all discharges of pollutants into waters of the state be in conformance with a valid NJPDES permit. This permit has been developed to authorize discharges to surface water which are essentially clean yet may contain detectable levels of regulated pollutants. These discharges are not directly associated with industrial processes, site remediation activities or sanitary sewerage systems, and are of a temporary, short-term, non-continuous nature, yet require regulation by the Federal and State statutes and regulations, in accordance with 33 U.S.C. 1251 et seq. at 1972 P.L. 92-500, the Federal Water Pollution Control Act as amended (the federal Clean Water Act), N.J.S.A. 58:10A et seq., and N.J.A.C. 7:14A 1.1 et seq. The Department has determined that these types of discharges are appropriately controlled under a general permit, and is issuing this general permit in accordance with 40 CFR §122.28 and §123.25 and N.J.A.C. 7:14A-6.13, thereby exempting this class of discharges from obtaining individual NJPDES/DSW permits. These types of discharges are similar in nature because of their low probability of containing pollutants (other than the pollutants specified below), the relatively infrequent nature of the discharge, and the relatively low concentration of pollutants present in the discharges. Pollutants that may be present in these discharges are specified below and include filterable or dissolved solids, suspended solids, and chlorine and chlorine related compounds. This General Permit requires that these discharges be subject to Best Management Practices (BMPs) to minimize if not eliminate any environmental impact that may otherwise result from the discharge. This permit operates under the premise that if appropriate BMPs are implemented prior to discharge; no negative or negligible environmental impact should result from the discharge. If appropriate BMPs are not employed and the discharge causes adverse environmental impacts to the receiving waters, the discharge is in violation of this permit and the entity authorizing the activity and certifying compliance with the requirements of this general permit.

There are no requirements to file with the Department in order for a discharge to be authorized by this permit. The company or entity conducting the activity which will result in a surface water discharge to be authorized by this permit must execute a certification stating that the discharge will comply with all applicable conditions of this permit, in addition to providing specific information about the discharge itself. This certifying agent will also be responsible for ensuring that the discharge meets all applicable requirements of this general permit during the discharge event. (Specific information regarding the required certification is found in Section C of this permit. Certification forms are available from the Division of Water Quality.) The company or entity authorizing the work must maintain the original copy of the certification. A copy of this certification must be maintained on site during the discharge event. Where it is not practical to keep a copy on site, a copy must be maintained in the business office of the certifying agent and provided to the clerk in the town or municipality where the discharge activity is occurring.

The discharges from the draining of and filter backwash from municipal, commercial, or other non-residential swimming pools which use chlorine may be eligible for authorization by this permit:

Discharges eligible for authorization under this permit may be discharged to all surface waters of the State of New Jersey (State), directly and via storm sewers, except for waters categorized as FW1, as defined in N.J.A.C. 7:9B-1.15.

Schedúled multiple short-term discharges occurring over a period of time are eligible for authorization under this permit. In these instances the Department requires the certification to include a schedule of occurrence of all of the discharges. If a discharge cited above exceeds a short-term nature due to unforeseen circumstances and it becomes necessary to extend the duration of the discharge, the certifying agent may submit a written request to the Department for a determination of eligibility to be authorized by or to continue to be authorized by this permit.

The Department may authorize other (multiple) discharges that are short-term in nature but which will occur over a period of time under this general permit upon written approval. The agent should submit a request to the Department to be authorized under this permit and include an estimated discharge schedule. Other similar types of planned, non-continuous short-term discharges may qualify for coverage under this permit on a case-by-case basis based upon individual written approval by the Department.

Discharges resulting from filter backwash operations (other than swimming pools using chlorine) are required to obtain authorization under another general or individual NJPDES permit. Questions regarding discharges, which are similar to the discharges, listed above but which are not specified, or questions regarding the eligibility of any discharge by this general permit, should be directed to the Division of Water Quality at (609) 292-4543 so that a permit determination can be made.

Incidental discharge to ground waters of the State which may result from a discharge authorized by this permit, such as from overland flow on the way to the storm sewer or surface water conveyance, are also authorized under this general permit.

EXCLUSIONS

Discharges **specifically excluded** from authorization under this permit include:

- all discharges of industrial process wastewater including contact and non-contact cooling water,
- sanitary sewer flushing,
- discharges from domestic, publicly or privately owned, and industrial treatment works (except for potable water storage tank overflow),
- combined sewer overflow,
- sanitary sewer overflow,
- all stormwater discharges,
- discharges associated with site remediation activities, including water from well construction and development,
- contaminated water from monitoring well construction and development or capping,
- discharges from water and wastewater treatment system bench scale and pilot testing,
- discharges resulting from filter backwash operations (except from swimming pools meeting the requirements set forth in this permit),
- draining of and filter backwash from municipal, commercial, or other non-residential swimming pools which use pool chemicals other than chlorine,
- water used to clean and rinse storage tanks, natural gas pipelines, or other vessels,
- contaminated waters resulting from construction dewatering activities,
- discharges resulting from water main breaks and water distribution system infrastructure failures, and
- emergency discharges of polluted waters.
- dewatering from construction activities from commercial industrial development such as gasoline stations, auto repair shops, brownfields development, etc.

A. <u>GENERAL CONDITIONS</u>

1. This permit is revocable, or subject to modification or change at any time, pursuant to the applicable regulations, when in the judgment of the New Jersey Department of Environmental Protection such revocation, modification or change is deemed necessary.

2. The issuance of this permit shall not be deemed to affect or restrict in any way action by the Department of Environmental Protection of the State of New Jersey on any future application.

3. This permit does not waive the requirement to obtain other Federal, State or local government consent or approvals when necessary. No work shall be undertaken until such time as all other required approvals and permits have been obtained. This permit does not grant permission to use publicly or privately owned storm sewers or conveyances.

4. The Department reserves the right to require the certifying agent to apply for an individual or other general NJPDES permit if deemed appropriate, or the certifying agent may request exclusion from coverage under this general permit by applying for an individual or other general NJPDES permit.

5. Representatives of the Department shall have the right to enter and inspect any area associated with a discharge authorized under this permit.

B. WATER QUALITY REQUIREMENTS

1. The discharge shall not contain toxic pollutants in toxic amounts, as defined under 33 U.S.C. 1251 et seq., the Federal Water Pollution Control Act, or N.J.S.A. 58:10A-1 et seq., the New Jersey Water Pollution Control Act, or other pollutants, including temperature and pH, in mass, concentration, or other measures of degree which could cause adverse impacts or be detrimental to the natural aquatic biota, or which could cause instream exceedances of applicable Federal or New Jersey Surface Water Quality Standards criteria (N.J.A.C. 7:9B-1.14 et seq.) of the receiving water.

2. The discharge shall not cause or result in erosion to the area of the discharge or the surrounding stream banks. Adequate dewatering structures and velocity dissipation devices should be used when necessary to prevent and minimize erosion, stream scouring, and increases in turbidity or any other potential damage to the receiving waters and its environs. Dischargers may refer to "Standards for Soil Erosion and Sediment Control in New Jersey", as promulgated by the State Soil Conservation Committee and N.J.A.C. 2:90-1.3 et. seq. In addition, the regional Soil Conservation District office (organized by county) may be contacted for guidance on soil erosion control.

3. The discharger shall take into account the conveyance capacity of the discharge outlet structure and/or conveyance structure prior to discharge and shall manage or control the flow of the discharge accordingly. The discharge shall not cause or create downstream flooding conditions.

4. The discharge shall not contain any scum, foam or other residual matter.

5. The following pollutant-specific guidelines and requirements shall be employed, when necessary, to comply with the terms of this general permit. Best Management Practices (BMP) appropriate to the type of discharge shall be employed at all times.

   Suspended Solids

   The discharger shall minimize the amount of suspended solids or turbidity in the discharge to the maximum extent practical. If the discharge contains suspended solids, BMPs shall be utilized to reduce or eliminate the levels prior to discharge to receiving waters. These BMPs can include everything from increased retention time up to and including filtration devices (such as hay bales).

   Other Solids

   There shall be no discharge of floating solids in other than trace amounts. The discharger shall use appropriate BMPs to eliminate floating debris, floatable or settleable solids, including construction or maintenance-related dirt, rust, or scale present in the waters prior to discharge.

   Chlorinated Discharges

The discharger shall take measures to reduce or eliminate any residual chlorine contained in the discharge. Swimming pool water may only be authorized under this permit if the level of chlorine has been effectively dissipated or reduced to prevent deleterious impacts to aquatic life or degradation of the surface water quality of the receiving waters. Contained chlorinated discharges (e.g., swimming pool water) shall be retained, after receiving the last dosing of chlorine, for a minimum of seven days, (or until such time that analysis indicates the level of chlorine to be non-detectable,) such that the chlorine level is reduced or dissipated through aeration or other means, prior to discharging these waters. A pool chlorination kit can be used to confirm that there is no detectable level of chlorine in the water prior to discharge.

Swimming Pool Filter Backwash

Only swimming pool filter backwash that meets all applicable requirements of this permit, including those set forth in this paragraph, are authorized by this permit. Whenever possible, discharges of swimming pool filter backwash shall be directed to the sanitary sewer. If disposal into a sanitary sewer system is not an option, the following measures must be taken prior to discharging the filter backwash into a storm sewer or to a surface water body. The swimming pool filter water shall be retained, until such time that the chlorine has dissipated, prior to discharging. The water used to backwash the filter should also be retained or discharged over a grassy area so those solids settle out and can be removed or are filtered out prior to discharging the water. Solids, residue, or sediment shall not be discharged to a waterway and shall be removed (i.e., discharged to a publicly owned treatment works (POTW), disposed of as solid waste, etc.) prior to discharging the filter backwash water to the receiving waterbody.

C. CERTIFICATION BY AGENT

1. The company or entity authorizing the activity which will result in the discharge to be authorized by this permit, must designate an agent. The agent will be responsible for ensuring that the discharge complies with all applicable requirements of this permit and must certify this compliance in writing.

2. A certification legally executed by the designated agent shall be maintained by the entity authorizing the work. A copy of the certification shall be kept on site. Where this is impractical, a copy shall be kept at the business office of the designated agent and a copy of this certification should be sent to the clerk in the town or municipality in which the discharge will occur. (The discharger is not required to submit a copy of the certification to the Department.) This certification shall be available so that it may be provided to a Department representative, or other person or persons, upon request. The certification shall contain all of the following information (printed or typed):

    a) Name of entity authorizing the work (company, town or municipality) resulting in the discharge to surface water. Name and title of a principal officer in the company or of a specified official in the town or municipality other than the designated agent and the business address and telephone number of same;

    b) Name and title of designated agent, affiliation, address and telephone number;

c) The scheduled date(s) of the discharge event(s);

d) Source of the water being discharged (e.g., filter backwash, pool draining) and nature of the discharge;

e) approximate quantity or flow rate, as appropriate, of the discharge;

f) approximate duration of the discharge;

g) location(s) (street name(s) or street address (as appropriate), municipality, and county) of the discharge;

h) the receiving waters to which the discharge is directed, including the method of transport (i.e., via storm sewer, ditch, tributary, etc.); and

i) Best Management Practices to be used (including any chemical dechlorination agents).

j) The certification shall state specifically: "I, the undersigned, certify under penalty of law that the information provided in this document is true, accurate and complete. I maintain full responsibility for this discharge and its compliance with all applicable requirements as set forth in the NJPDES/DSW General Permit for Swimming Pool Discharges, NJ0128589. I am aware that there are significant civil and criminal penalties for submitting false, inaccurate or incomplete information, including fines and/or imprisonment. I certify that Best Management Practices appropriate to the discharge have been employed. I have no prior knowledge which would deem this discharge ineligible for coverage under this permit." The certification shall be signed and dated both by the designated agent and by the person listed above who is representing the entity authorizing the work.

Certification forms are available from the Division of Water Quality.

3. If this certification is not made as specified above, or cannot be produced upon request of a Department or other government or jurisdictional representative, the discharger may be subject to enforcement actions. The certifying agent should maintain the certification for 90 days following the last discharge event authorized by this certification pursuant to this general permit.

4. The Department reserves the right to require the discharger to cease discharging and obtain an individual or other general NJPDES permit or to utilize other alternate disposal methods. The Department reserves the right to enforce all applicable NJPDES regulations should there be a suspected or confirmed violation of the conditions of the General Permit for Swimming Pool Discharges or of the Federal or New Jersey Water Pollution Control Act. Discharges which are not conducted in accordance with all applicable conditions of this permit and

which therefore may result in adverse environmental impacts, including, but not limited to, a fish kill, may subject the authorizing entity to enforcement actions, including penalties.

From: Sharpe.Taylor@epamail.epa.gov
To: Multiple recipients of list <stormwater@valley.rtpnc.epa.gov>
Date: 4/3/00 1:01PM
Subject: Re: swimming pools & training

Region 6 has recognized swimming pool discharges as a potential problem. We've sent a mailing to about 1700 pool contractors in the State of Texas reminding them that discharges to waters of the US without a permit is a violation of 301 of the CWA. We've also told MS4's to keep an eye on these discharges and to try to eliminate these discharges. Some people balked and said that it was hard to stop. Told them to apply as a group for a general permit to TNRCC (State Agency) as a possible solution. However, without some type of NPDES permit, its a violation and I might enforce on it if they continue. Thats it from Region 6!

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|--------+----------------------->
|        |    Wendy         |
|        |    Bell/DC/USEPA|
|        |    /US@EPA       |
|        |                   |
|        |    03/31/2000   |
|        |    03:27 PM      |
|        |    Please        |
|        |    respond to   |
|        |    stormwater   |
|        |                   |
|--------+----------------------->
  >-----------------------------------------------------|
  |                                                     |
  |   To:    stormwater@valley.rtpnc.epa.gov            |
  |   cc:                                               |
  |   Subject:    swimming pools & training             |
  >-----------------------------------------------------|
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I received a question today about chlorinated swimming pool discharges. The caller said that many swimming pools have a pipe that discharges a small amount to the street daily. In addition, there are the large discharges from emptying a pool.

Since addressing illicit discharges is a requirement for medium & large MS4s, I am wondering how States, Regions, and MS4s have addressed this issue. Do any States have policies on this issue or has it been ignored?

On another matter- we are getting close to finalizing the first training sessions that we are setting up with the Navy. We will have info. on the web site once we know for sure but we expect the training sessions for this year to be in New Orleans, Seattle, San Diego, Denver, Hartford, and

Jacksonville. We would like to involve both other regulators and the regulated community in this training. Therefore, I am looking for suggestions of speakers. Some possibilities are phase I MS4s with good programs that could share their experience of developing a storm water program; military representatives with industrial permits that have been looking at how to address their phase II municipal requirements; storm water agencies that are developing joint a program that covers different entities, and of course, State and Regional coordinators.
If you would like to volunteer yourself or have suggestions, please let me know. Priorities are people in or near the above mentioned cities but I would appreciate suggestions from other areas as well. You can either respond to the list or e-mail me directly at bell.wendy@epa.gov

From: elizabeth.gehrman@pca.state.mn.us
To: Multiple recipients of list <stormwater@valley.rtpnc.epa.gov>
Date: 4/5/00 6:19AM
Subject: FW: swimming pools & training

> Swimming pools are a difficult issue .Obviously, pools have high levels of chlorine -- and sometimes other chemicals -- that can be extremely toxic to aquatic organisms. A direct discharge to the storm sewer, without a permit, is illegal.

> For private homeowners, we have a policy that we encourage them to let the water sit for 3-5 days before discharging. This allows much of the chlorine to dissipate. Additionally, we encourage homeowners to run the water across a lawn or long driveway to provide additional opportunity for chlorine to leave the water.

> For commercial pools (hotels, health clubs, schools, etc.) the volumes are larger, and they can rarely allow the water to sit, untreated, for that length of time. We encourage them to discharge to the sanitary sewer, but I know that some municipalities have begun to prohibit these discharges; it's probably a sewer capacity issue for them. A swimming pool discharge is comparable to a cooling water discharge, all of which have an NPDES permit and are required to meet a chlorine limit. Some other states have a general permit for swimming pool discharges; that would be ideal for us, too, but I've never heard it discussed here. (Obviously, again, it's a resource issue for us.) So, in summary, I believe that many commercial-size pools around the state are inappopriately discharging to the storm sewer, in lieu of better options and/or guidance from us.

> A couple of additional notes:
> There are probably two activities that go on with swimming pools.
> 1. draining the whole or most of the pool down. Large volume, maybe once or twice a year.
> 2. backwash of filters. every few days or so, much smaller volume.
> both of these activities probably have high chlorine in the water at levels that are toxic to aquatic life.

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COUNTY OF LOS ANGELES

OFFICE OF THE COUNTY COUNSEL

648 KENNETH HAHN HALL OF ADMINISTRATION
500 WEST TEMPLE STREET
LOS ANGELES, CALIFORNIA 90012-2713

LLOYD W. PELLMAN
County Counsel

TDD
(213) 633-0901
TELEPHONE
(213) 974-1904
TELECOPIER
(213) 687-7300

April 6, 2000

Ms. Carol Browner
Administrator
United States Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

Ms. Felicia Marcus
Regional Administrator
United States Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, California 94105-3901

Re: Natural Resource Defense Council Petition for Correction of Legal Deficiencies or Withdrawal of EPA Approval

Dear Administrator Browner and Regional Administrator Marcus:

This office represents the County of Los Angeles ("County") and its Department of Public Works. As principal permittee over the Los Angeles Municipal Storm Water Permit, the County is an interested person in the above-referenced petition.

As you know, should the EPA decide to initiate withdrawal proceedings, there are relatively short time frames specified in the federal regulations to seek participation in the proceedings.

The County may wish to move for intervention or other appropriate method of participation if withdrawal proceedings are initiated. It is imperative that the County receive timely notice concerning your decision in this matter. The County requests that it be placed on the service list to receive all notices or correspondence served on the parties to the petition.

We understand that pursuant to federal regulations, "an informal investigation" is underway to determine whether cause exists to initiate withdrawal proceedings. The County requests that it be kept informed of the status of the investigation and, to the extent possible, be allowed to participate in the process to protect its interests.

Notices and correspondence should be addressed to:

Peter J. Gutierrez
Senior Deputy County Counsel
652 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Thank you for your attention to this matter.

Very truly yours,

LLOYD W. PELLMAN
County Counsel

By
PETER J. GUTIERREZ
Senior Deputy County Counsel
Public Works Division

PJG:asm
2g:Browner.ltr

c: Donald L. Wolfe, Assistant Director
County of Los Angeles , Department of Public Works

Dennis A Dickerson, Executive Officer
California Regional Water Quality Control Board -
Los Angeles Region

David S. Beckman, Esq.
Natural Resources Defense Council

Steve Fleischli, Esq.
Executive Director
Santa Monica Baykeeper

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

900 SOUTH FREMONT AVENUE
ALHAMBRA, CALIFORNIA 91803-1331
Telephone: (626) 458-5100

HARRY W. STONE, Director

ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1460
ALHAMBRA, CALIFORNIA 91802-1460

July 31, 2000

IN REPLY PLEASE REFER TO FILE EP-3

Mr. Dennis Dickerson, Executive Officer
California Regional Water Quality
Control Board--Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013-1105

Dear Mr. Dickerson:

MUNICIPAL STORMWATER PERMIT NO. CAS614001--ORDER NO. 96-054
COUNTYWIDE STORMWATER MANAGEMENT PLAN
REPORT OF EFFECTIVENESS

In the Los Angeles County Municipal National Pollutant Discharge Elimination System Permit, Part 2.VII.C.2, the Principal Permittee, in consultation with the Permittees, shall, not later than July 31, 2000, prepare and submit a report on the assessment of the effectiveness of the CSWMP components (except that identified in C.1.). Enclosed, as required, is the Countywide Stormwater Management Plan (CSWMP) Report of Effectiveness for your review.

As you know, the model programs were only recently approved so there was limited feedback on detailed items, but the feedback that was received was very beneficial for determining which program management techniques are preferred.

If you have any questions, please contact Tim Piasky at (626) 458-5969, Monday through Thursday, 7:00 a.m. to 5:30 p.m.

Very truly yours,

HARRY W. STONE
Director of Public Works

Terri M. Grant
Supervising Civil Engineer IV
Environmental Programs Division

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Enc.

cc: All Permittees
Interested Parties

R0008700

FINAL REPORT

LOS ANGELES COUNTY
CSWMP REPORT OF EFFECTIVENESS

July 31, 2000

Prepared by

Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, California 91803

INTRODUCTION

This report was prepared in response to NPDES Permit Section VII.C.2 requiring an assessment on the effectiveness of the CSWMP components. To assess the effectiveness of the Countywide Storm Water Management Plan (CSWMP) components, the County distributed a survey to the Permittees. The questions were grouped into six categories:

- Program Management
- Illicit Connections and Illicit Discharges
- Development Planning
- Development Construction
- Public Agency Activities
- Public Information and Participation

Thirty-nine cities responded to the survey.

PROGRAM MANAGEMENT

This section of the survey received much attention. It includes 17 questions regarding how Permit responsibilities should be issued and which groups should be involved in meetings. A summary of the responses to each question within this section follows.

1. *How would you prefer the next Permit be developed?*

Twenty-eight of the responding cities are in favor of a Countywide Permit. Six cities prefer a Watershed Permit and three cities prefer a COG or sub-watershed Permit. None of the cities were in favor of maintaining their own Permit.

2. *Do you want the County to continue as Principal Permittee?*

Thirty-six of the responding cities prefer to have the County continue as the Principal Permittee, or at least retain certain functions, such as program leadership in Monitoring, Public Education, Reporting, and Administration. Only one city does not want the County to continue as Principal Permittee.

3. *Are you satisfied with current Principal Permittee responsibilities?*
4. *Should other Principal Permittee responsibilities be added?*

Thirty-two of the responding cities find current Principal Permittee responsibilities adequate. Four cities recommend adding to the County's responsibilities, namely taking the lead in developing and implementing a new Countywide trash monitoring program to satisfy trash TMDL and Notice to Meet and Confer (NTMC) requirements. One city would like the monitoring program to be coordinated with local efforts.

5. *Are you satisfied with current Permittee responsibilities?*
6. *Should other Permittee responsibilities be added?*

Thirty-five of the responding cities agree current Permittee responsibilities are adequate. Three cities are open to having responsibilities added to city duties, and one would like to see responsibilities removed. Added responsibility suggestions include monitoring, cost sharing, help in distributing information, and negotiating directly with the Regional Board. The suggested responsibility removal is TMDL monitoring.

7. *Were the WMC meetings successful?*

The opinion of the success of WMC meetings is generally positive, mainly as an informational forum. Five cities disagree, emphasizing that there is room for improvement.

8. *What was the most useful aspect of the WMC meetings?*

The most useful aspects of the WMC meetings:

Developing watershed direction
Discussing common issues
Sharing information and ideas
Pooling resources
Receiving EAC updates
Obtaining new information
Having a dedicated time to coordinate activities

9. *What could be improved at the WMC meetings?*

Suggestions for improvements at the WMC meetings:

Chair should be large city rather than an outside contractor
Follow through on action items
Start on time
Stick to the agenda
Present an education topic or invite guests
Respond to Watershed issues
Participation of all cities
Focus on one or two issues per meeting

Acquire grant funding
Propose projects
Meet less frequently
Ensure Regional Board attends consistently
More leadership by County
Have more invited guests from other watershed stakeholders

10. Should the WMC set goals?

Opinions are split as to whether the WMC should set goals (20 responding cities are for, 13 against). There is a slight favoritism toward setting goals such as monitoring, participation, and uniformity. Those against believe the Permit defines WMC goals and that adding goal-setting would add bureaucracy.

11. Should the WMC be included in the next Permit?

Thirty cities wish to continue WMC meetings. Two cities are against continuing WMC meetings, with one of the cities recommending a COG-based Committee.

12. Were the EAC meetings successful?

Cities that attend EAC meetings basically agree that they are successful.

13. What was the most useful aspect of the EAC meetings?

Useful aspects of the EAC meetings:

Allowing Permittees to quickly voice concerns to the Regional Board
Hearing other watershed opinions
Learning of new means to comply with the Permit
Sharing information and resources
Providing leadership on issues

14. What could be improved at the EAC meetings?

Improvements could be made to the EAC meetings by:

Distributing minutes faster and to more City Management
Negotiating solutions (reducing combativeness)
Including watershed chairs
Sharing more specific experiences

15. *Would you support one large group watershed meeting immediately followed by individual watershed meetings?*

Twenty-eight cities are in favor of a large group watershed meeting followed by individual watershed meetings. Pros are large scale problem solving and the ability to address specific issues that are not recognized in smaller group meetings. Cons are the time involved, scheduling, and attendance for multi-watershed Permittees. If this type of meeting is put into place, most cities feel the larger group should meet less frequently than once a month.

16. *How often should the groups meet?*

Most cities (24) would like to see watershed meetings continue on a monthly basis. If the group watershed meeting is added, it could meet quarterly. Other suggestions include meeting once a month with both groups, holding watershed meetings semimonthly or quarterly, and holding watershed meetings more frequently at the beginning of the new Permit.

17. *Should the public review process be modified?*

Generally, cities are satisfied with the public review process. Seven cities suggested modifications. Suggestions to modify the process:

Commission a third party to summarize each opinion at public hearings
Exclude public review of permit submittals
Develop technical work groups

ILLICIT CONNECTION AND ILLICIT DISCHARGES

The Illicit Connections and Illicit Discharges (IC/ID) Model Program has been received well, although some cities feel it is too early in the program to comment.

18. *Has the Illicit Connections and Illicit Discharges Model Program been successful so far?*
19. *What are the biggest successes of the program?*

The most noted success of the IC/ID program is greater awareness among the public and city staff members. Other successes include behavioral changes, code enforcement clarity and development of a Public Hot Line program for receiving, responding, tracking and reporting public complaints.

20. *What are the biggest failures of the program?*

Failures of the IC/ID program:

Identifying, responding, enforcing, and documenting all IC/IDs due to resource limitations
Lack of standardized enforcement procedures

21. *How could the program be improved?*

Suggestions to improve the program:

Increase funds to hire more staff
Hire County people to do IC on a contract basis
Establish fire truck washing as a conditionally exempted discharge
Recognize non-stormwater connections and address them
Provide uniform guidelines for washing impervious surfaces
Standardize enforcement and spill response procedures
Enforce pro-actively
Introduce more outreach
Improve documentation

22. *Should any of the exempted or conditionally exempted discharges be dealt with as illicit connections or illicit discharges?*

In general, cities do not want to deal with exempted or conditionally exempted discharges as IC/IDs. Three cities disagree. The items suggested for IC/ID are homeowner wash water, street washing, fire fighting, dechlorinated swimming pool discharges, and individual car washing.

23. *Have there been any noticeable improvements from the program?*

Noted improvements from the IC/ID program include:

Increased public awareness
Increased public reporting
Fewer sewage overflows and grease interceptor problems
Improved sawcut slurry vacuuming
Decreased illicit discharges from Industrial/Commercial sites

DEVELOPMENT PLANNING

The Development Planning Model Program is rather new. Almost one third of the cities feel it is too early to comment on the success of this program. Cities that commented generally feel the program is succeeding.

24. *Has the Development Planning Model Program been successful?*

The program is viewed as successful by 18 of the responding cities. Sixteen cities found it too early to judge. Noted downfalls of the program include:

Resistance to implement BMPs due to aesthetic reasons
Disapproval of Regional Board SUSMPs

25. *How could the program be improved?*

Suggestions for improvement include:

Make the program clear and sensible
Condense and clarify the program
Support the August 1999 Permittee-submitted SUSMPs
Develop standards
Enforce consistently
Reject the Regional Board's SUSMPs
Enhance brochures
Simplify and expedite the approval process for the SUSMP and BMPs
Make Regional Board requirements consistent and feasible
Allow cities greater flexibility
Increase harvesting requirements
Implement on a widespread basis
Conduct follow-up training for city staff
Tailor program for local soil and relief conditions
Acquire more information regarding the effectiveness of all BMPs
Exclude non-discretionary projects

26. *Which BMPs have been successful and why?*

Different BMPs have worked for different cities. However, there is still limited information to develop effectiveness opinions. Generally, cost-effective BMPs that can be readily implemented for a project without significantly interfering with other project aspects are the most successful. BMPs that have been successful on a limited basis include:

Reducing impervious surfaces

Requiring large percentage of lot area to be landscaped
Incorporating trash container areas
Implementing basic housekeeping practices
Education
Introducing CDS units and Jensen Stormwater Interceptors
Incorporating catch basin protection and runoff protective measures
Building dry gravel wells, pits, trenches, permeable paving, french drains
Using treatment control devices and post-construction management plans

27. Which BMPs have not been successful and why?

Due to the short time that BMPs have been being implemented, there was a limited response as to which BMPs have not been successful. More will be understood about the successfulness of various BMPs as the results of these recently installed BMPs become available. However, it was noted by one city that redevelopment is actually hindered due to the expense of incorporating BMPs. The reason some BMPs failed is due to maintenance, cost, aesthetics, and physical constraints. Some of these include:

Catch basin inserts
Fossil filters
Detention basins
Planters
Maximizing pervious surfaces

28. Have there been any noticeable improvements?

There is a consensus that the program is making improvements, although they are difficult to quantify. Ten cities noted improvements. Improvements as a result of the Development Planning Model Program:

Increased awareness in permit applicants
Increased runoff collection
Appreciation of city efforts by local entities

DEVELOPMENT CONSTRUCTION

Again, this program is too new for all the cities to comment on.

29. Has the Development Construction Model Program been successful?

All of the cities that gave a definitive response (31) feel the program is successful. Its main benefits are increased awareness and BMP implementation.

30. *How could the program be improved?*

Suggested improvements for the program:

Improve coordination of inspections between the Regional Board and City Staff
Improve document clarity
Provide BMP training for inspectors and developers
Improve enforcement
Increase the involvement from the Regional Board on 5+ acre projects
Need reference information from the Regional Board

31. *Which BMPs have been successful and why?*

Sand bags and other containment methods (silt fences, k-rail, berms, and gravel bags) are the most successful BMPs. Favored BMPs are generally useful, cost effective, easily understandable, and maintainable. Other successful BMPs include street sweeping, retention ponds, vegetated areas, and storm drain inlet protection.

32. *Which BMPs have not been successful and why?*

Although there were considerably more BMPs noted for successfulness, there are aspects that need improvement. The downside of sand bags is their natural deterioration and possible failure. A negative aspect of silt fences is their maintenance. The use of hay as a method for preventing intrusion of surface water into catch basins is adverse, because the hay tends to collapse quickly under high flow conditions. The BMPs reducing the tracking of dirt from construction sites to streets was noted as impractical and ineffective. Training and scheduling BMPs posed a problem due to the unpredictability of rainfall. Contractor compliance is a main concern that can impede the success of any BMP.

33. *Have there been any noticeable improvements from the program?*

Through inspectors cognizance and enforcement of BMPs, contractor awareness and compliance have improved. Other noted improvements of the program include agency coordination, construction site erosion control, and trash reduction.

PUBLIC AGENCY ACTIVITIES

34. *Has the Public Agency Activities Model Program been successful so far?*

The Public Agency Activities Model Program received a positive response. All responding cities, except for two, agree it has been successful so far. Awareness and street cleanliness have been very positive aspects of the program.

35. *How could the program be improved?*

Improvements can be made to the program by:

- Expanding and increasing education and training
- Reducing record keeping
- Modifying the Annual Report questionnaires
- Clarifying the document by adding Development Planning/Development Construction requirements
- Ensuring County flood control crew compliance
- Increasing Regional Board enforcement of their general permits
- Renaming the program to "Municipal Agency Programs"
- Adding operations such as refuse collection and water production

36. *Which activities should be added to the program?*

Suggested additions to the program are more training materials and better data-tracking systems.

37. *Which activities should be removed from the program?*

The emergency procedure was recommended for removal. It was also suggested that the dry weather flow diversion be moved to a separate program.

38. *Have there been any noticeable improvements from the program?*

Improvements from the program include:

- Cleaner streets, catch basins, and city facilities
- Increased awareness
- Staff involvement
- Equipment procurement

PUBLIC INFORMATION AND PARTICIPATION

39. *What has been the effectiveness of the industrial/commercial educational program?*

The industrial/commercial educational program received a mixed review. Responses ranged from finding the program moderately effective to a huge success. Positive aspects noted were increased knowledge, awareness and compliance. However, compliance was problematic for other cities.

40. What has been your experience in submitting site visit data to the County?

There was a mixed response to data submittal as well. The majority of cities found submitting to the County difficult, while others responded positively. Editing and formatting data were noted complications using the SiteViz program. County staff was helpful to many cities encountering these difficulties.

41. What is the database software of preference for your City?

Preferred City database software includes Microsoft products such as Access and Excel. FileMaker Pro was also noted as a preference over SiteViz. However, the majority of cities (33) support Microsoft products currently or will soon.

42. What kind of benefits have come from the program?

As with other programs, the main benefits reported are public awareness and education. Other positive aspects of the program are:

Improved business operations
Enhanced communication with businesses
Improved permit compliance

43. What is the main issue involved when managing the program?

Many issues faced when managing the program revolve around the SiteViz database. Data entry is time consuming, tedious, and requires specialized training. Other factors impeding program management are:

Changing ingrained polluting habits
Coordinating with the County
Finding staff time to conduct and document the program
Getting the most accurate business information
Coordinating all departments
Deciphering inspector reports

44. What data should be added or removed from the industrial/commercial educational program databases?

Suggestions for modifying the database:

Add State IDs for sites with State General Industrial Storm Water Permits
Add a field to recommend a follow-up
Add a field for narrative comments

- Remove codes
- Remove one of the two date fields
- Limit the activities assessment list to checkmark fields
- Allow multiple values in one field rather than multiple fields with one value
- Focus on the 14 categories in the Countywide program guidance
- Improve the Health Department's performance
- Clarify the PPD rating process
- Add procedure for adding and deleting businesses from the database

45. *What sites should be added to the educational site visits?*

Many of the sites that were suggested to include on educational site visits involve vehicle maintenance or sales. Other sites that may benefit from site visits are:

- Schools
- Hospitals
- Nurseries
- Contractor yards
- Business Parks
- Shopping centers
- Carpet cleaners
- Pool service businesses
- Dry-cleaning establishments with onsite facilities
- Veterinary clinics/animal hospitals
- Hotels/Motels
- Residential care facilities
- Parking lots
- Trailer parks

It was also suggested to discontinue visits to certain vehicle supply wholesale distributors, sweatshops, out of home businesses and out of business sites.

46. *What information should be added to the educational site visits?*

To make the site visits more useful, inspectors could discuss current trash and litter issues, product substitution (for pollution prevention), State Law AB 2019 concerning non-filers, and the 5-Year Education Strategy. Improvements could also be made by developing more industry specific BMPs.

CONCLUSIONS

The CSWMP is still in its infancy and thus it is premature at this time to accurately measure its effectiveness, however it has been determined to be an effective tool for increasing stormwater pollution awareness and prevention.

RECOMMENDATIONS

The items listed, throughout this evaluation, as potential improvements to a respective Program should be studied further, such that final results and recommendations can be included in the submittal of the ROWD and WMAPs to the RWQCB by Febuary 1, 2001.

PROJECT
Pollution
PREVENTION

Storm Water/Urban Runoff Public Education Program

Five-Year Storm Water Public Education Strategic Analysis

Submitted by:
Los Angeles County
Department of Public Works
July 31, 2000

R0008714

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INTRODUCTION

The 1996 National Pollutant Discharge Elimination System Municipal Storm Water Permit requires that the County of Los Angeles, as Principal Permittee, conduct a five-year public education program. A budget of $5.2 million for five years was allocated for the public education program. As the Program enters its fifth and final year, it has become recognized as a model pollution prevention public education program among municipalities on a regional and statewide basis.

At the time of the Permit's inception, the County and the 85 Permittee cities did not have a clear picture of who among the County's diverse population to target for public education, and what messages were needed to motivate significant behavior change. Moreover, all parties acknowledged that a $5.2 million budget was extremely limited for a public education program of this complexity, necessitating that funds be allocated judiciously. The conclusion was that, while not mandated, financial support would need to be solicited from Permittees to leverage limited resources and extend the Public Education Program's media reach.

After a full year of information gathering, original quantitative and qualitative research and consensus-building with Permittees, the County's public relations contractors, Rogers & Associates, with their lead subcontractors Harris & Company and Larry Walker Associates, submitted the Five-Year Public Education Plan to the Regional Water Quality Control Board (RWQCB) on July 30, 1997 and received approval to proceed.

We are now completing Year Four of the five-year Permit period and Year Three of the Five-Year Public Education Plan. The final qualitative research report on the public education program will be available in June 2001. However, interim research studies, anecdotal information, public/private partnerships and media coverage have been included in this report to offer RWQCB a "snapshot" of how the Public Education Plan has faired to date -- and what steps should be taken to advance the effort in the new permit period.

Following is a brief analysis of public relations activities from Years One through Four and recommendations for Year Five public education outreach efforts and the new permit's public education component.

The Five-Year Public Education Program was designed to be:

- Grounded in research
- Broad-based with an overarching approach
- Flexible, adaptable, and cost-effective
- Accessible, providing simple, everyday actions that will make a difference
- Integrated and coordinated
- Results-oriented

Overall Program Goals and Strategies

At the outset, the County of Los Angeles identified seven primary program goals aimed at reducing storm water pollution:

- Reduce the amount of storm water / urban runoff pollution ~~in Los Angeles~~ County.
- Build bridges and forge partnerships that integrate County, city and jurisdictional programs, appropriately mix educational outreach with technical understanding and leverage resources.
- Improve general understanding of storm water / urban runoff pollution and its prevention methods.
- Incorporate storm water activities into other County environmental education programs by the end of the second year of implementation.
- Move existing County BMPs under the storm water pollution prevention program umbrella by August 1998.
- Integrate the County storm water overarching theme into a minimum of 35%* of the Permittee programs by August 1998 and 50%* by August 2000.
- Increase *awareness* of storm water pollution prevention messages among the adult population to 83%* in five years.

* *Note:* These percentage goals will be measured on a countywide basis.

To reach these core objectives, the Public Education Program identified and recommended eight key programmatic strategies – designed to work synergistically, leverage resources and expand the Program's potential reach and impact.

Strategy 1: Overarching Approach
Develop a unified overall public education approach, "look" and message(s) that promote Los Angeles County's overall storm water / urban runoff goals to set the tone and feel for the overall public education program. This approach helps all target audiences identify the program and its pollution prevention messages.

Strategy 2: Partnerships
Build bridges and forge partnerships that are conducive to maximum leverage of resources and that integrate: (1) County, city and jurisdictional programs and (2) the public and private sectors.

Strategy 3: Unified Pollution Prevention Efforts
Create synergy by unifying multiple pollution prevention efforts (such as recycling, proper household hazardous waste and used oil disposal recycling) under a single, all-encompassing agenda rather than conducting individual, splinter programs. Link all programs to the impact they have on storm water pollution under "Project Pollution Prevention."

Overall Program Goals and Strategies cont.

Strategy 4: Segment and Target Specific Audiences

Prioritize audiences and activities within each audience that will target the greatest potential polluters who (1) are the most likely to adopt change in their personal and professional behaviors, and (2) that will result in the highest pollutant removals in the most cost-effective manner.

Identify as primary targets those people who are most likely to attempt pollution prevention activities and to repeat their usage if the experience is positive, simple and convenient. While no one will be ignored, downgrade to a secondary level of importance those people who would not, for a variety of reasons, try to change their habits and behaviors and those people who have a minimal level of impact on storm water pollution.

Strategy 5: Simple, "How-To" Instructions Incorporated Into Everyday Routines

Develop specific guidelines supported by simple tasks and concise "how-to" or "tips" instructions that will motivate Los Angeles County residents and businesses to use pollution prevention actions in their "everyday" routines.

Strategy 6: Monitoring and Evaluation

Establish a monitoring and evaluation system to: (1) measure the effectiveness of the program by assessing the number of people who show increased awareness, intent and/or actions in reducing storm water/urban runoff pollution; and (2) ensure program components and outreach efforts are adjusted and enhanced on a regular basis in relation to what is working and what isn't in the various communities and target audiences.

Strategy 7: Implement Countywide Programs and Supplement with Local Programs

Develop an overall program with individual activities that impact pollution on a countywide basis. Utilize overarching materials for all audiences that are developed and implemented by the County, yet are supportable and supplemented on a local basis in a manner that meets Permit minimum requirements, is cost effective and efficient.

Strategy 8: Multiple Audience Impact

Wherever possible, develop program materials and activities that can be implemented and will have impact on more than one audience at a time.

Using Research to Develop the Program

In order to lay the groundwork for implementing these eight-core strategies, identify target audiences and set goals, comprehensive, multi-phased research was conducted.

◆ ***Issues, Pollutants and Materials Report***

The first research report, *Issues, Pollutants and Materials Report,* was a compilation of: (1) existing research on target audiences and public education programs in Los Angeles County; (2) an analysis of storm water public education model programs throughout the country; and (3) a review of existing information and analysis of pollutants of concern. In this report, several overall challenges became apparent and have served as the impetus in formulating research and monitoring questions and methods.

These overall challenges were:

- Discovering exactly what motivates or influences behavior change in each target audience;
- Deciding who to target within each audience segment;
- Prioritizing audiences to maximize the budget;
- Addressing the County's vast ethnic, cultural, geographical and socioeconomic diversity; and
- Demonstrating that the education effort has helped to reduce storm water / urban runoff pollution.

Segmentation Research

Based on these challenges, it was decided that a segmentation study would offer the best approach for arriving at answers.
The two primary objectives for the Segmentation Study conducted in February 1997 were:

Objective 1 Segment Los Angeles County residents for the purpose of directing limited County and Permittee resources toward those residents who pose the *greatest threat* to storm water quality and who represent the *greatest opportunity* to respond to a public education program.

Objective 2 Provide a baseline measurement of residents' current storm water-related practices and habits.

Prior to conducting this segmentation study, it was hypothesized that all Los Angeles County residents are not equally responsible for storm water pollution, or at least may differ in the type of pollution they are contributing. An analysis of the collected data supports this hypothesis that different groups of residents differ significantly in terms of: (1) the amount of pollution they contribute; (2) their demographics and lifestyles; and (3) their attitudes related to storm water pollution and the likelihood of changing their behaviors.

Using Research to Develop the Program cont.

♦ ***Methodology Overview***

Total number of interviews:	1191 among Los Angeles County residents
Timeframe of interviews:	February 8 - March 23, 1997
General population sample:	- Countywide random sampling - Selected by random digit phone numbers - Established for gender and age based on census data
Participants were screened for these criteria:	- 16 years or older - Must be a permanent resident of Los Angeles County and have lived here for more than six months
Surveys were conducted in language of preference:	- English - Mandarin - Spanish - Korean - Cantonese - Vietnamese
Recent immigrant segments:	- Latino (sample = 101), Asian (sample = 101) - Residents who moved to the County from another country - Lived in County at least six months, but less than five years - Speak Spanish, Cantonese, Mandarin, Korean or Vietnamese most often at home

Segmentation is the result of a cluster analysis performed by a computer filtering and sorting the total population based on their survey answers by attitudinal and behavioral variables. The segments/groups are reflective of those residents who are most/least likely to change behavior and who have more or less damaging behavior by volume[1]. The residents characterized as "Neat Neighbors," "Fix It Foul-Ups," and "Rubbish Rebels" are the three segments that were identified as the primary targets of the Five-Year Public Education Program.

We learned from the segmentation that overall, Los Angeles County residents are interested in and concerned about local water quality. They are also willing to change many of their behaviors that contribute to storm water pollution.

Unfortunately, even with their high overall level of concern, many residents are unknowingly engaging in practices that threaten storm water quality. Additionally, although the County's indicators of concern and potential compliance are positive, not all residents are equally concerned about or willing to change their behaviors in order to improve storm water quality. By segmenting the population, however, a clearer picture emerges of who should be targeted with limited resources and how best to reach them.

[1] Estimated volumes of pollution created by pollution-causing behaviors were derived from the self-reporting activities recorded in the segmentation study. For example, if 1.09 million people self-reported dropping one cigarette butt per day on the ground.

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Using Research to Develop the Program cont.

Target Audiences

From the segmentation analysis, two groups of Los Angeles County residents emerged as most promising in terms of allocating public education resources:

"Neat Neighbors"
(primary target)
50% of County's population

Because of their numbers in the population and because of their desire to 'do the right thing,' "Neat Neighbors" will likely heed the program's messages and even small, but widespread changes in these residents' habits will positively impact the County's storm water quality.

"Fix It Foul-Ups"
(primary target)
13% of County's population

"Fix It Foul-Ups" contribute disproportionately to storm water pollution through their do-it-yourself activities. However, they have good intentions and are very receptive to modifying their pollution-causing behaviors. They can be effectively reached through do-it-yourself channels.

To effectively promote behavior change among the primary target audiences -- Neat Neighbors and Fix It Foul-Ups -- the Program needed to tap into their desire to 'do the right thing' and provide them 'how-to' information about alternative, anti-polluting behaviors. These residents were likely to be affected by credible messages that imply that a change in their behavior will help protect children, keep their neighborhoods from smelling and preserve the environment for the future.

Total Population Reached Based on Segmentation Recommendations

Neat Neighbors	50%	72% of Los Angeles County residents receive messages using two different communications campaigns
Fix It Foul-Ups	13%	
Rubbish Rebels	9%	
	72%	
Concerned Non-Contributors	20%	Additional 20% gained from spillover of Neat Neighbor/Fix It campaign (92% total)
	20%	
Prove-It-To-Me Polluters	5%	8% considered non-targets due to low polluting behavior or low number (100% total)
Preoccupied Polluters	3%	
	8%	

Status of Results/Achievements

Once target audiences were confirmed, focused goals were set, and key messages were developed, the County initiated a comprehensive and multi-faceted public education program. In order to effectively reach the target 83% of County residents with pollution prevention messages and bring about measurable behavioral change, the Program employed a strategic mix of communications tactics, which included:

- Paid advertising (radio, print, outdoor and transit shelter)
- Nontraditional advertising (movie slides, radio promotions, coffee jackets)
- Media relations (broadcast and editorial coverage)
- Partnerships with corporations, retailers, nonprofit organizations, community-based organizations and trade associations
- Participation in high-profile special events
- Strategic outreach to schools and businesses
- Collaboration with synergistic DPW programs and local city efforts
- Specialized "Project Pollution Prevention" Program collateral and premiums

Just as program strategies and goals were founded on research, research was used as a critical monitoring tool throughout the duration of the Program – to help evaluate its effectiveness on an ongoing basis and modify strategies where appropriate.

Interim "Touchbase" Tracking Study – July 1998

In July 1998, an interim tracking research study was completed assessing the near-term impact of the Program against the May 1997 baseline segmentation study. The "touchbase" was specifically designed to assess the effectiveness of the January-June 1998 paid media advertising campaign and to provide recommendations for improving the overall effectiveness of the media campaign for 1999. Based on the "touchbase" study, the storm water program was proven to be: (1) communicating accurately; (2) perceived by Los Angeles County residents to be delivering important messages; (3) successful in changing attitudes; and (4) starting to positively impact behaviors.

According to the touchbase study, the Program and Media Campaign appeared to be most successful in their first six months in *getting residents to understand the connection that what goes into the streets, goes into the ocean.* Residents also understood that the water from storm drains goes to the ocean *untreated.* In the baseline study, residents were asked about their level of concern about issues of concern facing Los Angeles County. At that time, residents ranked crime, quality of public schools, air pollution, smog and pollution of the ocean, lakes, and rivers as their top four concerns, in that order. One year later, the ranking shifted – and *the only issue that increased in concern was pollution of the ocean, lakes and rivers* – moving from the fourth priority issue to the third priority issue.

Status of Results/Achievements cont.

Pollution Volumetrics – Total Number of Occurrences Per Month
Target audience exposed to media advertising campaign for six months (January – June 1998)

Pollution-causing behaviors with significant changes between 1997 and 1998	**1997**	**1998**	**Difference**
Allow paper or trash to blow into the street	692,194	565,585	-126,609
Drop a cigarette butt on the ground	1,094,297	807,978	-286,319
Empty a car ashtray into the street	168,928	69,275	-99,653
Wash off paint brushes under an outdoor faucet	195,399	126,510	-68,889

Pollution volumetrics – an estimate of the number of people in the County engaging in polluting activities – extrapolated from the research showed significant changes in polluting behaviors between 1997 and 1998 with the following representative activities:

- Allowing paper or trash to blow into the street, down from about 692,000 times per month in May 1997 to about 565,000 times per month in June 1998
- Dropping a cigarette on the ground, down from about one million butts per month in 1997 to about 800,000 butts per month in 1998
- Emptying a car ashtray into the street, down from about 168,000 time per month in 1997 to about 69,000 times in 1998
- Washing off paint brushes under an outdoor faucet, down from about 195,000 to about 126,000

Final Segmentation Study – June 2001

A final segmentation study will be conducted in June 2001 – at the culmination of the five-year program – to assess the overall effectiveness of the Program and to provide detailed recommendations for the next permit's public education component. The survey sample size and demographics will mirror the May 1997 baseline study and will be designed to comprehensively measure awareness levels and polluting behaviors among all target audience segments.

Topline public education recommendations are provided in this report, based on all anecdotal and field experience, qualitative and quantitative research conducted to date. Final program recommendations will be submitted upon completion of the Year Five segmentation study.

Status of Results/Achievements cont.

"Snapshot" of Public Education Program Results – select results through June 2000

In addition to the measurable behavior change identified in the two interim segmentation studies (July 1998 and July 2000), public education program activities have been "quantified," whenever possible, to capture the Program's reach and depth. Media campaign tactics have been strategically recommended and executed to garner maximum impressions (number of times audience hears campaign message) and to leverage limited media advertising resources. In most primary areas of activity, additional value in marketing dollars has been secured – meaning pro bono advertising, media and corporate partnerships were secured that would have otherwise cost the Program significant budget resources.

Program Activity	Added Value/Impact
Advertising – Traditional	♦ Countywide media campaign (radio, print, billboards and transit shelters) ***reached upwards of 86% of the target audience*** during its first two years and ***leveraged more than $1,985,000*** in pro bono media placements. ♦ The third annual media advertising campaign ran from April to July 2000.
Advertising – Nontraditional	♦ Nontraditional advertising venues–including Project Pollution Prevention-imprinted movie theater slides, coffee jackets, and Countywide radio promotions–generated ***upwards of 28,000,000 impressions.***
Media Relations	♦ Print and electronic media placements secured to date– including media campaign launch, interim segmentation study results, El Nino and Earth Day tie-ins, and diversion system coverage--are ***valued at an estimated $712,000*** and generated ***upwards of 87,000,000 impressions.***
Corporate Partners	♦ Program partners secured to date – including COSTCO, CSK/Kragen, Chevron, Brita, Petco, City of Los Angeles and Initiative Media – have generated an ***estimated $3,808,000 in additional value.***
Special Events	♦ Participation in more than 25 Los Angeles County special events (County Fair, Earth Faire, etc.) has reached an ***estimated total attendance of 860,000.***
Business Outreach	♦ Los Angeles County Health Dept. restaurant rating system trainings – including storm water BMPs – ***reached 50,000 County restaurant workers.*** ♦ Specialized automotive repair BMPs video and manual reached ***up to 19,000 automotive repair students.***
School Education Grades: K-6	♦ Environmental Defenders Program reached ***more than 1,000,000 students*** at ***1,500 Los Angeles County schools*** through assembly events and through community events.
School Education Grades: 7-12	♦ Generation Earth Program includes a service learning curriculum and projects for students, field studies, radio campaign, a battle of the schools competition, community events for students and teachers, concerts and the internet www.generationearth.com
Used Oil Program	♦ Regional Used Oil Media Campaign – Annual media campaign (radio, print and outdoor advertisement) with proper disposal/recycling messages for the Rubbish Rebel/do-it-yourselfer demographic providing them with straight forward information on how and where to recycle used motor oil and filters.

Getting Results:
What it Takes to Make Social Marketing Programs Work

Social marketing campaigns, unlike public awareness campaigns, are designed to bring about behavioral change utilizing a variety of mutually reinforcing communications strategies. The mandate to "normalize" or "denormalize" a specific social behavior is challenging on many levels, and the most successful campaigns are those that have been focused in their efforts and well financed – allowing for sustained saturation of consistent messages through multiple outreach venues.

The intended targets of such programs must pass through several stages on their road to behavior change. In the case of storm water pollution, the County aims to guide ten million residents from a vastly diverse population base – from awareness of the issue and polluting behaviors, to acknowledgment that they are contributing to the problem through their actions, to the adoption of pollution prevention practices in their daily life. Given the challenges implicit in developing new social "norms" and the particular complexities of the storm water issue, this complete shift to a pollution prevention mindset and lifestyle will take many years – and only then, if there has been a consistently high level of message exposure among residents. Without prolonged, consistent reach and frequency *and* significant long-term budget, a social marketing campaign has little chance of meeting its formidable objectives.

To understand what it does take to achieve success on this level, we will refer to a movement widely regarded as the leader in the social marketing arena – the tobacco control movement. This model social marketing campaign should be reviewed by the RWQCB as it develops the new permit in its entirety, and the public education component, specifically.

The tobacco control movement – illustrated in this case by the Los Angeles County Tobacco Control Program and its parent program, the California Tobacco Control Program (established under Proposition 99) -- has achieved overwhelming success in "denormalizing" and modifying a variety of smoking behaviors. After ten years of sustained public education, and new laws regarding the use of tobacco in public places, the number of smokers has plummeted from 24% in 1988 to 18% in 2000 across the state, including Los Angeles County. This represents just one of many successes, which include reduced incidence of smoking among youth, lowered case rates of lung and other cancers, and increased protection from secondhand smoke.

In analyzing California's tobacco control movement, it is important to note:

- That the movement has achieved these successes through the combined efforts of many multi-media campaigns – designed and implemented by local health departments, community coalitions and organizations, voluntary health organizations, regional, statewide and federal projects
- That the movement has a simple message that links smoking, disease and death and is able to put a face on the consequences of this behavior
- That the movement is able to focus efforts against an "external" enemy (the tobacco industry)
- That the movement has been in full swing for ten years and has benefited from high-profile legislation and extensive media coverage throughout its history
- And that the media campaign has been well funded in order to meet its objectives

Getting Results:
What it Takes to Make Social Marketing Programs Work cont.

COMPARATIVE LOS ANGELES COUNTY PROGRAM BUDGETS STORM WATER VS. TOBACCO CONTROL PROGRAM		
Annual Program Budgets	**Storm Water/Urban Runoff Program**	**Los Angeles County Tobacco Control**
Advertising Budget	$400,000 [2]	$390,000 [3]
Other Source Contributions	$450,000 (City of Los Angeles and Permittee contributions) [2]	$5,500,000 [4]
Subtotal	**$850,000 per year**	**$5,890,000 per year**
Public Relations Budget	$800,000 [2]	$500,000 [3]
Other Source Contributions	NA	$750,000 [4]
Subtotal	**$800,000 per year**	**$1,250,000 per year**
Total Annual Program Funds:	**$1,650,000 per year**	**$7,140,000 per year**

In the simplest terms, the funding levels outlined above are key to understanding the success of the tobacco control movement. Los Angeles County Tobacco Control's annual combined PR/advertising budget is just under $1 million. However, the state's overarching public education program directs more than $6 million per year specifically to Los Angeles County – nearly 25% of its annual operating budget. Because the state's high-profile advertising and public education campaigns provide "umbrella" coverage of key campaign messages across and within the state's key markets, the Los Angeles County program is able to strategically direct its monies to very specific outreach needs within the community. Add to this a ten-year track record, a steady stream of support among key stakeholders in the public health arena, and highly publicized legislative victories, and it becomes clear that significant and lasting behavioral change is precipitated by a finely-tuned mix of resources and strategies.

Juxtaposed against this is the Los Angeles County Storm Water Public Education Program. To our credit, with only three years of program implementation at limited spending levels, the Program has seen some measurable success in modifying the polluting behaviors of Los Angeles County residents. However, in order to have a substantial and long-term impact on the region's pollution levels, the Program needs dramatically increased funding levels over a prolonged period of time. Current program dollars are only enough to purchase advertising during a 3-4 month period each year. Due to rising media costs (radio advertising costs increased 20% between 1999 and 2000) and static public education dollars, the Stormwater Program has actually received less media value (decreasing reach and frequency) for its money each year. Now add to this lack of an overarching statewide or federal pollution prevention advertising/public education campaign, "optional" funding contributions from Permittees and other Municipal NPDES permit holders within the Los Angeles media market, and a very complex issue without a universal "enemy" or "face," and it becomes clear that the Storm Water Public Education Program is in need of significant funding. The State and Federal Government along with the private sector must step to the plate and become actively and financially involved to assure the continual success of the Program.

[2] *Avg. advertising and public relations budgets for LA County Storm Water Program since Year Two (1997-98)*
[3] *Avg. advertising and public relations budgets for L A County Tobacco Control Program since 1997*
[4] *Approximate percentage of annual contributions to target LA County from the California Tobacco Control Program (Prop 99); total advertising/PR budget of $25,000,000*

Recommendations to Date

As noted, this report captures and analyzes Los Angeles Storm Water Public Education Program activities conducted through Year Four of the Permit -- June 2000. Utilizing all available qualitative and quantitative research, field/anecdotal experience and knowledge gleaned from other synergistic DPW programs and social marketing campaigns, the County has presented the chronology of the Five-Year Public Education Program, its strategic underpinnings and achievements to date.

The Permit has recently completed Year Four, but only Year Three of Public Education Program implementation. As outlined in the Five-Year Public Education Plan and under the current NPDES Permit, public education will be implemented through June 2001 and a final segmentation study will be conducted at the culmination of the program. Thus, results garnered through 2001 should be carefully reviewed, as they will provide a more complete picture of the effectiveness of the Five-Year Public Education Plan and will provide a strong foundation on which to base future program recommendations.

Based on results to date, we recommend the following elements be implemented to effectively conduct the public education and outreach program:

1. **Public Education Programs should continue** - As supported by research, we believe that eighty-three percent (83%) of Los Angeles County's population can be reached with key pollution prevention messages through a single, integrated, multi-faceted communications campaign which focuses on a desire to "do the right thing" and provide "how to" information about alternative, anti-polluting behaviors. Working in concert with the Permittees, the County's Public Education Program adopted the "problem/solution" - oriented approach and reinforced it with strong visual cues and an identifying "signature" look and feel--"Project Pollution Prevention."

   Through a strategic and cost-effective combination of educational outreach tools and activities, the comprehensive Public Education Program has shown measurable increases in awareness among target audiences after three years of implementation. The Program has seen increases both in knowledge base (about the impacts of storm water pollution and potential solutions to reduce the problem), and in behaviors (by encouraging the adoption of appropriate solutions).

   Through a unified and coordinated effort between the County and Permittees, an integrated Public Education Program can continue to:

   - Change the mindset of a large, diverse population while educating target audiences about solutions to storm water pollution;
   - Create synergy by using an overarching campaign approach, "look" and tone, and by unifying multiple pollution prevention efforts;
   - Impact more than one audience at a time with a single communications campaign;
   - Build bridges and forge partnerships that integrate city and jurisdictional programs; and
   - Document and prove that the educational outreach efforts result in behavioral change and reduced pollution -- in all communities within Los Angeles County.

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Recommendations to Date cont.

2. **Research should continue to play a major role in the development and execution of the new public education program.** Research has proven to be a critical component of the current Storm Water Public Education Program. Upfront, it enabled the Media Campaign to segment and prioritize target audiences and allocate limited budget resources accordingly. At key benchmarks, interim research enabled the Media Campaign to monitor its effectiveness, evaluate communications tactics and modify strategies to achieve optimal results. Raising the bar in the new public education program – both in terms of reaching numeric goals and judiciously allocating increased dollars – will require continuous monitoring and evaluation.

3. **Additional funds from various sources should be allocated to the Public Education Program** – Interim Tracking Study results (July 1998) indicated that the media campaign was: communicating accurately; perceived by Los Angeles County residents to be delivering important messages; successful in changing attitudes; and was starting to impact behaviors. Because Los Angeles is a cluttered and expensive media market, a significant increase in funding and coordination is required to consistently build upon public education program results and deliver media messages with optimal reach and frequency.

   Unlike the Los Angeles County tobacco control program (previously noted), the Storm Water Public Education Program does not benefit from any statewide media campaign "spillover,"-- nor statewide budget dollars earmarked for Los Angeles County, nor a high-profile, multi-media campaign conveying complementary messages.

   In order to effectively convey the Program's complex messages and maintain consistent visibility throughout the program year – and not just during specific seasonal "windows,"--the program under the new permit needs to receive ***3-5 times the current annual program budget.***

   This is clearly beyond the means of the few local governments now supporting the effort. All Permittees, the State and the Federal Government need to pitch-in and contribute to the long-range success of the Program.

Recommendations to Date cont.

4. **Specific funds should be allocated to paid advertising and should reflect rising media costs.** Of the total public education program budget, ***approximately 70% per year should be earmarked for paid media.*** Paid media is the venue where we can best pinpoint target audiences, control placement, reach and frequency of the outreach, and can ensure consistent exposure to proven messages.

   Advertising costs are rising exponentially in the LA media market. To lend perspective, *radio advertising costs increased 20% between 1999 and 2000, while public education dollars remained consistent.* What that means is that instead of increasing the reach of program messages among County residents annually, program dollars were actually able to buy less and less advertising time each year, with total target audience reach also decreasing annually. To match anticipated cost increases, paid advertising allocations should range between 65% - 75% of the total annual program budget between Year One and Year Five.

   As delineated in the Program's core strategies, unified efforts are necessary to meet the program's challenging objectives. One collective media buy – coordinated by the County and supplemented by all parties -- will provide the County as a whole with the most strategic use of limited dollars and a media campaign most likely to achieve success.

5. **Final public education recommendations should be based on Year Five segmentation study findings.** The final segmentation should be utilized as the comprehensive benchmark of the Program's effectiveness and serve as the critical foundation for public education recommendations under the new permit. Given that the public education program has only enjoyed less than three years of implementation, the final full year of program activity (and its subsequent measurement) is expected to play a significant role in developing future educational strategies.

Data from the final segmentation study will be analyzed to determine the following additional items:

- **The effectiveness of advertising creative concepts and materials** – dependent on findings, new creative concepts and messages may be recommended to maximize media impact.
- **Confirmation on the *extent* to which an increase in funds *specifically allocated towards paid advertising* is recommended.**
- **The need to allocate funds towards business outreach** -- given that this audience is reached to a great degree through general public/residential outreach efforts and the industrial/commercial education site visit program.

Storm Water Public Education Program Overview

The following section is broken down by fiscal year and category of activity. Supporting this overview are representative samples of the education activities. Work was performed under ten categories of activities.

Activity	Five-Year Plan (Section 4)
1. Graphic Design/Advertising	General Public/Residents, Activities 1, 2, 4, 5, 8; Businesses, Activities 1, 6; Public Agency Employee, Activity 2
2. Corporate Partnerships	General Public/Residents, Activities 6, 9; Businesses, Activity 4
3. Media Relations and News Bureau	General Public/Residents, Activity 3; Businesses, Activity 5; Public Agency Employee, Activity 4
4. Special Events	General Public/Residents, Activity 10
5. Trade Show Displays	General Public/Residents, Activity 7
6. Tips Cards and Other General Public Collateral Materials	General Public/Resident. Activities 2, 5; Public Agency Employee, Activity 2
7. Business Outreach Materials	Businesses, Activities 1, 2
8. Training/Workshops	Businesses, Activities 3, 4; 8; Public Agency Employee, Activities 1,2, 3
9. Bulletins	Public Agency Employee, Activity 4
10. Research	Section 5, Five-Year Public Education Plan

Year One (1996 - 1997) Highlights

Research and Development of Five-Year Plan

- Developed ***Public Education Advisory Committee***, an ad hoc committee of various Permittee and County representatives, assembled to provide constructive input into the development of the ***Five-Year Public Education Plan*** and elicit buy-in from Permittee cities. Facilitated meetings throughout the fiscal year.

- Developed ***Initial Five-Year Public Education Plan – Part One***, detailing situation analysis, goals and objectives for the four primary target audiences: general public/residential; commercial/industrial and new development/ construction; K-12 school children; and public agencies.

- Developed ***Research Report on Issues, Pollutants and Materials***. The report served as a resource for reviewing and assessing the individual and collective efforts of Los Angeles County, 85 Permittees and some of the nation's leading storm water / urban runoff prevention programs. Focus areas in the report included: complex issues surrounding storm water / urban runoff prevention efforts; the prioritization of pollutants of concern, land uses and associated target audiences; specific materials and programs being implemented throughout the country; and overall recommendations on how to proceed in developing the ***Five-Year Public Education Plan.***

- Developed ***Initial Five-Year Public Education Plan – Part Two***, detailing overall strategies and public education tactics.

- Developed ***Residents and Industry Storm Water Awareness, Practices and Communications Report***. Report detailed focus group findings on current levels of awareness, knowledge and concern about storm water pollution; current usage of BMPs; reactions to potential program messages, creative materials and outreach strategies.

- Developed two-volume ***Public Employee Trainers' Manual*** (Volume One: Municipal Activities; Volume Two: Construction). Manuals were developed to provide Permittees with training materials for educating appropriate Permittee employees regarding compliance with applicable storm water permits. Conducted three training sessions for public agency employees.

- Conducted ***Los Angeles County Segmentation Study*** to define target audiences, quantify polluting behaviors and provide a strategic foundation for the ***Five-Year Public Education Plan's*** goals, objectives, messages, strategies and outreach tactics. Study identified three primary target audience segments around which to strategically and cost-effectively focus public education efforts. Segments, characterized as "Neat Neighbors," "Fix-It Foul-ups," and "Concerned Non-Contributors," were defined as the largest contributors to storm water pollution and those most likely to change behaviors, and represent approximately 83% of LA County's 10 million residents.

Year One (1996 - 1997) Highlights - cont.

Research and Development of Five-Year Plan

- Conducted presentations on ***Segmentation Study*** results, creative concepts and scenarios within the ***Five-Year Public Education Plan*** to the Public Education Advisory Committee and WMA Committees.

- Developed first three BMP posters for Site Visit Program and began distribution.

Special Events

- Attended the Los Angeles County Fair and other community events.

Year Two (1997 - 1998) Highlights

Research and Development of Five-Year Plan

- Developed final ***Five-Year Public Education Plan*** for review and approval by the *Public Education Advisory Committee, WMA Committees*, and ultimately, the *RWQCB*.

- Conducted ***Interim "Touchbase" Tracking Study*** following six-month implementation of the advertising campaign. Study indicated that the media campaign proved to be: (1) communicating accurately; (2) perceived by LA County residents to be delivering important messages; (3) successful in changing attitudes; and (4) starting to impact behaviors.

Graphic Design/Advertising

- Developed and produced letterhead package, including the ***Channel Bulletin*** and media release letterhead, and ***The Report*** covers.

- Developed ***Project Pollution Prevention*** logo and made available to Permittees via the Internet (www.freethmoroz.com).

- Developed and planned Countywide media buy in accordance with the ***Segmentation Study***.

- Tested media messages through mall intercept studies done in partnership with the City of Los Angeles.

- Conceptualized and produced ***Now You Know*** media campaign in accordance with the ***Segmentation Study*** and mall intercept results. Creative materials utilizing the ***Now You Know*** theme, included radio spots, print ads, and bus shelter poster designs.

- Paid media campaign leveraged **$1,085,000 in pro bono outdoor and radio placements**.

Media Relations

- Secured print and electronic media stories garnering **upwards of 22,766,000 impressions** at a **value of $162,439.**

- Developed ***Guide to Storm Water Media Relations***, a comprehensive resource manual to assist Permittees in executing local media relations campaigns: conducted workshop for Permittees in conjunction with the distribution of the media guide.

- Developed and distributed Spanish and English radio PSAs.

Year Two (1997 - 1998) Highlights - cont.

Corporate Partnerships

- Confirmed partnerships with Metro Display Advertising, Eller Media, Vista Metropolitan Outdoor Media, Worldwide Pet Supply Association, LA County Police Canine Association, PETCO, CrazyDog, Doggie Walk Bags at an **estimated value of $2.7 million.**

- Implemented training partnership with County of Los Angeles Health Services Department for restaurant worker storm water BMP training. Upwards of 50,000 businesses were identified for training over the next fiscal year.

Business Outreach

- Developed ***Businesses and Industries for a Clean Environment*** overview brochure.

- Finalized copy and design of 18 BMP fact sheets, technically specific and researched among target audience.

- Conducted an auto repair workshop with the California Dept. of Toxic Substances Control and the LA Urban League Toyota Training Center.

- Developed ***Southeastern Targeted Opportunities to Prevent Pollution (STOPP) Business Outreach Pilot Program***, detailing site visit reports, recommendations for business outreach (to auto repair shops and restaurants) and preparations for public workshops.

- Conducted ***Auto Mechanics Clean Business Fair***, an entertainment-oriented education event for automotive repair shop managers and employees hosted by County inspector David Dolphin and KTNQ/KLVE Spanish-language radio celebrity, Humberto Luna.

- Developed ***Project Pollution Prevention (PPP) Automotive Repair Workshop Report,*** detailing the ***Auto Mechanics Clean Business Fair.***

- Conducted ***Clean Business Expo*** for restaurants in conjunction with California Department of Toxic Substances Control, California Restaurant Association, and Bell Gardens Merchants and Commerce Association.

- Developed and distributed a series of topical small space ads for Permittee use (available on disk and via the Internet).

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Year Two (1997 - 1998) Highlights - cont.

Special Events

- Attended County special events (including Earth Fest '98, and Los Angeles County Fair). **Estimated attendance: 258,000.**

Bulletins

- Developed seven ***Channel Bulletins*** and distributed to Permittees, Public Education Advisory Committee and special interest mailing list.

Year Three (1998 - 1999) Highlights

Research

- Compiled results of ***Interim "Touchbase" Tracking Study***; produced and distributed research report to RWQCB, Public Education Advisory Committee, SCAG, SMBRP, County and Permittees.

Graphic Design/Advertising

- Conceptualized and produced new radio, print and outdoor media campaign reflecting 1998 interim evaluation results. Creative materials using the ***Warning Sign*** theme, included radio commercials, print ads, bus shelter poster designs and movie theatre slides.

- Paid advertising campaign leveraged **$900,000 in pro bono outdoor and radio placements.**

- Distributed ad launch materials to Permittees, Board of Supervisors and RWQCB.

- Secured advertising space on the screens of four high-traffic movie theaters coinciding with summer blockbuster season **(860,000 impressions)** and highlighted in the AMC Magazine's July issue **(circulation 100,000).**

- Secured advertising space on the back of grocery receipts in four high-traffic County stores for eight weeks, garnering **325,000 impressions**.

Tips Cards and Other General Public Collateral Materials

- Produced pesticide and fertilizer tips cards with PPP branding; produced used oil tips cards in conjunction with Chevron; produced recycling tips cards in conjunction with COSTCO.

- Produced interactive storm water pollution prevention game to increase participation at special events.

Corporate Partnerships

- Confirmed partnerships with Chevron, COSTCO, Petco, LA County Arboretum, Southern California Veterinary Medicine Association, and Doggie Walk Bags, garnering an **estimated 2,775,000 impressions** at a **value of $136,066**.

R0008736

Year Three (1998 - 1999) Highlights - cont.

Media Relations

- Secured print and electronic media stories garnering **8,530,000 estimated impressions** at a **value of $157,030.**
- Secured media coverage regarding County storm water diversion systems in the *Los Angeles Times* (front page), *Beach Reporter*, *Daily Breeze* and *Long Beach Press-Telegram.* **Estimated impressions: 1,500,000.**
- Secured ad launch coverage in *Adweek*, *Daily Breeze*, *News-Pilot*, KFWB-AM and KCSN-FM. **Estimated impressions: over 500,000.**
- Secured County panelists and coordinated storm water program on Century *Cable's Bill Rosendahl Show.* **Estimated impressions: 404,000.**
- Developed and distributed five template media releases to all Permittees.
- Produced two audio news releases (general storm water pollution prevention and lawn and gardening care). **Estimated impressions: 1,075,000.**

Special Events

- Attended ten County special events (including Earth Faire, Los Angeles County Fair, America's Family Pet Expo, Long Beach Home and Garden Show). **Estimated attendance: over 250,000.**

Business Outreach

- Conducted meetings with the Building Industry Association regarding the new State Construction Permit.
- Conducted educational site visits.

Bulletins

- Developed four ***Channel Bulletins*** and distributed to Permittees, Public Education Advisory Committee and special interest mailing list.

R0008737

Year Four (1999 – 2000) Highlights

Graphic Design/Advertising

- Secured and coordinated four-week radio promotion with KIIS FM, ***2000 Superbowl Storm Water Sweep,*** including: partnerships with Universal Studios, Pepsi and Popeye's Chicken; four weeks of on-air spots and announcements. Website postings, interactive phone messages and promotions at live remotes; and a station-sponsored beach clean-up and picnic, wherein more than 2,200 pounds of trash was collected along Santa Monica Beach. **Estimated impressions: 22,567,000.**

- Secured advertising space on the screens of five high-traffic movie theaters coinciding with holiday blockbuster season **(1,106,700 impressions)** and highlighted in the AMC Magazine's November issue **(circulation 100,000).**

- Secured advertising space on the back of grocery receipts in four high-traffic County stores for 12 weeks. **Estimated impressions: 975,000.**

- Produced two additional radio ads. "Encounter Group" and "Salute."

- Annual Countywide media campaign aired from April into July 2000 and has not been evaluated to date.

- Distributed media campaign materials to Permittees, Board of Supervisors and RWQCB.

Media Relations

- Secured print and electronic media stories garnering **53,892,100 estimated impressions** at a **value of $310,604.**

- Secured media coverage on less toxic/alternative products, used oil recycling centers and HHW Roundups, including four live feature segments on the *KTLA Morning* News and two segments on *KTLA Pacesetters*. **Estimated impressions: upwards of 2,120,000 at a value of $80,000.**

- Secured media coverage on launch of five new underground storm water diversion systems. in conjunction with Heal the Bay. the City of Long Beach and the American Lung Association. **Estimated impressions: upwards of 3,000,000 at a value of $22,000.**

Year Four (1999 - 2000) Highlights - cont.

Tips Cards and Other General Public Collateral Materials

- Produced 65,000 customized coffee jackets imprinted with PPP messages, and secured distribution at 31 County coffeehouses. **Estimated impressions: 1,296,000.**

- Produced 10,000 customized magnets – focused on used automotive fluid recycling – imprinted with PPP and CSK/Kragen logos. Initial distribution took place at the Toyota/Long Beach Grand Prix.

- Produced 7,500 general pollution prevention tips cards imprinted with PPP and Brita logos. Initial distribution took place at Earth Faire 2000.

- Produced 20,000 customized shop towels (10,000 English, 10,000 Spanish) – focused on used automotive fluid recycling – imprinted with PPP messages and logo, and developed in conjunction with the City of Los Angeles and CIWMB. Initial distribution took place at Eagle One Nationals.

Corporate Partnerships

- Confirmed partnerships with CSK/Kragen, Brita. American Lung Association, City of Los Angeles and CIWMB garnering **an estimated value of $66,000.** Note: partnership with high-profile corporate and nonprofit entities such as Kragen, Brita and American Lung contributed considerable added value to the Program, though one that is not quantifiable in traditional advertising/marketing dollars. The Program benefited significantly from these affiliations via their significant "brand equity," increased credibility among target audience segments and greatly expanded program visibility and reach.

Special Events

- Attended six County special events (including the Los Angeles County Fair, Latin Business Association Expo, Toyota/Long Beach Grand Prix, Earth Faire, Cinco de Mayo at Whittier Narrows and Eagle One Nationals); **estimated attendance: over 500,000.**

Business Outreach

- Developed and distributed specialized automotive repair BMP workbooks and videos to 319 automotive instructors at targeted high schools. ROP programs. adult vocational schools, community colleges (potentially **reaching upwards of 19,000 students**).

Bulletins

- Developed three ***Channel Bulletins*** and distributed to Permittees and special interests.

R0008739

Winston H. Hickox
Secretary for Environmental Protection

California Regional Water Quality Control Board

Los Angeles Region

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640
Internet Address: http://www.swrcb.ca.gov/~rwqcb4

Gray Davis
Governor

August 3, 2000

Jeff Pratt
Deputy Director, Department of Public Works
Ventura Countywide Stormwater Quality Management Program
Ventura County Flood Control District (Principal Co-Permittee)
800 South Victoria Avenue, L#1600
Ventura, CA 93009

Directors of Public Works/City Engineers
Municipal Co-Permittees
Ventura County MS4

VENTURA COUNTY MUNICIPAL STORM WATER NPDES PERMIT (BOARD ORDER No. 00-108; NPDES PERMIT No. CAS004002) – LETTER OF TRANSMITTAL

Dear Mr. Pratt, et al:

We are pleased to send you the final municipal storm water permit for the Ventura County (attached), which was adopted by the Regional Board at its meeting on July 27, 2000, pursuant to Division 7 of the California Water Code. Board Order No. 00-108 serves as your permit, under the National Pollutant Discharge Elimination System (NPDES), for storm water discharges and urban runoff within Ventura County, and will expire on July 27, 2005.

The Order requires the Ventura County Flood Control District, herein referred to as the Principal Co-Permittee, and other Co-Permittees to implement the NPDES Permit No. CAS004002, including the Monitoring and Reporting Program, Ventura Countywide Stormwater Quality Urban Impact Mitigation Plan (SQUIMP), and Ventura Countywide Stormwater Quality Management Plan (SMP). The first Annual Storm Water Report and Assessment, for the period July 1, 1999 through July 27, 2000, is due on October 1, 2000. The first Annual Monitoring Report is due July 15, 2001.

Once again, we wish to thank you and your staff for their participation and assistance during the development and adoption of the permit for the Ventura County. Should you have any questions, please do not hesitate to call me at (213) 576-6605 or Dr. Xavier Swamikannu at (213) 576-6654.

Sincerely,

Dennis A. Dickerson
Executive Officer

cc: Jorge Leon, State Water Resources Control Board
Marilyn Levin, Office of the State Attorney General

County of Ventura	Co-Permittee
City of Camarillo	Co-Permittee
City of Fillmore	Co-Permittee
City of Moorepark	Co-Permittee
City of Ojai	Co-Permittee
City of Oxnard	Co-Permittee
City of Port Hueneme	Co-Permittee
City of San Buenaventura	Co-Permittee
City of Santa Paula	Co-Permittee
City of Simi Valley	Co-Permittee
City of Thousand Oaks	Co-Permittee

Interested Parties on File

R0008741

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WASTE DISCHARGE REQUIREMENTS

FIGURE 1

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ATTACHMENT B

MONITORING AND REPORTING PROGRAM

ATTACHMENT

STATE OF CALIFORNIA

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER NO. 00-108 NPDES PERMIT NO. CAS004002
WASTE DISCHARGE REQUIREMENTS
FOR
MUNICIPAL STORM WATER AND URBAN RUNOFF DISCHARGES
WITHIN
VENTURA COUNTY FLOOD CONTROL DISTRICT,
COUNTY OF VENTURA, AND THE CITIES OF VENTURA COUNTY

FINDINGS

The California Regional Water Quality Control Board, Los Angeles Region (hereinafter called the Regional Board), finds that:

Permit Parties

1. Ventura County Flood Control District (VCFCD), the County of Ventura, and the Cities of Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, San Buenaventura, Santa Paula, Simi Valley, and Thousand Oaks (hereinafter referred to separately as Co-permittees and jointly as the Discharger) have joined together to form the Ventura Countywide Storm Water Quality Management Program to discharge wastes under waste discharge requirements contained in Order No. 94-082, adopted by this Board on July 27, 2000. The Discharger discharges or contributes to discharges of storm water and urban runoff from municipal separate storm sewer systems (MS4s), also called storm drain systems, into receiving waters of the Santa Clara River, Ventura River, Calleguas Creek, and other coastal watersheds within Ventura County.

2. The Regional Board may require a separate National Pollutant Discharge Elimination System (NPDES) permit for any entity that discharges storm water into coastal watersheds of Ventura County. Such entity can be any State or Federal agency, State or Federal facility, real estate development, waste disposal facility, special district, private interest, etc. Pursuant to 40 CFR 122.26(a), the Regional Board will give these entities the option to become a Co-permittee, after obtaining the concurrence of the Co-permitees, or obtain an individual storm water discharge permit.

Nature of Discharge

3. Storm water discharges consist of surface water runoff generated from various land uses in all the hydrologic drainage basins which discharge into waters of the State. The quality of these discharges varies and is affected by hydrology, geology, land

use, season, and sequence and duration of hydrologic events. The primary pollutants of concern currently identified by the Program for these discharges are total and fecal coliform, mercury, polyaromatic hydrocarbons (PAHs), DDT and their by-products, diazinon, sediment/total suspended solids (TSS), chlorpyrifos, copper, lead, thallium, bis(2-ethylhexyl) phthalate, and phosphorous.

4. In general, the substances that are found in urban storm water runoff can harm human health and aquatic ecosystems. In addition, the high volumes of storm water discharged from MS4s in areas of urbanization can significantly impact aquatic ecosystems due to physical modifications such as bank erosion and widening of channels. It is anticipated that, due to the nature of storm water events (i.e., large volumes of water and high velocities) that there will be short-term, reversible impacts to beneficial uses that are not directly related to water quality.

5. Water quality assessments conducted by the Regional Board identified impairment, or threatened impairment, of beneficial uses of water bodies in the Ventura Coastal Watersheds. These impairments include many of the pollutants of concern identified by the program. These impairments are identified on the Federal 303(d) list of impaired water bodies.

Permit Background

6. The Discharger has filed a report of waste discharge (ROWD) and has applied for renewal of its waste discharge requirements and an NPDES permit to discharge wastes to surface waters. The ROWD includes the Ventura Countywide Storm Water Quality Management Plan (hereinafter called Ventura County SMP) which describes in detail all group activities and entity-specific activities. The Ventura County SMP also describes management measures that are included and how they are organized; it lists tasks required to accomplish the measures, the schedule for implementation, and specific goals. The schedule and tasks are projected for the 5-year permit period. An outline of the Ventura County SMP is presented in Attachment B. The Implementation chapter of the Ventura County SMP consists of the following elements:

   a. Program management
   b. Programs for residents
   c. Programs for industrial/commercial businesses
   d. Programs for land development
   e. Programs for construction sites
   f. Programs for Co-permittee facility maintenance, and
   g. Programs for illicit discharge control

   The Ventura County SMP is implemented by the Co-permittees with general funds, and/or Benefit Assessment Program funds.

7. The Ventura Countywide Storm Water Quality Management Program also includes the Storm Water Monitoring Plan. To date, the monitoring program has consisted of land-use based monitoring combined with receiving water monitoring and modeling. The Discharger intends to sign an agreement to participate in the Regional Monitoring

Program established for Southern California municipal programs under the guidance of the Southern California Coastal Water Research Project.

8. The Regional Board has reviewed the ROWD and has determined it to be complete under the reapplication policy for MS4s issued by the USEPA on July 1996. The Regional Board finds that the Permittee's proposed Storm Water Management Plan is acceptable at this time, and when fully implemented, is expected to be consistent with the statutory standard of Maximum Extent Practicable (MEP).

Permit Coverage

9. The area subject to permit requirements includes all areas within the boundaries of the cities as well as unincorporated areas of Ventura County defined as urban by the U.S. Census Bureau (Figure 1). Municipal storm drain systems in this area discharge either directly into the Pacific Ocean or one of five major water bodies:

Water Body	Receives Municipal Storm Drain Discharges from:
Ventura River	City of Ojai, City of San Buenaventura (part), unincorporated Ventura County (part)
Santa Clara River	City of Fillmore, City of Oxnard (part), City of San Buenaventura (part), City of Santa Paula, unincorporated Ventura County (part)
Calleguas Creek	City of Camarillo, City of Moorpark, City of Simi Valley, City of Thousand Oaks (part), unincorporated Ventura County (part)
Malibu Creek	City of Thousand Oaks (part), unincorporated Ventura County (part)
Bays/ Estuaries	City of Oxnard (part), City of Port Hueneme, City of San Buenaventura (part)

10. The Co-permittees are separate legal entities and have the authority to develop, administer, implement, and enforce storm water quality management programs within their own jurisdiction. The Ventura County SMP defines certain storm water discharge requirements that apply to the Discharger, and others that apply to specific Co-permittees. Each Co-permittee is responsible for compliance with relevant portions of this permit within their jurisdiction.

11. VCFCD is the Principal Co-permittee for permit implementation while the remaining entities, including the County of Ventura and the ten cities, are designated as Co-permittees. The following Implementation Agreement exists between the Principal Co-permittee and the Co-permittees:

As the Principal Co-permittee, VCFCD will:

a. Coordinate permit activities;
b. Establish uniform data submittal format;
c. Set time schedules;
d. Prepare regulatory reports;
e. Forward information to the Co-permittees;

f. Arrange for public review;
g. Secure services of consultants as necessary;
h. Implement activities of common interest;
i. Develop/prepare/generate all materials and data common to all Co-permittees;
j. Update Co-permittees on Regional Board and US Environmental Protection Agency (USEPA) regulations;
k. Arrange for collection and payment of annual permit renewal fee; and,
l. The Principal Co-permittee shall convene all Management Committee and Subcommittee meetings.

All Co-permittees will:

a. Comply with the requirements of the permit within their own jurisdictional boundaries;
b. Prepare and provide to the Principal Co-permittee permit-required submittals;
c. Develop programs to address:
   - Implementation of controls to reduce pollution from commercial, industrial, and residential areas;
   - Implementation of structural/non-structural controls on land development and construction sites;
   - Implementation of controls to reduce pollution from maintenance activities;
   - Elimination of illegal connections, including discouragement of improper disposal, encouragement of spill prevention and containment, and implementation of appropriate spill response;
   - Inspection monitoring and control programs for industrial facilities; and,
   - Implementation of public awareness and training programs.

d. Co-permittees shall be represented at Management Committee Meetings;
e. There are currently five subcommittees which were developed during the first permit cycle: Residents, Businesses/Illicit Discharges, Planning and Land Development, Construction, and Co-permittee Facilities Maintenance. The Management Committee will assign subcommittee attendance requirements in proportion to Co-permittee population. Co-permittees shall be represented at all assigned subcommittee meetings, and,
f. Within its own jurisdiction, each Co-permittee is responsible for adoption and enforcement of storm water pollution prevention ordinances, implementation of self-monitoring programs and Best Management Practices (BMPs), and conducting applicable inspections. Based upon a countywide model, each Co-permittee, except the City of Simi Valley, has adopted a Storm Water Quality Ordinance applicable to their jurisdiction. This is in addition to 'the

'Control of Water Quality, Soil, Erosion and Sedimentation of New Agricultural Hillside Developments' adopted by the Board of Supervisors of the County of Ventura on March 20, 1984. The Principal Co-permittee is responsible for the preparation and submittal of progress and annual reports to the Regional Board.

12. This permit is intended to develop, achieve, and implement a timely, comprehensive, cost-effective storm water pollution control program to minimize pollutants to the maximum extent practicable in storm water discharges from the permitted area in Ventura County to the waters of the United States.

Federal and State Regulations

13. The Water Quality Act of 1987 added Section 402(p) to the Federal Clean Water Act (CWA). This section requires the U.S. Environmental Protection Agency (EPA) to establish regulations setting forth NPDES requirements for storm water discharges. The first phase of these requirements was directed at municipal separate storm drainage systems (MS4) serving a population of 100,000 or more and storm water discharges associated with industrial activities, including construction activities. Other dischargers, including municipalities with a population of less than 100,000, for which the U.S. EPA Administrator or the State determines that the storm water discharge contributes to a violation of a water quality standard, or is a significant contributor of pollutants to waters of the United States, may also be subject to NPDES requirements. On November 16, 1990, EPA published these final regulations in the Federal Register under Part 122 Code of Federal Regulations.

14. The CWA allows the EPA to delegate its NPDES permitting authority to states with an approved environmental regulatory program. The State of California is a delegated State. The Porter-Cologne Water Quality Control Act (California Water Code) authorizes the State Water Resources Control Board (State Board), through the Regional Boards, to regulate and control the discharge of pollutants into waters of the State and tributaries thereto.

15. Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) requires coastal states with approved coastal zone management programs to address non-point pollution impacting or threatening coastal water quality. CZARA addresses five sources of non-point pollution: agriculture, silviculture, urban, marinas, and hydromodification. This NPDES permit addresses the management measures required for the urban category, with the exception of septic systems. The Regional Board addresses septic systems through the administration of other programs.

16. The State Water Resources Control Board adopted a revised Water Quality Control Plan for Ocean Waters of California (Ocean Plan) on July 23, 1997. The Ocean Plan contains water quality objectives for the coastal waters of California.

17. This Regional Board adopted a revised Water Quality Control Plan (Basin Plan) for the Los Angeles Region on June 13, 1994. The Basin Plan, which is incorporated into this Order by reference, specifies the beneficial uses of Ventura County water

bodies and their tributary streams and contains both narrative and numerical water quality objectives for these receiving waters. The following beneficial uses are identified in the Basin Plan and apply to all or portions of each watershed covered by this Permit:

a. Municipal and domestic supply
b. Agricultural supply
c. Industrial service supply
d. Industrial process supply
e. Ground water recharge
f. Freshwater replenishment
g. Navigation
h. Hydropower generation
i. Water contact recreation
j. Non-contact water recreation
k. Ocean commercial and sport fishing
l. Warm freshwater habitat
m. Cold freshwater habitat
n. Preservation of Areas of Special Biological Significance
o. Saline water habitat
p. Wildlife habitat
q. Preservation of rare and endangered species
r. Marine habitat
s. Fish migration
t. Fish spawning
u. Shellfish harvesting

18. To facilitate compliance with federal regulations, the State Water Resources Control Board (State Board) has issued two statewide general NPDES permits: one for storm water from industrial sites [NPDES No. CAS000001, General Industrial Activities Storm Water Permit (GIASP)] and the other for storm water from construction sites [NPDES No. CAS000002, General Construction Activity Storm Water Permit (GCASP)]. The GCASP was issued on August 20, 1992. The GIASP was reissued on April 17, 1997. Facilities discharging storm water associated with industrial activities and construction projects with a disturbed area of five acres or more are required to obtain individual NPDES permits for storm water discharges, or be covered by these statewide general permits by completing and filing a Notice of Intent (NOI) with the State Board. The USEPA guidance anticipates coordination of the state-administered programs for industrial and construction activities with the local agency program to reduce pollutants in storm water discharges to the MS4.

19. The State Board, on October 28, 1968, adopted Resolution No. 68-16, "Maintaining High Quality Water" which established an anti-degradation policy for State and Regional Boards.

20. The State Board, on June 17, 1999, adopted Order No. WQ 99-05, which specifies standard receiving water limitations language to be included in all municipal storm water permits issued by the State and Regional Boards.

21. California Water Code (CWC) Section 13263(a) requires that waste discharge requirements issued by Regional Boards shall implement any relevant water quality control plans that have been adopted; shall take into consideration the beneficial uses to be protected and the water quality objectives reasonably required for that purpose; other waste discharges; and, the need to prevent nuisance.

22. California Water Code Section 13370 *et seq.* requires that waste discharge requirements issued by the Regional Boards comply with provisions of the Federal Clean Water Act and its amendments.

<u>Public Notification</u>

23. This action to adopt and issue waste discharge requirements and an NPDES permit for this discharge is exempt from the provisions of the California Environmental Quality Act (CEQA), Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Section 13389 of the California Water Code.

24. The Regional Board has notified the Discharger and interested agencies and persons of its intent to issue waste discharge requirements for this discharge, and has provided them with an opportunity to submit their written views and recommendations.

25. The Regional Board, in a public hearing, heard and considered all comments pertaining to the discharge and to the tentative requirements.

26. This Order shall serve as a National Pollutant Discharge Elimination System (NPDES) Permit, pursuant to Section 402 of the Federal Clean Water Act, or amendments thereto, and shall take effect on August 11, 2000 provided the Regional Administrator of the EPA has no objections.

IT IS HEREBY ORDERED that the Ventura County Flood Control District, the County of Ventura, and the Cities of Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, San Buenaventura, Santa Paula, Simi Valley, and Thousand Oaks, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act, as amended, and regulations and guidelines adopted thereunder, shall comply with the following:

PART 1 - DISCHARGE PROHIBITIONS

A. The Co-permittees shall, within their respective jurisdictions, effectively prohibit non-storm water discharges into the MS4 (storm drain systems) and watercourses except where such discharges:

   1. Are covered by a separate individual or general NPDES permit; or

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2. Meet one of the conditions below:

   a. Not identified as a source of pollutants:

      1. Flows from riparian habitats or wetlands;
      2. Diverted stream flows;
      3. Natural springs;
      4. Rising ground waters;
      5. Uncontaminated ground water infiltration [as defined at 40 CFR 35.2005(20)]; or;

   b. Not identified as a source of pollutants, subject to conditions:

      6. Water line flushing;
      7. Discharges from potable water sources;
      8. Foundation drains;
      9. Footing drains;
      10. Air conditioning condensate;
      11. Water from crawl space pumps;
      12. Reclaimed and potable irrigation water;
      13. Dechlorinated swimming pool discharges;
      14. Individual residential car washing;
      15. Sidewalk washing;
      16. Discharges or flows from emergency fire fighting activities.

   If any of the above categories of non-storm water discharges (Part I, A.2.b) are determined to be a source of pollutants by the Regional Board Executive Officer, the discharge need not be prohibited if the Co-permittee implements appropriate BMPs to ensure that the discharge will not be a source of pollutants. Notwithstanding the above, the Regional Board Executive Officer may impose the prohibition in consideration of anti-degradation policies.

   The Discharger may, for any of the above non-storm water categories, require BMPs deemed necessary to ensure that the discharge will not be a source of pollutants.

   c. The Regional Board Executive Officer may authorize the discharge of additional categories of non-storm water, after consideration of anti-degradation policies and upon presentation of evidence that the non-storm water discharge will not be a source of pollutants. This evidence may include the implementation of BMPs to control pollutants.

3. Discharges originating from federal, state, or other facilities which the Discharger is pre-empted by law from regulating.

PART 2 - RECEIVING WATER LIMITATIONS

A. Discharges from the MS4 that cause or contribute to the violation of water quality standards or water quality objectives are prohibited.

B. Discharges from the MS4 of storm water, or non-storm water, for which a Discharger is responsible, shall not cause or contribute to a condition of nuisance.

C. The Discharger shall comply with the permit through timely implementation of control measures and other actions to reduce pollutants in the discharges in accordance with the Ventura County SMP and other requirements of this permit including any modifications. The Ventura County SMP shall be designed to achieve compliance with receiving water limitations. If exceedance(s) of water quality objectives or water quality standards persist, notwithstanding implementation of the Ventura County SMP and other requirements of this permit, the Discharger shall assure compliance with discharge prohibitions and receiving water limitations by complying with the following procedure:

   1. Upon a determination by either the Discharger or the Regional Board that discharges are causing or contributing to an exceedance of an applicable water quality standard(s), the Discharger shall promptly notify and thereafter submit a report to the Regional Board that describes BMPs that are currently being implemented, and additional BMPs that will be implemented, to prevent or reduce any pollutants that are causing or contributing to the exceedances of water quality standards. This report may be included with the Annual Storm Water Report and Assessment, unless the Regional Board directs an earlier submittal. The report shall include an implementation schedule. The Regional Board may require modifications to the report.

   2. Submit any modifications to the report required by the Regional Board within 30 days of notification.

   3. Within 30 days following the approval of the report, the Discharger shall revise the Ventura County SMP and monitoring program to incorporate the approved, modified suite of BMPs, implementation schedule, and any additional monitoring required.

   4. Implement the revised Ventura County SMP and monitoring program according to the approved schedule.

D. So long as the Discharger complies with the procedures set forth above and is implementing the revised Ventura County SMP, the Discharger does not have to repeat the procedure for continuing or recurring exceedances of the same water quality standard(s) unless directed by the Regional Board to develop additional BMPs.

PART 3 - STORM WATER QUALITY MANAGEMENT PLAN IMPLEMENTATION, MONITORING, AND REPORTING

A. General Requirements

1. The Discharger shall, at a minimum, adopt and implement the elements of the Ventura County SMP that are consistent with the terms of this permit.

   Additionally, modifications to the Ventura County SMP made during the term of the permit including those made in accordance with Part 3. B. of this permit shall be implemented.

2. The Ventura County SMP shall, at a minimum, comply with applicable requirements of 40 CFR 122.26(d)(2). The Ventura County SMP shall be implemented so as to reduce the discharges of pollutants in storm water to the maximum extent practicable. The Ventura County SMP is described in Attachment B.

3. Each Co-permittee shall be responsible for implementation of relevant portions of the Ventura County SMP within its jurisdictional boundaries. The Principal Co-permittee shall be responsible for program coordination as described in Section 1 of the Ventura County SMP as well as compliance with relevant portions of the permit within its jurisdiction.

B. Modifications

1. The Discharger shall modify the Ventura County SMP adopted with this Order to make it consistent with the requirements herein. The revised Ventura County SMP will be submitted to the Regional Board Executive Officer for approval no later than January 27, 2001].

2. The Regional Board Executive Officer may approve changes to the Ventura County SMP, except as noted in Part 3 B.1, either:

   a. Upon petition by the Discharger or interested parties, and after providing for and considering public comment, or,

   b. As deemed necessary by the Regional Board Executive Officer following notice to the Discharger, and after providing for and considering public comment.

The Discharger shall modify the Ventura County SMP, at the direction of the Regional Board Executive Officer, to incorporate regional provisions. Such provisions may include watershed-specific requirements for watersheds shared by the Discharger with other MS4 programs.

C. Legal Authority

1. Co-permittees shall possess the necessary legal authority to prohibit non-storm water discharges and control the contribution of pollutants to the storm drain system from storm water discharges, including, but not limited to:

   a. A prohibition on illicit discharges and illicit connections and a requirement for removal of illicit connections;

      i. Prohibit the discharge of wash waters to the MS4 when gas stations, auto repair garages, or other types of automotive service facilities are cleaned;
      ii. Prohibit the discharge of runoff to the MS4 from mobile auto washing, steam cleaning, mobile carpet cleaning, and other such mobile commercial and industrial operations;
      iii. Prohibit the discharges of runoff to the MS4 from areas where, repair of machinery and equipment which are visibly leaking oil, fluid or antifreeze, is undertaken;
      iv. Prohibit the discharge of runoff to the MS4 from storage areas of materials, containing grease, oil, or other hazardous substances, and uncovered receptacles containing hazardous materials;
      v. Prohibit the discharge of chlorinated swimming pool water and filter backwash to the MS4;
      vi. Prohibit the discharge of untreated runoff from the washing of toxic materials from paved or unpaved areas to the MS4;
      vii. Prohibit washing impervious surfaces in industrial/commercial areas which results in a discharge of untreated runoff to the MS4, unless specifically required by State or local health and safety codes; and
      viii. Prohibit the discharge from washing out of concrete trucks, pumps, tools, and equipment to the MS4.

   b. A prohibition on spills, dumping, or disposal of materials other than storm water ;

      i. Litter, landscape debris and construction debris;
      ii. Any state or federally banned pesticide, fungicide or herbicide;
      iii. Food wastes; and
      iv. Fuel and chemical wastes, animal wastes, garbage, batteries, and other materials which have potential adverse impacts on water quality.

   c. A mechanism to control, through interagency agreement, the contribution of pollutants from one portion of the MS4 to another portion of the MS4;

d. A requirement for compliance with conditions in ordinances, permits, contracts, or orders; and,

e. The ability to carry out all inspections, surveillance and monitoring procedures necessary to determine compliance and non-compliance with permit conditions, including the prohibition on illicit discharges to the MS4.

2. Each Co-permittee shall adopt, no later than July 27, 2001, an agency-specific storm water and urban runoff ordinance or amend an existing one if necessary, based on the countywide model (Appendix A of the Ventura County SMP) to be able to enforce all requirements of the permit.

D. Annual Storm Water Report and Assessment

1. The Discharger shall submit, by October 1 of each year beginning the Year 2001, an Annual Storm Water Report and Assessment documenting the status of the general program and individual tasks contained in the Ventura County SMP, as well as results of analyses from the monitoring and reporting program CI 7388. The Annual Storm Water Report and Assessment shall cover each fiscal year from July 1 through June 30, and shall include the information necessary to assess the Discharger's compliance status relative to this Order, and the effectiveness of implementation of permit requirements on storm water quality. The Annual Storm Water Report and Assessment shall include any proposed changes to the Ventura County SMP as approved by the Management Committee.

   The Discharger shall submit, by October 1, 2000, the Annual Report for the period July 1, 1999 through July 27, 2000 documenting the status of the general program up to permit reissuance and the results of analyses from the monitoring and reporting program.

2. Storm Water Management Program Budget

   a. The Discharger shall prepare annually a storm water budget update on resources applied to the storm water program. This budget report shall include an annual update identifying the storm water budget for the following year using [estimated percentages and written explanations where necessary], for the specific categories noted below:

      i. Program management
      ii. Illicit connections/illicit discharge
      iii. Development planning/development construction
      iv. Construction inspection activities
      v. Public Agency Activities
         - Operations and Maintenance
         - Municipal Street Sweeping

- Fleet and Public Agency Facilities
- Landscape and Recreational Facilities

vi. Capital Costs
vii. Public Information and Participation
viii. Monitoring Program
ix. Other

Co-permittees, in addition to the Benefit Assessment budget, shall report any supplemental dedicated budgets, if any, for the same categories.

E. Storm Water Monitoring Report.

1. The Discharger shall submit a Storm Water Monitoring Report on July 15, 2001 and annually on July 15 thereafter. The report shall include:

   a. Status of implementation of the monitoring program as described in the attached Monitoring and Reporting Program, CI-7388.

   b. Results of the monitoring program; and

   c. A general interpretation of the significance of the results, to the extent that data allows.

F. Modification

1. The Regional Board Executive Officer or the Regional Board consistent with 40 CFR 122.41 may approve changes to the Ventura County Monitoring Program, after providing the opportunity for public comment, either:

   a. By petition of the Permittee or by petition of interested parties, after the submittal of the Annual Monitoring Program Report. Such petition shall be filed, not later than 60 days after the Annual Monitoring Program Report submittal date, or

   b. As deemed necessary by the Regional Board Executive Officer following notice to the Permittee.

PART 4 – SPECIAL PROVISIONS

The Ventura County SMP submitted by the Discharger is an integral and enforceable component of the permit.

Changes to Storm Water Quality Management Plan may be made as follows:

It is anticipated that the storm water quality management program, as delineated in the Ventura County SMP may need to be modified, revised, or amended from time-to-time in response to changed conditions, and to incorporate more effective approaches to pollutant control. Minor changes to the Ventura County SMP may be made at the direction of the Regional Board Executive Officer. Minor changes requested by the Discharger shall become effective upon written approval of the Regional Board Executive Officer. If proposed changes constitute a major revision in the overall scope of effort of the program, such changes must be approved by the Regional Board as permit amendments. The Discharger shall implement the Ventura County SMP on July 27, 2000, and for the duration of this permit.

Requirements of the permit shall take effect on August 11, 2000 provided the US EPA Regional Administrator has no objections.

A. Programs for Residents

1. Co-permittees shall identify staff who will serve as the public reporting contact person(s) for reporting clogged catch basin inlets and illicit discharges/dumping, and general storm water management information within 6 months of permit issuance, and thereafter include this information, updated when necessary, in public information, the government pages of the telephone book, and the annual report as they are developed/published. The designated contact staff will be provided with relevant storm water quality information including current resident program activities, preventative storm water pollution control information and contact information for responding to illicit discharges/illegal dumping.

2. Co-permittees shall mark storm drain inlets with a legible "no dumping" message. In addition, signs with prohibitive language discouraging illegal dumping must be posted at designated public access points to creeks, other relevant water bodies, and channels by July 27, 2002.

3. Each Co-permittee shall conduct educational activities within its jurisdiction and participate in countywide events.

4. Each Co-permittee shall distribute outreach materials to the general public and school children at appropriate public counters and events. Outreach material shall include information such as proper disposal of litter, green waste, and pet waste, proper vehicle maintenance techniques, proper lawn care, and water conservation practices.

5. The Discharger shall insure that a minimum of 2.1 million impressions per year are made on the general public about storm water quality via print, local TV access, local radio, or other appropriate media.

B. Programs for Industrial/Commercial Businesses

1. Each Co-permittee shall implement an industrial/commercial educational site inspection program.

2. Co-permittees shall inspect automotive service and food service facilities in its jurisdiction once every two years. During site visits, Co-permittees shall:

   a. Consult with a representative of the facility to explain applicable storm water regulations;

   b. Distribute and discuss applicable BMP and educational materials; and,

   c. Conduct a site walk-through to inspect for, at a minimum, evidence of illicit discharges and storm water educational programs for employees.

3. Co-permittees shall revisit automotive and food service facilities where evidence of illicit discharge is found within six months of the inspection. If necessary, Co-permittees will begin enforcement action to remove sources of illicit discharges.

4. Based on Pollutants of Concern source identification, additional target businesses may be identified to be included in the inspection program. Co-permittees shall report on the types and proposed actions to be taken in regard to the additional target businesses in annual reports.

5. No later than July 27, 2002, each Co-permittee shall conduct a site visit and complete a site visit check-list provided by the Regional Board, and distribute educational program materials to facilities identified as subject to the State Board General Industrial Permit. Thereafter, material will be redistributed once every two years. These industrial facilities shall be notified of specific requirements contained in the Statewide Industrial General Permit including: that such facilities must file an Notice of Intent (NOI) with the State Board, and that a Storm Water Pollution Prevention Plan (SWPPP) must be available on the site. Educational materials shall also include information describing illicit discharges. The information shall include: types of discharges prohibited, how to prevent illicit discharges, what to do in the event of an illicit discharge, and the array of enforcement actions the facility may be subject to, including penalties that can be assessed. The Co-permittee shall note on the site-visit check-list if an NOI has been submitted and if a SWPPP is available on site.

6. Co-permittees shall provide an annual update of the inspected automotive service, food service, and other targeted facilities, and the facilities identified as Phase I industrial facilities to this Regional Board in the annual report. The database shall include at a minimum; facility name, site address, applicable SIC code(s), and NPDES storm water permit coverage.

7. Co-permittees shall train their employees in targeted positions (whose jobs or activities directly affect storm water quality, or those who respond to questions from the public), including inspection staff, regarding the

requirements of the storm water management program by January 27, 2001, and annually thereafter.

C. Programs for Planning and Land Development

1. The Discharger shall implement the approved Ventura Countywide Stormwater Quality Urban Impact Mitigation Plan (SQUIMP) (Attachment A) no later than January 27, 2001. The SQUIMP shall address conditions and requirements for new development and significant redevelopment. At a minimum, appropriate elements of the SQUIMP will be included as project requirements for the following development categories:

   a. Single-family hillside residences;
   b. 100,000 square foot commercial developments;
   c. Automotive repair shops;
   d. Retail gasoline outlets;
   e. Restaurants;
   f. Home subdivisions with 10 or more housing units;
   g. Locations within, or directly adjacent to or discharging directly to an environmentally sensitive area; and,
   g. Parking lots of 5,000 square feet or more or with 25 or more parking spaces and potentially exposed to storm water runoff.

2. The Discharger shall no later than July 27, 2002, prepare a technical manual which shall include:

   a. specifications for treatment control BMPs and structural BMPs based on the flow-based and volume-based water quality design criteria for the purposes of countywide consistency, and
   b. criteria for the control of discharge rates and duration.

   Notwithstanding the requirement that the BMP design criteria be incorporated into a technical manual, the criteria shall be effective as of July 27, 2000. The technical manual criteria shall be consistent with, and must not be less stringent than the design criteria in the SQUIMP, and shall be subject to approval by the Regional Board Executive Officer.

3. The Discharger shall identify no later than January 27, 2001, specific environmentally sensitive areas in Ventura County for the application of SQUIMP requirements, based on the Regional Board's Basin Plan and CWA Section 303 (d) Impaired Water-bodies List, and submit the list to the Regional Board Executive Officer for approval. Once approved, this list will supplement the state designations included in the definition of "Environmentally Sensitive Areas".

4. Co-permittees shall make appropriate modifications to their internal planning procedures for preparing / reviewing CEQA documents, and for linking storm water quality mitigation conditions to legal discretionary project approvals.

linking storm water quality mitigation conditions to legal discretionary project approvals.

5. Co-permittees shall train their employees in targeted positions (whose jobs or activities are engaged in development planning) regarding the requirements of the SQUIMP no later than January 27, 2001, and annually thereafter.

6. The Permittee shall include watershed and storm water management considerations in the appropriate elements of the Permittee's General Plan whenever said elements are significantly rewritten. Appropriate elements include, but are not limited to, water quality protection, development goals and policies, open space goals and policies, preservation of and integration with natural features, and water conservation policies.

D. Programs for Construction Sites

1. Co-permittees shall require the preparation, submittal, and implementation of a Storm Water Pollution Control Plan (SWPCP) prior to issuance of a grading permit for construction projects that meet one of the following criteria:

   a. Will result in soil disturbance of one acre or more in size;
   b. Is within or discharging directly to or directly adjacent to an environmentally sensitive area or,
   c. Is located in a hillside area.

2. Co-permittees shall prepare and implement a SWPCP on Co-permittee construction projects, as required above.

3. The SWPCP shall include appropriate construction site BMPs selected from documents such as the California Storm Water BMP Handbook, the Caltrans Storm Water Quality Handbook, Ventura County Stormwater Quality Standard Sheet, EPA database and American Society of Civil Engineers (ASCE) database. In addition, Co-permittees shall ensure the following minimum requirements are met, to the maximum extent practicable, at construction sites regardless of size:

   a. Sediments generated on the project site shall be retained using structural drainage controls;

   b. No construction-related materials, wastes, spills, or residues shall be discharged from the project site to streets, drainage facilities or adjacent properties by wind or runoff;

   c. Non-storm water runoff from equipment and vehicle washing and any other activity shall be contained at the project site;

d. Erosion from slopes and channels will be eliminated, by implementing BMPs, including, but not limited to, limiting of grading scheduled during the wet season, inspecting graded areas during rain events, planting and maintenance of vegetation on slopes, and covering erosion susceptible slopes.

4. The SWPCP must include the rationale used for selecting or rejecting BMPs. The project architect, or engineer of record, or authorized qualified designee, must sign a statement on the SWPCP to the effect:

"As the architect/engineer of record, I have selected appropriate BMPs to effectively minimize the negative impacts of this project's construction activities on storm water quality. The project owner and contractor are aware that the selected BMPs must be installed, monitored, and maintained to ensure their effectiveness. The BMPs not selected for implementation are redundant or deemed not applicable to the proposed construction activity."

The landowner shall sign a statement to the effect:

"I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that submitting false and/or inaccurate information, failing to update the SWPCP to reflect current conditions, or failing to properly and/or adequately implement the SWPCP may result in revocation of grading and/or other permits or other sanctions provided by law."

The SWPCP certification shall be signed by the landowner as follows:

(1) For a corporation: by a responsible corporate officer which means (a) a president, secretary, treasurer, or vice president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation, or (b) the manager of the construction activity if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

(2) For a partnership or sole proprietorship: by a general partner or the proprietor; or

(3) For a municipality or other public agency: by an elected official, a ranking management official (e.g., County Administrative Officer, City Manager, Director of Public Works, City Engineer, District Manager), or the manager of the

construction activity if authority to sign SWPCPs has been assigned or delegated to the manager in accordance with established agency policy.

5. Co-permittees shall require proof of filing a Notice of Intent for coverage under the State General Construction Activity Storm Water Permit prior to issuing a grading permit for all projects requiring coverage under the state general permit.

6. Co-permittees shall inspect sites with SWPCPs for storm water quality requirements during routine inspections a minimum of once during the wet season. For inspected sites that have not adequately implemented their SWPCP, a follow-up inspection to ensure compliance will take place within 2 weeks. If compliance has not been achieved, and the site is covered under the State General Construction Activity Storm Water Permit, the Regional Board shall be notified. Co-permittees shall develop and implement a checklist for inspecting storm water quality control measures at construction sites by January 27, 2001.

7. Co-permittees shall discuss storm water controls at construction sites and distribute educational materials targeted to the construction community during meetings, inspections, and as appropriate.

8. Co-permittees shall train employees in targeted positions (whose jobs or activities are engaged in construction activities including construction inspection staff) regarding the requirements of the storm water management program by January 27, 2001, and annually thereafter.

E. Public Agency Activities

Corporation Yards

1. The Principal Co-permittee shall develop a model SWPCP for corporation yards and the Co-permittees shall implement the minimum requirements of the SWPCP in all corporation yards by July 27, 2002. Thereafter, Co-permittees shall inspect corporation yards on an annual basis.

2. Co-permittees shall prohibit the discharge of untreated storm water runoff to the storm drain system from toxic or hazardous material storage areas no later than January 27, 2001.

3. Co-permittees shall prohibit the discharge of untreated storm water runoff to the storm drain system from fueling areas, and repair/maintenance areas for vehicle maintenance and repair facilities no later than July 27, 2001.

4. Co-permittees shall require that all vehicle/equipment wash areas must be self-contained, or covered, or equipped with a clarifier, or other

pretreatment facility, and properly connected to a sanitary sewer. This provision does not apply to fire fighting vehicles.

Other Facilities

5. Co-permittees shall inspect and clean the catch basins, open drainage facilities, and detention/retention basins at least one time each year prior to the wet season. At any time, any catch basin that is at least 40% full of trash and debris shall be cleaned out. All reinforced concrete open channels shall be cleaned at least once each year prior to the wet season.

6. Co-permittees shall conduct street sweeping on curbed public streets in their permitted area according to the following schedule:

   a. A monthly average not less than 4 times per month in high traffic downtown areas;
   b. A yearly average of not less than 6 times per year in moderate traffic collector streets, and residential areas;
   c. In addition, Co-permittees will sweep continuously bermed public streets once per year prior to the rainy season.

7. Co-permittees shall prohibit street saw cutting and paving during a storm event of 0.25 inches or greater (except during emergency conditions).

8. Co-permittees shall prohibit discharge of untreated runoff from temporary or permanent street maintenance material and waste storage areas.

9. The Discharger shall develop a standardized protocol for the routine and non-routine application of pesticides, herbicides (including preemergents), and fertilizers within one year after permit adoption.

   There shall be no application of pesticides or fertilizers during the following conditions:

   a. During rain events;
   b. Within one day of a rain event forecasted to be greater than 0.25 inches except for application of preemergent herbicides;
   c. After a rain event where water is leaching or running or,
   d. When water is running off-site.

   The Discharger shall ensure that staff applying pesticides are either certified by the California Department of Food and Agriculture, or are under the direct supervision on-site of a certified pesticide applicator.

10. Co-permittees shall train their employees in targeted positions (whose jobs and activities affect storm water quality) regarding the requirements of the storm water management program no later than January 27, 2001, and annually thereafter.

11. Co-permittees shall routinely conduct trash collection along, or in improved open channels within their jurisdiction.

12. The Discharger shall encourage the establishment of voluntary programs for the collection of trash in natural stream channels.

F. Programs for Illicit Discharges / Illegal Connections

1. Co-permittees shall investigate the cause, determine the nature and estimated amount of reported illicit discharge/dumping incidents, and refer documented non-storm water discharges/connections or dumping to an appropriate agency for investigation, containment and cleanup. Appropriate action including issuance of an enforcement order that will result in cessation of the illicit discharge, and/or elimination of the illicit connection, shall take place within six months after the Co-permittee gains knowledge of the discharge/connection.

2. Each Co-permittee shall train its employees in targeted positions, as defined by the Ventura County SMP, on how to identify and report illicit discharges by January 27, 2001, and annually thereafter.

3. Automotive, food facility, construction and Co-permittee facility site inspection visits shall include distribution of educational material that describes illicit discharges and provides a contact number for reporting illicit discharges.

4. New information developed for Phase I industrial facility educational material shall include information describing illicit discharges. The information shall include: types of discharges prohibited, how to prevent illicit discharges, what to do in the event of an illicit discharge, and the array of enforcement actions the facility may be subject to, including penalties that can be assessed.

G. Total Maximum Daily Loads [40 CFR 130.7]

1. The Permittee shall modify the Ventura County SMP to comply with waste load allocations developed and approved pursuant to the process for the designation and implementation of Total Daily Maximum Loads (TMDLs) for impaired water bodies.

H. Stormwater Quality Urban Impact Mitigation Plan

1. The terms and requirements in the Storm Water Quality Urban Impact Mitigation Plan (SQUIMP) may be amended by the Regional Board Executive Officer to conform with the State Board's decision in: In Re: *The Consolidated Petitions of Cities of Bellflower et al. (Review of January 26, 2000, Action of the Regional Board and its Executive Officer Pursuant to*

Board Order No. 96-054) or any subsequent ruling on the matter by a court of law.

2. Requirements for new development and significant redevelopment in environmentally sensitive areas shall be incorporated into enforceable documents such as land development guidelines and city ordinances no later than July 27, 2001.

a. Requirements of the SQUIMP as they relate to the supplemental list of "Environmentally Sensitive Areas" identified based on the Regional Board's Basin Plan and the CWA Section 303(d) Impaired Water-bodies List shall take effect no later than July 27, 2001.

b. Requirements of the Stormwater Quality Urban Impact Mitigation Plan for state designations of "Environmentally Sensitive Areas" shall take effect no later than January 27, 2001.

I. PART 5 - DEFINITIONS

A. The following are definitions for terms applicable to this Order:

1. **"Anti-degradation policies"** means the *Statement of Policy with Respect to Maintaining High Quality Water in California* (State Board Resolution No. 68-16) which protects surface and ground waters from degradation. In particular, this policy protects waterbodies where existing quality is higher than that necessary for the protection of beneficial uses including the protection of fish and wildlife propagation and recreation on and in the water.

2. **"Applicable Standards and Limitations"** means all State, interstate, and federal standards and limitations to which a "discharge" or a related activity is subject under the CWA, including "effluent limitations,"water quality standards, standards of performance, toxic effluent standards or prohibitions, "best management practices," and pretreatment standards under sections 301, 302, 303, 304, 306, 307, 308, 403 and 404 of CWA.

3. **"Automotive Repair Shop"** means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

4. **Best Management Practices (BMPs)** are methods, measures, or practices designed and selected to reduce or eliminate the discharge of pollutants to surface waters from point and nonpoint source discharges including storm water. BMPs include structural and nonstructural controls, and operation and maintenance procedures, which can be applied before, during, and/or after pollution producing activities.

5. **"CWA"** means the Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Public Law 92—500, as amended by Public Law 95—217, Public Law 95—576, Public Law 96—483 and Public Law 77—117, 33 U.S.C. 1251 et seq.

6. **"Construction"** means constructing, clearing, grading, or excavation that results in soil disturbance. Construction includes structure teardown. It does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of facility, nor does it include emergency construction activities required to immediately protect public health and safety.

7. **"Co-permittee"** shall mean any of the following public entities; the Ventura County Flood Control District (VCFCD), the County, or the City of Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, San Buenaventura, Santa Paula, Simi Valley, or Thousand Oaks. Each Co-permittee is responsible for compliance with the terms of the NPDES Permit.

8. **"Designated Public Access Points"** means any pedestrian, bicycle, equestrian, or public vehicular point of access to jurisdictional channels in the area of Ventura County subject to permit requirements.

9. **"Development"** shall mean any construction, rehabilitation, redevelopment or reconstruction of any public or private residential project (whether single-family, multi-unit or planned unit development); industrial, commercial, retail and other non-residential projects, including public agency projects; or mass grading for future construction.

10. **"Directly Adjacent"** means situated within 200 feet of the contiguous zone required for the continued maintenance, function, and structural stability of the environmentally sensitive area.

11. **"Director"** shall mean the Director of Public Works of the County and Person(s) designated by and under the Director's instruction and supervision.

12. **"Directly Discharging"** means outflow from a drainage conveyance system that is composed entirely or predominantly of flows from the subject, property, development, subdivision, or industrial facility, and not commingled with the flows from adjacent lands.

13. **"Discharge"** when used without qualification means the "discharge of a pollutant."

14. **"Discharge of a Pollutant"** means: Any addition of any "pollutant" or combination of pollutants to "waters of the United States" from any "point source" or, Any addition of any pollutant or combination of pollutants to the waters of the "contiguous zone" or the ocean from any point source other than a vessel or other floating craft which is being used as a means of transportation. The term discharge includes additions of pollutants into waters of the United States from: surface runoff which is collected or channeled by man; discharges through pipes,

sewers, or other conveyances owned by a State, municipality, or other person which do not lead to a treatment works; and discharges through pipes, sewers, or other conveyances, leading into privately owned treatment works. This term does not include an addition of pollutants by any "indirect Discharger."

15. **"Effluent limitation"** means any restriction imposed by the Regional Board on quantities, discharge rates, and concentrations of "pollutants" which are "discharged" from "point sources" into "waters of the United States," the waters of the "contiguous zone," or the ocean.

16. **"Environmental Protection Agency"** or **"EPA"** means the United States Environmental Protection Agency.

17. **"Environmentally Sensitive Areas"** means an area "in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which would be easily disturbed or degraded by human activities and developments" (California Public Resources Code § 30107.5). Areas subject to storm water mitigation requirements are : areas designated as an Area of Special Biological Significance (ASBS) by the State Water Resources Control Board, an area designated as a significant natural resource by the California Resources Agency, or an area identified by the Discharger as environmentally sensitive for water quality purposes, based on the Regional Board Basin Plan and Clean Water Act Section 303(d) Impaired Water-bodies List for the County of Ventura.

18. **"Facility or Activity"** means any NPDES "point source" or any other facility or activity (including land or appurtenances thereto) that is subject to regulation under the NPDES program.

19. **"Hillside"** means property located in an area with known erosive soil conditions, where the development contemplates grading on any natural slope that is 25% or greater and where grading contemplates cut or fill slopes.

20. **"Illicit Connection"** shall mean any man-made conveyance that is connected to the storm drain system without a permit or through which prohibited non-storm water flows are discharged, excluding roof-drains and other similar type connections. Examples include channels, pipelines, conduits, inlets, or outlets that are connected directly to the storm drain system.

21. **"Illicit Discharge"** means any discharge to the storm drain system that is prohibited under local, state, or federal statutes, ordinances, codes, or regulations. The term illicit discharge includes all non storm-water discharges except discharges pursuant to an NPDES permit, discharges that are identified in Part 1 of this order, and discharges authorized by the Regional Board Executive Officer.

22. **"Infiltration"** means the downward entry of water into the surface of the soil.

23. "**MS4**" see Municipal Separate Storm Sewer System.

24. **"Municipal Separate Storm Sewer System"** means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains) owned by a State, city, town or other public body, that is designed or used for collecting or conveying storm water, which is not a combined sewer, and which is not part of a publicly owned treatment works. Commonly referred to as an "MS4".

25. **"National Pollutant Discharge Elimination System (NPDES)"** means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of CWA. The term includes an "approved program."

26. **"NPDES"** means National Pollutant Discharge Elimination System.

27. **"New Development"** means land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and land subdivision.

28. **"Non-Storm Water Discharge"** means discharge other than storm water runoff or snowmelt.

29. **"Parking Lot"** means land area or facility for the parking of commercial or business or private motor vehicles.

30. **"Permit"** means an authorization, license, or equivalent control document issued by EPA or an "approve State" to implement the requirements of 40 CFR Parts 122, 123, and 124. "Permit" includes an NPDES "general permit" (§ 122.28). Permit does not include any permit which has not yet been the subject of final agency action, such as a "draft permit" or a "proposed permit."

31. **"Pollutants of Concern"** means a prioritized list of pollutants identified in the Ventura County SMP as requiring additional investigation.

32. **"Potable Water Sources"** means flows from drinking water storage, supply and distribution systems including flows from system failures, pressure releases, system maintenance, well development, pump testing fire hydrant flow testing; and flushing and dewatering of pipes, reservoirs, vaults, and wells.

33. **"Priority Pollutants"** are those constituents referred to in 40 CFR 401.15 and listed in the EPA NPDES Application Form 2C, pp. V-3 through V-9.

34. **"Rain Event"** means any rain event greater than 0.1 inch in 24 hours.

35. **"Redevelopment"** means, but is not limited to, the expansion of a building footprint or addition or replacement of a structure; structural development including an increase in gross floor area and/or exterior construction or remodeling; replacement of impervious surface that is not part of a routine maintenance activity; land disturbing activities related with structural or

impervious surfaces. Redevelopment that results in the creation or addition of 5,000 square feet or more of impervious surfaces is subject to the requirements for storm water mitigation. If the creation or addition of impervious surfaces is fifty percent or more of the existing impervious surface area, then storm water runoff from the entire area (existing and additions) must be considered for purposes of storm water mitigation. If the creation or additions is less than fifty percent of the existing impervious area, then storm water runoff from only the addition area needs mitigation.

36. **"Regional Administrator"** means the Regional Administrator of the Regional Office of the Environmental Protection Agency or the authorized representative of the Regional Administrator.

37. **"Restaurant"** means a facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC Code 5812).

38. **"Side Walk Washing"** means pressure washing of paved pedestrian walkways with average water usage of 0.006 gallons per square foot, with no cleaning agents, and properly disposing of all debris collected, as authorized under Regional Board Resolution No. 98-08.

39. **"Site"** means the land or water area where any "facility or activity" is physically located or conducted, including adjacent land used in connection with the facility or activity.

40. **"Source Control BMP"** means any schedules of activities, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent storm water pollution by reducing the potential for contamination at the source of pollution.

41. **"SQUIMP"** shall mean the Ventura Countywide Stormwater Quality Urban Impact Mitigation Plan. The SQUIMP shall address conditions and requirements of new development.

42. **"State General Permit"** shall mean a permit issued by the State Water Resources Control Board or the Regional Board pursuant to 40 CFR § 122 and 123 to regulate a category of point sources. The term State General Permit includes but is not limited to the General Permit for Stormwater Discharges Associated with Construction Activity and the General Industrial Activities Stormwater Permit and the terms and requirements of both. In the event the EPA revokes the in-lieu permitting authority of the State Water Resources Control Board, then the term State General Permit shall also refer to any EPA administered stormwater control program for industrial, construction, and any other category of activities.

43. **"Storm Water"** shall mean "Stormwater".

44. **"Storm Water Pollution Prevention Plan"** shall mean a plan, as required by a State General Permit, identifying potential pollutant sources and describing the design, placement and implementation of BMPs, to effectively prevent non-stormwater Discharges and reduce Pollutants in Stormwater Discharges during activities covered by the General Permit.

45. **"Stormwater"** shall mean any surface flow, runoff, and/or drainage associated with rainstorm events and/or snowmelt.

46. **"Stormwater Pollution Control Plan (SPCP)"** shall mean a plan identifying potential pollutant sources from a construction site and describing proposed design, placement and implementation of BMPs, to effectively prevent non-stormwater Discharges and reduce Pollutants in Stormwater Discharges to the Storm Drain System, to the maximum extent practicable, during construction activities.

47. **"Stormwater Quality Management Plan"** shall mean the Ventura Countywide Stormwater Quality Management Plan, which includes descriptions of programs, collectively developed by the Co-permittees in accordance with provisions of the NPDES Permit, to comply with applicable federal and state law, as the same is amended from time to time.

48. **"Structural BMP"** means any structural facility designed and constructed to mitigate the adverse impacts of storm water and urban runoff pollution (e.g. canopy, structural enclosure). The category may include both treatment control BMPs and source control BMPs.

49. **"Total Maximum Daily Load (TMDL)"** means the amount of pollutant, or property of a pollutant, from point, nonpoint, and natural background sources, that may be discharged to a water quality-limited receiving water. Any pollutant loading above the TMDL results in a violation of applicable water quality standards.

50. **"Treatment"** means the application of engineered systems that use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to, filtration, gravity settling, media absorption, biodegradation, biological uptake, chemical oxidation and UV radiation.

51. **"Treatment Control BMP"** means any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media absorption or any other physical, biological, or chemical process.

52. **"Upset"** means an exceptional incident in which there is unintentional and temporary noncompliance with the permit limit because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper maintenance.

53. **"Water Quality Standards and Water Quality Objectives"** applicable to the Permittee include those contained in the Los Angeles Regional Water Quality Control Plan (Basin Plan), the California Ocean Plan, the National Toxics Rule, the California Toxics Rule, and other state or federally approved surface water quality plans. Such plans are used by the Regional Board to regulate all discharges, including storm water discharges.

54. **"Waters of the State"** means any surface water or groundwater, including saline waters, within boundaries of the state.

55. **"Waters of the United States or Waters of the U.S."** means:

a. All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
b. All interstate waters, including interstate "wetlands";
c. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, "wetlands," sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:
1. Which are or could be used by interstate or foreign travelers for recreational or other purposes;
2. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
3. Which are used or could be used for industrial purposes by industries in interstate commerce;
d. All impoundments of waters otherwise defined as waters of the United States under this definition;
e. Tributaries of waters identified in paragraphs (a) through (d) of this definition;
f. The territorial sea; and
g. "Wetlands" adjacent to waters (other than waters that are themselves wetlands) identified in paragraph (a) through (f) of this definition.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.22(m), which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to man-made bodies of water, which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States. *[See Note 1 of this section.]* Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with US EPA.

56. **"Watercourse"** shall mean any natural or artificial channel for passage of water, including the VCFCD jurisdictional channels included in the List of Channels

within the Comprehensive Plan of the VCFCD, as approved by the Board of Supervisors of the VCFCD on October 4, 1993, and any amendments thereto.

57. **"Wet Season"** means the calendar period beginning October 1 through April 15.

58. **"Whole Effluent Toxicity"** means the aggregate toxic effect of an effluent measured directly by a toxicity test.

PART 6 – STANDARD PROVISIONS

A. The Discharger shall comply with all provisions and requirements of this permit.

B. Should the Discharger discover that it failed to submit any relevant facts or that it submitted incorrect information in a report, it shall promptly submit the missing or correct information.

C. The Discharger shall report all instances of non-compliance not otherwise reported at the time monitoring reports are submitted.

D. This Order includes the attached Monitoring and Reporting Program, and Storm Water Quality Urban Impact Mitigation Plan, which are a part of the permit and must be complied with in the same manner as with the rest of the requirements in the permit.

E. Public Review

1. All documents submitted to the Regional Board in compliance with the terms and conditions of this Permit shall be made available to members of the public pursuant to the Freedom of Information Act (5 U.S.C. Section 552 (as amended) and the Public Records Act (California Government Code Section 6250 *et seq.*).

2 All documents submitted to the Executive Officer for approval shall be made available to the public for a 30-day period to allow for public comment.

F. Duty to Comply [40 CFR 122.41(a)]

1. The Discharger must comply with all of the terms, requirements, and conditions of this Order. Any violation of this order constitutes a violation of the Clean Water Act, its regulations and the California Water Code, and is grounds for enforcement action, Order termination, Order revocation and reissuance, denial of an application for reissuance; or a combination thereof.

2. A copy of these waste discharge specifications shall be maintained by the Discharger so as to be available during normal business hours to Discharger employees and members of the public.

3. Any discharge of wastes at any point(s) other than specifically described in this Order is prohibited, and constitutes a violation of the Order.

G. Duty to Mitigate [40 CFR 122.41 (d)]

The Discharger shall take all reasonable steps to minimize or prevent any discharge that has a reasonable likelihood of adversely affecting human health or the environment.

H. Inspection and Entry [40 CFR 122.41(i)]

The Regional Board, USEPA, and other authorized representatives shall be allowed:

1. Entry upon premises where a regulated facility is located or conducted, or where records are kept under conditions of this Order;

2. Access to copy any records that are kept under the conditions of this Order;

3. To inspect any facility, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Order; and,

4. To photograph, sample, and monitor for the purpose of assuring compliance with this Order, or as otherwise authorized by the Clean Water Act and the California Water Code.

I. Proper Operation and Maintenance [40 CFR 122.41 (e)]

The Discharger shall at all times properly operate and maintain all facilities and systems of treatment and (and related appurtenances) that are installed or used by the Discharger to achieve compliance with this Order. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar system that are installed by a Discharger only when necessary to achieve compliance with the conditions of this Order.

J. Signatory Requirements [40 CFR 122.41(k)]

Except as otherwise provided in this Order, all applications, reports, or information submitted to the Regional Board shall be signed by the Director of Public Works, City Engineer, or authorized designee under penalty of perjury.

K. Reopener and Modification [40 CFR 122.41(f)]

1. This Order may only be modified, revoked, or reissued, prior to the expiration date, by the Regional Board, in accordance with the procedural requirements of the Water Code and Title 23 of the California Code of Regulations for the issuance of waste discharge requirements, and upon prior notice and hearing, to:

   a. Address changed conditions identified in the required reports or other sources deemed significant by the Regional Board;

   b. Incorporate applicable requirements or statewide water quality control plans adopted by the State Board or amendments to the Basin Plan;

   c. Comply with any applicable requirements, guidelines, and/or regulations issued or approved pursuant to CWA Section 402(p); and/or,

   d. Consider any other federal, or state laws or regulations that became effective after adoption of this Order.

2. After notice and opportunity for a hearing, this Order may be terminated or modified for cause, including, but not limited to:

   a. Violation of any term or condition contained in this Order;

   b. Obtaining this Order by misrepresentation, or failure to disclose all relevant facts; or,

   c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

3. This Order may be modified, revoked and reissued, or terminated for cause.

4. The filing of a request by the Discharger for a modification, revocation and re-issuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any condition of this Order.

5. This Order may be modified to make corrections or allowances for changes in the permitted activity listed in this section, following the procedures at 40 CFR Part 122.63, if processed as a minor modification. Minor modifications may only:

   a. Correct typographical errors, or

   b. Require more frequent monitoring or reporting by the Permittee.

L. Severability

The provisions of this permit are severable; and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected.

M. Duty to Provide Information [40 CFR 122.41(h)]

The Discharger shall furnish, within a reasonable time, any information the Regional Board or USEPA may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this Order. The Discharger shall also furnish to the Regional Board, upon request, copies of records required to be kept by this Order.

N. Twenty-four Hour Reporting[1]

1. The Discharger shall report any noncompliance that may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the Discharger becomes aware of the circumstances. A written submission shall also be provided within five days of the time the Discharger becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times and, if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

2. The Regional Board may waive the required written report on a case-by-case basis.

O. Bypass [40 CFR 122.41(m)][2]

Bypass (the intentional diversion of waste streams from any portion of a treatment facility) is prohibited. The Regional Board may take enforcement action against the Discharger for bypass unless:

1. Bypass was unavoidable to prevent loss of life, personal injury or severe property damage. (Severe property damage means substantial physical damage to property, damage to the treatment facilities that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a

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[1] This provision applies to incidents where effluent limitations (numerical or narrative) as provided in this Order or in the Ventura County SMP are exceeded, and which endanger public health or the environment.

[2] This provision applies to the operation and maintenance of storm water controls and BMPs as provided in this Order or in the Ventura County SMP.

bypass. Severe property damage does not mean economic loss caused by delays in production.);

2. There were no feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated waste, or maintenance during normal periods of equipment down time. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass that could occur during normal periods of equipment downtime or preventive maintenance;

3. The Discharger submitted a notice at least ten days in advance of the need for a bypass to the Regional Board; or,

4. The Discharger may allow a bypass to occur that does not cause effluent limitations to be exceeded, but only if it is for essential maintenance to assure efficient operation. In such a case, the above bypass conditions are not applicable. The Discharger shall submit notice of an unanticipated bypass as required.

P. Upset [40 CFR 122.41(n)][3]

1. A Discharger that wishes to establish the affirmative defense of an upset in an action brought for non compliance shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

   a. An upset occurred and that the Discharger can identify the cause(s) of the upset;

   b. The permitted facility was being properly operated by the time of the upset;

   c. The Discharger submitted notice of the upset as required; and,

   d. The Discharger complied with any remedial measures required.

2. No determination made before an action for noncompliance, such as during administrative review of claims that non-compliance was caused by an upset, is final administrative action subject to judicial review.

3. In any enforcement proceeding, the Discharger seeking to establish the occurrence of an upset has the burden of proof.

Q. Property Rights [40 CFR 122.4(g)]

This Order does not convey any property rights of any sort, or any exclusive privilege.

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[3] *Supra*. See footnote number 2.

R. Enforcement

1. Violation of any of the provisions of the NPDES permit or any of the provisions of this Order may subject the violator to any of the penalties described herein, or any combination thereof, at the discretion of the prosecuting authority; except that only one kind of penalties may be applied for each kind of violation. The Clean Water Act provides the following:

Criminal Penalties

a. *Negligent Violations*
The CWA provides that any person who negligently violates permit conditions implementing sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or both.

b. *Knowing Violations*
The CWA provides that any person who knowingly violates permit conditions implementing sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or both.

c. *Knowing Endangerment*
The CWA provides that any person who knowingly violates permit conditions implementing sections 301, 302, 307, 308, 318, or 405 of the Act and who knows at that time that he is placing another person in imminent danger of death or serious bodily injury is subject to a fine of not more than $250,000, or by imprisonment for not more than 15 years, or both.

d. *False Statement*
The CWA provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed of required to be maintained under the Act or who knowingly falsifies, tampers with, or renders inaccurate, any monitoring device or method required to be maintained under the Act, shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than two years, or by both. If a conviction is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment

of not more than four years, or by both. (See section 309(c)(4) of the Clean Water Act.)

Civil Penalties:

a. The CWA provides that any person who violates a permit condition implementing sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed $27,500 per day for each violation.

2. The California Water Code provides that any person who violates a waste discharge requirement provision of the California Water Code is subject to civil penalties of up to $5,000 per day, $10,000 per day, or $25,000 per day of violation; or when the violation involves the discharge of pollutants, is subject to civil penalties of up to $10 per gallon per day or $25 per gallon per day of violation; or some combination thereof, depending on the violation or combination violations.

S. Need to Halt or Reduce Activity not a Defense [40 CFR 122.41(c)]

It shall not be a defense for a Discharger in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this Order.

T. This Order may be modified, revoked, or reissued, prior to the expiration date as follows:

1. To address changed conditions identified in the required technical reports or other sources deemed significant by the Regional Board;

2. To incorporate applicable requirements or statewide water quality control plans adopted by the State Board, or amendments to the Basin Plan;

3. To comply with any applicable requirements, guidelines, or regulations issued or approved under Section 402(p) of the CWA, if the requirement, guideline, or regulation so issued or approved contains different conditions or additional requirements not provided for in this Order. The Order as modified or reissued under this paragraph shall also contain any other requirements of the CWA then applicable; or,

4. Any amendments under the Clean Water Act.

U. Regional Board Order No. 94-082 is hereby rescinded.

V. This Order expires on July 27, 2005]. The Discharger must submit a Storm Water Quality Management Plan in accordance with Title 23, California Code of Regulation, not later than 180 days in advance of such date as application for reissuance of waste discharge requirements.

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

MONITORING AND REPORTING PROGRAM NO. CI 7388

FOR

STORM WATER MANAGEMENT/URBAN RUNOFF DISCHARGES
FOR
VENTURA COUNTY FLOOD CONTROL DISTRICT,
COUNTY OF VENTURA, AND THE CITIES OF VENTURA COUNTY

NPDES PERMIT NO. CAS004002

I. Program Reporting Requirements

A. The Discharger shall submit, by October 1, 2000, the Annual Storm Water Report and Assessment for the period July 1, 1999, through July 27, 2000 documenting the status of the general program up to permit reissuance and the results of analyses from the monitoring and reporting program.

B. The Discharger shall submit, by October 1 of each year beginning the year 2001, an Annual Storm Water Report and Assessment documenting the status of the general program and individual tasks contained in the Ventura County SMP, and an integrated summary of the results of analyses from the monitoring program described under *II. Monitoring Requirements*.

The Annual Storm Water Report and Assessment shall include any proposed changes to the Ventura County SMP as approved by the Management Committee. The Annual Storm Water Report and Assessment Report shall cover each fiscal year from July 1 through June 30. At a minimum, the annual report will include the following:

Program Management

1. A comparison of program implementation results to performance standards established in the Ventura County SMP;

2. Status of compliance with permit requirements including implementation dates for all time-specific deadlines. If permit deadlines are not met, the Discharger shall report the reasons why the requirement was not met, how the requirements will be met in the future, including projected implementation date;

3. An assessment of the effectiveness of Ventura County SMP requirements to reduce storm water pollution. This assessment will be based upon the specific

record-keeping information requirement in each major section of the permit, monitoring data, and any other data the Discharger has, or is aware of that provides information on program effectiveness. Beginning in the Year 2003, to the extent data collected in monitoring requirements included herein allows, the discharger shall include an analysis of trends, land use contributions, pollutant source identifications, BMP effectiveness, and impacts on beneficial uses.

4. An analysis of the data to identify areas of the Program coverage which cause or contribute to exceedances of water quality standards or objectives, predominate land uses in these areas, and potential sources of pollutants in those areas;

5. Discussion of the compliance record and the corrective actions taken or planned that may be needed to bring the discharge into full compliance with the waste discharge requirements.

Programs for Residents

6. Number of storm drain inlets and signs in the Co-permittees' systems that are marked or posted with a no dumping message. Percent of total system marked/signed;

7. Description of activities on distributing brochures, community outreach efforts, public communication efforts and educational programs in schools including an estimate of the number of impressions per year made on the general public about storm water quality via print, local TV access, local radio presentations, meetings or other appropriate media;

Programs for Industrial / Commercial Businesses

8. Number of automotive, food facility and industrial facilities targeted under the program. During the past year, the number of industrial and commercial site visits conducted and the number of outreach contacts made and the number of industrial facilities the Co-permittees have identified that have failed to file an NOI;

9. An annual update of a database of industrial/commercial facilities identified as subject to the State Board General Industrial Permit. The database shall include at a minimum: facility name, site address, SIC code, and NPDES storm water permit coverage status, if applicable;

10. The percentage of targeted staff trained annually;

Programs for Planning and Land Development

11. The percentage of total development projects reviewed for storm water and conditioned to meet SQUIMP requirements in the previous year;

12. The scheduled date of significant rewrite of the Co-permittees' General Plan;

13. Description of activities on distributing brochures, outreach efforts, communication efforts including an estimate of the number of contacts made to the land development community about storm water quality via print, meetings or other appropriate venues.

14. The percentage of targeted staff trained annually;

Programs for Construction Sites

15. Number of construction projects requiring SWPCPs in the past year and the percentage of projects in categories requiring submittal of a SWPCP for which SWPCPs were completed;

16. Number and type of enforcement actions, applicable to storm water enforcement, taken at construction sites during the past year;

17. Description of the outreach program to the construction community and assessment of its effectiveness; This assessment should include a discussion of the number of inspections, site visits, or other meetings conducted;

18. The percentage of targeted staff trained annually;

Programs for Illicit Discharge and Illegal Connection Control

19. Number of reports of illicit discharges that Co-permittees responded to, percentage that were identified as actual illicit discharges, and percentage of the actual illicit discharges where the incident was either cleaned up, referred to another responsible agency and/or follow up/education with the discharger was conducted;

20. For groups of identified illicit discharge types where the probable causes for the discharge can be identified, report probable causes and the actions taken to prevent similar discharges from occurring;

21. Number of illicit connections identified in the past year;

22. Number of illicit connections eliminated in the past year;

23. Number and type of enforcement actions for storm water illicit discharges and/or illicit connections taken in the past year;

24. A summary from records on illicit discharges and connections which includes

type of material, type of source, date of initial inspection, enforcement action taken, date of follow-up inspection, date of conclusion/clean up/removal/ follow up/education;

Programs for Facilities Maintenance

25. A summary which at a minimum includes the quantity, predominant types and likely sources of trash removed from catch basin inlets;

26. A summary of the total curb miles of streets swept annually and the percentage of total curb miles swept annually as a function of total curb miles;

27. The percentage of targeted staff trained annually; and,

Pollutants of Concern

28. A progress report on sources of Pollutants of Concern (POCs), BMPs for their control, and implemented BMP effectiveness.

B. The Discharger shall submit a Storm Water Monitoring Report on July 15, 2001, and annually on July 15, thereafter. The report shall include:

1. status of implementation of the monitoring program;
2. results of the monitoring program;
3. a general interpretation of the results;
4. both tabular and graphical summaries of the monitoring data obtained during the previous year; and

The Discharger shall submit, by October 1, 2000, the results of analyses from the monitoring and reporting program for the period July 1, 1999 through July 27, 2000 together with the Annual Report for the same period.

C. All applications, reports, or information submitted to the Regional Board shall be signed and certified pursuant to EPA regulations 40 CFR 122.41 (k). Each report shall contain the following completed declaration:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted.
>
> Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for

submitting false information, including the possibility, of a fine and imprisonment for knowing violations.

Executed on the __ day of ________, 19__,

at ________________________.

(Signature)________________(Title)__________________";

Co-permittee submittals to the Principal Co-permittee shall also be signed and certified pursuant to EPA regulations 40 CFR 122.41 (k).

D. The Discharger shall mail the original of each annual report to:

INFORMATION TECHNOLOGY
CALIFORNIA REGIONAL WATER QUALITY
CONTROL BOARD - LOS ANGELES REGION
320 W. 4TH STREET, SUITE 200
LOS ANGELES, CA 90013

A copy of the annual report shall also be mailed to:

REGIONAL ADMINISTRATOR
ENVIRONMENTAL PROTECTION AGENCY
REGION 9
75 Hawthorne Street
San Francisco, CA 94105

II. Monitoring Requirements

A. The Discharger shall implement the Countywide Monitoring Plan, as described in Chapter 6 of the Report of Waste Discharge (ROWD), which addresses discharge characterization (outfall monitoring), receiving water and watershed monitoring. To achieve this, the Discharger shall:

1. Conduct land use monitoring as shown in the summary table shown below:

Monitoring Station	Minimum Number Events (per year)	Sample Type	Constituents[1]
A-1, Wood Road	1[2]	Automated composite and grab samples	Metals Organics Conventional Inorganics Microbiological Toxicity and TIEs[3]
R-1, Swan St.[3]	3 Per Permit Term	Automated composite and grab samples	Metals Organics Conventional Inorganics Microbiological Toxicity and TIEs[3]
I-2, Ortega St. [3]	3 Per Permit Term	Automated composite and grab samples	Metals Organics Conventional Inorganics Microbiological Toxicity and TIEs[3]

1 The list of specific constituents, analytical methods, detection limits, and holding times is included in Attachment to the Monitoring and Reporting Program No. 7388.
2 A maximum of 5 events shall be monitored during the permit term.
3 Toxicity monitoring shall occur during at least one storm per year until baseline information has been collected, and then be discontinued. A Toxicity Identification Evaluation (TIE) shall be performed when acute toxicity results are greater than 1 TUa. Freshwater acute toxicity test shall be conducted on the most sensitive of the two species - Fathead minnow and Ceriodaphnia.

2. Conduct receiving water and watershed monitoring:

   a. For Revolon Slough the following monitoring program shall be implemented:

Monitoring Station	Minimum Number of Events (per year)	Type of Sample	Constituents[1]
W-3, La Vista Drain	1[2]	Automated composite and grab samples	Metals Organics Conventional Inorganics Microbiological Toxicity and TIEs[3]
W-4, Revolon Slough @ Wood Road	1[2]	Composite and grab samples	Metals Organics Conventional Inorganics Microbiological Toxicity and TIEs[3]

1 The list of specific constituents, analytical methods, detection limits, and holding times is included in Attachment to the Monitoring and Reporting Program No. 7388.
2. A maximum of 5 events shall be monitored during the permit term.
Toxicity monitoring shall occur during at least 1 storm event a year until baseline information has been collected, and then be discontinued. A Toxicity Identification Evaluation (TIE) shall be performed when acute toxicity results are greater than 1 TUa. Freshwater acute toxicity test shall be conducted on the most sensitive of the two species - Fathead minnow and Ceriodaphnia.

b. The Discharger shall participate as part of the Federal 205(j) grant non-point source grant study of the Calleguas Creek watershed;

c. The Principal Co-permittee shall participate in appropriate water quality meetings of watershed management planning, including the Santa Clara River Enhancement and Management Plan, the Calleguas Creek Watershed Management Plan, and the Steelhead Restoration and Recovery Plan;

d. The Discharger shall participate with the Southern California Coastal Water Research Project (SCCWRP) in storm water studies, as set forth in the signed Memorandum of Agreement.

e. The Discharger shall participate in the development and implementation of volunteer monitoring programs in the Ventura Coastal watersheds.

f. The Discharger shall develop a work plan for an instream bioassessment monitoring program and submit it to the Regional Board Executive Officer for approval no later than January 27, 2001. On approval by the Regional Board Executive Officer, the Discharger shall implement the instream bioassessment monitoring program, and submit the results with the Annual Monitoring Report. The bioassessment program shall include an analysis of the community structure of the instream macroinvertebrate assemblages in urban runoff-impacted stream segments at experimental sites. The Discharger shall make all efforts to locate such sites in the Ventura River, but if they are not available then the Discharger may consider other watersheds.

g. The Discharger shall monitor a total of three mass emission stations to establish baseline conditions and load estimates, for the Ventura River and Calleguas Creek, beginning with the 2000-2001 monitoring season, and for the Santa Clara River beginning with the 2001-2002 monitoring season. Up to six station events per year, including a minimum of two dry weather samples must be monitored. All samples for mass emissions may be taken with an automatic sampler except for the following constituents: (i) pathogen indicators; and (ii) oil and grease. The constituents to be analyzed and their detection limits are listed in Attachment 1. If a constituent is not detected at the method detection limit (MDL) for its respective test in more than 75 percent of the first 48 sampling events, it will not be further analyzed unless the observed occurrences show concentrations greater than state water quality standards. The Discharger will also conduct annual confirmation sampling for non-detected constituents at each station for as long as the station is monitored. Chronic toxicity tests shall be

conducted using the most sensitive marine species for two wet weather events (preferably the first significant storm and one other event) and one dry weather flow sample per monitoring season. Toxicity Identification Evaluations (TIEs) shall be conducted when toxicity manifests in:
(1) two consecutive wet weather samples , or;
(2) any dry weather flow sample.

h. An update of the Watershed Management Model (WMM) may be required by the Regional Board Executive Officer based on the needs of TMDL development. The Regional Board will assist the Discharger in identifying fund sources to assist in the implementation of this requirement, if invoked.

B. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

C. The Discharger shall retain records of all monitoring information, including all calibration and maintenance of monitoring instrumentation, copies of all reports required by this Order, and records of all data used to complete the Report of Waste Discharge and application for this Order, for a period of at least five(5) years from the date of the sample, measurement, report, or application. This period may be extended by request of the Regional Board or EPA at any time and shall be extended during the course of any unresolved litigation regarding this discharge.

D. Records of monitoring information shall include:

1. The date, exact place, and time of sampling or measurements;

2. The individual(s) who performed the sampling or measurements;

3. The date(s) analyses were performed;

4. The individual(s) who performed the analyses;

5. The analytical techniques or methods used; and,

6. The results of such analyses.

E. All sampling, sample preservation, and analyses must be conducted according to test procedures under 40 CFR Part 136, unless other test procedures have been specified in this Order.

F. All chemical, bacteriological, and bioassay analyses shall be conducted at a laboratory certified for such analyses by an appropriate governmental regulatory agency.

G. If no flow occurred during the reporting period, the monitoring report shall so state.

H. For any analyses performed for which no procedure is specified in the EPA guidelines or in this Monitoring and Reporting Program, the constituent or parameter analyzed and the method or procedure used must be specified in the monitoring report.

I. Whenever feasible, all MDLs shall be less than California Toxic Rule and Ocean Plan standards. If this is not feasible, the Discharger shall use analytical methods with the lowest MDL.

J. The Regional Board Executive Officer or the Regional Board, consistent with 40 CFR 122.41, may approve changes to the Monitoring and Reporting Program, after providing the opportunity for public comment, either:

a. By petition of the Discharger or by petition of interested parties after the submittal of the Annual Monitoring Program Report. Such petition shall be filed not later than 60 days after the Annual Monitoring Program Report submittal date, or
b. As deemed necessary by the Regional Board Executive Officer following notice to the Discharger.

III. Program Evaluation

A. All Co-permittees shall perform a self-audit to verify implementation of the Ventura County SMP through January 1 of each year and report the results of the self-audit to the principal Co-permittee by February 1, 2001, and annually thereafter.

B. All Co-permittees shall submit program evaluation results, in a standardized format, to the principal Co-permittee by August 1, 2001, and annually thereafter.

The above monitoring and reporting program, or subsequent modification thereto, shall become effective when Order No. 00-108 is adopted. All reports shall be signed by a responsible officer or duly authorized representative (as specified in 40 CFR Section 122.22) of the Discharger and submitted under penalty of perjury.

Ordered by:

Dennis A. Dickerson
Executive Officer

Date: July 27, 2000

Attachment

Analytes, Methods, Limits, and Holding Times

Constituent	Method	MDL	Holding Time
Metals; (Total Recoverable and Diss.)	(units = ug/l unless specified)		
Arsenic	EPA 206.3	1	6 mos.
Cadmium	EPA 213.2	0.1	6 mos.
Chromium	EPA 218.2	1	6 mos.
Copper	EPA 220.1	1	6 mos.
Lead	EPA 239.2	1	6 mos.
Mercury, total and diss.	EPA 1631	0.001	6 mos.
Nickel	EPA249.2	1	6 mos.
Selenium	EPA 270.3	2	6 mos.
Silver	EPA 272.2	0.2	6 mos.
Zinc	EPA 289.1	1	6 mos.
Organics			
MTBE*	EPA 8020	1	14 days
Organochlorine Pesticides	EPA 8080	1-10 ng/L	7/40 days
Orthophosphate Pesticides	EPA 8140	2	7/40 days
Chlorinated Herbicides	EPA 8150	2-50 ug/L	7/40 days
Semi-volatiles	EPA 625	10-200 ng/L	7/40 days
TOC	EPA 415.1	1000	28 days
Conventional Inorganics	(units = mg/l)		
Ammonia	EPA 350.2	0.05	28 days
BOD	EPA 405.1	1	48 hours
Bromide	SM 4500BR	0.0001	immediate
Chloride	EPA 325.3	0.0001	28 days
Conductivity & pH	Electrometric	n/a	immediate
Hardness	EPA 130.2/SM2340B	1	6 mos.
Nitrate	EPA 352.1	0.01	28 days
TKN	EPA 351.3	0.05	28 days
Oil & Grease	EPA 413.1/413.2	0.1	28 days
Petroleum hydrocarbons (TRPH)	EPA 413.1/SM5520B,F	0.1	7 days
Orthophosphate	EPA 365.3	0.01	28 days
Phosphorous, total and diss.	EPA 365.3	0.01	28 days
Solids, Total Dissolved	EPA 160.1	1	7 days
Solids, Total Suspended *Turp.*	EPA 160.2	1	7 days
Microbiological	(units = MPN/100ml)		
Coliform, Total and Fecal	SM9221	2	6 hours
Fecal Streptococcus	SM9230	2	6 hours
Toxicity			
Ceriodaphnia Acute Toxicity/(TIE)	EPA 600/4-91/002	-	36 hours

* MTBE is an extra compound for EPA 8020 analysis and must be specifically requested, e.g. "8020 with MTBE"

Note: Holding times for methods 625, 8080, 8140, and 8150 are 7 days until extraction, 40 days after extraction.

ATTACHMENT A

Tentative Order No. 00-108 (NPDES NO. CAS004002)
Waste Discharge Requirements

for
Municipal Storm Water and Urban Runoff Discharges

VENTURA COUNTYWIDE STORMWATER QUALITY URBAN IMPACT MITIGATION PLAN

FOR THE VENTURA COUNTY FLOOD CONTROL DISTRICT, THE COUNTY OF VENTURA, AND THE CITIES OF VENTURA COUNTY

VENTURA COUNTYWIDE STORMWATER QUALITY URBAN IMPACT MITIGATION PLAN

FOR THE VENTURA COUNTY FLOOD CONTROL DISTRICT, THE COUNTY OF VENTURA, AND THE CITIES OF VENTURA COUNTY

R0008791

VENTURA COUNTYWIDE URBAN RUNOFF AND STORM WATER NPDES PERMIT

STORM WATER QUALITY URBAN IMPACT MITIGATION PLAN

BACKGROUND

The Ventura Countywide Stormwater Quality Management Program (Ventura Program) was established pursuant to Section 402(p) of the Federal Clean Water Act, which requires that all point source discharges of pollutants into waters of the United States, including discharges from municipal storm drain systems, be regulated by a National Pollutant Discharge Elimination System (NPDES) permit. On August 22, 1994 the California Regional Water Quality Control Board, Los Angeles Region (Regional Board), issued NPDES permit CAS063339 (Permit) to the Ventura County Flood Control District (VCFCD), the County of Ventura, and the cities of Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, San Buenaventura, Santa Paula, Simi Valley, and Thousand Oaks for discharges from municipal storm drain systems in Ventura County. On February 11, 1999 these twelve agencies, the Co-permittees, submitted a Stormwater Quality Management Plan (1999 Plan) in accordance with Title 23, California Code of Regulation and as required by Permit. The 1999 Plan served as application for reissuance of waste discharge requirements and presented activities designed to advance the municipal storm water program that the Co-permittees implemented during the first five-year permit term. The 1999 Plan included a program for development planning. The Regional Board accepted the 1999 Plan, however, delayed reissuance of the Permit. On March 8, 2000, the Regional Board approved a final Standard Urban Storm Water Mitigation Plan (SUSMP) for Los Angles County and the Cities in Los Angeles County. Subsequently, at the request of the Regional Board, the Co-permittees prepared the Ventura Countywide Stormwater Quality Urban Impact Mitigation Plan (SQUIMP) to be consistent with SUSMP requirements and will be modifying the 1999 Plan to include the modified requirements.

The requirement to implement a program for development planning is based on, federal and state statutes including: Section 402 (p) of the Clean Water Act, Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 ("CZARA"), and the California Water Code. The Clean Water Act amendments of 1987 established a framework for regulating storm water discharges from municipal, industrial, and construction activities under the NPDES program. The primary objectives of the municipal storm water program requirements are to:

1. Effectively prohibit non-storm water discharges, and

2. Reduce the discharge of pollutants from storm water conveyance systems to the Maximum Extent Practicable (MEP statutory standard).

The SQUIMP was developed as part of the municipal storm water program to address storm water pollution from new development and redevelopment by the private sector. This SQUIMP contains a list of the minimum required Best Management Practices (BMPs) that shall be used for a designated project. Additional BMPs may be required by ordinance or code adopted by the Co-permittees and applied generally or on a case by case basis. The Co-permittees are required to implement the requirements set herein in their own jurisdictions. Developers shall incorporate appropriate SQUIMP requirements into the project plans for the projects covered by the SQUIMP requirements. Each Co-permittee will approve the project plan as part of the development plan approval process.

All projects that fall into one of eight categories are identified in the Ventura Countywide Municipal Permit as requiring SQUIMPs. These categories are:

- Single-Family Hillside Residences
- 100,000 Square Foot Commercial Developments
- Automotive Repair Shops
- Retail Gasoline Outlets
- Restaurants
- Home Subdivisions with 10 or more housing units
- Location within or directly adjacent to or discharging directly to an environmentally sensitive area
- Parking lots with 5,000 square feet or more impervious parking or access surfaces or with 25 or more parking spaces and potentially exposed to storm water runoff

The SQUIMP requirements shall take effect not later than January 27, 2001 for projects identified herein that have not received development/planning permit approval or been deemed complete for processing prior to July 27, 2000..

DEFINITIONS

"100,000 Square Foot Commercial Development" means any commercial development that creates at least 100,000 square feet of impermeable area, including parking areas.

"Automotive Repair Shop" means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

"Best Management Practice (BMP)" means any program, technology, process, siting criteria, operational methods or measures, or engineered systems, which when implemented prevent, control, remove, or reduce pollution.

"Commercial Development" means any development on private land that is not heavy industrial or residential. The category includes, but is not limited to: hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, multi-apartment buildings, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses and other light industrial complexes.

"Designated Public Access Points" means any pedestrian, bicycle, equestrian, or vehicular point of access to jurisdictional channels in the area of Ventura County subject to permit requirements.

"Directly Adjacent" means situated within 200 feet of the contiguous zone required for the continued maintenance, function, and structural stability of the environmentally sensitive area.

"Directly Connected Impervious Area (DCIA)" means the area covered by a building, impermeable pavement, and/ or other impervious surfaces, which drains directly into the storm drain without first flowing across permeable land area (e.g. lawns).

."Directly Discharging" means outflow from a drainage conveyance system that is composed entirely or predominantly of flows from the subject, property, development, subdivision, or industrial facility, and not commingled with the flows from adjacent lands.

"Environmentally Sensitive Area" means an area "in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which would be easily disturbed or degraded by human activities and developments" (California Public Resources Code § 30107.5)

Areas subject to storm water mitigation requirements are: areas designated as an Area of Special Biological Significance (ASBS) by the State Water Resources Control Board, an area designated as a significant natural resource by the California Resources Agency, or an area identified by the Discharger as environmentally sensitive for water quality purposes, based on the Regional Board Basin Plan and Clean Water Act Section 303(d) Impaired Water-bodies List for the County of Ventura.

"Hillside" means property located in an area with known erosive soil conditions, where the development contemplates grading on any natural slope that is twenty-five percent or greater.

"Infiltration" means the downward entry of water into the surface of the soil.

"New Development" means land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and land subdivision.

"Parking Lot" means land area or facility for the temporary parking or storage of motor vehicles used personally, for business or for commerce with an impervious surface area of 5,000 square feet or more, or with 25 or more parking spaces.

"Redevelopment" means, but is not limited to, the expansion of a building footprint or addition or replacement of a structure; structural development including an increase in gross floor area and/or exterior construction or remodeling; replacement of impervious surface that is not part of a routine maintenance activity; land disturbing activities related with structural or impervious surfaces. Redevelopment that results in the creation or addition of 5,000 square feet or more of impervious surfaces is subject to the requirements for storm water mitigation. If the creation or addition of impervious surfaces is fifty percent or more of the existing impervious surface area, then storm water runoff from the entire area (existing and additions) must be considered for purposes of storm water mitigation. If the creation or additions is less than fifty percent of the existing impervious area, then storm water runoff from only the addition area needs mitigation.

"Restaurant" means a stand-alone facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption. (SIC code 5812).

"Retail Gasoline Outlet" means any facility engaged in selling gasoline and lubricating oils.

"Source Control BMP" means any schedules of activities, structural devices, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent storm water pollution by reducing the potential for contamination at the source of pollution.

"Storm Event" means a rainfall event that produces more than 0.1 inch of precipitation and that, which is separated from the previous storm event by at least 72 hours of dry weather.

"Structural BMP" means any structural facility designed and constructed to mitigate the adverse impacts of storm water and urban runoff pollution (e.g. canopy, structural enclosure). The category may include both Treatment Control BMPs and Source Control BMPs.

"Treatment" means the application of engineered systems that use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to, filtration, gravity settling, media adsorption, biodegradation, biological uptake, chemical oxidation and UV radiation.

"Treatment Control BMP" means any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process.

CONFLICTS WITH LOCAL PRACTICES
Where provisions of the SQUIMP requirements conflict with established local codes, (e.g., specific language of signage used on storm drain stenciling), the Co-permittees may continue the local practice and modify the SQUIMP to be consistent with the code, except that to the extent that the standards in the SQUIMP are more stringent than those under local codes, such more stringent standards shall apply.

SQUIMP PROVISIONS APPLICABLE TO ALL CATEGORIES

REQUIREMENTS

1. PEAK STORM WATER RUNOFF DISCHARGE RATES

The Discharger shall control the post-development peak storm water runoff discharge rates to maintain or reduce pre-development downstream erosion, and to protect stream habitat.

2. CONSERVE NATURAL AREAS

If applicable, the following items are required and shall be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Concentrate or cluster Development on portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

3. MINIMIZE STORM WATER POLLUTANTS OF CONCERN

Storm water runoff from a site has the potential to contribute oil and grease, suspended solids, metals, gasoline, pesticides, and pathogens to the storm water conveyance system. The development shall be designed so as to minimize, to the maximum extent practicable, the introduction of pollutants of concern that may result in significant impacts, generated from site runoff of directly connected impervious areas (DCIA), to the storm water conveyance system. Pollutants of concern consist of any pollutants that exhibit one or more of the following characteristics: current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at concentrations or loads considered potentially toxic to humans and/or flora and fauna. The storm water pollutants of concern currently identified by the Program are total and fecal coliform, mercury, PAHs, DDT and byproducts, diazinon, sediment/TSS, chlorpyrifos, copper, lead, thallium, bis(2-ethylhexyl)phthalate, and phosphorous. The program may amend the list of pollutants of concern as additional information becomes available.

In meeting this specific requirement, "minimization of the pollutants of concern" will require the incorporation of a BMP or combination of BMPs best suited to maximize the reduction of pollutant loadings in that runoff to the Maximum Extent Practicable. Those BMPs best suited for that purpose are those listed in the *Ventura Countywide Stormwater Quality Management Program's Land Development Guidelines*; *California Storm Water Best Management Practices Handbooks*; *Caltrans Storm Water Quality Handbook: Planning and Design Staff Guide*; *Start at the Source (1999) by Bay Area Stormwater Management Agencies Association*, *Manual for Storm Water Management in Washington State*; *The Maryland Storm Water Design Manual*; *Florida Development Manual: A Guide to Sound Land and Water Management*; Denver *Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices* and *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, USEPA Report No. EPA-840-B-92-002, as "likely to have significant impact" beneficial to water quality for targeted pollutants that are of concern at the site in question. However, it is possible that a combination of BMPs not so designated may, in a particular circumstance, be better suited to maximize the reduction of the pollutants.

Examples of BMPs that can be used for minimizing the introduction of pollutants of concern generated from site runoff are identified in Table 2. All BMPs for development planning recommended in one of the above references may be used, subject to the criteria set in this SQUIMP.

4. PROTECT SLOPES AND CHANNELS

Project plans shall include BMPs consistent with local codes and ordinances and the SQUIMP to decrease the potential of slopes and/or channels from eroding and impacting storm water runoff:

- Convey runoff safely from the tops of slopes and stabilize disturbed slopes
- Utilize natural drainage systems to the Maximum Extent Practicable
- Control or reduce or eliminate flow to natural drainage systems to the Maximum Extent Practicable

- Stabilize permanent channel crossings
- Vegetate slopes with first consideration given to native or drought tolerant species
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion, with the approval of all agencies with jurisdiction, e.g., the U.S. Army Corps of Engineers and the California Department of Fish and Game

5. PROVIDE STORM DRAIN SYSTEM STENCILING AND SIGNAGE

Storm drain stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets. The stencil contains a brief statement that prohibits the dumping of improper materials into the storm water conveyance system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message.

- All storm drain inlets and catch basins within the project area shall be stenciled with prohibitive language (such as: "DON'T DUMP! DRAINS TO OCEAN") and/or graphical icons to discourage illegal dumping.
- Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, shall be posted at designated public access points along channels and creeks within the project area.
- Legibility of stencils and signs shall be maintained.

6. PROPERLY DESIGN OUTDOOR MATERIAL STORAGE AREAS

Outdoor material storage areas refer to storage areas or storage facilities solely for the storage of materials. Improper storage of materials outdoors may provide an opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the storm water conveyance system. Where proposed project plans include outdoor areas for permanent storage of materials that may contribute pollutants to the storm water conveyance system, the following Structural or Treatment BMPs are required:

- Materials with the potential to contaminate storm water shall be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the storm water conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.
- The storage area shall be paved and sufficiently impervious to contain leaks and spills.

- The storage area shall have a roof or awning to minimize collection of storm water within the secondary containment area.

7. PROPERLY DESIGN TRASH STORAGE AREAS

A trash storage area refers to an area where a trash receptacle or receptacles are located for use as a repository for solid wastes. Loose trash and debris can be easily transported by the forces of water or wind into nearby storm drain inlets, channels, and/or creeks. All trash container areas shall meet the following Structural or Treatment Control BMP requirements (individual single family residences are exempt from these requirements):

- Trash container areas shall have drainage from adjoining roofs and pavement diverted around the area(s).
- Trash container areas shall be screened or walled to prevent off-site transport of trash.

8. PROVIDE PROOF OF ONGOING BMP MAINTENANCE

Improper maintenance is one of the most common reasons why water quality controls will not function as designed or systems to fail entirely. It is important to consider who will be responsible for maintenance of a permanent BMP and what equipment is required to perform the maintenance properly. As part of project review, if a project applicant has included or is required to include, Structural or Treatment Control BMPs in project plans, the Co-permittee shall require that the applicant provide verification of maintenance provisions through such means as may be appropriate, including, but not limited to legal agreements, covenants, CEQA mitigation requirements and/or Conditional Use Permits.

For all properties, the verification will include the developer's signed statement, as part of the project application, accepting responsibility for all structural and treatment control BMP maintenance until the time the property is transferred and, where applicable, a signed agreement from the public or private entity assuming responsibility for Structural or Treatment Control BMP maintenance. The transfer of property to a private or public owner shall have conditions requiring the recipient to assume responsibility for maintenance of any Structural or Treatment Control BMP included in the sales or lease agreement for that property. The condition of transfer shall include a provision that the property owners conduct maintenance inspection of all Structural or Treatment Control BMPs at least once a year and retain proof of inspection. For residential properties where the Structural or Treatment Control BMPs are located within a common area which will be maintained by a homeowner's association, language regarding the responsibility for maintenance shall be included in the projects conditions, covenants and restrictions (CC&Rs). Printed educational materials will be required to accompany the first deed transfer to highlight the existence of the requirement and to provide information on what storm water management facilities are present, signs that maintenance is needed, how the necessary maintenance can be performed, and assistance that the Co-permittee can provide. The transfer of this information shall also be required with any subsequent sale of the property.

If Structural or Treatment Control BMPs are located within a public area proposed for transfer, they will be the responsibility of the developer until they are accepted for transfer by the appropriate public agency. Structural or Treatment Control BMPs proposed for transfer shall meet design standards adopted by the public entity for the BMP installed and should be approved by the appropriate public agency prior to installation.

9. DESIGN STANDARDS FOR STRUCTURAL OR TREATMENT CONTROL BMPs

Structural or Treatment Control BMPs selected for use at any project covered by this SQUIMP shall meet the design standards of this Section unless specifically exempted.

Volume-based and flow-based design standards may be used separately or in combination to equivalent treatment of storm water discharges. Volume-based criteria should be used in the sizing of detention/retention or infiltration structures; flow-based criteria should be used on swales, catch basin devices, or wetlands. Other, BMP-specific criteria may be applicable. Project applicants should refer to the *Ventura Countywide Storm Water Quality Management Program Land Development Guidelines* for further information.

Volume-based Post-construction Structural or Treatment Control BMPs shall be designed to mitigate (infiltrate or treat) storm water runoff from either:

1. the volume of annual runoff based on unit basin storage water quality volume, to achieve 80 percent or more volume treatment by the method recommended in *California Stormwater Best Management Practices Handbook – Industrial/ Commercial,* (1993), the *Ventura Countywide Stormwater Quality Management Program Land Development Guidelines*, or

2. the 85th percentile 24-hour runoff event determined as the maximized capture storm water volume for the area, from the formula recommended in *Urban Runoff Quality Management, WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87, (1998)*, or

3. the volume of runoff produced from a 0.75 inch storm event, prior to its discharge to a storm water conveyance system, or

4. the volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for "treatment" that achieves approximately the same reduction in pollutant loads achieved by the 85th percentile 24-hour runoff event,

OR

Flow Based Post-Construction Structural or Treatment Control BMPs shall be sized to handle the flow generated from either:

1. 10% of the 50-year design flow rate, or
2. a flow that will result in treatment of the same portion of runoff as treated using volumetric standards above, or
3. a rain event equal to at least 0.2 inches per hour intensity, or
4. a rain event equal to at least two times the 85th percentile hourly rainfall intensity for Ventura County

Limited Exclusion

Where the land area for development or redevelopment is less than 5,000 square feet, restaurants are excluded from the numerical Structural or Treatment Control BMP design standard requirement only.

10. PROVISIONS APPLICABLE TO INDIVIDUAL PRIORITY PROJECT CATEGORIES

REQUIREMENTS

A. 100,000 SQUARE FOOT COMMERCIAL DEVELOPMENTS

1. PROPERLY DESIGN LOADING/UNLOADING DOCK AREAS

Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

- Cover loading dock areas or design drainage to minimize run-on and runoff of storm water.
- Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.

2. PROPERLY DESIGN REPAIR/MAINTENANCE BAYS

Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays shall include the following:

- Repair/maintenance bays shall be indoors or designed in such a way that does not allow storm water run-on or contact with storm water runoff.
- Design a repair/maintenance bay drainage system to capture all washwater, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

3. PROPERLY DESIGN VEHICLE/EQUIPMENT WASH AREAS

The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include, in the project plans, an area for washing/steam cleaning of vehicles and equipment. The area in the site design shall be:

- Self-contained and/or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer.

B. RESTAURANTS

1. PROPERLY DESIGN EQUIPMENT/ACCESSORY WASH AREAS

The activity of outdoor equipment/accessory washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for the washing/steam cleaning of equipment and accessories. This area shall be:

- Self-contained, connected to a grease interceptor, and properly connected to a sanitary sewer.
- If the wash area is to be located outdoors, it shall be covered, paved, have secondary containment, be connected to a grease interceptor and be connected to the sanitary sewer.

C. RETAIL GASOLINE OUTLETS

1. PROPERLY DESIGN FUELING AREA

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. The project plans shall include the following BMPs:

- The fuel dispensing area shall be covered with an overhanging roof structure or canopy. The canopy's minimum dimensions shall be equal to or greater than the area within the grade break. The canopy shall not drain onto the fuel dispensing area, and the canopy downspouts shall be routed to prevent drainage across the fueling area.
- The fuel dispensing area shall be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
- The fuel dispensing area shall have a 2% to 4% slope to prevent ponding, and shall be separated from the rest of the site by a grade break that prevents run-on of storm water to the extent practicable.
- At a minimum, the concrete fuel dispensing area shall extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

D. AUTOMOTIVE REPAIR SHOPS

1. PROPERLY DESIGN FUELING AREA

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. Therefore, design plans, which include fueling areas, shall contain the following:

- The fuel dispensing area shall be covered with an overhanging roof structure or canopy. The cover's minimum dimensions shall be equal to or greater than the area within the grade break. The cover shall not drain onto the fuel dispensing area and the downspouts shall be routed to prevent drainage across the fueling area.
- The fuel dispensing areas shall be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
- The fuel dispensing area shall have a 2% to 4% slope to prevent ponding, and shall be separated from the rest of the site by a grade break that prevents run-on of storm water.
- At a minimum, the concrete fuel dispensing area shall extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

2. PROPERLY DESIGN REPAIR/MAINTENANCE BAYS

Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays shall include the following:

- Repair/maintenance bays shall be indoors or designed in such a way that does not allow storm water run-on or contact with storm water runoff.
- Design a repair/maintenance bay drainage system to capture all wash-water, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, an Industrial Waste Discharge Permit should be obtained.

3. PROPERLY DESIGN VEHICLE/EQUIPMENT WASH AREAS

The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include, in the project plans, an area for washing/steam cleaning of vehicles and equipment. This area shall be:

- Self-contained and/or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer or to a permitted disposal facility.

4. PROPERLY DESIGN LOADING/UNLOADING DOCK AREAS

Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

- Cover loading dock areas or design drainage to minimize run-on and runoff of storm water

- Direct connections to storm drains from depressed loading docks (truck wells) are prohibited

E. PARKING LOTS

1. PROPERLY DESIGN PARKING AREA

Parking lots contain pollutants such as heavy metals, oil and grease, and polycyclic aromatic hydrocarbons that are deposited on parking lot surfaces by motor vehicles. These pollutants are directly transported to surface waters. To minimize the offsite transport of pollutants, the following design criteria are required:

- Reduce impervious land coverage of parking areas
- Infiltrate runoff before it reaches the storm drain system
- Treat runoff before it reaches the storm drain system

2. PROPERLY DESIGN TO LIMIT OIL CONTAMINATION AND PERFORM MAINTENANCE

Parking lots may accumulate oil, grease, and water insoluble hydrocarbons from vehicle drippings and engine system leaks.

- Treat to remove oil and petroleum hydrocarbons at parking lots that are heavily used (e.g. fast food outlets, lots with 25 or more parking spaces, sports event parking lots, shopping malls, grocery stores, discount warehouse stores)
- Ensure adequate operation and maintenance of treatment systems, particularly sludge and oil removal, and system fouling/plugging prevention control

11. WAIVER

A Co-permittee may, through adoption of an ordinance or code incorporating the treatment requirements of the SQUIMP, provide for a waiver from the requirement if impracticability for a specific property can be established. A waiver for impracticability shall be granted only when all other Structural or Treatment Control BMPs have been considered and rejected as infeasible. Recognized situations of impracticability include, (i) extreme limitations of space for treatment on a redevelopment project, (ii) unfavorable or unstable soil conditions at a site to attempt infiltration, and (iii) risk of ground water contamination because a known unconfined aquifer lies beneath the land surface or an existing or potential underground source of drinking water is less than 10 feet from the soil surface. Any other justification for impracticability shall be separately petitioned by the Co-permittee and submitted to the Regional Board for consideration. The Regional Board may consider approval of the waiver justification or may delegate the authority to approve a class of waiver justifications to the Regional Board Executive Officer. The supplementary waiver justification becomes recognized and effective only after approval by the Regional Board or the Regional Board Executive Officer. A waiver granted by a Co-permittee to any development or redevelopment project may be revoked by the Regional Board Executive Officer for cause and with proper notice upon petition.

If a waiver is granted for impracticability, the Co-permittee shall require the project proponent to transfer the savings in cost, as determined by the Co-permittee, to a storm water mitigation fund operated by a public agency or a non-profit entity to be used to promote regional or alternative solutions for storm water pollution in the watershed.

12. LIMITATION ON USE OF INFILTRATION BMPs

Three factors significantly influence the potential for storm water to contaminate ground water. They are (i) pollutant mobility, (ii) pollutant abundance in storm water, (iii) and soluble fraction of pollutant. The risk of contamination of groundwater may be reduced by pretreatment of storm water. A discussion of limitations and guidance for infiltration practices is contained in, *Potential Groundwater Contamination from Intentional and Non-Intentional Storm water Infiltration, Report No. EPA/600/R-94/051, USEPA (1994).*

The distance of the groundwater table from the infiltration BMP may also be a factor determining the risk of contamination. A historic high water table distance separation of ten feet depth in California presumptively poses negligible risk for storm water not associated with industrial activity or high vehicular traffic except in cases where groundwater basins are unconfined. Unconfined groundwater basins and vulnerable unconfined aquifers are areas that have been identified by the County of Ventura Public Works Agency, Water Resources Division and the Regional Board as areas where the application of infiltration BMPs should be limited to those that provide pre-treatment to ensure groundwater is protected from pollutants of concern.

Infiltration BMPs are not recommended for areas of industrial activity or areas subject to high vehicular traffic (25,000 or greater average daily traffic (ADT) on main roadway or 15,000 or more ADT on any intersecting roadway) unless appropriate pretreatment is provided to ensure groundwater is protected and the infiltration BMP is not rendered ineffective by overload.

13. ALTERNATIVE CERTIFICATION FOR STORM WATER TREATMENT MITIGATION

In lieu of conducting detailed BMP review to verify Structural or Treatment Control BMPs adequacy, a Co-permittee may elect to accept a signed certification from a Civil Engineer or a Licensed Architect registered in the State of California, that the plan meets the criteria established herein. The Co-permittee is encouraged to verify that certifying person(s) have been trained on BMP design for water quality, not more than two years prior to the signature date. Training conducted by an organization with storm water BMP design expertise (e.g., a University, American Society of Civil Engineers, American Society of Landscape Architects, American Public Works Association, or the California Water Environment Association) may be considered qualifying.

14. RESOURCES AND REFERENCE

TABLE 1

SUGGESTED RESOURCES	HOW TO GET A COPY
Ventura Countywide Stormwater Quality Management Program Land Development Guidelines Presents guidance for designing storm water BMPs	Ventura County Flood Control District 800 South Victoria Avenue Ventura, CA 93009 805-650-4064
Start at the Source (1999) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schuler Presents detailed engineering guidance on ten different storm water-filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Better Site Design: A Handbook for Changing Development Rules in Your Community (1998) Presents guidance for different model development alternatives.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Design Manual for Use of Bioretention in Stormwater Management (1993) Presents guidance for designing bioretention facilities.	Prince George's County Watershed Protection Branch 9400 Peppercorn Place, Suite 600 Landover, MD 20785

SUGGESTED RESOURCES	HOW TO GET A COPY
Operation, Maintenance and Management of Stormwater Management (1997) Provides a thorough look at storm water practices including, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	Watershed Management Institute, Inc. 410 White Oak Drive Crawfordville, FL 32327 850-926-5310
California Storm Water Best Management Practices Handbooks (1993) for Construction Activity, Municipal, and Industrial/Commercial Presents a description of a large variety of Structural BMPs, Treatment Control, BMPs and Source Control BMPs	Los Angeles County Department of Public Works Cashiers Office 900 S. Fremont Avenue Alhambra, CA 91803 626-458-6959
Second Nature: Adapting LA's Landscape for Sustainable Living (1999) by Tree People Detailed discussion of BMP designs presented to conserve water, improve water quality, and achieve flood protection.	Tree People 12601 Mullholland Drive Beverly Hills, CA 90210 818-753-4600
Florida Development Manual: A Guide to Sound Land and Water Management (1988) Presents detailed guidance for designing BMPs	Florida Department of the Environment 2600 Blairstone Road, Mail Station 3570 Tallahassee, FL 32399 850-921-9472
Stormwater Management in Washington State (2000) Vols. 1-5 Presents detailed guidance on BMP design for new development and construction.	Department of Printing State of Washington Department of Ecology P.O. Box 798 Olympia, WA 98507-0798 360-407-7529
Maryland Stormwater Design Manual (2000) Presents guidance for designing storm water BMPs	Maryland Department of the Environment 2500 Broening Highway Baltimore, MD 21224 410-631-3000
Texas Nonpoint Source Book – Online Module (1998)www.txnpsbook.org Presents BMP design and guidance information on-line	Texas Statewide Storm Water Quality Task Force North Central Texas Council of Governments 616 Six Flags Drive Arlington, TX 76005 817-695-9150

SUGGESTED RESOURCES	HOW TO GET A COPY
Urban Storm Drainage, Criteria Manual – Volume 3, Best Management Practices (1999) Presents guidance for designing BMPs	Urban Drainage and Flood Control District 2480 West 26th Avenue, Suite 156-B Denver, CO 80211 303-455-6277
National Storm water Best Management Practices (BMP) Database, Version 1.0 Provides data on performance and evaluation of storm water BMPs	American Society of Civil Engineers 1801 Alexander Bell Drive Reston, VA 20191 703-296-6000
Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993) Report No. EPA–840-B-92-002. Provides an overview of, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	National Technical Information Service U.S. Department of Commerce Springfield, VA 22161 800-553-6847
Caltrans Storm Water Quality Handbook: Planning and Design Staff Guide (Best Management Practices Handbooks (1998) Presents guidance for design of storm water BMPs	California Department of Transportation P.O. Box 942874 Sacramento, CA 94274-0001 916-653-2975

TABLE 2

EXAMPLE BEST MANAGEMENT PRACTICES (BMPs)

The following are examples of BMPs that can be used for minimizing the introduction of pollutants of concern that may result in significant impacts, generated from site runoff to the storm water conveyance system. (See Table 1: Suggested Resources for additional sources of information):

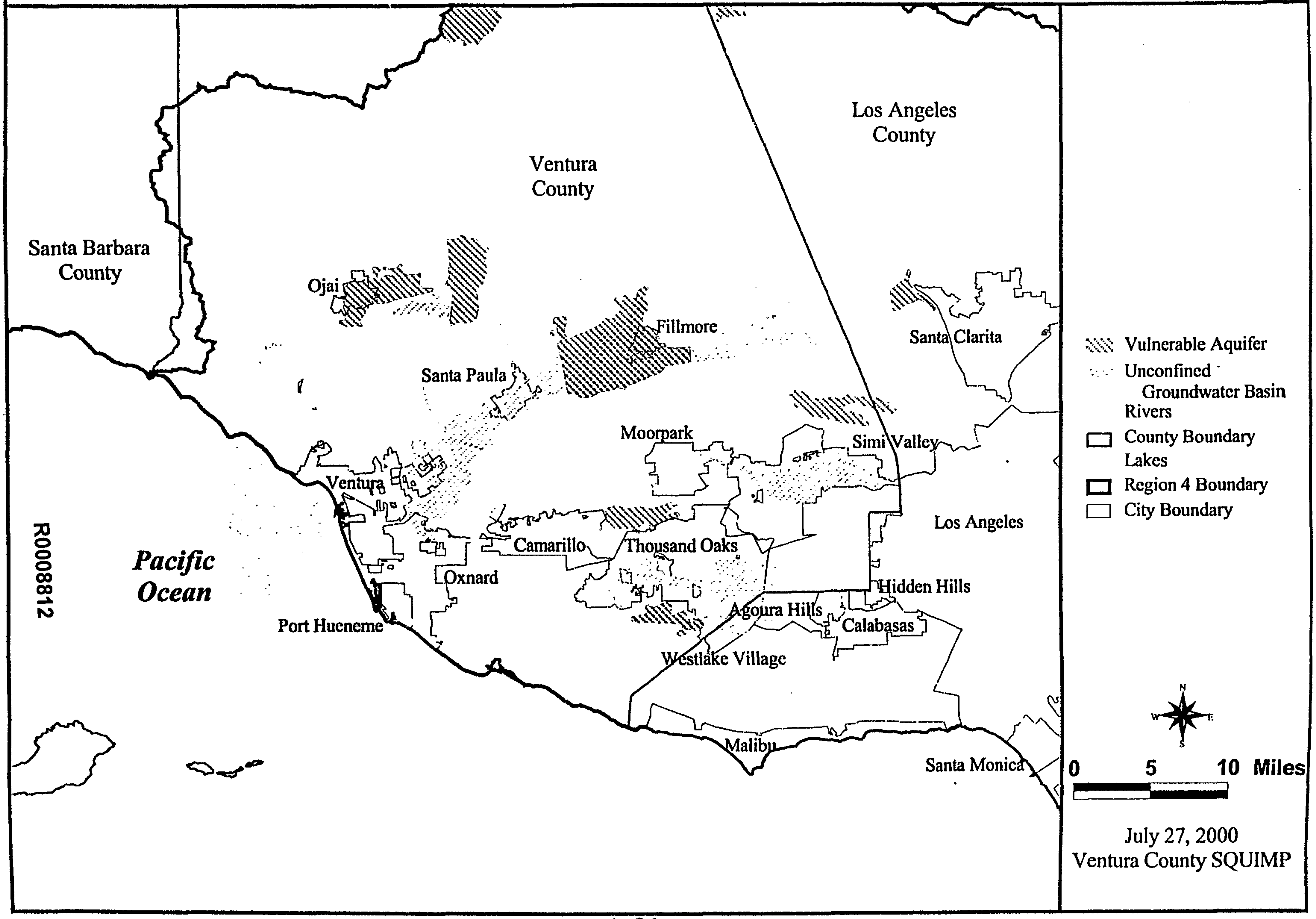
- Provide reduced width sidewalks and incorporate landscaped buffer areas between sidewalks and streets. However, sidewalk widths shall still comply with regulations for the Americans with Disabilities Act and other life safety requirements.
- Design residential streets for the minimum required pavement widths needed to comply with all zoning and applicable ordinances to support travel lanes; on-street parking; emergency, maintenance, and service vehicle access; sidewalks; and vegetated open channels.
- Comply with all zoning and applicable ordinances to minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
- Use permeable materials for private sidewalks, driveways, parking lots, or interior roadway surfaces (examples: hybrid lots, parking groves, permeable overflow parking, etc.).
- Use open space development that incorporates smaller lot sizes.
- Reduce building density.
- Comply with all zoning and applicable ordinances to reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
- Comply with all zoning and applicable ordinances to reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.
- Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas, and avoid routing rooftop runoff to the roadway or the storm water conveyance system.
- Biofilters including vegetated swales and strips
- Extended/dry detention basins
- Infiltration basin
- Infiltration trenches or vaults
- Wet detention basins/wet ponds
- Constructed wetlands

TABLE 2 (Continued)

- Catch basin inserts
- Continuous flow deflection/separation systems
- Storm drain inserts
- Media filtration
- Bioretention facility
- Foundation planting
- Catch basin screens
- Normal flow storage/separation systems
- Clarifiers
- Filtration systems
- Primary waste water treatment systems
- Dry Wells[1]
- Cistern

1 The proponent must ensure that this BMP complies with all applicable federal, state, and local requirements for siting, construction, operation and maintenance.

FIGURE 1: Unconfined Groundwater Basins and Vulnerable Unconfined Aquifers



ATTACHMENT B

to

Tentative Order No. 00-108 (NPDES No. CAS004002)
Waste Discharge Requirements

for

Municipal Storm Water and Urban Runoff Discharges

within

Ventura County Flood Control District
County of Ventura
Cities of Ventura County

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For the

Ventura Countywide Stormwater Quality Management Plan (SMP)

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CITY OF LOS ANGELES

CALIFORNIA

RICHARD J. RIORDAN
MAYOR

DEPARTMENT OF
PUBLIC WORKS

BUREAU OF SANITATION

JUDITH A. WILSON
DIRECTOR

JAMES F. LANGLEY
JOSEPH E. MUNDINE
DREW B. SONES
VINCENT J. VARSH
ASSISTANT DIRECTOR

STORMWATER MANAGEMENT DIVISION
650 SOUTH SPRING ST., SUITE 700
LOS ANGELES, CA 90014
(213) 847-6350
FAX: (213) 847-5443

October 18, 2000

Wendy Phillips
California Regional Water Quality Control Board
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

SUSMP REQUIREMENTS AS PART OF CEQA MITIGATION MEASURES

Dear Ms. Phillips:

The City Planning Department has incorporated the Standard Urban Stormwater Mitigation Plan (SUSMP) requirements into their existing CEQA Mitigation Measures. As a result, SUSMP requirements are now imposed not only on the nine (9) Planning Priority Projects but also as appropriate on all other discretionary projects.

Under the CEQA process, all discretionary projects undergo a review to determine if they may have any significant adverse impact on the environment, including impacts from stormwater discharges. If a potentially significant impact is determined, appropriate BMP(s) must be incorporated into the design plans prior to the project applicant obtaining a building or grading permit. Currently, the Stormwater Management Division staff review the design plans of all projects having stormwater mitigation measures to ensure that the proposed BMPs are properly sized.

Should you have any questions, please call me at 213-847-6346 or Wing Tam at 213-847-5225.

Sincerely,

Gary Lee Moore

Gary Lee Moore, P.E.
Program Manager

GLM/MFS/WKT/PT:tn
H:\ENG\PROJECTS\MODEL\PLANNING\City SUSMPs\Wendy4.doc

cc: Xavier Swamikannu, California Regional Water Quality Control Board
Frank Eberhard, Deputy Director, City Planning Department
James F. Langley, Assistant Director, Bureau of Sanitation

R0008821

County of Los Angeles • Fire Department
Prevention Bureau
Health Hazardous Materials Division
5825 Rickenbacker Rd., Commerce CA 90040

FACSIMILE TRANSMITAL SHEET

TO: HHMC, Trauma Scene management Subcommittee Members.

Phone:

FAX:

Date/Time: 12-11-2000

FROM: GERALD P. MUNOZ, SUPERVISING HMS

Health Hazardous Materials Division
EMERGENCY OPERATIONS
5825 Rickenbacker Road
Commerce, CA 90040
Phone: (323) 890-4088 FAX: (323) 890-4046

Total number of pages, including this cover sheet: SEVEN

COMMENTS: Please review the attached letters. The first is from Dr. Fannin, I believe that there is not much more to be said. This letter is great. The second is from Los Angeles County Fire Department Management. We may find that this is may be the most expedient way to answer this question. We will maintain an active Ad Hoc committee status until we have an answer from the Public Works or there is a need to take this question to the State level. Thanks for your participation. As a "responder" I feel better that agency reps like you are dedicated to address issues such as this one.

COUNTY OF LOS ANGELES - DEPARTMENT OF HEALTH SERVICES
PUBLIC HEALTH

DISEASE CONTROL PROGRAMS

August 1, 2000

Dennis Dickerson
California Regional Water Quality
Control Board
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Dear Sir:

I am Shirley L. Fannin, M.D.; Director of Disease Control Programs for Public Health in Los Angeles County. My job includes describing and tracking the communicable diseases which affect the citizens of Los Angeles and preventing outbreaks of those diseases to the greatest extent possible.

I recently attended an ad hoc committee meeting convened by the Los Angeles County Hazardous Materiels Coordinating Committee to address the issue of cleanup of blood and other human tissue at accident sites or accidental spills. Your employee, Dr. Xavier Swammikannu asked that I put my recommendations for an exception to the storm drain discharge requirements in the washdown of accidental blood/tissue spills in writing for the consideration of your Board.

The subject we discussed at the meeting was washdown of an accident site where blood had been spilled. This generally occurs on the streets or in other public places following a vehicle or pedestrian accident, or when a container holding blood spills onto the pavement or ground.

In Los Angeles County, we have encountered these situations regularly and proceed with clean-up by washing down the contaminated surface with a lot of water. Some agencies have used chemicals such as chlorine prior to washdown to inactivate potential viruses which might be present in the blood. I have not recommended this. The runoff would either soak onto the soil or be carried to a storm drain.

My recommendations to the fire department or others responsible for clean up have been based on the following considerations:

1. The greatest safety for cleanup personnel and the safety of the public. The amount of blood at the scene of one of these accidental spills is usually small, less than a unit of blood, or 750 cc. It generally spreads thinly over the surface it covers, and like any liquid quickly flows into

cracks and crevices of the surface it is on. If the blood is cleaned up directly by a person, there is a risk of spatter exposure to the mouth or eyes or direct exposure through cuts on the hands or exposed surfaces of the body. The likelihood of complete cleanup is small since any liquid could spread widely throughout the accident scene. The action of water on blood is to immediately destroy the blood cells and to dilute the material contained inside them rapidly. The likelihood of survival of biologic agents associated with the blood is minuscule. The actions of road chemicals on such agents would also be to destroy them or render them harmless. Allowing the runoff to drain into a storm sewer would not be a health hazard either at the accident scene or further down the drain. It certainly would not be a problem at the ocean drain site.

The biologic agents which concern most people on a theoretic basis are HIV virus, Hepatitis B virus, and Hepatitis C virus. These are the most likely viruses to be present in blood in California citizens. None of these viruses reproduce outside a living human cell. The HIV virus is a fragile virus and is inactivated by numerous chemicals, heat , and light. In fact, a 1:10 dilution of household bleach is adequate to inactivate the virus under most conditions. Hepatitis C virus is probably the most prevalent virus in the blood of Califonians. It is present in between 0.5% to 2%) people in the US and Europe. The risk at an accident scene for encountering Hepatitis C would be no greater than 2:100 on average. The second most prevalent virus would be Hepatitis B. In California, the risk of encountering Hepatitis B contaminated blood at an accident site would be approximately 5:1,000. The risk of blood at an accident being contaminated with HIV virus would be approximately 1:1,000 or less on an average.

2. Increased effectiveness and efficiency of cleanup. Because the blood spreads and splatters the most rapid and effective clean up will be a washdown. This will prevent undue delays of freeway traffic and the long waiting periods necessary to call special cleaning squads. It will also remove the visible remains of the accident much faster thus preventing citizen concern from escalating.

3. Cost savings to the fire department, highway patrol, and CalTrans employees. It will decrease the cost of accident investigation and cleanup by decreasing the cleanup time for major injury accidents and eliminate the need for special cleanup units. .

4. Demonstration to the public that such visible blood is not a reason for undue concern if handled properly. Treating a blood spill as if it were a class 4 contamination gives the wrong message concerning risk to the public. In addition, the use of plain water would not unecessarily add increased amounts of chemicals to the runoff water. This will further decrease the burden of runoff water contamination on the storm drain system, keeping chemical contaminants to an unavoidable minimum.

I am an active supporter of efforts to protect the environment of the Santa Monica Bay and all Coastal waters. My Department has been an active participant in evaluating storm drain runoff into the Bay and we monitor it carefully. Though there is no likelihood of sterile effluent from storm drains, we still need to assure the community that we are watching those drains and minimizing the products of civilization which get into them. My recommendations are made in the spirit of these activities.

If there is any further information I can provide, please let me know. I can be reached at (213)240-7728, FAX (213)202-5980, e-mail sfannin@dhs.co.la.ca.us.

Sincerely yours,

Shirley L. Fannin MD

Shirley L. Fannin, MD
Director, Disease Control Programs
Public Health, Department of Health Services,
Los Angeles County

cc: James G. Haughton, M.D.

COUNTY OF LOS ANGELES

FIRE DEPARTMENT

1320 NORTH EASTERN AVENUE
LOS ANGELES, CALIFORNIA 90063-3294

(323) 881-2401

P. MICHAEL FREEMAN
FIRE CHIEF
FORESTER & FIRE WARDEN

November 30, 2000

Harry W. Stone, Director
Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, CA 91803

Dear Mr. Stone:

SUBJECT: **MITIGATION OF RESIDUAL BLOOD RELEASES**

Our Department is requesting your assistance in addressing an issue that continually surfaces during public agency responses to trauma scenes involving mitigation of residual blood from victims.

The Los Angeles County Board of Supervisors established the Hazardous Materials Coordinating Committee (HMCC) to "facilitate information sharing among government and private agencies for the coordinated influence and development of legislation, policies and procedures to assure comprehensive protection of communities from hazardous materials." The HMCC is chaired by our Department and includes representatives from several government agencies.

A Trauma Scene Management Subcommittee was established to address the mitigation of residual blood releases. This ad-hoc Committee is focused on the health and safety issues that responders, victims, and the environment may face at trauma scenes in public areas. The following agencies are Committee members: The Los Angeles County Department of Health Services (DHS), Los Angeles City Fire Department, Los Angeles County Sanitation Districts, Los Angeles Sheriff's Department, Office of Public Safety, Long Beach Department of Health and Human Services, Pasadena Fire Department, Cal Trans, City and County Department's of Public Works, Coroner's Office, and the Regional Water Quality Control Board.

Members of this Committee recently met with staff from the State Department of Health Services, Medical Waste Management Program, and were advised that the 1998 Trauma Scene Waste Management Act did not apply to public agencies. An inquiry to the Federal Environmental Protection Agency (EPA) Region 9 and their Office of Solid Waste and Emergency Response produced no documents that address this issue on the Federal level. The EPA suggested that this should be resolved at the regional level.

R0008826

The HMCC has received a letter from Dr. Shirley Fanin, Medical Director, Disease Control Programs, Los Angeles County DHS, that indicates the most rational method of protecting the health of responders and the public is the practice of washing down residual blood. A copy of this letter is enclosed for your review. Discussions with Mr. Rod Kubomoto of your Watershed Management Division led us to believe that this approach may be consistent with the limits and exemptions of the Los Angeles County National Pollutant Discharge Elimination System (NPDES) permit. We present this issue to you as the administrator of the County NPDES permit to resolve with the State Regional Water Quality Control Board (Los Angeles Region) as part of the permitting process.

Your assistance in addressing this important issue will be of great benefit to the public agencies of Los Angeles County. Also, your direction on this matter will greatly influence the way that first responders across the region prepare and respond to trauma scenes.

If you have any further questions, please call me or have your staff contact Michael Wilkinson, Acting Deputy Fire Chief, Prevention Bureau, at (323) 881-2461 or William Jones, Chief, Health Hazardous Materials Division, at (323) 890-4043.

Sincerely yours,

for P. MICHAEL FREEMAN

PMF:na

Enclosure

c: Rod Kubomoto, Assistant Deputy Director (DPW)

bc: Freeman, Miller, Wilkinson, Jones, Ochoa, Munoz

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

DEC 19 2000

In Reply
Refer to: WTR-5

Dennis A. Dickerson
Executive Officer
California Regional Water Quality Control Board,
Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Dear Mr. Dickerson:

The letter is in follow up to our meeting on October 5, 2000 concerning the NRDC Petition to Withdraw the NPDES storm water permit program administered by the Los Angeles Regional Board. One of the NRDC's principal concerns with the Regional Board's program is the alleged absence of an effective program for controlling pollutants in storm water discharges from industrial facilities. NRDC also recognizes, however, that the root of the problem is the lack of adequate staffing at the Regional Board to implement the program. At the October 5 meeting, we suggested that the upcoming MS4 permit reissuance for Los Angeles County require that the MS4 permittees provide more assistance to the Regional Board in this regard. We also indicated that we would provide this letter of support to the Regional Board for such requirements.

EPA's storm water permit application regulations of November 16, 1990 (55 Fed. Reg. 47990) set forth the permit application requirements for industries and municipalities and also provide guidance concerning the implementation of the program over the longer term. The storm water regulations envision a cooperative effort on the part of the NPDES permitting authority and permitted MS4s in the implementation of the industrial storm water program (55 Fed. Reg. 47997). The regulations at 40 CFR 122.26(d)(2)(iv)(C) also specifically require that MS4 permittees develop and implement controls on industrial sources which discharge into the storm sewer system, including:

> "a description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system."

The current MS4 permit for Los Angeles County requires "educational visits" by MS4 personnel to assist industrial/commercial facilities in complying with local ordinances and prohibitions. We understand that the intent of this particular requirement was to provide time for the permittees to gain experience in controlling pollutants in storm water discharges from these facilities. Now that the permittees have had five years to gain such experience, we recommend that the next permit explicitly require that the permittees require compliance with local ordinances and implement an effective enforcement program to ensure compliance. For industrial facilities, such a requirement would be fully consistent with EPA regulations at 40 CFR 122.26(d)(2)(iv)(C). We also believe that the Regional Board's extension of the program to commercial facilities is consistent with EPA regulations at 40 CFR 122.26(d)(2)(iv)(A); however, NRDC's concerns are primarily related to industrial facilities.

Since the intent and requirements of local MS4 ordinances are usually similar (but perhaps less detailed) to the requirements of the State's general NPDES permit for industries, the above recommendation should significantly assist the Regional Board in more effectively controlling pollutants in storm water discharges from industrial (and commercial) facilities. As noted above, NRDC's concerns with the Regional Board's program are fundamentally resource-related, and by utilizing the resources of the MS4 permittees more effectively, this should help to address NRDC's concerns.

It should also be noted that the above recommendation would be nothing new for California MS4 permits. For example, the MS4 permits issued in 1996 for Orange and Riverside Counties already include explicit requirements for enforcement of local ordinances for storm water pollution control. Detailed enforcement requirements for local ordinances have also been proposed by the San Diego Regional Board for the upcoming reissuance of the San Diego County MS4 permit.

Should you have any questions regarding this matter, please call me at (415) 744-1860, or refer your staff to Eugene Bromley of the CWA Standards and Permits Office at (415) 744-1906.

Sincerely,

Alexis Strauss
Director, Water Division

cc: Xavier Swamikannu, Los Angeles RWQCB
David Beckman, NRDC

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City Council Meeting 12-19-2000 Santa Monica, California

ORDINANCE NUMBER 1995 (CCS)
(City Council Series)

AN ORDINANCE OF THE CITY COUNCIL
OF THE CITY OF SANTA MONICA
ADDING CHAPTER 8.108 TO THE SANTA MONICA MUNICIPAL CODE
WHICH ADOPTS SANTA MONICA AMENDMENTS
TO THE CALIFORNIA BUILDING STANDARDS CODE
RELATING TO GREEN BUILDING STANDARDS

WHEREAS, on June 8, 1999, the City Council adopted Ordinance Number 1945 (CCS), which adopts the California Building Standards Code, Santa Monica amendments to the California Building Standards Code; and other technical codes; and

WHEREAS, Health and Safety Code Sections 18938 and 17958 provides that the California Building Standards Code establishes building standards for all occupancies throughout the State; and

WHEREAS, Health and Safety Code Section 18941.5 provides that the City may establish more restrictive building standards if they are reasonably necessary due to local climatic, geological or topographical conditions; and

WHEREAS, the City Council has considered the 1998 edition of the California Building Standards Code, which incorporates by reference the 1996-1997 editions of the Technical Codes, and all of the referenced standards, tables, matrices and appendices of each of these codes therein; and

WHEREAS, based upon the findings contained in the Resolution adopted concurrently with this Ordinance, the City Council has found that certain modifications and additions to the California Building Standards Code are reasonably necessary based upon local climatic, topographical and geological conditions; and

WHEREAS, Public Resource Code Section 25402.1(h)(2) says that a local enforcement agency may adopt more restrictive energy standards when they are cost-effective and approved by the Energy Commission; and

WHEREAS, the City hired a private consultant to conduct a cost study of the proposed changes and said study demonstrated the cost effectiveness of these changes; and

WHEREAS, the State Energy Commission approved the proposed standards on September 20, 2000;

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF SANTA MONICA DOES ORDAIN AS FOLLOWS:

SECTION 1. Chapter 8.108 is hereby added to the Santa Monica Municipal Code to read as follows:

CHAPTER 8.108 GREEN BUILDING STANDARDS

8.108.010 Purpose.

The green building design and construction standards established in this chapter are intended to reduce human exposure to noxious materials; conserve non-renewable energy and scarce materials; minimize the ecological impact of energy and materials used; use renewable energy and materials that are sustainably harvested; and protect and restore local air, water, flora and fauna. These standards will help protect the health of building occupants; improve employee productivity; use energy, water and materials more efficiently; incorporate recycled-content building materials; and increase the durability, ease of maintenance, and economy of building operations.

8.108.020 Scope.

The provisions of this chapter shall apply to all new buildings, and existing buildings whose repair, alteration or rehabilitation costs exceed 50 percent of their replacement cost as determined by Section 8.84.040 except (a) one-and-two-family dwellings and their accessory structures and (b) qualified historic buildings as defined in the State Historic Building Code (Title 24, Part 8).

8.108.030 Compliance Methods.

(a) Except as provided in subsections (b) and (c) of this Section, the envelope, space-conditioning, lighting and service water-heating systems of all buildings subject to the provisions of this chapter shall be designed, constructed and installed to use no more source energy from non-renewable sources than the allowable energy budget calculated in accordance with the performance approach set forth in Chapter 8.36 and reduced in accordance with Section 8.108.040.

(b) Multi-family residential buildings that are three stories or less in height may use the prescriptive approach set forth in Chapter 8.36 for the envelope, space-conditioning, lighting and service water-heating systems if these buildings also meet the following requirements:

(1) all windows and glass patio doors are equipped with double-glazed, low-emissivity glazing, with center- of-glass U-value not more than 0.32 Btu/(hr.sq.ft. deg. F.), and Solar Heat Gain Coefficient not more than 0.37;

(2) fixed lighting fixtures installed within the dwelling units have a combined average efficacy of not less than 40 lumens per watt;

(3) water heaters have a minimum energy factor of 0.60; and

(4) space cooling appliances (if installed) have a Seasonal Energy Efficiency Ratio (SEER) of not less than 12.

(c) When building designs, materials or devices cannot be adequately modeled by the performance approach, alternate calculation methods may be used when approved by the California Energy Commission pursuant to their administrative regulations for exceptional methods.

8.108.040 Reductions in Allowable Energy Budgets.

Allowable energy budgets shall be the allowable energy budget determined in accordance with Chapter 8.36 and reduced by the following factors for the occupancy types shown in Table 8.108-A. Required reduction factors for occupancies not shown in Table 108-A shall be determined by the Building Officer for the most similar energy consuming use.

Table 8.108-A

Required Reduction Factors for Allowable Energy Budgets

Multi-family residences	20%
Hotels and motels	25%
Commercial and institutional offices	25%
Light industrial	25%
Retail	20%

When determining compliance with the percentage reduction, alternate calculation methods that consider energy savings in addition to those recognized in Chapter 8.36 may be used when approved by the Building Officer. These savings may include, but are not limited to, efficiency of fan systems with motors less than twenty-five horsepower and garage ventilation controls.

8.108.050 Use of Recycled Construction Materials.

All new buildings subject to the provisions of the chapter shall be built with a minimum of four major construction materials that have a post-consumer recycled content that meets the Environmental Protection Agency (EPA) recycled content guidelines as set forth in the Comprehensive Guideline for Procurement of Products Containing Recovered Materials (CPG) and the Recovered Materials Advisory Notices (40 CFR Part 247), or any successor publication. Building and Safety Division shall maintain copies of the most recent guidelines issued by the EPA. Major construction materials are those materials that serve a structural, partitioning or finishing function throughout the building or cover more than one-half of the floor, roof or wall surfaces.

8.108.060 Additional Mandatory Features for All Buildings.

(a) Solar Water Heating. Solar collectors shall be the primary source to heat swimming pool water and to preheat industrial process water, including but not limited to, car washes and laundries.

(b) Pipe Insulation. All hot water distribution and recirculating system piping shall be thermally insulated from the heater to the end-use fixtures. Pipe insulation shall have R-value equal to R-4 for piping 2 inches or less in diameter and R-6 for larger piping. The R-value specified shall not be exceeded.

(c) Heat Traps. Heat traps shall be provided on the inlets and outlets of non-circulating hot water heaters and tanks to reduce the buoyancy-induced flow of hot water through the piping. Bent piping for heat traps shall have a minimum external diameter of twelve inches.

SECTION 2. Section 8.36.010 of the Santa Monica Municipal Code is amended to read as follows:

8.36.010. Adoption.

That certain document entitled "California Energy Code, 1998 Edition," which is Part 6 of Title 24 of the California Code of Regulations, as published by the California Building Standards Commission and the International Conference of Building Officials is hereby adopted as the Energy Code of Santa Monica, subject to the provisions of Chapter 8.108 Green Building Standards.

SECTION 3. Any provision of the Santa Monica Municipal Code or appendices thereto, inconsistent with the provisions of this Ordinance, to the extent of such inconsistencies and no further, are hereby repealed or modified to that extent necessary to effect the provisions of this Ordinance.

SECTION 4. If any Section, subsection, sentence, clause, or phrase of this Ordinance is for any reason held to be invalid or unconstitutional by a decision of any court of any competent jurisdiction, such decision shall not affect the validity of the remaining portions of this Ordinance. The City Council hereby declares that it would have passed this Ordinance, and each and every Section, subsection, sentence, clause, or phrase not declared invalid or unconstitutional without regard to whether any portion of the Ordinance would be subsequently declared invalid or unconstitutional.

SECTION 5. The Mayor shall sign and the City Clerk shall attest to the passage of this Ordinance. The City Clerk shall cause this ordinance, or a summary thereof to be published once in the official newspaper within 15 days after its adoption. This Ordinance shall be effective 30 days after its adoption.

APPROVED AS TO FORM:

MARSHA JONES MOUTRIE
City Attorney

Adopted and approved this 19th day of December, 2000.

Michael Feinstein, Mayor

State of California)
County of Los Angeles) ss.
City of Santa Monica)

I, Maria M. Stewart, City Clerk of the City of Santa Monica, do hereby certify that the foregoing Ordinance No. 1995 (CCS) had it's introduction on December 5, 2000, and was adopted at the Santa Monica City Council meeting held on December 19, 2000, by the following vote:

Ayes:	Council members:	Holbrook, O'Connor, McKeown, Genser, Katz, Mayor Pro Tem Bloom, Mayor Feinstein
Noes:	Council members:	None
Abstain:	Council members:	None
Absent:	Council members:	None

ATTEST:

Maria M. Stewart, City Clerk

Los Angeles County
Municipal NPDES Permit
Executive Advisory Committee
Wednesday, January 10, 2000 - 1:30 P.M.
Los Angeles County Department of Public Works
900 South Fremont Avenue, Alhambra
12th Floor Conference Room

1. Call to Order
2. Approval of December 13, 2000, Minutes
3. Presentation by Paul Polizzotto of "Adopt a Stormdrain"
4. Regional Board Update
5. Permit Activities Update

   Annual Report
6. Total Maximum Daily Load (TMDL)
   - Monitoring Plan
   - Task Force Report
7. Public Comments
8. Closed Session Discussion
9. Next Meeting - February 14, 2000
10. Adjournment

UNIT2\CRIOS\EAC\EAC-Agenda-Jan2001.wpd

From: Dennis Dickerson
To: Dan Radulescu; Dennis Dasker; Wendy Phillips; Xavier Swamikannu
Date: 1/10/01 4:11PM
Subject: Today's EAC Mtg

This notes will range several topics

TMDL Zero trash appears to be the big issue for the cities. Were there any way to modify or rephrase it would go a long way to reduce controversy.

Any mtg on the permit/TMDL with enviro groups they are asking to be participants

Asking that we post TMDL comment response on the web

TMDL I committed that we should get any change sheet or response to comenmts out not later than two days before the mtg.

NTMC comment that we appeared to stray from our commitment early on not to link NTMC to the TMDL, i.e., monitoring They want a mtg to discuss the NTMC letter and our outlook. Wendy, pls arrange.

Suggestion that I support that we establish after the TMDL is adopted a standing TMDL implementation working group

I requested that they offer a review/overview of the ROWDs that are submitted early on. Feb 14 is tentative date Invite enviros - mtg not intended to debate but just present their viewpoint

THE ROUGE RIVER PROJECT
A WORLD CLASS EFFORT
BRINGING OUR RIVER BACK TO LIFE

Rouge River National Wet Weather Demonstration Project

Wayne County, Michigan

TASK PRODUCT MEMORANDUM
Evaluation of On-Line Media Filters in the Rouge River Watershed
Nonpoint Work Plan No. URBSW5, Task No. 3

RPO-NPS-TPM59.00

March 1999

R0008840

Rouge River National Wet Weather Demonstration Project

Wayne County, Michigan

Evaluation of On-Line Media Filters in the Rouge River Watershed TASK PRODUCT MEMORANDUM

Nonpoint Work Plan No. URBSW5, Task No. 3

Authors: Razik Alsaigh, Jeff Boerma, Amy Ploof & Louis Regenmorter

ACKNOWLEDGMENTS

We would like to thank Paul Geisert (Aqua-Net, Inc,), Henry Happel (Suntree Isles), Paul Renberg (Sonoco), Jorge R. Sainz (Geotechnical Marine), and Joseph B. H. Smith (Foss Environmental) for their assistance in this demonstration project.

The Rouge River National Wet Weather Demonstration Project is funded, in part, by the United States Environmental Protection Agency (EPA) Grant #X995743-01, 02, 03 and 04 and #C995743-01. The views expressed by individual authors are their own and do not necessarily reflect those of EPA. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

Rouge River National Wet Weather Demonstration Project

MISSION STATEMENT

The mission of the Rouge River National Wet Weather Demonstration Project is to demonstrate effective solutions to water quality problems facing an urban watershed highly impacted by wet weather and develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state and local environmental laws which protect human health and the environment.

This will be accomplished through the development, implementation and financial integration of technical, social and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

PREFACE

The Rouge River and its watershed are a primary source of pollution to the Great Lakes. The Clean Water Act of 1972 intended to make waterways "fishable and swimmable" by 1972. Although that goal has not been reached, great progress has been made in improving water quality in most waterways. The Rouge River Remedial Action Plan (RAP) provided a basis for which The Rouge River National Wet Weather Demonstration Project (Rouge Project) efforts were created: it identified the major sources of pollution and measured the relative contributions of each. The RAP is the continuing foundation for the Rouge Project and presents a framework for addressing the problems within the Rouge River by looking beyond treatment and focusing instead on prevention methods.

The Rouge Project was established under the initial Rouge Grant 1 from the United States Environment Protection Agency, Region 5, and enabled Wayne County to initiate a comprehensive watershed-wide pollution-control approach that addresses combined sewer overflow (CSO), stormwater management, and other nonpoint source controls through the application of innovative technologies, progressive financial and institutional arrangements, and creative public involvement and education programs.

Rouge Grant 2 provides the framework for the progression and implementation of Project goals as Wayne County continues its mission to develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The Project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state, and local environmental laws which protect human health and environment.

This will be accomplished through the development, implementation, and financial integration of technical, social, and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

Under Rouge Grant 2, the Rouge Project will build on lessons learned from Grant 1 efforts and focus on further integration of the goals of the overall Mission. To this end, Rouge Grant 2 concentrates on the following key Project areas:

- **Watershed Management** will continue under Rouge Grant 2 with the development and evaluation of wet weather and stormwater alternatives, the planning of long-term monitoring programs, and the ongoing efforts to enhance instream water quality, monitor rain and flow levels, interpret data analysis, and present recommendations.

- **Nonpoint Source Pollution Control** will provide for the stormwater management, permit applications, and development of financial and institutional alternatives for wet-weather watershed management in concert with enhanced efforts to establish institutional partnerships. Toward the goal of institutional partnering, several community projects will be undertaken with watershed communities. Additional efforts include the inventory of wetlands and measurement of pollutant loads from abandoned dumps and air deposition with possible remediation of some sites.

- **CSO Construction Coordination** will continue to monitor the construction of CSO demonstration projects established under Grant 1. Additional planning and assistance will allow project coordinators to make additional recommendations on the design criteria of future CSO abatement facilities.

- **Public Involvement and Information** will reach and interact with more stakeholders, institutions, and regulatory agencies, thus fostering a renewed understanding and continued commitment to reducing pollution, and continuing the transfer of watershed management approaches beyond the project. It will be the central mechanism for transmittal of the Project's Decision Support System tools, processes, and information necessary for sustaining a watershed management support system directly to varied audiences both within and outside the Rouge watershed.

Additional information on the Rouge River Project is available from many sources, including the Wayne County Department of Environment (WCDOE), the Rouge Program Office (RPO), and the Rouge Project website at http://www.rougeriver.com.

ABSTRACT

This report describes the performance of the on-line media filter demonstration pilot project for the period of October 1995 to June 1997. This best management practice (BMP) uses storm sewer inserts to filter sediments and absorb hydrocarbon products from storm sewer runoff before it reaches surface waters. These inserts were applied as a demonstration project in the Cities of Livonia and Westland, Michigan. These BMPs were recommended to evaluate the costs and benefits of low cost, inlet insert type devices for use in existing urban areas. Four devices were tested as part of this demonstration. The sediments and hydrocarbons collected by the four devices were measured and the results of the four devices were assessed. The operation and maintenance (O&M) considerations, capital cost, and estimated O&M costs are also addressed. All four filters performed well during the 19 month evaluation period and were relatively easy to maintain. The results of this demonstration show that the best filter depends on the conditions at the site and the objective of its installation.

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R0008846

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1.0 INTRODUCTION.

Urban stormwater has been extensively studied over the past 15-20 years and is recognized as a major source of pollution to many of the nations waterways. The 1989 Rouge River Remedial Action Plan (RAP) and 1994 Rouge RAP Update identified stormwater and/or nonpoint source pollution as a major contributor to flow, suspended solids, biochemical oxygen demand, nutrients, and trace contaminants and identified nonpoint source pollution as a major concern in the upper and middle reaches of all branches of the Rouge River (SEMCOG; 1989, 1994). One of the primary goals of the Rouge River National Wet Weather Demonstration Project (Rouge Project) is to implement pilot stormwater pollution control programs to test their applicability to southeast Michigan and nationwide. Data derived from the pilot storm water pollution control projects will be utilized by the Rouge Subwatershed advisory groups during development of management plans for the seven Rouge subwatersheds.

The purpose of this report is to describe the performance evaluation of the on-line media filter demonstration project for the period of October 1995 to June 1997. This demonstration project is structural BMP #8 as described in the Rouge Project document "Interim Final Report for the 319 Grant (RPO-NPSO1A-TR02.01)."

2.0 BEST MANAGEMENT PRACTICE (BMP) DESCRIPTION AND APPLICATION IN THE ROUGE WATERSHED.

2.0 BEST MANAGEMENT PRACTICE (BMP) DESCRIPTION AND APPLICATION IN THE ROUGE WATERSHED. This BMP uses storm sewer inserts to filter sediments and absorb hydrocarbon products from storm water runoff before it reaches surface waters. These BMPs are suitable for small impervious drainage areas. Storm sewer inserts were examined in the Rouge Watershed for the possibility of retrofitting existing small urban drainage areas as a means to provide water quality benefits. These devices are applicable for use in gas stations, small convenience stores, and small parking lots and they have a relatively low cost.

These inserts were applied as a demonstration project in the Cities of Livonia and Westland, Michigan. They are the only structures of this kind presently in use in the Rouge Watershed. Filter inserts have been used elsewhere in the U.S., most notably in the states of Florida and Washington.

3.0 ROUGE PILOT BMP PROJECT DEMONSTRATION ACTIVITIES.

The Rouge Program Office (RPO) recommended these BMPs for pilot demonstration in order to evaluate the costs and benefits of low cost, inlet insert type devices for use in existing urban areas in the Rouge Watershed. The information from these devices will be used to determine if existing storm sewer design criteria should be modified and if retrofit of existing catch basins with these devices is a viable, cost effective pollution management option for implementation watershed-wide. Four of these devices were tested as part of this demonstration.

3.1 SITE CHARACTERISTICS.

This pilot BMP was tested for a period of 19 months at two gas station sites: one at Schoolcraft and Merriman Roads in Livonia, Michigan and one at Ford and Newburgh Roads in Westland, Michigan. *Figure 3-1* contains site plans for both locations. Two catch basins (M1 and M2) were monitored at the Livonia site and five catch basins (N1, N2, N3, N4, and N5) were monitored at the Westland site. Each filter was installed within the catch basin and not within the sewer pipe, so the flow through the filters was only from the gas station tributary areas. The drainage areas for the two catch basins at the Livonia site are 0.16 acres for M1 and 0.60 acres for M2. The drainage areas for the five catch basins at the Westland site are 0.064 acres for N1, 0.048 acres for N2, 0.125 acres for N3, 0.049 acres for N4, and 0.033 acres for N5. The tributary area to all media filter devices was composed entirely of gas station property and is considered 100 percent impervious. Both locations (Livonia and Westland) had a very similar environment with respect to the type and frequency of traffic and both had a convenience store at the site.

3.2 DESIGN CHARACTERISTICS.

The catch basin insert type units selected for this BMP evaluation are presently manufactured and marketed by vendors throughout the United States and Canada. Many of the vendors are located in Florida and Washington due to the interest of local municipalities in this type of water quality improvement retrofit. Several vendors were contacted and four units were chosen for assessment:

- *Hydro-Cartridge®:* by Geotechnical Marine Corporation; Hialeah Gardens, Florida.
- *StreamGuard™:* by Foss Environmental; Seattle, Washington.
- *Gullywasher™:* by Aqua-Net Incorporation Seattle; Washington.
- *Grate Inlet Skimmer Box:* by Suntree Isles Incorporation; Cape Canaveral, Florida.

The chosen devices were selected because they are easy to install, did not require construction and were compatible with the catch basins at the gas station sites available to the Rouge Project for testing these devices.

The objective of these devices is to provide a unit that can be installed in existing storm water catch basins by simply lifting the catch basin manhole cover, inserting the unit, and replacing

Figure 3-1
Site Plans for On-line Media Filter Evaluation

Figure 3-1a: Livonia Site Plan

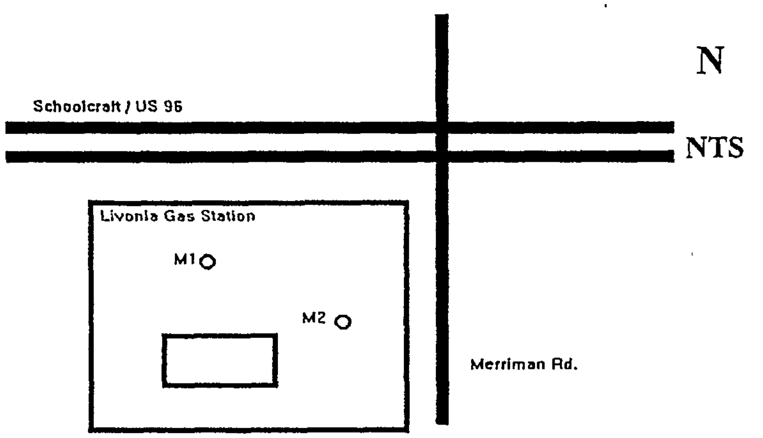
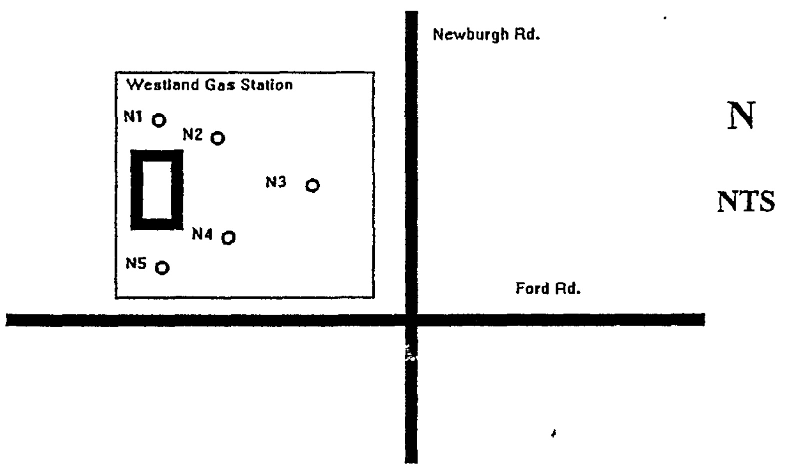


Figure 3-1b: Westland Site Plan



the cover to its original position. Units are sized to fit the existing catch basins. These units consist of materials and structures to capture solids and absorbent media to capture oil products. Overflow outlets are also provided to allow flow through for large runoff events. The design for each of these units is briefly explained in the following paragraphs.

3.2.1 **Hydro-Cartridge®**. The Hydro-Cartridge® is a fiberglass filter with an oil absorbing media. Two types of media were tested in this study, Woolzorb™ and Rubberizer™. This filter uses standing water to slow the flow through the filter allowing oil to separate to the top and sediment to settle at the bottom of the filter. Hydrocarbon polymer pillows are positioned at the top of the filter to absorb hydrocarbons. A sketch of the Hydro-Cartridge® is included in *Appendix A*.

3.2.2 **StreamGuard™**. The StreamGuard™ is a fabric filter bag that hangs in the storm inlet from the lid of the catch basin. It is held in place by the weight of the inlet cover on the inlet structure. This filter uses standing water to reduce the flow velocity and allow sediment to settle out. This filter also has one-half inch diameter holes on the side near the top of the device to allow storm water to overflow the filter. Oil absorbing media is positioned in the center of the filter to absorb hydrocarbons as storm water flows through the filter. A sketch of the StreamGuard™ is included in *Appendix A*.

3.2.3 **Gullywasher™**. The Gullywasher™ is a metal basket with cellulose filter media on the bottom and sides of the basket. Storm water flows into an aluminum funnel and enters a basket filled with cellulose material that hangs below the funnel. During large storm events, the basket will overflow. A sketch of the Gullywasher™ is included in *Appendix A*.

3.2.4 **Grate Inlet Skimmer Box**. The Grate Inlet Skimmer Box is a fiberglass filter with oil absorbing media. The Grate Inlet Skimmer Box has two filter parts: the first is a ring around the top of the filter that contains the oil absorbing media, and the second is a bucket with screened holes on the sides and bottom and open overflow holes at top. Storm water entering the filter first enters the top ring flow around a "boom" of oil absorbing media and drop into the bucket section. The bucket section is designed to hold the runoff from the first part of a large storm or from an entire small storm and slowly release the storm water to the storm sewer through screens. If the storm is large, the bucket fills up and drains through overflow holes at the top. A sketch of the Grate Inlet Skimmer Box is included in *Appendix A*.

3.3 **INSTALLATION CONSIDERATIONS.** Four devices were obtained from vendors and all four were installed at the sites. The only structural revision to the sites that was required was the purchase of one new manhole cover with an indent on the bottom side. The indent was necessary to allow the grate inlet skimmer box fit properly. The installation of these devices was performed by the RPO team and consisted of removing the catch basin cover, setting the device into the manhole, and reinstalling the catch basin cover.

The StreamGuard™ was the easiest to install. It is a fabric bag that can fit almost any inlet shape or size. The other three devices were also easy to install, but precise measurement of the inlet opening, rim configuration, and cover type were needed to ensure their proper fit. The Gullywasher™ required minor hammering due to the tight fit of this device on several of the inlets.

3.4 OPERATION AND MAINTENANCE CONSIDERATIONS. An important considerations of these insert devices is the maintenance required to ensure that the filters effectively capture sediment and absorb oil. A device may be excellent at capturing sediments and oils, but if it requires very frequent maintenance it may become impractical. The four devices used in this demonstration project functioned properly with only monthly maintenance based on the existing environmental conditions. For the purposes of this demonstration, a monthly basic maintenance schedule was chosen to assess the maintenance requirements of these devices for long-term use in a gas station environment. In only one instance, when the Hydro-Cartridge® froze in cold weather, was immediate attention necessary during the 19 month assessment period.

The RPO team performed the following operation and maintenance (O&M) activities in accordance with the standard operating procedures described in *Appendix B*.

1. Each filter was checked weekly in the field, preferably just after a rain event.
2. Sediment and organic materials were removed monthly from the filters. A sieve analysis was performed on the material removed.
3. Filter media samples were analyzed for oil and grease content on a monthly basis.

It should be noted that the maintenance schedule will vary depending on where these devices are used and the amount of hydrocarbons, sediment, or debris generated from the drainage area. The observations included in this report are related to the function of these devices in a gas station drainage area environment in southeast Michigan.

O&M procedures for each of the four filter types are detailed in the following sections.

3.4.1 Hydro-Cartridge®. The Hydro-Cartridge® is a fiberglass device molded to fit the catch basin. Installing the device requires only removal of the catch basin lid, inserting the device, and replacing the lid. During operation the filter fills with water making its removal more difficult. For maintenance, the full filter must be lifted out of the catch basin and generally required two persons. Initially, removal of the filter was relatively difficult, but became easier with increased familiarity with the device. Use of a vactor truck is likely to make clean-up of these filters easier.

This filter performed well during the 19-month evaluation period, with one exception. During a period when temperatures were below 10°F for about seven days, the standing water in the filter froze and the catch basin became plugged. A storm event occurred while the surface of the standing water in the device was frozen, causing storm water runoff to pond and flood an area of 12 feet by 20 feet and one foot in depth. This incident led to the filter being removed until warmer weather. This filter could be modified to work effectively in cold weather by adding several relief holes above the standing water surface to allow for a secondary path for the runoff if the standing water in the device froze. These holes would be plugged in the summer and unplugged in the winter. If this filter is modified it is expected that very little maintenance will be required throughout the year. The exchange of the absorbent pillow or pads is easy and consists of tying and untying a string.

3.4.2 **StreamGuard™.** The StreamGuard™ is a fabric filter basket held in a catch basin by being pinched between the lid and rim of the catch basin. This configuration makes the process of removing the filter difficult initially, but becomes relatively easy with experience. The advantage of this filter's design is that it can be cut to fit a variety of different catch basins. The versatility of the StreamGuard™ enabled installation at two different catch basins using the same filter size. The filter is thrown away once it is no longer useful, therefore, no time is spent cleaning it for reuse. Once the installation and removal techniques are mastered, this filter is easy to maintain.

3.4.3 **Gullywasher™.** The Gullywasher™ is a metal basket filled with cellulose booms designed to fit a specific catch basin size. When the cellulose booms are dry the filter is easy for one person to install and remove. When the cellulose booms are wet the filter becomes much heavier, but is still manageable for one person. Booms are constructed of plastic netting filled with cellulose. This plastic netting sometimes catches on the metal basket causing an inconvenience when loading or unloading the booms from the basket. Maneuvering the used cellulose booms out of the filter and putting in the new media makes this filter somewhat more difficult to maintain than the StreamGuard™ or Hydro-Cartridge®.

3.4.4 **Grate Inlet Skimmer Box.** The Grate Inlet Skimmer Box is relatively easy to maintain except for screens located in the main bucket. The oil absorbing media is simply lifted out for disposal and new media is installed. Decaying leaves and debris plugged the screens making them difficult to keep clear, even with use of a wire brush. Two different filters with different screen configurations were used and both experienced the plugging of the screens. The filter was easy to maintain except for this problem. A vactor truck could also be a great help to clean this device.

3.5 **HYDROLOGICAL CONDITIONS.** During the period of October 11, 1995 - June 5, 1997 the cumulative precipitation was 48.45 inches as recorded at the Wayne County rain gauge located at Merriman Road South of Ann Arbor Trail and at the Detroit Metropolitan Airport rain gage. *Table 3.1* outlines the hydrological conditions at the gas stations for the study period. *Table 3.1* shows the total amount of rain for a given month and the maximum amount of rain that fell in a one hour period. The time period each filter was in place is also indicated. During the winter months of November through March for both 1995-1996 and 1996-1997, the precipitation was mainly snow with some rain and the ground was generally frozen.

Table 3.1
Summary of Hydrological Conditions in the Rouge Watershed: October 11, 1995 - June 6, 1997[1]

Time Period	Temperature and Precipitation				Type of Insert			
	Avg. Temp. (F)	No. of Events	Total (inches)	Max. (inches per hour)	Hydro-Cartridge®	Stream Guard™	Gully-washer™	Grate Inlet Skimmer Box
10/11-10/31/95*	51.2	3	1.55	N.A.	Oct. 11 >	N.I.	N.I.	Oct. 13>
11/1-11/30/95	40.2	5	3.08	0.50	In	N.I.	N.I.	In
12/1-12/31/95	28.3	2	0.85	0.10	In	N.I.	N.I.	In
1/1-1/31/96	22.9	3	1.85	0.15	In	N.I.	N.I.	In
2/1-2/28/96	25.4	4	1.76	0.25	< Feb. 9	Feb. 9 >	N.I.	In
3/1-3/31/96	35.7	3	1.56	0.15	N.I.	In	Mar.25>	In
4/1-4/30/96	47.3	N.A.	3.39	N.A.	Apr. 10>	In	In	In
5/1-5/31/96	58.4	4	2.82	1.00	In	In	In	In
6/1-6/30/96	70.7	8	4.57	0.84	In	In	In	In
7/1-7/31/96	70.6	2	2.16	0.81	In	In	In	In
8/9-9/11/96	72.9	7	1.62	0.28	In	In	In	In
9/12-10/2/96	64.1	6	2.08	0.32	In	In	In	In
10/3-11/8/96	52.0	6	3.26	0.28	In	In	In	In
11/9-12/10/96	34.1	5	0.77	0.10	In	In	In	In
12/10-1/16/97	31.5	10	2.33	0.22	In	In	In	In
1/17-2/10/97	23.0	6	1.13	0.14	In	In	In	In
2/11-3/4/97	30.6	5	3.08	0.46	In	In	In	In
3/5-3/31/97	37.2	6	2.94	0.36	In	In	In	In
4/1-5/9/97	45.8	8	4.17	0.65	In	In	In	In
5/10-6/5/97	52.0	8	3.48	0.50	In	In	In	In
Total	-	101	48.45	-				

1 Source: National Weather Service Data for Detroit Metropolitan Airport (10/11/95-8/9/96). Wayne County Rain Gauge at Merriman Road, South of Ann Arbor Trail (8/9/96-6/5/97).

* October only includes data from October 11, 1995 through the end of the month.

N.A. indicates data are not available.

> indicates the filter was installed on the date written ahead of the marker.

< indicates the filter was removed on the date written behind the marker.

In indicates the filter was installed.

N.I. indicates the filter was not installed.

3.6 ASSESSMENT OF BENEFITS. The Rouge Project standard operating procedure (SOP) for field assessment of these devices "On-line Media Filter: Field Installation, Maintenance and Evaluation" (RPO/CDM-FLD-0629) is included as *Appendix B*.

All four filters were in use for more than one year. The Hydro-Cartridge® and Skimmer Box were in use from mid October 1995 until June 5, 1997, at the Livonia location. The StreamGuard™ was installed February 9, 1996 and the Gullywasher™ was installed March 25, 1996 at the Westland location; both were removed June 5, 1997. There was only one instance of a plugged filter backing up storm water flow, and during that event there were no complaints from the gas station managers regarding the devices. All of these devices removed sediment and oils from stormwater, although certain units were more effective than others. *Table 3.2* through *Table 3.5* document the data collected for these devices. *Table 3.6* summarizes the data by catch basin for the two sites. Sediment data evaluation comments were based on data collected from December 11, 1996 to May 9, 1997 and all oil data evaluation comments were based on data from August 9, 1996 to March 31, 1997.

The laboratory performed the oil and grease extraction of the samples in compliance with EPA SWA46 Method 9071 "Oil and Grease Extraction Method for Sludge Samples." The method used is to recover low levels of oil and grease by chemically drying a wet sludge sample and then extracting via the Soxhlet apparatus. This method is used when relatively polar, heavy petroleum fractions are present, or when the levels of nonvolatile greases challenge the solubility limit of the solvent. This method is suitable for biological lipids, mineral hydrocarbons, and some industrial waste waters. This method is not recommended for measurement of low-boiling fractions that volatilize at temperatures below 7 C.

The sediment analysis was performed in accordance with industry accepted methods. The samples were delivered to the lab in buckets. The lab dried the entire sample in the bucket to determine the dry weight of material trapped in the filer. The dry material was then tested for organic content by the loss on ignition test. If the dry material was found to have less than 75 percent organics, a sieve analysis was performed on the recovered material.

3.6.1 Sediment Removal and Retainage. All of the devices tested removed and retained sediment from stormwater runoff. As shown in *Table 3.7*, the Gullywasher™ was the most effective of the four devices tested at removing sediment. The Gullywasher™ was six times as effective at removing sediment than the next most effective device, the StreamGuard™ (6.60 pounds of sediment captured per 1,000 gallons of water filtered to 1.11 pounds of sediment captured per 1,000 gallons of water filtered). Fabric filters such as the StreamGuard™ and the Gullywasher™ retained a larger amount of sediment than rigid fiberglass filters. The Gullywasher™ is considered a fabric filter because the metal basket is just a means of holding the cellulose filter. The StreamGuard™ retained nearly three times the amount of the sediment as the Skimmer Box or Hydro-Cartridge®.

Table 3.2

Summary of Sediment and Oil Analysis for On-line Quality Devices by Device

Hydro-Cartridge® Data

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Table 2
Summary of Sediment and Oil Analysis for Online Quality Devices
Hydro-Cartridge Data

Time Period	Average Temp. (Farenheit)	Location	Drainage Area (sq. ft.)	Rainfall (inches)	Gallons Filtered (gallons) (1)	Sediment Captured (2) (pounds)	Sediment Captured / Gallon Filtered (2) (lbs / 1,000 gallons)	Sediment Analysis				Media Used	Oil Captured (mg/Kg) (3)	Oil Captured / Gallon Filtered ((mg/Kg) / 1,000 gallons)
								Percent Organic	Percent Gravel	Percent Sand	Percent Silt			
6/1-6/30/96	70.7	M1	26,136	4.57	74,500	5.00	0.07	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7/1-8/8/96	70.6	M1	26,136	2.16	35,200	1.50	0.04	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8/9-9/11/96	72.9	M1	26,136	1.62	26,400	n/a	n/a	n/a	n/a	n/a	n/a	Rubberizer	5,150	200
9/12-10/2/96	64.1	M2	6,970	2.08	9,000	n/a	n/a	n/a	n/a	n/a	n/a	Rubberizer	28,150	3,100
10/3-11/8/96	52.0	M1	26,136	3.26	53,100	5.62	0.11	n/a	n/a	n/a	n/a	Rubberizer	34,150	600
11/9-12/10/96	34.1	M1	26,136	0.77	12,500	2.04	0.16	n/a	n/a	n/a	n/a	Rubberizer	112,150	9,000
12/10-1/16/97	31.5	M2	6,970	2.33	10,100	4.07	0.40	24.8%	0.0%	75 6%	24.4%	Rubberizer	472,150	46,700
1/17-2/10/97	23.0	M1	26,136	1.13	18,400	3.75	0.20	25.4%	5.0%	80.0%	15.0%	Woolzorb	212,150	11,500
2/11-3/4/97	30.6	M1	26,136	3.08	50,200	4.17	0.08	20.7%	20.7%	71.1%	8.2%	Woolzorb	132,150	2,600
3/5-3/31/97	37.2	M2	6,970	2.94	12,800	2.64	0.21	12.3%	0.0%	88.7%	11.3%	Rubberizer	46,150	3,600
4/1-5/9/97			26,136	4.17	67,900	3.75	0.06	16.9%	0.0%	85.0%	15.0%	n/a	n/a	n/a
5/10-6/5/97	52.0	M2	6,970	3.48	15,100	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
Average	—	—	—	2.63	32,100	3.68	0.19	20.0%	5.1%	80.1%	14.8%	—	—	9,700

Notes:

(1) The gallons filtered is an estimate based on the drainage area and rainfall.

(2) The sediments from 6/1/1996 to 8/8/1996 were air dried by project personnel.
The sediments from 8/9/96 to 12/10/96 were mishandled ty the contracted lab. The lab was changed after 12/10/96.
Only the data from 12/10/96 to 5/9/97 are used to calculate the average sediment captured and sediment captured/gallon for the sediment analysis.

(3) These values are blank corrected.

n/a = data is not available

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Table 3.3
Summary of Sediment and Oil Analysis for On-line Quality Devices by Device
StreamGuard™ Data

Table 3
Summary of Sediment and Oil Analysis for Online Quality Devices
StreamGuard Data

Time Period	Average Temp. (Farenheit)	Location	Drainage Area (sq. ft.)	Rainfall (inches)	Gallons Filtered (gallons) (1)	Sediment Captured (2) (pounds)	Sediment Captured / Gallon Filtered (2) (lbs / 1,000 gallons)	Sediment Analysis: Percent Organic	Sediment Analysis: Percent Gravel	Sediment Analysis: Percent Sand	Sediment Analysis: Percent Silt	Media Used	Oil Captured (mg/Kg) (3)	Oil Captured / Gallon Filtered ((mg/Kg) / 1,000 gallons)
6/1-6/30/96	70.7	N2	2,112	4.57	6,000	6.50	1.08	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7/1-8/8/96	70.6	N3	5,447	2.16	7,300	5.00	0.68	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8/9-9/11/96	72.9	N3	5,447	1.62	5,500	n/a	n/a	n/a	n/a	n/a	n/a	Oil Media	7,800	1,400
9/12-10/2/96	64.1	N1	2,793	2.08	3,600	n/a	n/a	n/a	n/a	n/a	n/a	Oil Media	8,800	2,400
10/3-11/8/96	52.0	N5	1,414	3.26	2,900	0.52	0.18	n/a	n/a	n/a	n/a	Oil Media	9,800	3,400
11/9-12/10/96	34.1	N5	1,414	0.77	700	0.23	0.33	n/a	n/a	n/a	n/a	Oil Media	7,800	11,100
12/10-1/16/97	31.5	N2	2,112	2.33	3,100	4.76	1.53	21.7%	1.4%	52.0%	46.6%	Oil Media	24,800	8,000
1/17-2/10/97	23.0	N3	5,447	1.13	3,800	4.98	1.31	11.2%	12.3%	80.7%	7.0%	Oil Media	18,800	4,900
2/11-3/4/97	30.6	N1	2,793	3.08	5,400	5.22	0.97	6.7%	0.6%	90.5%	8.9%	Oil Media	7,800	1,400
3/5-3/31/97	37.2	N5	1,414	2.94	2,600	2.43	0.94	9.5%	1.2%	86.2%	12.6%	Oil Media	18,800	7,200
4/1-5/9/97	45.8	N4	2,118	4.17	5,500	4.28	0.78	15.9%	1.6%	75.0%	23.4%	n/a	n/a	n/a
5/10-6/5/97	52.0	N3	5,447	3.48	11,800	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	---	---	---	2.63	4,900	4.33	1.10	13.0%	3.4%	76.9%	19.7%	---	---	5,000

Notes:

(1) The gallons filtered is an estimate based on the drainage area and rainfall.

(2) The sediments from 6/1/1996 to 8/8/1996 were air dried by project personnel.
The sediments from 8/9/96 to 12/10/96 were mishandled ty the contracted lab. The lab was changed after 12/10/96.
Only the data from 12/10/96 to 5/9/97 are used to calculate the average sediment captured and sediment captured/gallon for the sediment analysis.

(3) These values are blank corrected.

n/a = data is not available

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Table 3.4
Summary of Sediment and Oil Analysis for On-line Quality Devices by Device
Gullywasher™ Data

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Table 4
Summary of Sediment and Oil Analysis for Online Quality Devices
Gullywasher Data

Time Period	Average Temp. (Farenheit)	Location	Drainage Area (sq. ft.)	Rainfall (inches)	Gallons Filtered (gallons) (1)	Sediment Captured (2) (pounds)	Sediment Captured / Gallon Filtered (2) (lbs / 1,000 gallons)	Sediment Analysis: Percent Organic	Percent Gravel	Percent Sand	Percent Silt	Media Used	Oil Captured (mg/Kg) (3) (4)	Oil Captured / Gallon Filtered ((mg/Kg) / 1,000 gallons)
6/1-6/30/96	70.7	N1	2,793	4 57	8,000	9.00	1.13	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7/1-8/8/96	70.6	N2	2,112	2.16	2,800	4.00	1.43	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8/9-9/11/96	72.9	N4	2,118	1.62	2,100	n/a	n/a	n/a	n/a	n/a	n/a	Cellulose	(3,350)	(1,600)
9/12-10/2/96	64.1	N3	5,447	2.08	7,100	n/a	n/a	n/a	n/a	n/a	n/a	Cellulose	4,050	600
10/3-11/8/96	52.0	N2	2,112	3.26	4,300	3.67	0.85	n/a	n/a	n/a	n/a	Cellulose	450	100
11/9-12/10/96	34.1	N2	2,112	0.77	1,000	0.94	0.94	n/a	n/a	n/a	n/a	Cellulose	5,250	5,300
12/10-1/16/97	31.5	N4	2,118	2.33	3,100	16.93	5.46	25.1%	1 2%	79 0%	19.8%	Cellulose	3,050	1,000
1/17-2/10/97	23.0	N2	2,112	1.13	1,500	20.34	13 56	29 4%	0 0%	83.9%	16.1%	Cellulose	12,250	8,200
2/11-3/4/97	30 6	N5	1,414	3.08	2,700	19.47	7 21	25 6%	6.2%	80.2%	13 6%	Cellulose	5,250	1,900
3/5-3/31/97	37.2	N4	2,118	2.94	3,900	19.59	5 02	23 9%	0 3%	89 6%	10 1%	Cellulose	5,250	1,300
4/1-5/9/97	45 8	N3	5,447	4.17	14,200	22.60	1.59	27 4%	0.5%	84 3%	15 2%	n/a	n/a	n/a
5/10-6/5/97	52.0	N1	2,793	3.48	6,100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	—	—	—	2.63	4,700	19.79	6.57	26.3%	1.6%	83.4%	15.0%	—	—	2,100

Notes:

(1) The gallons filtered is an estimate based on the drainage area and rainfall.

(2) The sediments from 6/1/1996 to 8/8/1996 were air dried by project personnel.
The sediments from 8/9/96 to 12/10/96 were mishandled ty the contracted lab. The lab was changed after 12/10/96.
Only the data from 12/10/96 to 5/9/97 are used to calculate the average sediment captured and sediment captured/gallon for the sediment analysis.

(3) These values are blank corrected.

(4) Some reported values are negative because of the high blank correction value. The negative value indicates very low or no capture of oil.

n/a = data is not available

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Table 3.5
Summary of Sediment and Oil Analysis for On-line Quality Devices by Device
Grate Inlet Skimmer Box Data

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Table 5
Summary of Sediment and Oil Analysis for Online Quality Devices
Grate Inlet Skimmer Box Data

Time Period	Average Temp. (Farenheit)	Location	Drainage Area (sq. ft.)	Rainfall (inches)	Gallons Filtered (gallons) (1)	Sediment Captured (2) (pounds)	Sediment Captured / Gallon Filtered (2) (lbs / 1,000 gallons)	Sediment Analysis				Media Used	Oil Captured (mg/Kg) (3) (4)	Oil Captured / Gallon Filtered ((mg/Kg) / 1,000 gallons)
								Percent Organic	Percent Gravel	Percent Sand	Percent Silt			
6/1-6/30/96	70.7	M2	6,970	4.57	19,900	11.00	0.55	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7/1-8/8/96	70.6	M2	6,970	2.16	9,400	12.50	1.33	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8/9-9/11/96	72.9	M2	6,970	1.62	7,000	n/a	n/a	n/a	n/a	n/a	n/a	Cellulose	2,750	400
9/12-10/2/96	64.1	M1	26,136	2.08	33,900	n/a	n/a	n/a	n/a	n/a	n/a	Cellulose	8,750	300
10/3-11/8/96	52.0	M2	6,970	3.26	14,200	2.16	0.15	n/a	n/a	n/a	n/a	Cellulose	(1,750)	(100)
11/9-12/10/96	34.1	M2	6,970	0.77	3,300	0.78	0.24	n/a	n/a	n/a	n/a	Cellulose	6,750	2,000
12/10-1/16/97	31.5	M1	26,136	2.33	38,000	3.26	0.09	37.6%	0.0%	84.2%	15.8%	Cellulose	9,750	300
1/17-2/10/97	23.0	M2	6,970	1.13	4,900	5.47	1.12	25.9%	5.4%	78.2%	16.4%	Cellulose	9,750	2,000
2/11-3/4/97	30.6	M2	6,970	3.08	13,400	4.74	0 35	19.2%	10.6%	74.2%	15.2%	Cellulose	7,750	600
3/5-3/31/97	37.2	M1	26,136	2.94	47,900	6.16	0.13	10.8%	0.0%	88.3%	11.7%	Cellulose	5,750	100
4/1-5/9/97	45.8	M2	6,970	4.17	18,100	4.96	0.27	24.6%	0.0%	79.9%	20.1%	n/a	n/a	n/a
5/10-6/5/97	52.0	M1	26,136	3.48	56,700	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	—	—	—	2.63	22,200	4.92	0.39	23.6%	3.2%	81.0%	15.8%	—	—	700

Notes:

(1) The gallons filtered is an estimate based on the drainage area and rainfall.

(2) The sediments from 6/1/1996 to 8/8/1996 were air dried by project personnel.
The sediments from 8/9/96 to 12/10/96 were mishandled ty the contracted lab. The lab was changed after 12/10/96.
Only the data from 12/10/96 to 5/9/97 are used to calculate the average sediment captured and sediment captured/gallon for the sediment analysis.

(3) These values are blank corrected.

(4) Some reported values are negative because of the high blank correction value. The negative value indicates very low or no capture of oil.

n/a = data is not available

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Table 3.6
Summary of Sediment and Oil Analysis for On-line Quality Devices by Catch Basin

Parameter	Livonia Catch Basins (2)			Westland Catch Basins (2)					
	M1	M2	Average	N1	N2	N3	N4	N5	Average
Average Temperature (Fahrenheit)	48.7	48.7	48.7	54.4	47.0	54.7	46.9	38.5	48.7
Average Rainfall (in)	2.63	2.63	2.63	3.3	2.37	2.44	2.77	2.51	2.63
Average Gallons Filtered (1)	42,900	11,400	27,200	5,800	3,100	8,300	3,700	2,200	4,800
Sediment Analysis									
Sediment Captured (pounds)	4.22	4.38	4.30	5.22	12.55	13.79	13.6	10.95	12.06
Sediment Captured / Gallon Filtered (lbs / 1,000 gallons)	0.11	0.47	0.29	0.97	7.55	1.45	3.75	4.07	3.84
Percent Organic	22.3	21.4	21.8	6.7	25.6	19.3	21.6	17.6	19.6
Percent Gravel	5.1	3.2	4.2	0.6	0.7	6.4	1.0	3.7	2.5
Percent Sand	81.7	79.3	80.5	90.5	68.0	82.5	81.2	83.2	80.1
Percent Silt	13.1	17.5	15.3	8.9	31.4	11.1	17.8	13.1	17.3
Oil Analysis									
Oil Captured (mg/Kg)	65,000	71,500	68,000	8,300	10,700	10,200	4,200	10,400	8,000
Oil Captured / Gallons Filtered ((mg/KG) / 1,000 gallons)	3,100	7,300	5,200	1,900	5,400	2,300	1,200	5,900	3,300

Notes:
(1) Gallons Filtered is estimated as the drainage area multiplied by the rainfall.
(2) All numbers in this table are averages of the monitoring periods shown in *Table 3.2* through *Table 3.5*.

The sediment collected at each catch basin was analyzed by the lab to estimate the composition of the sediment collected. As shown in *Table 3.6*, the sediment consisted of approximately the same composition ratios at both the Westland and Livonia sites. Organics made up about 20 percent of the sediment collected. The remainder of the sediment was approximately 5 percent gravel, 80 percent sand, and 15 percent silt. The sediment collected by each of the four devices was also analyzed to determine if the filters captured the same composition of sediment. As shown in *Tables 3.2 - 3.5* the sediment collected by the four devices consisted of approximately the same composition ratios.

3.6.2 **Oil Removal and Absorption.** The four devices removed and absorbed oil from the runoff. Of the four devices tested, the Hydro-Cartridge® removed the most oil per gallon of stormwater filtered. As shown in *Table 3.8*, the Hydro-Cartridge® removed nearly two times more oil than the next most effective tested device, the StreamGuard™ (9,700 mg/Kg of oil per 1,000 gallons to 5,000). The design of the Hydro-Cartridge® allows it to temporarily hold several gallons of oil from a spill. The base of the filter is always full of water and thus if oil entered the filter, it would float on the standing water and would not pass through the filter, even in wet weather. This feature enabled the Hydro-Cartridge® to perform the best between the four tested filters at handling oil.

The Hydro-Cartridge®and StreamGuard™devices absorbed oil than the Skimmer Box and Gullywasher. The difference could be due to the retained water slowing the flow and enabling oil to collect on the media, or that a better oil absorbing media was used. The Skimmer Box and Gullywasher™ both used a cellulose media, while the Hydro-Cartridge® and StreamGuard™ both used other materials as their media. This may suggest that the other materials used were more effective at removing oil than the cellulose media. In summary, filters that retain storm water appear to allow more oil absorption and absorbing material other than the cellulose media appear to absorb more oil.

3.6.3 **Summary of Benefits.** All on-line quality devices evaluated by the Rouge Project demonstrated stormwater sediment and oils removal benefits. The four devices were all relatively easy to maintain. During the 19 month evaluation period no complaints were received from the gas station managers regarding these devices.

The results of the four devices for the average amount of sediment removed per gallon of water are listed in *Table 3.7*. The results of the four devices for the average amount of oil removed per gallon of water are listed in *Table 3.8*. The selection of device and media should be made based on the pollutant you are interested in controlling. The results of this demonstration show that the best filter depends on the conditions at the site and the objective of its installation.

Table 3.7
On-line Quality Devices Sediment Removal Summary

Device	Average Sediment Captured / Gallon Filtered (lbs/ 1,000 gallons)
Gullywasher™	6.60
StreamGuard™	1.11
Grate Inlet Skimmer Box	0.39
Hydro-Cartridge®	0.19

Table 3.8
On-line Quality Devices Oil Adsorption Summary

Device	Average Oil Captured / Gallon Filtered ((mg/Kg) / 1,000 gallons)
Hydro-Cartridge®	9,700
StreamGuard™	5,000
Gullywasher™	2,100
Grate Inlet Skimmer Box	700

3.7 **CAPITAL AND O&M COSTS.** Capital costs for each of these media filters are listed below (as of 1995). Operation and maintenance (O&M) costs were also estimated for sites similar to the gas stations monitored during this evaluation.

3.7.1 **Hydro-Cartridge®.** The Hydro-Cartridge® is a fiberglass structure with media inserts. The fiberglass structure costs around $700 to $800 each depending on the size of the catch basin. The media inserts are about $9 each. At sites similar to the gas stations monitored during this evaluation, we estimate it would be necessary to replace the media inserts approximately every three months. The actual amount of time before the inserts need to be replaced will vary depending on the specific site conditions.

3.7.2 **StreamGuard™.** The StreamGuard™ is a fabric insert with a cost of $40 to $80 each depending on the design of the filter, the quantity ordered, and if the insert has oil absorbing media. At sites similar to the gas stations monitored during this evaluation, we estimate it would be necessary to replace the StreamGuard™ approximately every two months. The actual amount of time before the inserts need to be replaced will vary depending on the specific site conditions.

3.7.3 **Gullywasher™**. The Gullywasher™ is an aluminum basket with cellulose media. The cost of the basket decreases as the quantity of similar baskets ordered increases. This is due to tooling costs for each differently dimensioned storm inlet. The cost of a basket when ordering 100 or more baskets is approximately $440 each. The cost of the cellulose media is approximately $60 per basket. These prices also depend on the size of the filter and the quantity ordered. At sites similar to the gas stations monitored during this evaluation, we estimate it would be necessary to replace the cellulose media approximately every three months. The actual amount of time before the inserts need to be replaced will vary depending on the specific site conditions.

3.7.4 **Grate Inlet Skimmer Box.** The Skimmer Box is a fiberglass filter with replaceable filter media. The fiberglass structure costs around $475 each depending on the size of the catch basin. The media inserts are about $25 each. At sites similar to the gas stations monitored during this evaluation, we estimate it would be necessary to replace the media inserts approximately every three months. The actual amount of time before the inserts need to be replaced will vary depending on the specific site conditions.

3.7.5 **Summary of Capital Costs**. The following table shows a summary of the costs, estimated for 1995, for the various four tested devices.

Table 3.9
On-line Quality Devices Capital Cost Summary
(1995 costs)

Device	Hydro-Cartridge®	Stream Guard™	Gullywasher™	Grate Inlet Skimmer Box
Structure	$700 - $800	n/a	$440	$475
Media	$9	$40 - $80	$60	$25
Approximate Media Replacement Interval	every three months	every two months	every three months	every three months
Estimated First Year Capital Cost	$736-$836	$240-$480	$680	$575

3.7.6 **O&M COSTS.** The O&M of the devices by the RPO team consisted of a weekly site visit to ensure the devices were operating correctly and a monthly clean out of sediment, organic materials, and changing the oil absorbing materials. The amount of time spent for a typical weekly site visit was relatively short, about 10 minutes. This gave the two person RPO team adequate time to ensure that the devices were functioning as designed. The monthly clean out of the filters took approximately 30 minutes per device. The clean out was performed as described in the SOP included as *Attachment B*. The RPO team also took samples of the media during these visits, so clean out time should be less than the one indicated above without sampling activities. Also, the weekly visits can be reduced to by-weekly and the monthly clean out visits can be reduced to by-monthly.

The devices were all relatively easy to maintain and with experience became even easier. Maintenance of the devices could be performed by city maintenance personnel or comparable staff. The current wage for a two person crew in this area of work is about $40 per hour. For a typical catch basin, the weekly site visits can be reduced to bi-weekly or less and the monthly clean out visits can be reduced to bi-monthly. Then, for a typical two month period with O&M consist two site visits and a one monthly clean out, approximately one hour per device would be spent on O&M activities. The O&M cost for one year would be approximately $240 per device. The actual amount of time needed to for O&M will very depending on how frequent each site generates sediment or oil.

Disposal cost for dry material range from $10 - $20 per cubic yard. Disposal cost will be reduced if a dewatering/drying area is available.

4.0 CONCLUSIONS.

Four on-line media filter devices were monitored for a 19 month period at two gas station sites in southeast Michigan. These devices were monitored to evaluate the costs and benefits of low cost, inlet insert type devices for use in existing urban areas in the Rouge Watershed. The Capital costs for the four devices were reasonable, and all devices were easy to operate and maintian. All four filters demonstrated the ability during the 19 month monitoring period to remove some debris, sediment, and oil without causing storm water backup. (With one exception when one filter froze and runoff ponded; this ponding could be prevented with some modifications to the filter.)

The results of this demonstration show that the best filter depends on the conditions at the site and the objective of its installation.

- In terms of amount of sediment removed and retained per gallon of stormwater filtered, the Gullywasher™ was the most effective, retaining six times the amount of sediment as the next most effective device.
- In terms of oil absorption and removal per gallon of stormwater filtered, the Hydro-Cartridge® was the most effective, retaining almost two times the amount of oil as the next most effective device.
- In terms of O&M, all devices were easy to operate and maintain. The Hydro-Cartridge® and StreamGuard™ were the easiest to maintain.
- In terms of Capital cost for the device, the StreamGuard™ had the lowest cost at $40-$80 because the only part is the filter itself. The Gullywasher™ and the grate inlet skimmer box both cost less ($440 and $475) than the Hydro-Cartridge® at $700-$800.
- In terms of cost of insert replacements, the cost varied considerably among the filters. The lowest priced is the Hydro-Cartridge® at $9 each while the costs for the skimmer box, Gullywasher™ and StreamGuard™ were $25, $60, and $40-$80, respectively.
- In terms of first year Capital cost, the lowest cost is the StreamGuard™ at $240-$480. The grate inlet skimmer box, Gullywasher™, and Hydro-Cartridge® were $575, $680, and $736-$836, respectively.
- In terms of labor O&M time, it is estimated that a two person crew would spend approximately one hour per two month period maintaining and checking each device. In southeast Michigan, the personnel cost for maintaining the devices for one year is approximately $240 per device.

5.0 REFERENCES.

Southeast Michigan Council of Governments, *Rouge River Remedial Action Plan*, 1989.

Southeast Michigan Council of Governments, *Rouge River Remedial Action Plan Update*, 1994

Wayne County Rouge Program Office, *Field Sampling Plan, Nonpoint Pollution Storm-Event Monitoring Program Element*, RPO-SAM-FSP11. July 1994.

Wayne County Rouge Program Office, *Interim Final Report for the 319 Grant*, RPO-NPS01A-TR02.01. January 1996.

Wayne County Rouge Program Office, *Pilot Structural Best Management Practice Site Selection and Assessment.* RPO-NPS-TM31.00. December 1994.

Wayne County Rouge Program Office, *Selection of Stormwater Pollutant Loading Factors.* RPO-MOD-TM34.00. October 1994.

APPENDIX A
FILTER DRAWINGS

GEOTECHNICAL MARINE CORP.

HYDRO-CARTRIDGES®

STORM DRAIN FILTRATION SYSTEM

A SAINZ DESIGN

Hydro-Cartridges is the latest environmental fiberplastic product developed by our company, directed to help our communities in the task of improving storm drainage systems and the protection of the delicate aquifer. Its design allows its use in new or already existing storm drainage, giving it retrofitting characteristics, saving expensive improvements elasticity in accordance with each situation.

Hydro-Cartridges is a very simple and flexible concept with a rugged construction aimed to last and perform its duties any time.

Hydro-Cartridges also can be used by environmental enforcing agencies as a valuable tool to monitor and control dangerous situations

R0008874

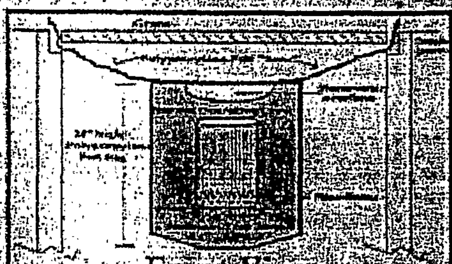
⇨ ***New & Improved*** ⇦

StreamGuard™
CATCH BASIN FILTERS

THE MOST TALKED ABOUT BEST MANAGEMENT PRACTICE FOR STORMWATER POLLUTION REDUCTION SINCE THE IMPLEMENTATION OF THE NPDES STORMWATER PROGRAM!

BY REMOVING OVER 90% OF OIL AND SEDIMENT FROM STORMWATER RUNOFF AT THE CATCH BASIN INLET, *StreamGuard™ Catch Basin Filters* KEEP THE ENVIRONMENT CLEANER, REDUCE THE NEED FOR CATCH BASIN CLEANING AND . . . *will not cause flooding!*

CBF Type II-OS



Front View

Side View

Innovative Design

☑ *4 Models* ☑ *Inexpensive* ☑ *Universal Fit* ☑ *Durable*
☑ *Effective* ☑ *Easy Installation and Removal* ☑ *Disposable*

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

StreamGuard™ – THE FUTURE OF INLET PROTECTION

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

MANUFACTURED BY:

"LEADERS IN INLET PROTECTION"

DISTRIBUTED BY:

FOSS
FOSS ENVIRONMENTAL
7440 West Marginal Way S.
Seattle, WA 98108 USA
206.767.0441 / Fax 206.767.3460

R0008875

StreamGuard™...THE FUTURE OF INLET PROTECTION

Description

A StreamGuard™ Type II Catch Basin Filter (CBF) consists of a specially designed, nonwoven polypropylene felt filter bag which is suspended in the catch basin using a nonwoven polypropylene felt fabric "boot". *StreamGuard*™ units can be quickly installed in most catch basins by simply removing the catch basin grating, placing the filter in the basin opening, and replacing the grating. The weight of the grating holds the catch basin filter in place, even when full. There are four (4) *StreamGuard*™ models to choose from: oil and sediment (OS), industrial (IND), sediment (S) and trash (T).

Operation

The *StreamGuard*™ Type II-OS has been specially designed to remove oil, grease, and sediment from stormwater runoff. The unit differs from the sediment only unit in that it has a measured amount of specially modified hydrophobic and oleophilic polypropylene oil absorbent in the bag. Every major component of the *StreamGuard*™ Type II-OS (the felt fabric bag, felt fabric "boot" and special oil-absorbent media) attracts oil like a magnet. As water enters the catch basin inlet, it is directed into the filter bag. Contaminants are initially filtered from the runoff by the boot, and then the bag and absorbent media where oil, grease and sediment are captured. Soon this felt cloth is masked over and then the bag operates in the "normal" mode with the bag ¾ full of water. This gives the oil-absorbing media more time to capture the oil and grease, also allowing the sediment to drop directly into the sediment trap zone (see drawings on reverse side). Water flow is down through the oil-absorbing media and then through the flow holes back up to the overflow pockets where it is released to the catch basin. During the peak storm periods, emergency overflow openings allow the unit to be bypassed at a rate of up to 200 gallons per minute (the industrial unit does not have this overflow mechanism).

Maintenance

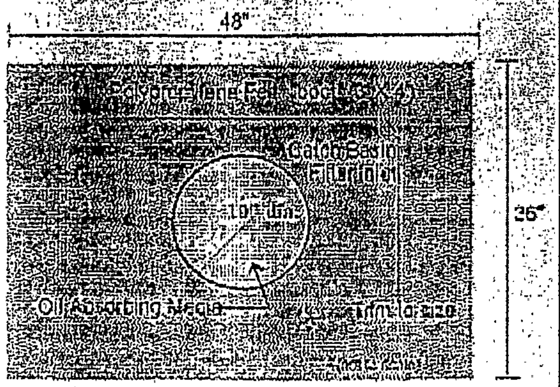
Maintaining *StreamGuard*™ CBFs is a quick and inexpensive procedure; replacement frequency depends on sediment/oil loading and runoff volume. The maintenance interval can be as often as weekly at busy construction sites for the sediment (S) only unit. For use in parking lot applications the oil and sediment (OS) unit is an excellent choice. Frequency of replacement is very site dependant; a good rule of thumb is to replace the filter every 3-5 inches of rainfall. For industrial (IND) applications with heavier sediment and oil loads, more frequent maintenance may be required. The *StreamGuard*™ is disposable, so maintenance of the units is as simple as removing the used unit (using the handy retrieval strap attached to the boot) and installing a new one. In all cases it is recommended that a monitoring program be put into place after the installation of any catch basin filter.

Disposal

Disposal of the material accumulated in the *StreamGuard*™ catch basin filters (CBFs), and the filters themselves is dependent on the nature of the pollutants being collected. At some sites, the Type II-OS CBFs could contain up to 50 percent oil (dry weight basis). In certain industrial applications, the accumulated sediment may contain other contaminants (e.g., heavy metals) and should be managed in accordance with local, state and federal regulations. In all cases, the generator is responsible for the proper characterization and disposal of the waste.

Applications

StreamGuard™ Catch Basin Filters provide a cost-effective BMP for removal of oil, grease, sediment and floatables at *industrial facilities, car and truck washing locations, construction sites, steam cleaning operations, parking lots, ports, marinas, shipyards, airports, intermodal rail yards, service stations, truck stops, shopping malls and many other sites where sediment, oil, trash and floatables can enter storm water drainage systems.*



Top View

Specifications

Type II-OS (oil and sediment)

Construction material: polypropylene
Maximum overflow rate: 200 GPM (except IND model)
Absorbent Material: Polypropylene (oleophilic)
Optimum filtration rate: 10 GPM (Type OS)
Boot adapter dimensions:
Nominal depth: 24"

Note: Boot adapter may be trimmed to size for a neat appearance

Stormwater Services Corporation (SSC) expressly warrants this product to be free from defects in material and workmanship. Except as specifically provided above, SSC makes no representation or warranty, either expressed or implied, with respect to the Catch Basin Filter, including its performance, merchantability, or fitness for a particular purpose. In no event will SSC be liable for any lost profits or consequential or special damages.

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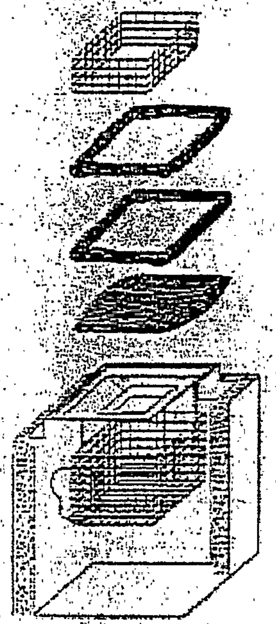
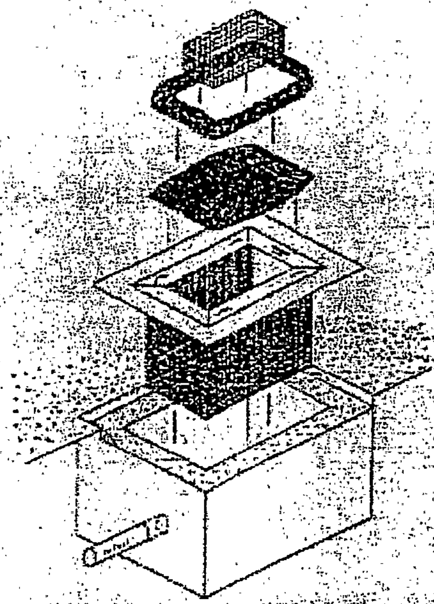
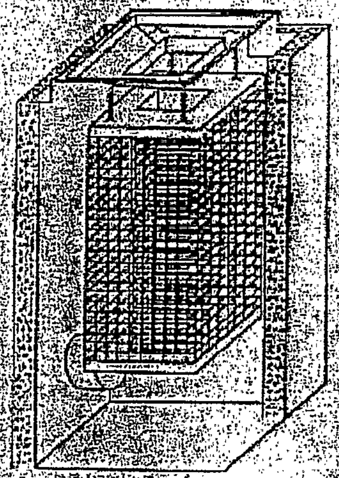
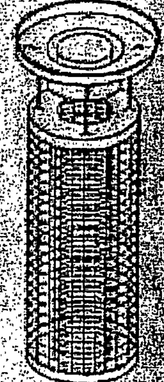


Aqua-Net catch basin insert used with 90 degree elbow and placed below the water line allows for both direct filtration and absorption of retained oil.



Standard 1/2" mesh basket with fixed top and bypass cut-outs. Use with absorbent to help reduce oil or without absorbent as a simple debris basket.





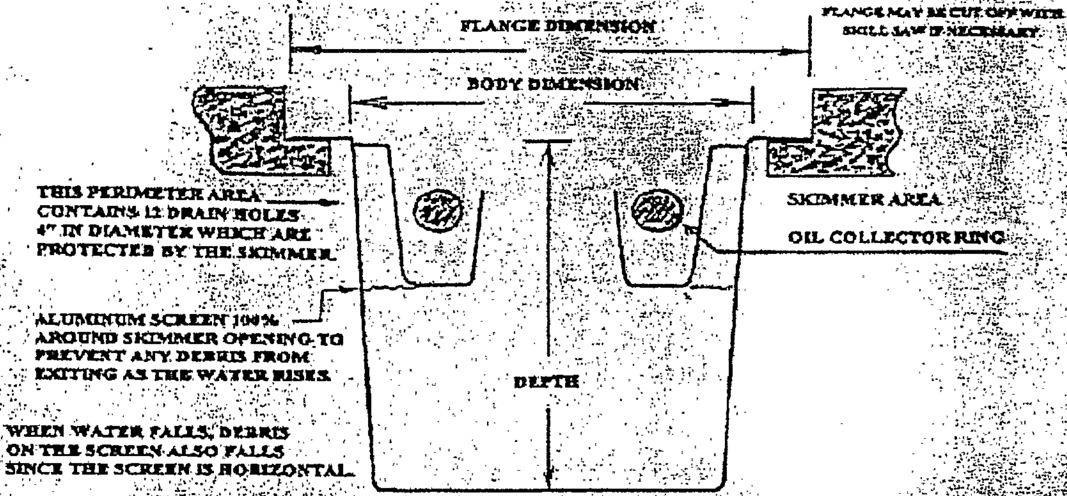
Aqua-Net filter cells for manholes, dry wells, and catch basins with sufficient rim to invert depths. Filter cells can be used with a variety of media including cellulose fiber absorbents, shredded polyurethane or polypropylene, and certified CSF© compost.

R0008877

GRATE INLET SKIMMER BOX

SUNTREE ISLES, INC., 720 MULLET RD., UNIT "H"
CAPE CANAVERAL, FL 32920
TEL: (407) 799-0001 FAX: (407) 799-1245

GRATE INLET SKIMMER BOX, AN EROSION CONTROL DEVICE FOR GRATED INLETS (INTERNAL POLLUTANT, TRASH AND OIL COLLECTOR)



SPECIAL SIZES AVAILABLE UPON REQUEST

LARGE FLANGE SIZE — BODY SIZE 28" X 36" — 22" X 30"			HIGH MID FLANGE SIZE — BODY SIZE 23" X 18" — 22" X 12"			LOW MID FLANGE SIZE — BODY SIZE 24" X 24" — 18" X 18"			SMALL FLANGE SIZE — BODY SIZE 14" X 25" — 10" X 21"		
DEPTH			DEPTH			DEPTH			DEPTH		
36" MOD.	24" MOD.	18" MOD.	36" MOD.	24" MOD.	18" MOD.	36" MOD.	24" MOD.	18" MOD.	36" MOD.	24" MOD.	18" MOD.
283636	283424	283618	231836	231824	231818	242436	242424	242418	142536	142524	142518

TECHNICAL DATA

*** WILL FIT ANY SIZE GRATE*

*** NO TOOLS REQUIRED FOR INSTALLATION*

*** ALTERATION OF EXISTING INLETS NOT REQUIRED*

*** CONTAINS OVERFLOW DRAINS SO UNIT NEVER OVERFLOWS EVEN IF IT IS NEVER CLEANED*

*** COMES COMPLETE WITH A 100% PERIMETER SKIMMER WITH TRASH SCREEN ATTACHED WHICH CAN BE REMOVED OR REPLACED WITH NO TOOLS REQUIRED*

*** ALSO AVAILABLE WITH UNIT IS AN ABSORBENT OIL COLLECTOR RING WHICH CAN BE ADDED OR REMOVED WITH NO TOOLS REQUIRED*

*** THE OIL COLLECTOR RING IS 100% AROUND THE INSIDE PERIMETER OF THE GRATE WHICH ALLOWS 90% OF ALL WATER ENTERING THE UNIT FROM ALL DIRECTIONS TO PASS THROUGH AND AROUND THE OIL COLLECTOR ENSURING THAT MOST OF THE OIL IS COLLECTED IN THE MEMBRANE*

*** UNIT CONTAINS AN INTERNAL DRAINAGE SYSTEM FITTED WITH A FILTER SILT SCREEN WHICH ALLOWS ALL REMAINING WATER THAT DID NOT GO UP AND THROUGH THE SKIMMER TO BE FILTERED AND DRAINED OUT, PREVENTING MOSQUITO BREEDING*

*** BECAUSE OF THE WAY THE UNIT IS CONSTRUCTED WITH THE REMOVABLE OIL TRAY AND TRASH SKIMMER, IT IS VERY ADAPTABLE TO NEW ITEMS OR REQUIREMENTS AT THE PRESENT TIME AND IN THE FUTURE*

APPENDIX B
STANDARD OPERATING PROCEDURE FOR ON-LINE MEDIA FILTERS

THE ROUGE RIVER PROJECT
A WORLD CLASS EFFORT
BRINGING OUR RIVER BACK TO LIFE

Online Media Filters: Field Installation, Maintenance and Evaluation

Standard Operating Procedure

RPO/CDM-FLD-0629

1.0 Scope and Application

This Standard Operating Procedure (SOP) defines how catch basin filters will be maintained and evaluated in the field. The results from the maintenance and evaluation activities will be used to estimate: (1) the cost of maintaining these filters; and (2) their effectiveness in removing pollutants from stormwater runoff entering the inlet.

2.0 Method Summary

Different types of catch basin filters and filter media will be field tested to qualitatively assess how they perform at removing sediment and oil from stormwater runoff. The maintenance requirements of each type of filter will be assessed. Catch basin filters will be installed in seven catch basins at two gas stations. One station is located at the intersection of Merriman and Schoolcraft in the City of Livonia and the other is at the intersection of Newburgh and Ford Road in Westland. During the evaluation period, the following items will be recorded for various types of filters: 1) all sediment captured by the filter will be weighed and recorded; 2) comments and observations about the oil absorbing characteristics; 3) a record of the time needed to maintain the filter; and 4) and rainfall from an on-site rain gage.

3.0 Safety, Restrictions, and Limitations

3.1 Safety

The primary safety concerns related to this survey are traffic and exposure to contaminated runoff. Traffic safety pertains to insuring that field personnel maintaining the catch basin filters minimize traffic obstructions and are not struck by cars entering or exiting from the gas stations. This will be prevented by the placement of traffic cones around the catch basin where work is being performed. In no case should field personnel leave the catch basin without first replacing the lid. Field personnel must be aware of the potential for exposure to contaminated water or sediments. Latex gloves should be worn at all times, and no food should be ingested without first washing hands with soap and water. Confined space entry will not be allowed.

3.2 Restrictions and Limitations

Field personnel shall be sensitive to the business needs and requests of the gas station manager and employees. Maintenance work should be done between the hours of 10:00-11:00 a.m. or 2:00 - 4:00 p.m. when traffic volume is lower. Any requests or restrictions made by the station manager or employees will be adhered to whenever possible.

4.0 Equipment and Materials

The required equipment is listed below:

-Rain gage
-Small water pump for water removal
-Small shovel for sediment removal
-Five gallon buckets for sediment and filter collection
-scale for weighing sediment
-manhole pick / crowbar
-extension cord to plug in pump
-traffic cones
-gloves for handling filter
-30 gallon plastic trash container

5.0 Procedures

5.1 Informing Gas Station Employees

Each time field personnel go to the gas station for either maintenance or installation of the filters, the field personnel must identify themselves to the employees of the gas station and state the purpose of the visit. After the work has been completed, employees of gas station will be told that the visit is over and field personnel are leaving the site.

5.2 Rain Data

Before any filter evaluations are performed a non-recording rain gage must be installed onsite at the gas station. The rain gage will be installed at a location where there are no obstructions overhead. Once a suitable location for the rain gage has been identified, field personnel must receive permission from the gas station manager to install the rain gage.

Throughout the portion of the year when temperatures remain above freezing (>0°C), a record of rainfall will be kept by observing the rain gage installed at the gas station. Field personnel must check the gage after each event to determine the amount of rain that occurred during the specific event. This rain data will be recorded on Form 219 that is attached to this SOP. The gage must be read as soon as possible after each rain event to ensure accurate records. Evaporation can impact the results if the readings are not performed until sometime later.

Once the air temperatures are consistently below freezing, a record of rainfall volume will be maintained by accessing rainfall data from heated rain gages located in the watershed. The nearest heated rain gages are located either in Oakland County or at Metro Airport. Call Tim Brown at (810) 452-9194 to get rain data from heated rain gages in Oakland County.

5.3 Catch Basin Filter Installation and Removal

Catch basin filters are designed to hang down, inside of the catch basin. When installing the filter, field personnel should make sure that the filter is installed as prescribed by the manufacturer (refer to the attached manufactures's instruction). Both the filter and the catch basin need to be inspected prior to installation. If either structure is found to be damaged, an assessment of it's functionality needs to be performed. There should be a tight seal between the filter and the catch basin rim to avoid water bypassing the filter. Field personnel should make certain that the catch basin is functional after the filter has been installed. The lid should be firmly in place and flush with the surrounding pavement. Care should be exercised when removing the filter to prevent damaging the filter or losing any sediment that has been trapped in the filter. Once a filter is removed, the catch basin lid should be immediately replaced.

5.4 Maintenance & Monitoring

When monitoring the various types of catch basin filters, there are three items of importance:

1. The volume of water that has flowed through the filter
2. The amount of sediment caught in the filter
3. The performance of the oil absorbing media

The amount of flow through the filter will be monitored by observations during rain events. The amount of sediment captured by the filter will be determined by removing the sediment from the filter, drying the sediment and weighing it. The performance of the oil absorbing media will be evaluated by visual observation.

Initially, the filter should be checked during every rainfall of five hundredths of an inch (0.05") or more. Field personnel should inspect the site to see if the filter is draining properly and take photographs if any unique situation occurs. Unique situations would be items such as drainage during heavy downpours or ponding around the catch basin during light rain fall.

The filter should be checked for sediment buildup and, the oil absorbing media should be inspected. Initially the filter should be inspected on the next dry working day after every rain event. Inspections will be performed less often once it is established how often maintenance needs to be performed.

The sediment can be left in the filter as long as the sediment does not block the filter's operation. If the sediment causes the filter to back up, the filter should be removed and cleaned out. Water may need to be pumped out of filter to remove sediment. Removing sediment can also require the removal of the filter from the catch basin. Sediment that is removed needs to be dried and weighed.

Drying the sediment will be performed by placing the sediment in five gallon buckets. The buckets will be kept open and allowed to dry at a Wayne County location to be arranged by Lou Regenmorter. Once the sediment is dry, it will be weighed and recorded.

Whenever checking for sediment, the oil absorbing media should also be inspected. If the media appears saturated with oil or there is a heavy film of oil inside the filter that the media is failing to remove, the media should be changed. Any observations or changes in the absorbing media need to be documented in the field notes.

When a visit is made to inspect or maintain the filters a record of the visit must be documented on Form 220 attached to this SOP. General field notes should be made for each visit.

5.5 Specific Maintenance & Monitoring

5.5.1 StreamGuard™ made by FOSS Environmental Services Co.

The StreamGuard™ filter is a fabric filter. It is a sack designed to hang down inside of the catch basin. It is secured by inserting the top of the filter between the catch basin lid and rim. The filter is designed to funnel storm water into the sack. The water flows out small flow holes in the sides during lower storm flow or out overflows near the top of the filter during high storm flow. An oil absorbing media is placed in the sack to collect oil carried in with the stormwater. The filter has a removal strap to be used to pull the filter out of the catch basin.

This filter is installed by removing the catch basin lid placing the filter in the catch basin and replacing the lid. The catch basin rim should be wiped clean of dirt and grit before the filter is placed inside. It is important for the top edge of the filter to completely cover the rim of the catch basin to prevent bypassing and provide maximum holding power. Once the lid is replaced any part of the filter fabric outside of the catch basin shall be trimmed to a uniform length of about two inches.

The StreamGuard™ filter will be removed by pulling the catch basin lid off and pulling the filter out. It is very important to either hang on to the filter-removal strap or secure the strap to the catch basin lid when removing the catch basin lid. If the removal strap is not secured the filter will fall into the catch basin. It may take two people to remove this filter. The first time the filter is removed, two people should perform the removal. After the first removal, field personnel can determine if two people are necessary for future filter removals.

The StreamGuard™ filter can be cleaned for reuse. Any sediment that has been collected should be removed and weighed to evaluate the performance of the filter. When a filter is removed, the sediment should be carefully dumped into a bucket. Some of the sediment may be pulled out of the filter by hand if necessary. It is important not to get the oil filter media in with the sediment. The oil absorbing media may need to be removed by hand set aside and replace after sediment is removed. When cleaning the filter it is more important not to lose any sediment, than it is to get all the sediment out of the filter. Once the filter is cleaned out and the oil absorbent media replaced, the filter can be placed back inside the catch basin.

5.5.2 Hydro-Cartridge® made by Geotechnical Marine Corp.

The Hydro-Cartridge® is a fiberglass filter that is inserted inside of a catch basin to remove sediment and oils from the stormwater runoff that enters the basin. The filter slows the flow of stormwater, allowing: (1) oil to separate and float to the top of the standing water in the filter; and (2) sediments to settle to the bottom of the filter.

The Hydro-Cartridge® hangs from the rim of the catch basin. Installation of the Hydro-Cartridge® is performed by removing the catch basin lid, cleaning the dirt and grit off the catch basin rim, placing the filter in the catch basin with the filter's top edge resting on the rim, and replacing the catch basin lid.

The Hydro-Cartridge® has a oil absorbing media that will require regular maintenance. The oil absorbing media is located at the top of the filter (refer to the attached manufacturer's document). The media will be removed and replaced when oil is visible on the surface of the standing water in the filter or the media appears saturated. Field personnel will use their best judgement and experience to determine when the media needs to be changed.

The Hydro-Cartridge® will collect sediment in the bottom of the filter and will require cleaning. The sediment that collects at the bottom of the filter will be measured from the ground surface during each site visit. After the filter is installed, the depth from the catch basin lid to the bottom of the filter will be measured. Each time the field personnel check on the filter, a depth measurement should be taken from the rim to the surface of the sediment. The difference in the depth to the filter bottom and the depth to the surface of the sediment equals the depth of the sediment. This depth should be noted in the field notes.

When the sediment reaches a depth of three inches above the bottom of the filter or when the filter begins to backup, the sediment will be removed. The filter will have to be removed from the catch basin to remove the sediment. First, the water in the filter will have to be pumped out. When pumping the water out, it is important not to pump out any sediment or oil if possible; the end of the pump tube should be kept below the surface of the water but above the sediment. If this is impossible, the field personnel will have to pump water into a container such as a 30 gallon trash barrel. After the sediment has been removed from the filter, the water in the barrel can be poured back into the filter insuring that no sediment left the filter without being weighed.

Once the filter is empty of water, it will be removed from the catch basin. The sediment is then removed and placed in a five gallon bucket for weighing. When removing sediment it is more important not to lose any sediment than it is to get all the sediment out of the filter. The filter should be replaced as described in the installation process.

5.5.3 Grate Inlet Skimmer Box made by Suntree Isles, Inc.

The Grate Inlet Skimmer Box is a fiberglass catch basin filter. The filter has two main parts; a skimmer tray with oil absorbing media and a box with screen filters. During a storm, runoff will first flow into the skimmer tray where oil absorbing media removes any oil carried along with the stormwater. The stormwater then overflows into a box located under the skimmer. The box has screen covered holes along the sides and bottom. The screens filter out sand and other debris from the stormwater. If the stormwater flow exceeds the capacity of the screens the top of the box has holes with no screens which allows the water to bypass the filter and overflow.

The Grate Inlet Skimmer Box is installed inside the catch basin. Installation of the Grate Inlet Skimmer Box is performed by removing the catch basin lid, cleaning the dirt and grit off the catch basin rim, placing the filter in the catch basin, resting the top edge on the rim, and replacing the catch basin lid.

The filter is visited after each rain event. The oil absorbing media should be removed and replaced when the media appears saturated with oil. Field personnel will have to use their best judgement and experience to determine when the media needs to be changed.

The Grate Inlet Skimmer Box will collect sediment in the bottom of the filter box. This box will require periodic cleaning. The sediment that collects at the bottom of the filter will be measured from this surface. After the filter is first installed, the depth from the catch basin lid to bottom of filter with no sediment is measured. Each time the field personnel checks on the filter, the depth to the sediment should be taken. When the sediment reaches a depth of three inches above the bottom of the filter or when the filter begins to backup, the sediment should be removed.

To remove the sediment, the filter will have to be removed from the catch basin. The sediment will be remove and placed in a five gallon bucket for weighing. When removing sediment it is more important not to lose any sediment than it is to get all the sediment out of the filter. The filter should be replaced as described in the installation process.

5.5.4 Gullywasher™ made by Aqua-Net, Inc.

The Gullywasher™ is an aluminum basket which holds filter media. The cylindrical basket hangs from a tray which rests in the catch basin lid. The basket is made of wire mesh with an open top and wire mesh bottom. Inside the basket is a second wire mesh cylinder that divides the center of the basket from the outside of the basket. The filter media is placed in the space between the center area and outside edge. Filter media is also placed in the bottom of the center portion of the basket. The filter media is an absorbent packed in plastic mesh booms or bags. The basket is hung with four cable straps to a tray. The tray is designed to hold the basket under the catch basin lid, and to funnel the stormwater into the center of the basket. During heavy flow, storm water will bypass the filter between the top of the wire basket and the bottom of the tray.

The Gullywasher™ is installed inside the catch basin. Installation of the Gullywasher™ is performed by removing the catch basin lid, cleaning the dirt and grit off the catch basin rim, placing the filter into the catch basin by means of the installation straps, resting the top edge on the rim, and replacing the catch basin lid.

The filter will be visited during rain events as often as possible. When the filter backs up and overflows instead of filtering the storm water, the filter media will need to be changed. Field personnel will determine when the filter media needs to be changed.

There are several steps that must be taken to monitor the amount of sediment the Gullywasher™ captures. Before the filter is installed the media should be soaked and placed into the basket. The basket and wet media will be weighed prior to installation. When the time comes to change the media the filter, the basket and media should again be weighed. The difference of the before and after weight will be the amount of sediment captured.

To change the Gullywasher™ media, the filter will have to be removed from the catch basin. Removal of the Gullywasher™ is performed by removing the catch basin lid, attaching the installation straps to the Gullywasher™ tray, and pulling the filter out of the catch basin. Removal will be done by two people the first time. Field personnel can decide if two people are needed on future removals.

Once the Gullywasher™ is out of the catch basin, the filter media can be changed. The filter media will be gently removed from the basket and placed in bags, and the bags containing the filter media will be marked with the time and date removed. New filter media will be placed in the Gullywasher™ and the filter will be replaced as described above.

6.0 Filter and Sediment Collection

6.1 Oil Absorbent Material

All the filters are designed with an absorbent media that collects oil and gasoline. The oil absorbent media should be collected and stored after it is saturated and can no longer be used in the filter. Every time the oil absorbent media is removed from a device it should be placed in a five gallon bucket or plastic bags with the following information included with the material: date removed, date installed, and reason why it was removed. If there is no reason to store the used filters, a means of disposing of the filters will be arranged by the field personnel through Wayne County Department of Environment.

6.2 Sediment Collection

Sediment collected from catch basins filters will be collected and stored in five gallon buckets. Sediment from each type of filter system will be kept in separate buckets. Each bucket must be labeled to identify which filter it came from and the date removed. Once the buckets of sediment are dried and weighed it may not be necessary to keep the sediment. Sediment disposal should be arranged by the field personnel through Wayne County Department of Environment.

7.0 Field QA/QC

Field QA/QC procedures will include calibration of the scale used to weigh sediment accumulations. Field crews will document all calibration and maintenance activities, observations, field measurements and cleaning in either field logbooks or on Forms 219 and 220. Since no laboratory analyses will be performed under this SOP, laboratory QA/QC procedures are not applicable.

8.0 Computations, Documentation, and Reporting

All field notes will be made on Forms 219 and 220. A report summarizing the maintenance and effectiveness of each catch basin filter will be made from field notes.

FORM 219
RAINFALL/RUNOFF RECORD

Rainfall

Date:____________________ Time:______________________________

Amount of rain (inches):_______ Location of rain gage:_________________

Period of rainfall time & date Start:_________ End:___________

Runoff

Manhole Location: Schoolcraft or Merriman

Drainage area in (acres): Schoolcraft =.16 Merriman =.6

Runoff is estimated by multiplying drainage area by .95 of Rain fall

Runoff volume Schoolcraft:_____ft^3 [(rainfall inches * .95/12)*(acres*43560ft^2)]
Runoff volume Merriman :_____ft^3 [(rainfall inches * .95/12)*(acres*43560ft^2)]

Comments

Name(s) of field personnel:____

R0008888

FORM 220
FILTER MAINTENANCE RECORD

Filter type:____

Media type:____

Date:____________________ Time:____________________

Reason For Visit:______________________________________

Sediment Removed Yes / No if removed (lbs):________________

Media Removed Yes / No if no, media condition:______________

Time spent maintaining the filter (hours):__________________________

Comments:

Name(s) of field personnel:___________________________________

Storm Water Best Management Practices for Retail Gasoline Outlets

Prepared for:

WSPA
Western States Petroleum Association

GEOMATRIX

Project No. S2498
January 12, 1996

R0008890

CONTENTS

GEOMATRIX

CONTENTS (continued)

GEOMATRIX

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TABLES

FIGURES

EXECUTIVE SUMMARY

This report summarizes and evaluates Best Management Practices (BMPs) that are potentially appropriate for Retail Gasoline Outlets (RGOs). This report also summarizes and evaluates several studies that characterized the chemical quality of storm water runoff from RGOs. These prior studies are important because they provide a basis for evaluating and recommending appropriate BMPs for RGO applications.

Based on the results of several storm water studies, it does not appear that the water quality of storm water runoff from properly operated and maintained RGOs is appreciably different than water quality from a number of other sources, including parking lots and roads. Additionally, in most cases, the mean concentrations of oil and grease, total suspended solids, and chemical oxygen demand are below the NPDES storm water permit limitations established by several states for vehicle-related activities.

Properly operated and maintained RGOs may currently be implementing a variety of BMPs to reduce storm water contaminant concentrations. Two basic categories of BMPs are presented in this paper. The first category consists of practical pollution prevention measures. These are the basic, common operational practices and relatively simple facility modifications that are effective in preventing storm water pollution. The second category consists of storm water treatment BMPs. These include structural controls that involve installation of equipment to reduce contaminant concentrations in storm water runoff.

Practical pollution prevention measures are appropriate for RGOs because they are simple, cost effective, and protective of storm water quality. In contrast, the storm water treatment BMPs are less appropriate for RGOs because they are ineffective or unproven for treatment of low contaminant concentrations and are relatively expensive to install and maintain.

STORM WATER BEST MANAGEMENT PRACTICES FOR RETAIL GASOLINE OUTLETS

SECTION 1.0 – INTRODUCTION

1.1 General

Storm water Best Management Practices (BMPs) are practices used to prevent or reduce the pollution of surface waters caused by storm water runoff. This report summarizes and evaluates BMPs that are potentially appropriate for Retail Gasoline Outlets (RGOs). This report also summarizes and evaluates several studies that characterized the chemical quality of storm water runoff from RGOs. These prior studies are important because they provide a basis for evaluating and recommending appropriate BMPs for RGO applications.

The Western States Petroleum Association (WSPA) commissioned this study in response to existing and anticipated regulation of storm water discharges from RGOs. In some cases, municipal ordinances require owners and operators of RGOs to implement BMPs that may not have beneficial effects on storm water quality. Additionally, the required BMPs may not be consistent between municipalities, causing compliance difficulties for RGO owners and operators. The information in this report is based on a variety of sources, including an extensive literature search and review; discussions with numerous researchers regarding on-going and unpublished studies; a review of local, state, and federal regulations; and a review of storm water BMPs currently utilized by WSPA members.

1.2 Background

In 1972, the Federal Water Pollution Control Act (also known as the Clean Water Act, or CWA) was amended to provide that any discharge of pollutants from a point source to waters of the United States is effectively prohibited unless it is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Although this technically prohibits discharge of pollutants in storm water, the focus at that time was on the bigger problems of industrial waste and sewage treatment.

As more significant sources of water pollution were brought under control, the impact of pollutants in storm water began to receive greater attention. Water quality studies conducted in the 1970s and 1980s identified urban runoff as a diffuse, or nonpoint, source of pollution. In response to these studies, the 1987 amendments to the Water Quality Act added Section 402(p). This section established a comprehensive, two-phased approach for the U.S. Environmental Protection Agency (EPA) to follow in addressing storm water discharges. Five types of storm water discharges are covered under the Phase I program. Dischargers within these five categories, listed below, were required to obtain permit coverage before October 1, 1992:

a. A discharge for which a permit has been issued prior to February 4, 1987.
b. A discharge associated with industrial activities.
c. A discharge from a municipal separate storm sewer system serving a population of 250,000 or more.
d. A discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000.
e. A storm water discharge determined by the EPA Administrator or the State to contribute to a violation of a water quality standard or to be a significant contributor of pollutants to the Waters of the United States.

Storm water discharges from commercial facilities, such as RGOs and parking lots associated with other commercial operations, are not included under the Phase I regulations. However, Phase II regulations now being promulgated are expected to increase the number and type of dischargers required to obtain NPDES permit coverage for storm water discharges. EPA, in a draft Phase II report to Congress (EPA, 1993), identified several business categories that are not currently regulated by NPDES permits but are proposed for regulation in Phase II. Automotive service facilities, including RGOs, are included on EPA's list of potential Phase II permittees.

In addition to potential regulation under state and federal programs, RGOs are likely to be regulated by local municipalities. Municipalities, as part of their mandated storm water management programs, are required to monitor and control pollutants in storm water discharges from their municipal storm drainage systems. Methods of control may include regulating storm water discharges from facilities, including RGOs, that are identified by municipalities as contributors of pollutants to the municipal storm drain system.

1.3 Water Quality of Storm Water Discharges from RGOs

To evaluate the BMPs appropriate for use at RGOs, it is necessary to develop an understanding of the types and concentrations of chemicals typically found in storm water runoff from RGOs. For this reason, summaries of three recent studies that characterized the water quality of storm water discharges from RGOs are included in this report. These studies are described in the following subsections.

1.3.1 WSPA/API RGO AND COMMERCIAL PARKING LOT STUDY

A WSPA/API storm water runoff study (WSPA/API, 1994) was conducted on six retail gasoline outlets (RGOs) and four commercial parking lots. The objective of the study was to characterize simulated storm water runoff from RGOs and compare the results with simulated runoff from commercial parking lots and published urban "background" values. The analytical results from this study are presented in Table 1.

The WSPA/API study was conducted on RGOs that were "normally operated and maintained." For the purposes of that study, "normally operated and maintained" signifies that the RGOs utilize Best Management Practices (BMPs) to minimize the buildup of potential storm water contaminants on exposed areas. These BMPs include regular sweeping of exposed areas, regular site inspections, and standardized spill response procedures. All of the RGOs were high-volume retailers, and three conducted on-site vehicle maintenance or repair services.

The study demonstrates that for the constituents analyzed, median event mean concentrations (EMCs) of chemicals in storm water runoff from normally operated and maintained RGOs are no higher than those in runoff from commercial parking lots. Additionally, median EMCs of total suspended solids, copper, lead, and zinc in runoff from RGOs and parking lots are no higher than background levels present in urban runoff as established by the National Urban Runoff Program (NURP). Furthermore, for the constituents analyzed, no significant differences were found between median EMCs of runoff from RGO pump islands and driveways. These results indicate that fueling activities at normally operated and maintained RGOs do not contribute significant additional concentrations of chemical constituents to storm water runoff.

1.3.2 DISCRETE LAND USE TYPES STUDY

Another recent study (Shepp, 1995) investigated the petroleum hydrocarbons and general water quality characteristics associated with four discrete land uses in the Washington D.C. Metropolitan Area. The monitored sites included a parking lot where cars typically are parked for relatively long periods; a parking lot for a commercial convenience store, where short-term parking occurs; a street; and an RGO. Details were not provided regarding the throughput or BMPs used at the RGO monitored for the study, however; the station is described as a "gas and go" style facility, providing no automotive service or maintenance. Samples were collected from 26 storm events for the longer-term parking lot, 14 storm events for the short-term parking lot, 9 storm events for the street, and 13 storm events for the RGO. The mean results, which are summarized in Table 2, indicate that the mean hydrocarbon concentration in runoff from the convenience commercial store is substantially higher than the closely grouped mean values for the RGO, longer term parking lot, and street. Similar results were reported for the majority of the other parameters measured.

1.3.3 ACTION PLAN DEMONSTRATION PROJECT

Sacramento County's Action Plan Demonstration Project (Uribe and Associates, 1994) characterized storm water runoff from RGOs and evaluated the use of mobile high-pressure washing as a BMP. The report presents the analytical results of storm water samples collected over two consecutive wet seasons from three RGOs in Sacramento County.

The Sacramento County project selected high-volume (more than 200,000 gallons per month), self-service RGOs with convenience markets and without automobile repair service bays for the study.

The initial analytical program for the collected samples included analyses for oil and grease, total suspended solids, metals (13 EPA priority pollutant metals plus aluminum and iron), polycyclic aromatic hydrocarbons (PAHs), and petroleum hydrocarbons. However, some of the metals, petroleum hydrocarbons, and PAHs were consistently not detected in samples collected from the first three storm events. On the basis of these results, the following parameters were selected for the remainder of the study:

- oil and grease
- total suspended solids
- heavy metals (cadmium, chromium, copper, lead, and zinc)

The analytical results from the study are presented in Table 3. The results of the study indicated that regular high-pressure washing of pavement surfaces at RGOs actually caused an increase in the concentrations of certain pollutants in storm water discharges.

1.4 Evaluation of RGO Storm Water Runoff Studies

The results of the three RGO storm water runoff studies described in the preceding subsections are summarized in Table 4. For comparison, Table 4 also presents the effluent limitations contained within draft or final NPDES storm water permits from several states that have promulgated effluent limitations for industrial facilities engaged in vehicle-related activities. Also presented are the mean concentrations for residential and commercial land uses from NURP (1983), a comprehensive study conducted from 1978 through 1983 with funding and guidance provided by EPA. The results of NURP provide insight on what can be considered background levels for urban runoff.

As summarized in Table 4, the mean concentrations of total suspended solids, lead, copper, and zinc in runoff from RGOs are generally below the background levels established by the results of NURP. Additionally, in most cases, the mean concentrations of oil and grease, total suspended solids, and chemical oxygen demand are below the limitations established for a number of NPDES permits, including storm water discharge limitations established for transportation-related industrial facilities located in Missouri, Alabama, Oregon, and Louisiana. On this basis, it appears that the concentrations of chemical constituents in storm water discharges from properly operated and maintained RGOs are below background concentrations and are generally below levels that require additional controls or treatment, as established by the effluent limitations developed for storm water discharges from sites where vehicle fueling, maintenance, and repair occur.

However, it should be noted that the preceding conclusions are based on the mean concentrations from samples collected from a total of ten RGOs. The analytical results for individual RGOs and storm events are variable, as would be expected based on typical variability in RGO age, construction, throughput, and management practices. The variability in analytical results for oil and grease and total suspended solids is illustrated on the histograms presented as Figure 1. In some cases, the results exceed the background concentrations established by NURP and/or the effluent limitations developed for vehicle-related sites. The variability in analytical results shown on this figure suggests that there may be cases where concentrations of specific chemical constituents in storm water discharges from RGOs are above levels where additional controls may be required. However, the histograms also indicate that the majority of the results are below concentrations where additional controls may be required, suggesting that, in most cases, the BMPs implemented at properly operated and maintained RGOs are effective and sufficient for preventing storm water pollution.

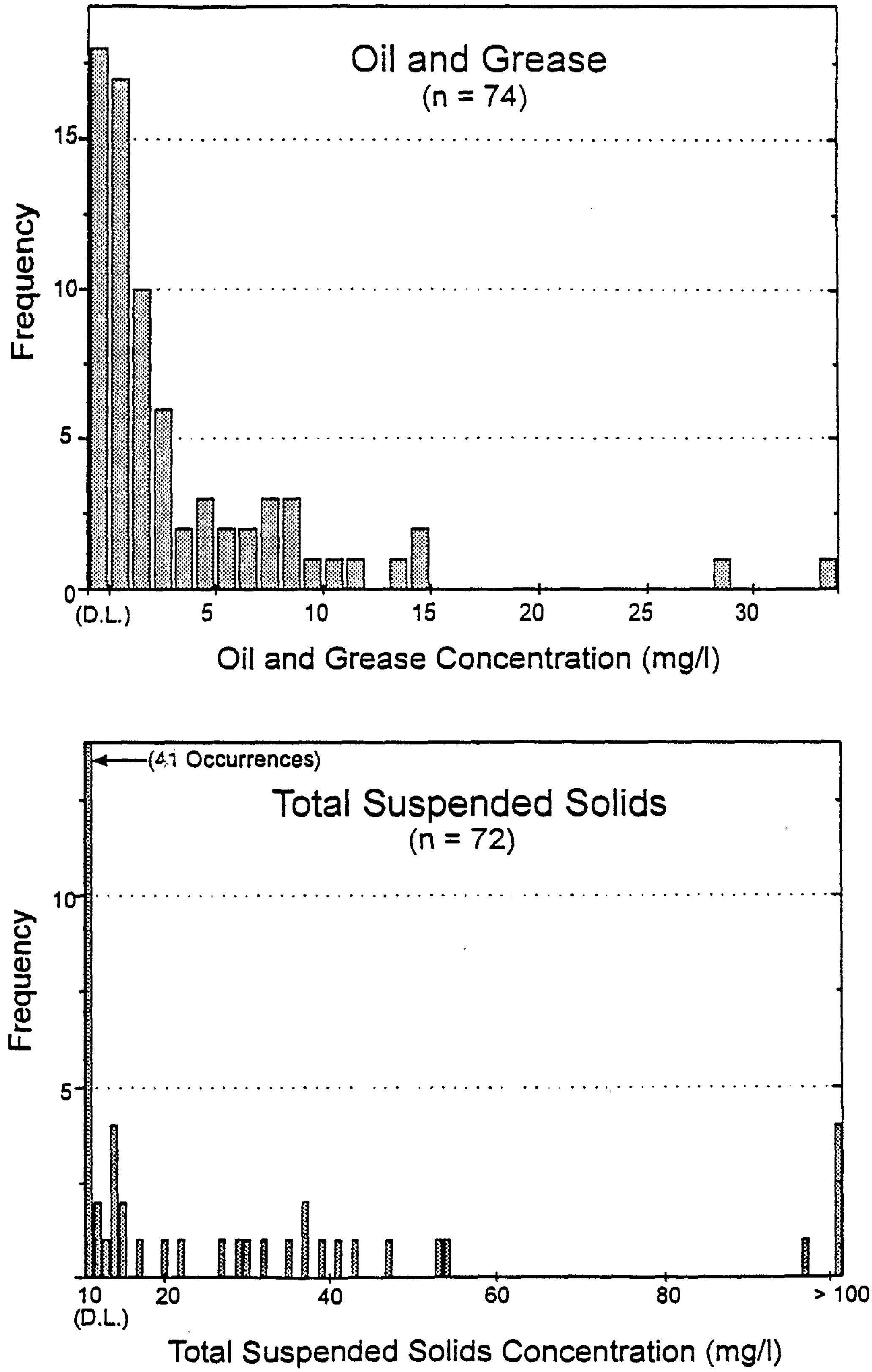

Figure 1 - Histograms of Mean Results for Oil & Grease and Total Suspended Solids from Three Recent Studies Characterizing Storm Water Runoff from RGOs

SECTION 2.0 -- BEST MANAGEMENT PRACTICES FOR RGOs

2.1 General

As described in Section 1.4 of this report, storm water discharges from RGOs contain concentrations of oil and grease, total suspended solids, heavy metals, and other constituents. Although the concentrations of these constituents from properly operated and maintained RGOs are often no higher than from other land uses, such as parking lots and streets, there may be a requirement to minimize pollutant loading of storm water through implementation of BMPs.

Two basic categories of BMPs are described in this report. The first category consists of practical pollution prevention measures. These are the basic, everyday operational practices and relatively simple facility modifications that are effective in preventing storm water pollution. The second category consists of storm water treatment BMPs. These include structural controls that usually involve installation of equipment to treat storm water. The storm water treatment BMPs described in this report are limited to on-site treatment devices applicable to relatively small sites that lack the room necessary for traditional urban BMPs such as extended dry detention basins or wet ponds.

The first category of BMPs, pollution prevention measures, are preferred over storm water treatment BMPs because they are relatively simple and cost effective. The results of a recent survey of several WSPA/API member companies, representing several thousand RGOs across the western United States, indicated that the types of pollution prevention and source control practices that are described in this report are already being used at many RGOs. This approach for preventing pollution is endorsed by EPA as one of the best means of pollution control. In fact, the Pollution Prevention Act of 1990 set forth a national policy that:

> "...pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should employed only as a last resort and should be conducted in an environmentally safe manner."

The second category of BMPs are storm water treatment measures. Storm water treatment may require a fairly significant capital outlay, along with operational and maintenance expenses, and may not result in an appreciable improvement in storm water quality. Treatment of storm water discharges from RGOs is problematic for two reasons. First, as characterized in Section 1.4 of this report, storm water discharges from RGOs typically carry relatively low concentrations of contaminants. The efficiency and removal rates for many structural BMPs at such low influent concentrations are questionable. Second, storms are often short-duration events with relatively high intensities. It is often difficult to effectively treat the necessary amount of rainfall that discharges from a 100 percent impervious RGO without storing a large volume of water. Creating on-site storage for the necessary volume of storm water runoff often is the most costly item in the overall BMP system (Bell & Nguyen, 1995). Nevertheless, structural BMPs may be required for sites where it has been demonstrated that operational practices are not sufficient to control pollutants. In addition, some municipalities require the installation of structural BMPs for new developments or significant remodels. The specific requirements vary greatly between jurisdictions, and it is recommended that owners and operators contact individual municipalities for specific requirements.

A description of practical pollution prevention measures and storm water treatment BMPs are described in the following sections.

2.2 Practical Pollution Prevention Measures Suitable for RGOs

The following are proactive practical pollution prevention measures that can be effective for all RGOs. The intent of these pollution prevention measures is to control pollutants to the extent that the treatment of storm water is unnecessary. A summary of these practical pollution prevention measures is presented in Table 5.

2.2.1 USING SPILL CONTAINMENT & OVERFILL PREVENTION EQUIPMENT

Using spill and overfill equipment for Underground Storage Tanks (USTs) can effectively reduce fuel spills during UST filling activities. Federal regulations have made installation of spill and overfill equipment mandatory for all RGO USTs installed after December 1988. For RGO USTs installed prior to December 1988, federal regulations will not require spill and overfill equipment until 1998; however, local and/or state regulations may require earlier installation. In addition, fuel pump shut-offs, including automatic shut-offs at each pump and a manual shut-off inside the building, are effective for preventing or minimizing the size of spills.

Proper maintenance of the spill containment equipment is required to ensure proper product delivery. The required maintenance includes regular removal of accumulated debris, water, and product.

2.2.2 POSTING SIGNS WARNING AGAINST "TOPPING OFF"

"Topping off" fuel tanks during fueling can lead to spills, which can potentially contribute hydrocarbon pollutants to storm water runoff. Posting high visibility signs, warning against "topping off" can be effective for minimizing these types of spills.

2.2.3 USING "HOLD OPEN" LATCHES ON DISPENSER NOZZLES

Proper use of "hold open" latches on dispenser nozzles can facilitate automated gasoline fueling and can minimize spills caused by improper fueling methods, including use of fixed objects such as gas caps, wallets, pieces of wood, etc., to keep dispenser latches open. It should be noted that "hold open" latches may not be allowed by local fire departments and may increase the potential for spills caused by customer drive-offs unless used in conjunction with break-away hoses.

2.2.4 PROVIDING CANOPIES AND USE OF CONCRETE FOR FUELING AREAS

Providing canopies over fueling areas can reduce storm water pollution caused by direct precipitation onto fueling areas. However, canopies may not be necessary for RGOs with effective good housekeeping and spill response procedures.

Portland Cement Concrete (PCC) can be used instead of asphaltic concrete in fuel areas. This is advantageous because asphalt soaks up fuel, or can be slowly dissolved by fuel, engine fluids, and other organic liquids. Over time, the asphalt itself can become a source of storm water pollutants.

2.2.5 AVOIDING STORM WATER RUNON

RGOs should be graded to prevent storm water runon to fuel islands and outdoor maintenance areas. Runon can also be prevented by installing berms, curbs, or valley gutters to redirect the runoff. It is also possible to redirect roof gutter downspouts so that they drain away from the fueling and maintenance areas.

2.2.6 MAINTENANCE PROCEDURES FOR EXISTING OIL & GREASE SEPARATORS AND OTHER TREATMENT BMPS

Any structural BMP, including oil and grease separators, drainage sumps, and catch basins, should be maintained regularly. This reduces the potential for re-suspension and transport of settled particulates, which can be a source of storm water pollutants. Proper maintenance of oil/grit separators includes periodic sediment clean out.

2.2.7 AVOIDING RGO WASH DOWNS

As described in Section 1.3.3 of this report, a study to evaluate the use of high-pressure washing as a storm water BMP was conducted for Sacramento County (Uribe and Associates, 1994). The results of the study indicated that regular high-pressure and high-temperature washing of pavement surfaces at RGOs can actually cause an increase in the concentrations of certain pollutants in storm water discharges. In addition, discharges to the street or storm drain system that result from RGO washdowns is prohibited by many municipalities. As an alternative, fuel dispensers should be regularly cleaned using a damp cloth or mop. Mop water should be discharged to a mop sink connected to the sanitary sewer. However, check with your local sewer authority regarding permitting or other requirements for mop water discharges to the sewer system.

2.2.8 SWEEPING EXPOSED AREAS

Regular sweeping of exposed areas, using hand brooms and/or vacuums, can be an effective storm water BMP. Sweeping may be most effective when conducted immediately prior to the wet season and forecasted rain events. Studies show that routine sweeping is effective in reducing concentrations of total suspended solids, particulate heavy metals, and hydrocarbons bound to particulates. In addition, pollutant removal rates are shown to vary directly with the frequency of sweeping. A street sweeping study in San Jose revealed approximate removal rates of 50 percent for heavy metals and total suspended solids when streets were swept once or twice a day (NVPDC, 1992). However, a significant reduction to less than 5 percent removal was observed when the frequency of sweeping dropped to once or twice a month (Pitt, 1979).

2.2.9 ELIMINATING NON-STORM WATER DISCHARGES AND ILLICIT CONNECTIONS

Non-storm water discharges and illicit connections are potentially significant sources of storm water pollution. An example of a non-storm water discharge is the wash water from vehicle or pavement washing that is discharged to the street or storm drain system. This type of discharge is prohibited by many municipalities. Examples of illicit connections are indoor drains or sinks that discharge to the storm drain instead of the sewer system. These illicit connections are also prohibited by most municipalities, and it is recommended that all RGOs be inspected to confirm that all illicit connections are eliminated.

2.2.10 STANDARDIZING SPILL RESPONSE PLAN

A standardized spill response plan ensures that spills are promptly detected, contained as necessary, and properly cleaned up. An effective plan provides a well-defined set of spill response procedures and establishes a training program to educate all employees about the procedures. Typical spill response techniques at RGOs include using shop rags for small spills and using absorbent materials such as vermiculite, sawdust, or cat litter for larger spills. In addition, there are commercially available adsorbent materials that can be recycled. Used shop rags should be stored in a closed bin for recycling by a cleaning service. Separate wet/dry vacuums also can be used for larger motor oil and antifreeze spills. Due to their potential flammability, spilled gasoline, solvents, or other volatile liquids should be removed using absorbent materials. Depending on the type of spill, the used absorbent materials may have to be disposed of as a hazardous waste.

2.2.11 TRAINING EMPLOYEES

Employee training is a key component of pollution prevention. Routine employee training can take the form of distinct BMP training programs or incorporating BMP training into existing employee safety or other general training sessions. An effective training program emphasizes routine employee observations of product deliveries to USTs and frequent inspections of self-serve fueling areas and other customer-related operations. RGOs with maintenance and/or repair facilities should also emphasize routine employee shop inspection to ensure that operations do not adversely impact storm water.

2.2.12 PROVIDING OVERHEAD COVERAGE OF VEHICLE MAINTENANCE AND REPAIR AREAS

Conducting vehicle maintenance and repair activities under canopies or inside buildings is an effective pollution prevention measure. Overhead coverage includes use of temporary roofs, permanent roofs, sheds, or indoor facilities. Overhead coverage prevents direct storm water contact with the maintenance area, which can potentially contribute automotive waste fluids to the storm water runoff.

2.2.13 PREVENTING DISCHARGES WHEN CHANGING FLUIDS

Preventing spills and other discharges in exposed maintenance and repair areas is an effective storm water BMP. A drip pan can be placed under a vehicle while disconnecting hoses, unscrewing filters, or removing other parts to capture the automotive fluids. However, if fluids are leaked onto exposed surfaces, proper spill response procedures should be performed, as described in Section 2.2.9 of this report.

2.2.14 USING PARTS CLEANING STATIONS

Using a self-contained parts cleaning station can prevent parts cleaning wash-off from contacting storm water. Parts cleaning wash-off can contain cleaning solvents, along with oil residues from the parts. Drip pans, drain boards, and drying racks can be installed as part of the cleaning station for drainage of parts cleaning wash-off into appropriate recycling or disposal equipment.

2.2.15 COLLECTING AND STORING FILTERS, WASTE OIL, AND OTHER FLUIDS

Proper collection and storage of oil filters, waste oil, and other fluids such as transmission fluid, degreasers, antifreeze, hydraulic fluid, and various cleaning solvents is an effective BMP. In addition, recycling these materials can significantly reduce the disposal costs associated with hazardous wastes. Many commercial recycling facilities pick up the wastes on site, but typically accept only separated wastes. Unseparated wastes are harder to recycle, and therefore, increase overall treatment costs. Used oil filters and fluids should be stored in covered drums. If the drums are stored in exposed areas, the drum exterior should be routinely checked for contaminants and wiped clean, if necessary.

2.3 Storm Water Treatment BMPs

In the event that the practical pollution prevention measures described above are determined to be insufficient, or in areas where additional controls are mandated, it may be necessary to install storm water treatment devices. Descriptions of the available treatment methods for RGO storm water runoff are provided in the following subsections. A summary of these treatment BMPs are included in Table 5. The BMPs described below are limited to those that can be used in urban areas where almost 100 percent of the surface is covered with structures or pavements, and where there is insufficient space available for relatively large structural storm water quality management facilities such as extended dry detention or wet ponds. The information presented is based on a review of published and unpublished studies, discussions with researchers with studies in progress, review of literature provided by manufacturers, and discussions with personnel from numerous regulatory agencies. The descriptions provide the approximate initial installation and yearly maintenance costs. Specific design information is not included in this report; however, references that provide sufficient design level information are cited and a list of useful references is attached to this report.

2.3.1 VEGETATIVE BUFFER AREAS

2.3.1.1 BMP Description

A vegetative buffer area (VBA), also referred to as a biofilter, is a nonstructural BMP designed to remove particulate pollutants by filtration through grass and infiltration through soil. According to U.S. EPA (1991), a VBA is designed as a permanent, maintained strip of planted or indigenous vegetation located between non-point sources of pollution and receiving water bodies to remove or mitigate the effects of non-point source pollutants such as nutrients, pesticides, sediments, and suspended solids. VBAs that are used as storm water conveyance systems usually are called grass swales. A schematic of a typical grass swale is presented as Figure 2.

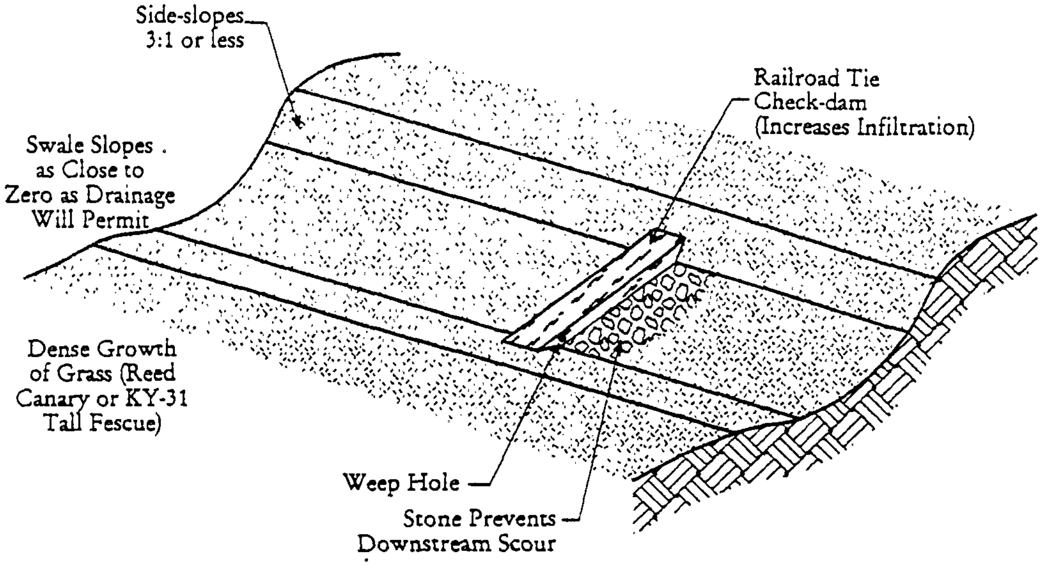

Figure 2 - Schematic of a Typical Grass Swale (MWCOG, 1987)

2.3.1.2 BMP Discussion

The vegetation in a VBA acts to filter and settle out particulate sediment and attached pollutants. The reduction in runoff velocity within the vegetated areas enhances the amount of settling and infiltration that occurs. Nutrient uptake, adsorption, and infiltration mechanisms may decrease the pollutant load entering the natural waterways. The reduced runoff velocity also lessens the potential for resuspension of particles as the flow travels toward the waterway (NVPDC, 1992). Results of modeling studies indicate that VBAs are somewhat effective in removing particulates, although settling is not optimized. VBAs are less effective in removing soluble nutrients (MWCOG, 1987).

Several methods have been proposed to size VBAs (Horner, 1988; FHWA, 1989; IEP, 1991; Tollner, et al., 1976). Using the method of Horner (1988) and assuming a 2-year event, a 3% slope, and a 4-inch grass height, the VBA area required to treat a 1/2 acre impervious site ranges between 400 and 650 square feet (Camp Dresser & McKee et. al., 1993). Typical design lengths for grass swales range from 100 to 200 feet (Horner, 1988). Studies have shown that swales are most effectively used on sites with a minimal amount of impervious cover, where peak discharge is less than 5 cubic feet per second (cfs) and velocities are less than 5 feet per second (fps). For these reasons, VBAs may not be a practical on-site BMP for RGOs.

Because VBAs rely on infiltration, fuel leaks or spills may potentially contaminate subsurface soils and, in some cases, groundwater. Even if discharges from leaks and spills can be avoided, metals and other contaminants may accumulate in the subsoils. As with the other infiltration BMPs, there may be waste discharge permitting requirements for VBAs (Camp Dresser & McKee et. al., 1993).

2.3.1.3 Range of Costs

According to MWCOG (1992), construction costs for a typical grass swale may range from $5 to $15 per linear foot, depending on the swale dimensions, grass type, and other possible characteristics. Maintenance costs for swales are estimated to be fairly low. Typical maintenance includes replacement of non-vegetated areas, periodic sediment removal, routine inspections, mowing, watering, and chemical applications.

2.3.2 POROUS PAVEMENT

2.3.2.1 BMP Description

Porous pavements use infiltration to control storm water runoff. This BMP is applicable as a substitute for conventional asphalt pavement on parking areas and low-traffic-volume roads, provided that the grades, subsoil characteristics, and groundwater table conditions are suitable for such use. In general, the grades should be very gentle to flat, the subsoil should have at least moderate permeability ($f \geq 0.27$ in/hr), and the depth to groundwater should be 2 to 4 feet (State of Maryland Department of the Environment). As indicated on Figure 3, porous pavements usually are layered systems, consisting of a porous asphalt surface overlying two layers of aggregate base course. The upper base course layer is designed as a filter layer, and the lower layer serves as a reservoir. A typical porous pavement asphaltic concrete mixture has approximately 16 percent voids, as opposed to conventional asphaltic concrete, which has 3 to 5 percent voids (NVPDC, 1992). The design of the actual porous pavement system is a function of several factors, including the load-bearing capacity of the subgrade, the expected traffic volume, and the storage capacity of the reservoir course layer. In turn, the storage capacity of the reservoir course layer is designed with respect to the depth to bedrock and the high water table, design storm, design method, allowable detention time, and existing subsurface soil infiltration rates. For sites with relatively pervious subgrade conditions, a porous pavement may allow infiltration of approximately 60 to 90 percent of the storm water runoff, depending on the rainfall intensity, existing subsurface conditions, and the actual design method used (MWCOG, 1987).

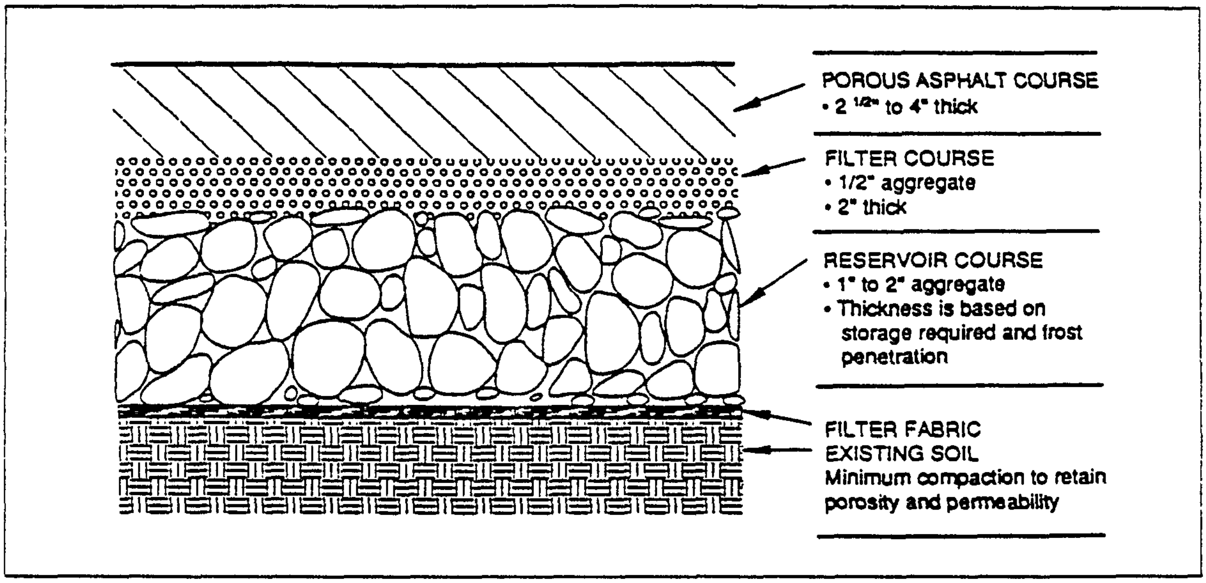

Figure 3 - Schematic of a Typical Porous Pavement (NVPDC, 1992)

2.3.2.2 BMP Discussion

Porous pavements may be an effective storm water BMP for some applications, however, because porous pavements are designed to allow rapid infiltration of storm water into subsurface soils, there is a significant potential for fuel leaks or spills to contaminate subsurface soils and, in some cases, groundwater. Also, depending on the types and concentrations of contaminants in the storm water discharge, metals and other contaminants may potentially accumulate in the subsoils. For these reasons, the use of porous pavements at RGOs is discouraged. Other problems associated with porous pavements are the high probability of pavement pore clogging from larger sized particulates and the absence of effective techniques to mitigate significant clogging that may occur. According to MWCOG (1992), 75 percent of all porous pavement systems surveyed in Maryland have partially or totally clogged within five years. For this reason, pretreatment of storm water to remove particulates often is recommended. Other disadvantages of porous pavements include the high level of required construction workmanship, the reduced strength of the pavement system, and the necessity of frequent inspections and maintenance after construction. Also, waste discharge permits may be required for infiltration BMPs, including porous pavements (Camp Dresser & McKee et. al., 1993).

2.3.2.3 Range of Costs

In general, a porous asphalt system may cost as much as 50 percent more than a conventional asphalt section and the necessary materials may be difficult to obtain in some regions of the country. An average additional construction cost over conventional asphaltic pavement was calculated by MWCOG (1987) for a 1-acre porous pavement BMP parking lot, using an 18-inch-thick reservoir course. The calculated construction cost was $75,054 greater than the cost of a conventional pavement section. This estimate did not include costs for initial site testing or pretreatment structures. Routine maintenance of porous pavements may constitute one to two percent of the initial construction costs (MWCOG, 1992).

2.3.3 INFILTRATION TRENCHES

2.3.3.1 BMP Description

An infiltration trench is a shallow excavation filled with a coarse stone medium to create an underground reservoir. The infiltration trench is designed to collect, store, and slowly exfiltrate storm runoff, relying on native subsurface biological, chemical, and physical pollutant removal mechanisms for treatment. A schematic of a typical infiltration trench is presented as Figure 4. The depth of the trench typically ranges from 2 to 10 feet, and the stone medium typically consists of washed aggregate with diameters of 1.5 to 3 inches (State of Maryland Department of the Environment). Infiltration trenches are only suitable for sites with relatively permeable subsurface conditions. It usually is recommended that an infiltration trench be installed at sites in conjunction with a pretreatment device (such as a filter strip, sump basin, or oil/grit separator) to remove particulate matter.

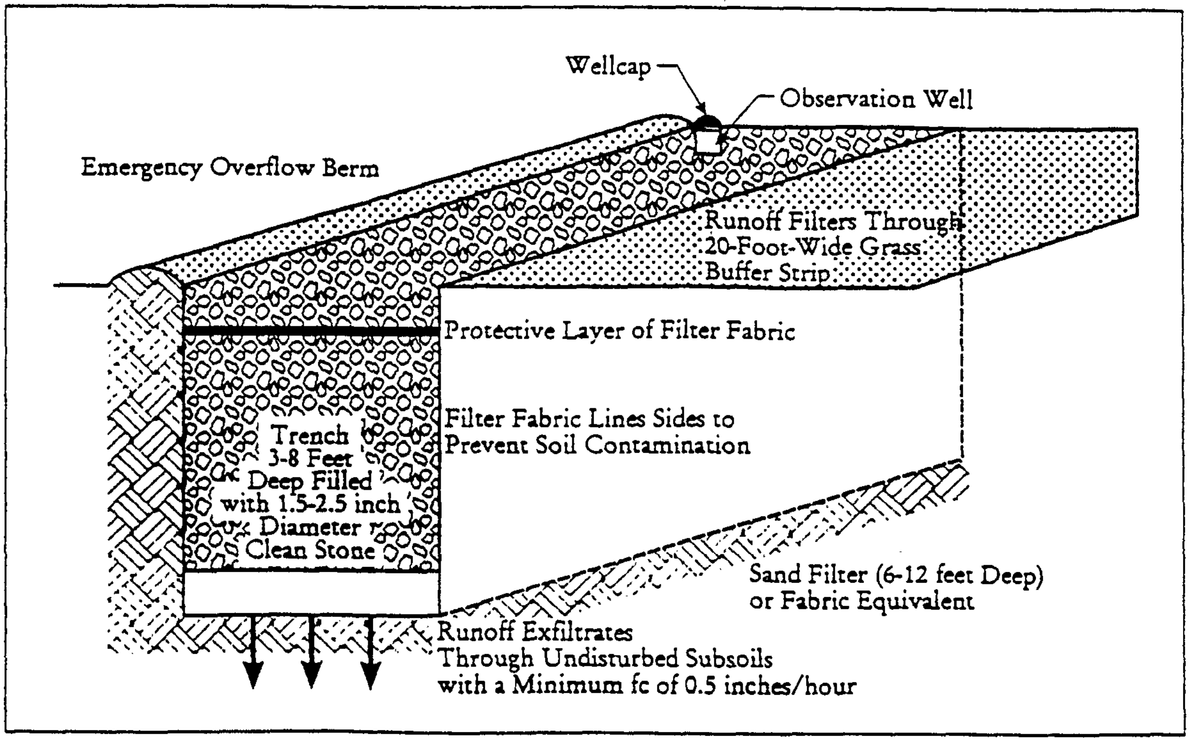

Figure 4 - Schematic of a Typical Infiltration Trench (MWCOG, 1987)

2.3.3.2 BMP Discussion

Where conditions are suitable, an infiltration trench is an adaptable BMP that effectively eliminates discharges containing soluble and particulate pollutants. However, as with other infiltration systems, trenches are not intended to trap coarse sediments and pretreatment is often necessary.

As with porous pavements, infiltration trenches are designed to allow rapid infiltration of storm water into subsurface soils. For this reason, there is a potential for fuel leaks or spills to contaminate subsurface soils and, in some cases, groundwater. RGOs that use infiltration trenches should be provided with a drainage sump equipped with a shut-off valve that can contain spills prior to discharge into the infiltration trench. In addition, depending on the types and concentrations of contaminants in the storm water discharge, metals and other contaminants may accumulate in the subsoils. There may also be waste discharge permitting requirements associated with use of infiltration trenches (Camp Dresser & McKee et. al., 1993).

Several studies of existing infiltration trenches have revealed high failure rates. A study by Galli (1992) indicated that less than half of the nearly 50 infiltration trenches surveyed were working as designed. Another study indicated that less than one-third still functioned after five years (Schueler, 1994). Failure of infiltration trenches usually is the result of clogging, which can be caused by a variety of factors, including inadequate pretreatment devices and/or an unsatisfactory subsurface location (including poor soil infiltration rates and close proximities to bedrock and/or water table).

2.3.3.3 Range of Costs

The construction cost of infiltration trenches is dependent on the excavation, stone fill, filter cloth, and inlet and outlet pipe costs. Construction costs of trenches with storage volumes ranging from 100 to 10,000 cubic feet range from $1,000 to $10,000 (Wiegand et. al., 1986). Operation and maintenance costs for infiltration trenches range from 5 to 15 percent of the capital cost of the facility, with an average cost of 9 percent (NVPDC, 1992). Also, possible replacement or rehabilitation of infiltration trenches may be required every ten years, and the cost of this may be equal to the initial construction cost (MWCOG, 1992).

2.3.4 SEPARATORS

2.3.4.1 BMP Description

The terms oil/grit separator, oil/water separator, oil and grease trap, and water quality inlet are often used interchangeably to describe treatment devices commonly installed to remove separate-phase hydrocarbons and, in some cases, sediment from storm water runoff. These devices are adaptations of the American Petroleum Institute (API) separator. A schematic of a separator is presented as Figure 5. The separator usually is a long basin with multiple chambers or vaults, typically installed below grade. The devices can be fairly easily fitted into an existing drainage system. The separator is designed to slow water flow which promotes settling of particulates and stratifies the flow to enhance phase separation. In this manner, the heavier particulates settle out, and the oil and grease rise for removal and disposal.

Another type of separator, called the coalescing plate interceptor (CPI) separator has a more advanced design. The CPI separator contains closely spaced plates, which enhance removal efficiencies. These are common for treating oil-bearing industrial wastewater, but, because they are typically designed to treat low flow rates with relatively high concentrations of oil, they are not typically used for treating storm water. A CPI separator generally achieves a greater removal efficiency than an API-type separator, but is more costly to purchase and operate.

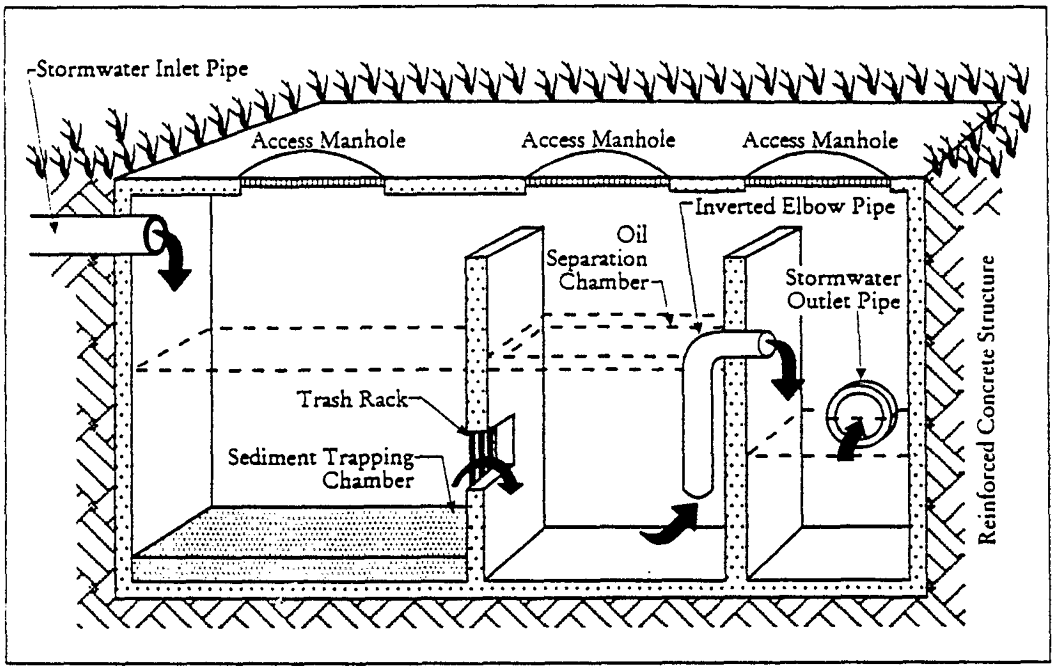

Figure 5 - Schematic of a Typical Oil/Grit Separator (NVPDC, 1992)

2.3.4.2 BMP Discussion

Although separators are commonly used, and are required in certain municipalities, recent research suggests that they are not appropriate as a storm water BMP. Separators are fairly costly to install and maintain, and most designs do not operate effectively with the low oil and grease concentrations typically found in properly operated and maintained RGOs. These devices are moderately effective for removing coarse-grained particulates along with hydrocarbons adsorbed onto particulates, but are typically not effective for removing fine-grained particulates or dissolved contaminants (NVPDC, 1992; MWCOG, 1987).

One significant problem with the use of separators as a storm water BMP is that the devices are typically designed as on-line systems with limited storage capabilities. This results in short detention times, which can cause significant re-suspension and discharge of pollutants. The

Northern Virginia BMP Handbook (1992) states that the average detention time of a conventional oil/grease separator system is barely more than one hour. Galli (1992) also demonstrated that the detention time within separators frequently is less than 30 minutes during storms. According to the California BMP Manual (Camp Dresser & McKee et. al., 1993), to provide the detention times necessary to effectively treat the majority of runoff resulting from a moderate storm event at a 1/2 acre paved site, a separator 57 feet long is required.

Alternative system designs treat the runoff only from the first approximate 0.06 to 0.12 inch of runoff and bypass the remainder for direct discharge. Although this methodology is somewhat effective in reducing the re-suspension of pollutants, it is ineffective for treating the volume of storm water customarily recommended or required. In Virginia, the Water Quality Volume (WQV), which is the minimum quantity of storm water that must be treated, is 0.5 inch. To store and effectively treat the volume of storm water that would result from this amount of rainfall, the separators would have to be significantly larger than those currently used at most sites.

In addition to alternative designs that bypass peak storm water discharges, several vendors currently offer innovative alternate designs that appear to significantly reduce the potential for re-suspension. However, these devices still rely on phase separation for removal of oil and grease, and have not been demonstrated effective for reducing the relatively low oil and grease concentrations typical of RGOs.

Maintenance is another factor that should be considered when evaluating separators. To function as designed, these devices require regular and frequent clean-out of trapped sediments to minimize re-suspension. The standing pool of water contained within the first chamber, along with the floating oil, must be periodically pumped out and replaced with clean water. Some commercial oil recyclers may accept this material for recycling; otherwise, it must be handled as hazardous waste. The maintenance requirements for separators have been termed the "Achilles heel" of existing separator technology. One study conducted in Maryland (Schueler, 1993) found not a single separator system out of more than 100 inspected that had ever been maintained. According to Schueler (1994), this poor track record is the result of several factors, including: a lack of outside companies that perform the required maintenance; a lack of enforcement by regulators; the expense associated with maintenance; and the actual or perceived toxicity of the trapped sediments, resulting in limited options for safe and economical sediment disposal.

2.3.4.3 Range of Costs

The purchase and installation costs for a standard API-type system ranges from approximately $5,000 to $15,000 depending on the size and location of the facility (NVPDC, 1992). In general, separator systems are costly on a runoff volume treated basis, averaging three to four times the unit cost of other BMPs such as trenches or sand filters (MWCOG, 1992). Maintenance costs are estimated to range from $1,000 to $2,000 per site each year (Schueler, 1994).

2.3.5 SAND FILTERS

2.3.5.1 BMP Description

Sand filters are a type of structural BMP that relies on sedimentation and sand filtration to remove total suspended solids, hydrocarbons, and heavy metals. Sand filter technology is rapidly advancing, and a number of sand filter designs are currently available. A schematic of one design, the D.C. Sand Filter, is presented as Figure 6. The D.C. Sand Filter is a three-chamber gravity-flow system. The first chamber and a portion of the second chamber contain a permanent pool, which traps grit and floating material, including oil and grease. The remaining portion of the second chamber contains a 24-inch-thick sand filter underlain by a layer of filter fabric, gravel, and collector pipes. Storm water entering the structure causes the pool to rise and overflow onto the filter. The water percolates through the sand and into the underdrain system. The water then enters a clearwell and is discharged through a connector pipe. Depending on the depth of the sand filter installation and the elevation of the street, storm drain, or other conveyance, it may be necessary to use a sump pump to discharge the treated storm water.

The D.C. Sand Filter is designed as an off-line system that treats only the initial discharge or water quality volume (WQV) from a storm event. The WQV typically used is the volume of runoff from the first 0.5 inch of rainfall. For a 1/2-acre, entirely impervious RGO, the WQV is approximately 900 cubic feet of water. A flow splitter is normally used to divert the remainder of the discharge for direct discharge. The WQV must be stored until it can be processed through the sand filter. To store and treat this volume of storm water, the underground vault needs to be 10 feet deep, 10 feet wide, and 23.5 feet long (City of Alexandria).

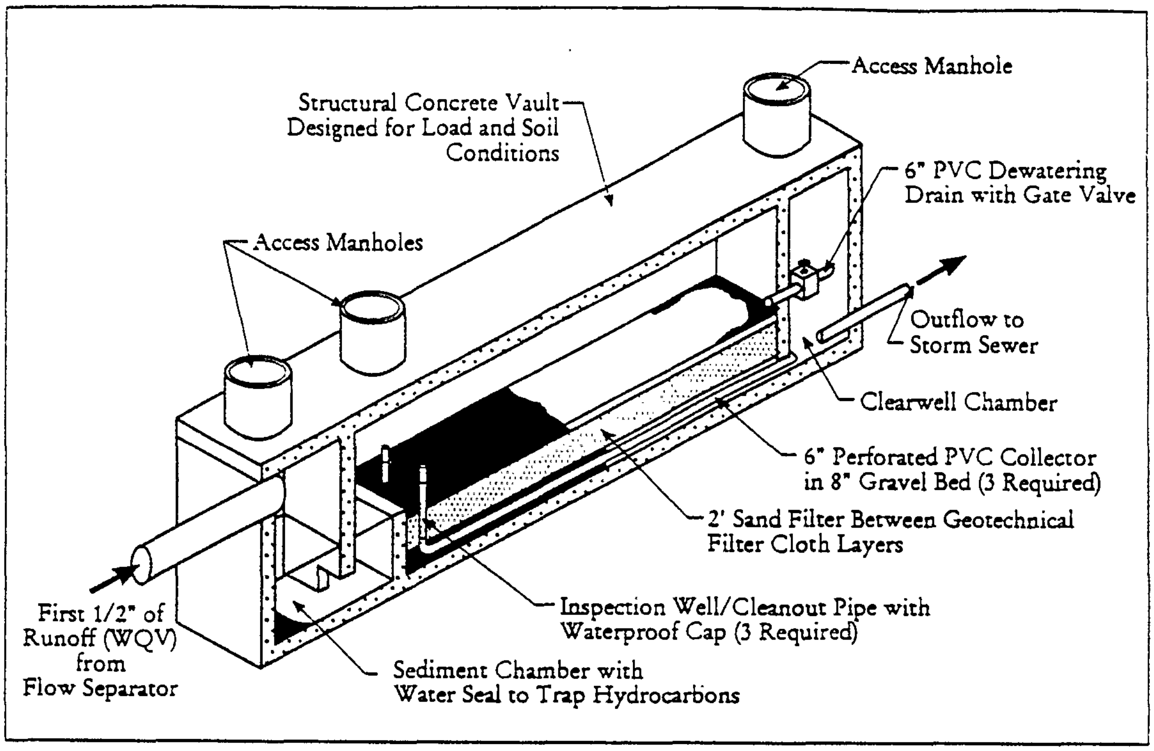

Figure 6 - Schematic of a D.C. Sand Filter (City of Alexandria, 1995)

A schematic of another type of sand filter, the Delaware Sand Filter, is presented as Figure 7. This filter consists of two parallel chambers connected by closely spaced notches in the top of the connecting wall. The filter is normally installed in-line. The first chamber is a sedimentation chamber with a permanent pool. Storm water flows into the first chamber through steel grates that cover the top of the chamber. As storm water enters the system, the permanent pool overflows through the weir notches into the second chamber, which contains an 18-inch-thick sand filter. The storm water percolates through the filter and is discharged through a filter fabric-covered grate located at the downhill end of the filter chamber. In some cases, a gravel bed and collector pipe are placed below the sand filter. The Delaware Sand Filter is designed to accept discharge until it has reached the capacity of the sedimentation chamber. The remaining storm water volume overflows and is discharged without treatment.

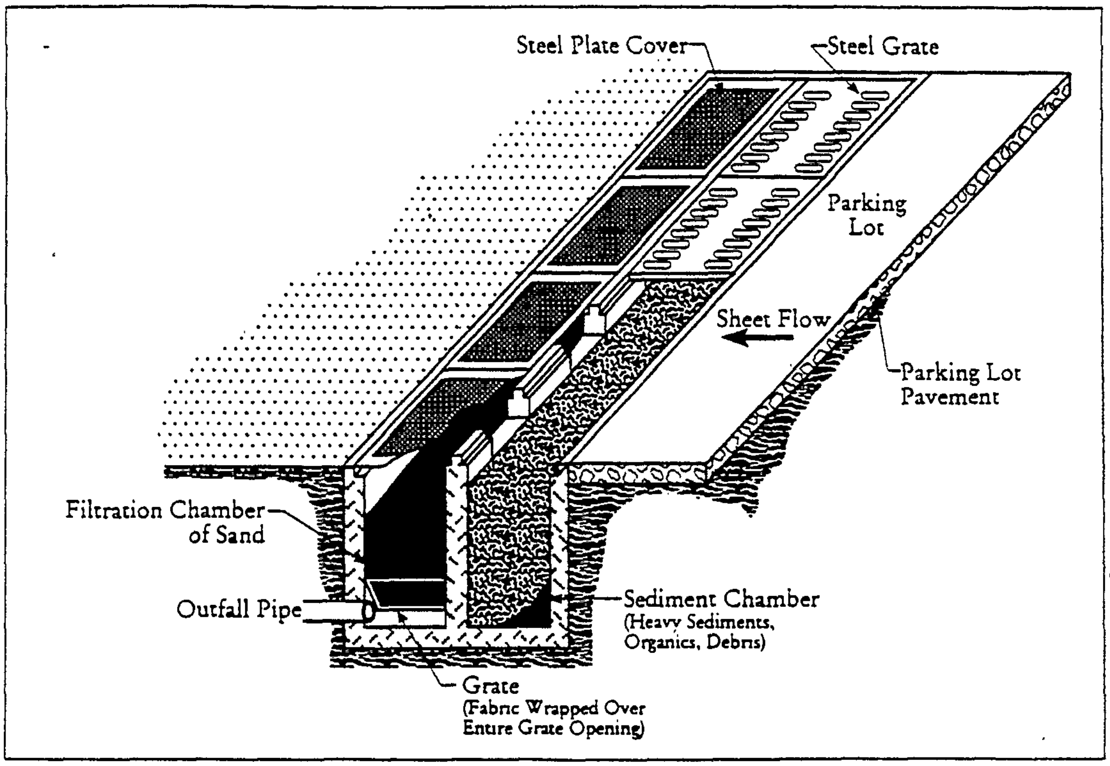

Figure 7 - Schematic of a Delaware Sand Filter (Bell & Nguyen, 1995)

2.3.5.2 BMP Discussion

Several studies have evaluated the performance of sand filters for treating storm water (City of Austin, 1991; Bell & Nguyen, 1995; Horner, 1994). The results of these studies indicate that sand filters are effective in removing particulate pollutants such as total suspended solids, lead, zinc, organic carbon, and organic nitrogen, with removal efficiencies generally exceeding 75 percent. These studies have not provided information regarding capabilities for removing dissolved metals. In some cases this could be significant, because dissolved metals are more mobile and toxic than particulate metals. The studies do indicate that sand filters can discharge nitrate and total dissolved solids, resulting in effluent concentrations of these constituents that are actually higher than influent concentrations. The net increase in nitrate concentrations suggests that nitrification may be occurring in the filter media. The net increase in total dissolved solids concentrations has been attributed to preferential leaching of cations from organic matter trapped on the surface of the sand (Schueler, 1994).

Sand filters appear to be prone to clogging, particularly in areas where high concentrations of suspended solids are present in storm water. Clogging problems are greatly reduced in areas that are completely impervious. The sedimentation chambers are also prone to freezing when used in colder climates. One significant concern with vault filters, such as the D.C. Sand Filter, is the buildup of potentially explosive gases within the vault and the determination that the vault is considered a "confined space," requiring special health and safety procedures for entry.

Routine maintenance is a fundamental requirement for the proper functioning of sand filters. In general, maintenance operations for sand filters include periodic excavation and replacement of the top layer filter media, regular removal of trash and other larger-sized debris, and routine visual inspections of the overall filter unit, particularly after storm events. Specific recommended maintenance for D.C. Sand Filter units include semi-annual pumping and refilling of the first chamber permanent pool, and replacement of the top two to three inches of sand or overlaying layers of geotechnical cloth every three to five years (Bell & Nguyen, 1995). The disposal of used sand filter media can be an additional maintenance burden if it is classified as a hazardous waste material.

2.3.5.3 Range of Costs

Construction costs for sand filters range from approximately $10,000 to $20,000 per impervious acre treated (Schueler, 1994). Maintenance costs for sand filters have been estimated to be approximately 5 percent of the construction cost per year (MWCOG, 1992), with the required maintenance operations including raking, disposal of contaminated sand, and trash and debris removal.

2.3.6 COMPOST FILTERS

2.3.6.1 BMP Description

Compost filters are similar to sand filters, except they use compost instead of sand for the filter media. Filtration through compost provides filtration, ion exchange, molecular adsorption, and biodegradation for pollutant removal. Currently, leaf compost is the most widely used compost media in storm water compost filters. A suitable compost has maturity, low contaminant levels, and high humic acid content and permeability (Schueler, 1994). Filtration through compost is a patented process. The patent holder, CSF Treatment Systems, has developed a drop-in compost storm water filter unit that is sized for small impervious sites such as RGOs. A schematic of a drop-in unit is presented in Figure 8. The drop-in unit is a three-chamber system. The first chamber collects and disperses the flow over the filter media. The second chamber contains an energy dissipator, a scum baffle, the compost filter media, and an overflow route. As storm water enters the second chamber, the design flow is filtered through the media, collected by a perforated underdrain system, and then discharged through a connector pipe. If the design storm is exceeded, overflow into the third chamber will occur and storm water will be discharged without treatment. Depending on the depth of the compost filter installation and the elevation of the street, storm drain or other conveyance, it may be necessary to use a sump pump to discharge the treated or bypassed storm water.

The drop-in unit is an in-line storm water treatment structure. It is typically installed below grade and its pre-cast concrete vaults range from a 6-foot by 12-foot to an 8-foot by 18-foot configuration. These vaults can be connected in series or parallel, depending on the design flow rate. Single drop-in units are rated to treat storm water discharges between 0.28 and 0.64 cubic feet per second. The drop-in filter is sized to handle a maximum of 2.5 gallons per minute per square foot of filter surface area (CSF, 1995).

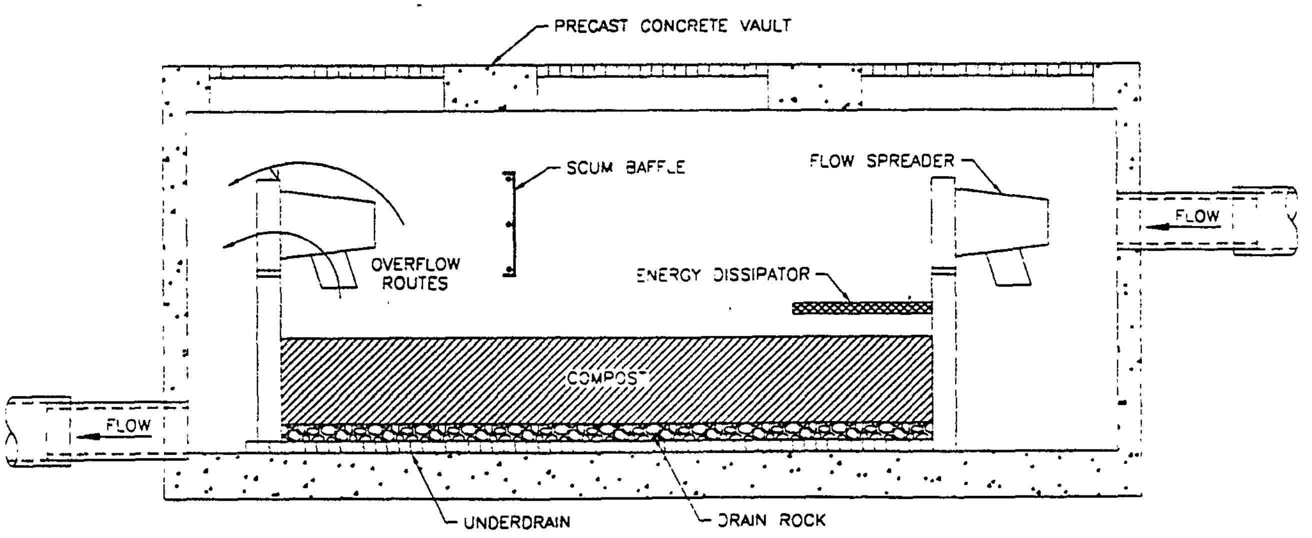

Figure 8 - Schematic of a Drop-In Compost Filter Unit (CSF, 1995)

2.3.6.2 BMP Discussion

A limited number of compost filters have been installed to date, and there is limited independent data regarding the actual performance. Based on results provided by the manufacturer, the drop-in CSF unit averages approximately 90 percent removal for total suspended solids, and ranges from 85 to 95 percent metals removal. The drop-in unit has also shown high efficiencies in removal of hydrocarbons and oil and grease at the low concentrations (5 to 10 ppm) typical of RGO operations. Average removal rates for hydrocarbons and oil and grease at these concentrations are approximately 80 percent. The Snohomish County (Washington) Surface Water Management Agency, which considers the compost filter to be an experimental BMP, has recently installed two compost filters. The performance of these filters will be monitored over the next wet season.

Some deficiencies of the compost filter system include the potential for a net increase in the concentrations of certain pollutants, including orthophosphorous, organic nitrogen, and total dissolved solids, in the compost filter discharge. The increase in orthophosphorous concentrations may be due to the inability of compost to perform anion exchange of soluble phosphorous, and the increase in organic nitrogen may suggest the occurrence of nitrification within the filter media. The increase in total dissolved solids may be explained through possible cation leaching processes within the compost filter media.

2.3.6.3 Range of Costs

In the northwest, initial costs for drop-in units designed for small sites such as RGOs range between $17,000 and $25,000 (CFS, 1995). For drop-in units, the manufacturer recommends that the compost media be replaced annually. The cost of this maintenance procedure should range from $800 to $1,200 per year (CFS, 1995). According to information provided by the manufacturer, the used compost can be directly landfilled as a non-hazardous waste.

2.3.7 CATCH BASIN INSERTS

2.3.7.1 BMP Description

Catch basin inserts are filtering devices that can be inserted into existing catch basins. Catch basin insert types include felt bags, tray(s), or "lobster trap" filters. A tray configuration is presented as Figure 9. Catch basin inserts are designed to remove suspended solids, trace metals, and hydrocarbons through mechanical straining, particle settling, and physical adsorption processes.

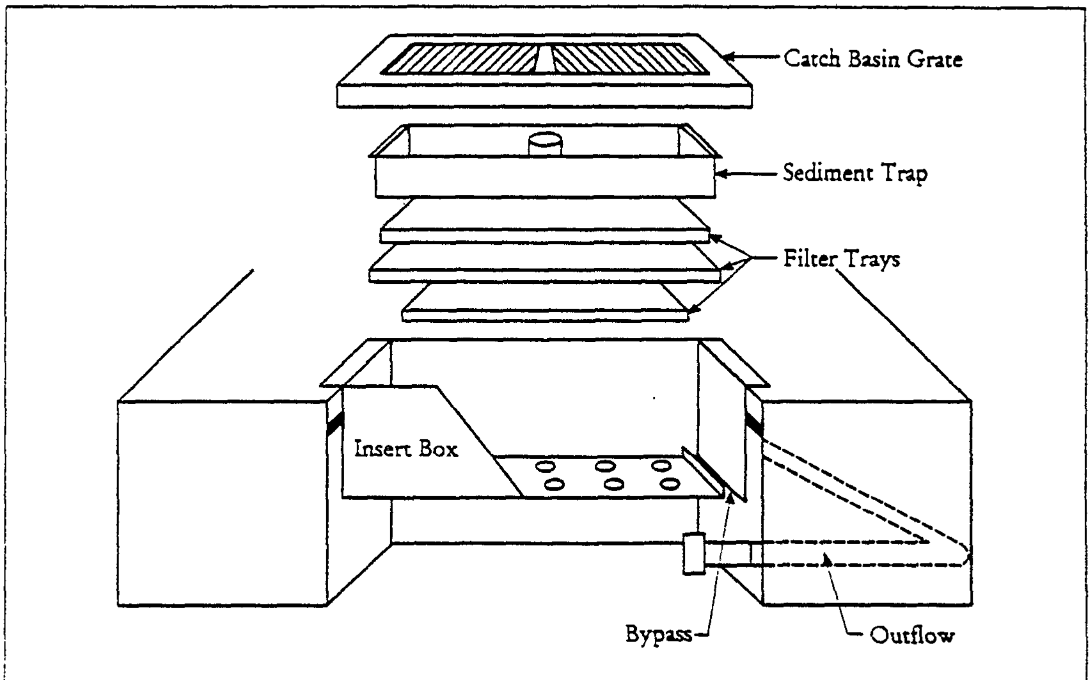

Figure 9 - Schematic of a Catch Basin Insert Tray (McPherson, 1992)

2.3.7.2 BMP Discussion

Results of one study on filter inserts indicates that filter inserts are nominally effective in removing fine sediment and associated pollutants and somewhat more effective in removing coarse material and debris (Interagency Catch Basin Insert Committee, 1995). There is little information regarding the effectiveness for hydrocarbons at the low inflow concentrations typical of properly operated and maintained RGOs. The available data does suggest, however, that removal efficiencies for hydrocarbons are low at low inflow concentrations and somewhat higher for high inflow concentrations. Clogging appears to be a potential problem with filter inserts, even on sites that are completely paved. In addition, preliminary indications are that the filters may require frequent replacement or cleaning.

2.3.7.3 Range of Costs

One vendor listed initial costs ranging from $1,600 to $3,200 for a three-tray filter with a flow rate capacity of 180 gpm. Annual maintenance costs for this three-tray system ranged from $6 to $520, depending on the frequency of maintenance and the respective filter media used. Disposal costs also need to be considered, and can vary considerably depending upon the classification of the used filter material waste.

SECTION 3.0 -- CONCLUSIONS

Based on the results of several storm water studies, it appears that the contaminant levels in storm water runoff from properly operated and maintained RGOs are not appreciably different from those of many other similar sources, such as parking lots and streets. In most cases, the mean concentrations of oil and grease, total suspended solids, and chemical oxygen demand in storm water runoff from RGOs are below the NPDES storm water permit limitations set by several states for vehicle-related activities.

Properly operated and maintained RGOs may currently be implementing a variety of BMPs to reduce storm water contaminant concentrations. Two basic categories of BMPs are presented in this paper. The first category consists of practical pollution prevention measures. These are the basic, common operational practices and relatively simple facility modifications that are effective in preventing storm water pollution. The second category consists of storm water treatment BMPs. These include structural controls that involve installation of equipment to reduce contaminant concentrations in storm water runoff.

Practical pollution prevention measures are appropriate for RGOs because they are simple, cost effective, and protective of storm water quality. In contrast, the storm water treatment BMPs are less appropriate for RGOs because they are ineffective or unproven for treatment of low contaminant concentrations and are relatively expensive to install and maintain.

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Table 1
Summary of Results from WSPA/API Study
(WSPA/API, 1994)

Constituent (units)	RGOs (Pump Islands and Driveways Combined)			Parking Lots (All Use Areas Combined)		
	Number of Samples	Mean	Median	Number of Samples	Mean	Median
Oil & Grease (mg/l)	12	7.1	1	8	5.2	4.6
Total Suspended Solids (mg/l)	12	11.5	10	8	61.7	69.5
Copper (µg/l)	2	20	20	8	20.3	21
Lead (µg/l)	2	7.5	7.5	8	9.75	9.5
Zinc (µg/l)	2	170	170	8	192	190
Cadmium (µg/l)	2	ND	ND	8	ND	ND

Table 2
Summary of Mean Concentrations from Discrete Land Use Type Study
(Shepp, 1995)

Constituent (units)	Parking Lot (All Day Parking)	RGO	Street	Commercial Parking Lot (Short-Term Parking)
Oil and Grease (mg/l)	0.9	3.7	2.2	12.4
Total Suspended Solids (mg/l)	26.8	41.3	93.3	42.9
Chemical Oxygen Demand (mg/l)	22.1	57.1	60.8	69.1
Total Organic Carbon (mg/l)	13.1	12.2	17.1	41.3
Copper (µg/l)	7.5	9	18.2	21.2
Lead (µg/l)	5.3	17.8	59.1	10.9
Zinc (µg/l)	107.8	204.3	199.6	451.6

Table 3
Summary of Results from Action Plan Demonstration Project
(Uribe, 1994)

Constituent (units)	Pre-BMP Monitoring (18 Storm Events)		Post-BMP Monitoring (18 Storm Events)	
	Mean	Median	Mean	Median
Oil & Grease (mg/l)	4.61	2.35	9.22	6.45
Total Suspended Solids (mg/l)	59.33	41	81.5	50
Copper (µg/l)	25.22	20	70.63	16
Lead (µg/l)	33.4	26	71.61	21
Zinc (µg/l)	379.4	195	349.33	285
Cadmium (µg/l)	0.66	0.54	0.84	0.57
Chromium (µg/l)	4.16	3.5	3.52	3.2

Table 4
Comparison of RGO Results with Typical Permit Limitations and NURP

Constituent (units)	Results from RGO Studies			Typical Permit Limitations and Results from NURP				
	WSPA/API Study (mean of all results)	Discrete Land Use Study (mean of all results)	Action Plan Demonstration Project (mean of pre-BMP results)	MO NPDES Permit[1] (daily max/ monthly avg)	AL NPDES Permit [2] (daily max/ monthly avg)	OR NPDES Permit[3] (daily max)	Louisiana Storm Water Quality Standard (daily max)	NURP - Residential/ Commercial Land Use[4]
Oil and Grease (mg/l)	7.1	3.7	4.61	15/10	15/10	10	15[5]	--
Total Suspended Solids (mg/l)	11.5	41.3	59.33	100/50	50/30	--	--	239
COD (mg/l)	--	57.1	--	--	--	--	100[6]	94
Lead (μg/l)	7.5	17 8	26	--	--	--	--	238
Copper (μg/l)	20	9	20	--	--	--	--	53
Zinc (μg/l)	170	204.3	195	--	--	--	--	353

Notes:

1. Draft NPDES permit by the State of Missouri Department of Natural Resources for firms engaged in motor freight transportation and warehousing (permit no. MO-S240000).
2. Draft NPDES permits by Alabama Department of Environmental Management for storm water discharges associated with vehicle and equipment storage, maintenance, repair, and washing (permit no. ALG140000).
3. Final NPDES permit issued by the State of Oregon, Department of Environmental Quality for transportation facilities classified as SIC codes 40, 41, 42 (except 4221-4225), 43, 44, 45, and 5171 (permit no. 1200-T).
4. Results of the National Urban Runoff Program, US EPA, 1983.
5. Standard applies to all storm water discharges (LAC 33:IV.708).
6. Ore Mining and dressing (40 CFR Part 440, Subpart C).

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Table 5
Summary of Storm Water BMPs

BMP	Description	BMP Considerations	Approximate Range of Costs[1]	Suitability for RGOs[2]
Using Spill Containment & Overfill Prevention Equipment	Prevents spills caused by overfilling USTs.	Federally required by 1998, already required in some areas.	Initial costs - high O&M costs - moderate	Suitable for RGOs.
Posting Signs Warning Against "Topping Off"	Minimizes spill occurrences by reminding employees and customers not to top off tanks.	None	Initial costs - low O&M costs - low	Suitable for RGOs.
Installing dispenser "hold open" latches	Minimizes spill occurrences by automating fuel dispensing.	Prevents use of fixed objects such as gas caps, wallets, pieces of wood, etc. to keep dispenser latches open. Can increase potential for spills caused by customer drive-offs unless used in conjunction with break away hoses. May not be allowed by local fire departments.	Initial costs - low to moderate O&M costs - low	Suitable of RGOs.
Providing Canopies and Use of Concrete for Fueling Areas	Canopies over fueling areas can minimize contact of storm water with potential pollutants. Portland Cement Concrete pavements are less prone to soak up fuel than asphaltic concrete.	Canopies also shield customers from sun and rain.	Initial costs - high O&M costs - low to moderate	Suitable for RGOs.
Avoiding Storm Water Runon	Reduces contact of storm water with fueling and maintenance areas.	Should be considered in the initial design of an RGO. Difficult to retrofit in most cases.	Initial costs - low (Initial costs for retrofit can be high) O&M costs - low	Suitable for RGOs.
Maintaining Existing Oil & Grease Separators and other treatment BMPs	The pollutant removal capabilities of oil & grease separators and other treatment BMPs can be maximized by conducting regular sediment cleanout.	Disposal of sediments removed must be properly managed.	Initial costs - N/A O&M costs - low to moderate	Suitable for RGOs with existing structural BMPs.

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Table 5 (Continued)
Summary of Storm Water BMPs

BMP	Description	BMP Considerations	Approximate Range of Costs[1]	Suitability for RGOs[2]
Avoiding RGO Wash Downs	Discharges from RGO wash downs may violate local municipal ordinances and may introduce pollutants to the storm drain system.	Discharges to the sanitary sewer from RGO wash downs may require permits.	Initial costs - low O&M costs - low	Suitable for RGOs.
Sweeping Exposed Areas	Removes particulates thereby reducing the concentrations in storm water runoff.	BMP also enhances RGO appearance.	Initial costs - low O&M costs - low to moderate	Suitable for RGOs.
Eliminating Non-Storm Water Discharges and Illicit Connections	Can eliminate potentially significant sources of storm water pollution.	Discharges from floor drains or other sources to the sanitary sewer may require permits.	Initial costs - low to moderate O&M costs - low	Suitable for RGOs.
Standardizing Spill Response Plans	Eliminates a potential source of storm water pollution by ensuring that spills are promptly detected, contained as necessary, and properly cleaned up.	Employees should be trained to properly implement the spill response plan.	Initial costs - low O&M costs - low	Suitable for RGOs.
Training Employees	Ensures that inspections and spill response procedures are properly conducted by employees.	Training program should emphasize routine inspections and standardized spill response procedures.	Initial costs - low O&M costs - low	Suitable for RGOs.
Providing Overhead Coverage of Vehicle Maintenance and Repair Areas	Prevents direct storm water contact with potential storm water pollution sources.	None	Initial costs - low to high O&M costs - low to moderate	Suitable for RGOs.
Preventing Discharges When Changing Fluids	Eliminates a potential source of storm water pollution.	Recycling fluids when possible can reduce disposal costs.	Initial costs - low O&M costs - low	Suitable for RGOs.

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Table 5 (Continued)
Summary of Storm Water BMPs

BMP	Description	BMP Considerations	Approximate Range of Costs[1]	Suitability for RGOs[2]
Using Parts Cleaning Stations	Prevents parts cleaning wash-off from contacting storm water.	Recycling fluids when possible can reduce disposal costs.	Initial costs - low to moderate O&M costs - moderate	Suitable for RGOs.
Collection and Storage of Oil Filters, Waste Oil, and Other Fluids	Minimizes contact of storm water with potential pollutants.	Used oil filters and automotive fluids should be stored in covered drums. The exterior of drums stored in exposed areas should be wiped clean on a routine basis.	Initial costs - low O&M costs - low	Suitable for RGOs.
Catch Basin Inserts	Filters storm water using devices that are inserted into existing catch basins.	Filter inserts appear to be nominally effective in removing fine sediment and associated pollutants and somewhat more effective in removing coarse material and debris. There is little information regarding the effectiveness for hydrocarbons at the low inflow concentrations typical of properly operated and maintained RGOs. The available data does suggest, however, that removal efficiencies for hydrocarbons are low at low inflow concentrations and somewhat higher for high inflow concentrations. Clogging appears to be a potential problem and frequent replacement may be necessary.	Initial costs - low to high O&M costs - low to high	May prove to be suitable for RGOs, but additional study is necessary to confirm effectiveness with low hydrocarbon inflow concentrations. Use may not be warranted where practical pollution prevention measures effectively control pollutants.
Sand Filters	Relies on sedimentation and filtration through sand to remove total suspended solids, hydrocarbons, and heavy metals.	Effective for removing particulate pollutants. Limited data regarding effectiveness for removing dissolved pollutants. May cause an increase in concentrations of nitrates and total dissolved solids.	Initial costs - high O&M costs - moderate	May be suitable for RGOs but may not be warranted where practical pollution prevention measures effectively control pollutants.

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Table 5 (Continued)
Summary of Storm Water BMPs

BMP	Description	BMP Considerations	Approximate Range of Costs[1]	Suitability for RGOs[2]
Compost Filters	Relies on sedimentation and filtration through compost to remove total suspended solids, hydrocarbons, and heavy metals.	Still considered to be an experimental BMP by many regulators and there is limited independent data regarding pollutant removal capabilities. Results provided by the manufacturer indicate a 90 percent removal for total suspended solids, 80 percent removal for hydrocarbons, and 85 to 95 percent removal for metals. The net export of orthophorous, organic nitrogen, and total dissolved solids may be problematic.	Initial costs - high O&M costs - moderate to high	May prove to be suitable for RGOs but additional independent study is necessary to confirm effectiveness. Use may not be warranted where practical pollution prevention measures effectively control pollutants.
Vegetative Buffer Areas	Removes particulate pollutants by filtration through grass and infiltration through soil.	Requires a fairly large surface area which may be problematic for highly urbanized areas and retrofits. Studies have indicated that vegetative buffer areas are somewhat effective for removing particulates and less effective in removing soluble nutrients. Because vegetative buffer areas rely on infiltration, there is a potential to contaminate subsurface soil and, in some cases, groundwater.	Initial costs - moderate to high O&M costs - low to moderate	Not suitable for most RGOs as detailed in BMP considerations.
Infiltration Trenches	Collects, stores, and slowly exfiltrates storm water runoff into subsoils.	For sites with permeable subsoils, an infiltration trench can effectively eliminate storm water discharges containing soluble and particulate pollutants. However, use at RGOs is problematic because of the significant potential for fuel leaks or spills to contaminate subsurface soils and, in some cases, groundwater. Studies have indicated high failure rates caused by clogging.	Initial costs - moderate to high O&M costs - moderate to high	Not suitable for most RGOs as detailed in BMP considerations.

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Table 5 (Continued)
Summary of Storm Water BMPs

BMP	Description	BMP Considerations	Approximate Range of Costs[1]	Suitability for RGOs[2]
Porous Pavement	Specially designed pavements allow infiltration of approximately 60 to 90 percent of the storm water runoff.	Use is limited to sites with relatively pervious subgrade conditions. Use at RGOs is problematic because of the significant potential for fuel leaks or spills to contaminate subsurface soils and groundwater. Studies also indicate a significant problem with clogging.	Initial costs - high O&M costs - moderate to high	Not Suitable for RGOs.
Separators	Designed to slow water flow which promotes settling of particulates and stratifies flow to enhance phase separation.	Most designs do not operate effectively with the low oil and grease concentrations typical of properly operated and maintained RGOs. Limited ability to remove fine-grained particulates and trace metals. On-line systems with insufficient detention times may cause re-suspension of pollutants.	Initial costs - high O&M - moderate	Not suitable for RGOs.

[1] Basis for cost estimates: Initial costs, Low: < $999, Moderate: $1000 to $5,000, High: $5000+; Operation and maintenance costs; Low: < $499 per year, Moderate: $500 to $999 per year, High: $1000+ per year

[2] Suitability determination based ability of BMP to effectively reduce concentrations of contaminants in storm water discharges from properly operated and maintained RGOs.

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ACTION PLAN DEMONSTRATION PROJECT

DEMONSTRATION OF GASOLINE FUELING STATION BEST MANAGEMENT PRACTICES

Submitted to
U.S. Environmental
Protection Agency
Region IX,
San Francisco
Estuary Project

Prepared for
County of Sacramento
Water Resources Division

Prepared by
Uribe & Associates
Larry Walker Associates

FINAL REPORT
OCTOBER 1994

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Funding for this project was provided by a grant from the U. S. Environmental Protection Agency through the San Francisco Estuary Project, with additional funding from the Sacramento County Water Resources Division.

Executive Summary

This report summarizes the findings of the Demonstration of Gasoline Fueling Station Best Management Practices project. The project is an "Action Plan Demonstration Project" (APDP) funded in part by a grant awarded by the U. S. Environmental Protection Agency (U.S. EPA) through the San Francisco Estuary Project to the County of Sacramento (County). The purposes of the study were to characterize storm water runoff from gasoline fueling stations, demonstrate the effectiveness of pollution prevention technologies or best management practices (BMPs) in reducing pollutant loadings from gasoline fueling station runoff, and to disseminate information on effectiveness and costs to a wide audience.

The basic project design involved a two year study in which:

- during the first wet season (1992/93), samples of sheet flow runoff from three gas stations were collected prior to BMP implementation and analyzed in the laboratory for a variety of pollutants (Phase 1);
- best management practices were developed and implemented during the following dry season (Phase 1); and
- the following wet season (1993/94), after BMP implementation, runoff samples were collected and analyzed for the purpose of comparing pre-BMP data to post-BMP data for a quantitative evaluation of BMP effectiveness (Phase 2).

The growing body of published studies and storm water monitoring data continues to indicate that vehicles are one of the most significant sources of storm water pollutants and that areas where service of vehicles is conducted may be of particular concern. Fueling station discharges may be regulated in the future, so cost-effective BMPs will be very important not only in pollution reduction, but regulatory compliance as well.

The initial work on Phase 1 included the selection of three representative gasoline fueling stations whose owners/operators were willing to participate in the BMP demonstration program. Runoff samples from six storms were collected at each of the three stations during the 1992/93 wet season. Multiple samples were collected manually from sheet flow to represent a flow-weighted composite sample of approximately the first 0.30 inch of rainfall. Climatological data were also compiled

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throughout the first wet season to aid in interpreting the storm water runoff results. The major classes of constituents analyzed in Phase 1 were:

Oil & Grease,
Total suspended solids,
Heavy metals (thirteen priority pollutant metals, aluminum, and iron),
Polycyclic aromatic hydrocarbons, and
Petroleum hydrocarbons.

After the first three storms, constituents not found in detectable concentrations or those found significantly below levels of concern were no longer included in the analyses, thereby allowing the analyses to focus on indicator pollutants. These pollutants were present in relatively high concentrations and were thought to be representative of the other pollutants on-site. The following pollutants were selected as indicators:

Oil & Grease,
Total suspended solids, and
Heavy metals (cadmium, chromium, copper, lead, and zinc)

Runoff water quality data from the first wet season of this study appeared comparable to results from recent related studies. Regressions of the pre-BMP data versus four rainfall parameters were performed: rainfall intensity during the period of sampling, cumulative precipitation to date, days since last storm of 0.10 inch or greater, and days since last storm of 0.25 inch or greater. This was done for each station individually and for the pooled data set. Overall, the regressions of pre-BMP runoff concentrations versus rainfall parameters showed the most consistent relationship to be between log concentration and days since last storm >0.25 inch, particularly for zinc. This result indicated that pollutant buildup occurs during dry periods, and runoff concentrations reflect the length of the buildup period.

The selection process for best management practices included all the potential BMPs applicable to the stations given the physical limitations of the sites. Off-site BMPs (e.g., detention pond, wetlands) were not considered because the scope and budget did not allow for these to be tested. Best management practices were selected using a semi-quantitative scoring method based on cost and perceived effectiveness in reducing pollutants. A suite of BMPs was selected to implement at each station that focuses on the areas with the greatest potential to generate pollutants (e.g., air/water supply area, fueling area, drive through area) as opposed to areas with less pollution potential (e.g., roof drains).

The following BMPs were selected for implementation at each station:

- Mobile Cleaning,
- Litter Control,
- Public Notices,
- Storm Drain Stenciling,
- Spill Cleanup Materials, and
- Employee Training.

The selected BMPs were implemented in the summer of 1993. Post-BMP runoff samples from the 1993-94 wet season were collected and analyzed to compare pre-BMP data to post-BMP data for a quantitative evaluation of BMP effectiveness.

Based on observations by project personnel and best professional judgment about the efficacy of source controls, it is highly likely that of the six BMPs implemented at the gas stations, the one BMP with the most significant chance to affect runoff quality was mobile high pressure water cleaning. The combined effect of the other five source controls was not likely to have a significant impact on the sources of pollution at the stations, namely, high volume vehicle traffic and leaks and spills of vehicle fluids. Consequently, the study can be considered in large part a pilot test of mobile cleaning as a best management practice.

When all the data from the pre-BMP condition is combined and compared against all the post-BMP condition data, the only statistically significant difference in the pre- to post-BMP concentrations was for oil and grease, and it was higher after the BMPs were implemented. For the event mass loading comparisons, no statistically significant differences were found between the pre- and post-BMP data. This indicates that, generally speaking, gas station runoff quality was not significantly different before and after implementation of BMPs.

Although visual observations by the field crew confirmed that a significant amount of pollutants were removed with each cleaning, it is likely that the cleanings may have made more pollutants "available" for washoff in the next event, either storm or cleaning, by freeing up pollutants and allowing them to redeposit on the pavement surface. Potential reasons for this observation include:

- High pollutant deposition
- Rough surface texture
- Heavy pollutant buildup
- Incomplete washoff after cleaning

All-in-all, it appears that this pilot test of mobile cleaning asphalt surfaces, at high sales volume gas stations, near busy intersections on major streets, was probably a worst case scenario for this potential best management practice. The cost of mobile cleaning the fueling stations used for this study was estimated to be about $600 per station washdown which is equivalent to $1,300 per acre of paved surface. Therefore, the cost of mobile cleaning a significant amount of the areas in a watershed exposed to vehicle traffic, on a regular basis, would be quite high.

Since the results were inconclusive, this study cannot recommend the implementation of the mobile cleaning BMP on a large scale. However, field observations and study results seem to indicate that, given the right conditions, mobile cleaning may have the potential to remove sources of storm water pollution. It is clear from this study and others that it is not just gas station runoff, but runoff from any area where vehicles travel, park, or are serviced that is of concern. Recommendations are made for further investigation of BMPs for impervious areas exposed to vehicle traffic.

Action Plan Demonstration Project

Demonstration of Gasoline Fueling Station

Best Management Practices

Final Report

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1.0 Introduction

1.1 Purpose and Scope

This report summarizes the findings of the Demonstration of Gasoline Fueling Station Best Management Practices project. The project is an "Action Plan Demonstration Project" (APDP) funded in part by a grant awarded by the U. S. Environmental Protection Agency (U.S. EPA) through the San Francisco Estuary Project to the County of Sacramento (County). The purposes of the study were to characterize storm water runoff from gasoline fueling stations, demonstrate the effectiveness of pollution prevention technologies or best management practices (BMPs) in reducing pollutant loadings from gasoline fueling station runoff, and to disseminate information on effectiveness and costs to a wide audience.

The basic project design involved a two year study in which:

- during the first wet season (1992/93), samples of runoff were collected prior to BMP implementation and analyzed in the laboratory for a variety of pollutants (Phase 1);
- best management practices were developed and implemented during the following dry season (Phase 1); and
- the following wet season (1993/94), after BMP implementation, runoff samples were collected and analyzed for the purpose of comparing pre-BMP data to post-BMP data for a quantitative evaluation of BMP effectiveness (Phase 2).

The scope of study was developed after a review of previous studies of storm water runoff. Information was obtained from a literature review and from discussions with researchers at agencies and in academia. Although no study was found that focused solely on runoff from gasoline fueling stations, several studies provided guidance for sample collection methodology and described pollutants typically found at gas stations.

1.2 Project Strategy

Approach

The project was conducted in two phases. The work in Phase 1 (first wet and dry seasons) consisted of identifying the pollutant loading from three representative gasoline fueling stations by collecting and analyzing runoff samples. Additionally, Phase 1 included selecting and implementing BMPs at the gas stations with the intent of reducing those pollutants found in the runoff water samples.

Specific tasks in Phase 1 included a literature review, gas station selection, sampling design, water quality monitoring and analysis, BMP selection and implementation, and public participation. This phase of the work culminated with the development of a Phase 1 Report (Sacramento County, 1993a) summarizing the completed tasks and associated findings.

The work in Phase 2 (second wet season) consisted of determining the effectiveness of the implemented BMPs in reducing pollutant loading by re-sampling the selected gas stations after BMP implementation and analyzing the results. The Phase 2 work culminates with the development of this comprehensive final report summarizing all the completed tasks, associated findings, results, and cost estimates to implement the BMPs on a basinwide scale.

Applied Science

As the term "Action Plan Demonstration Project" implies, this study was conducted as an applied science project, as opposed to a basic research project. This is an important distinction to make, because it influenced the project study design. The primary goal of this project was to demonstrate the effectiveness of BMPs in reducing storm water pollutants generated at gas stations. The most critical factor in demonstrating BMP effectiveness is the need to establish a sufficient database to show statistically significant differences between the pre- and post-control measure implementation. Without this, any conclusions will be judged and received with some hesitation. Such a database is difficult to develop because of the variability among storms (quantity, duration, intensity, etc.) and the variability among sites (runoff characteristics, activities located on-site, etc.).

The ability to discern statistically significant differences between two data sets hinges not only on the variability within each of the two data sets, but also on the number of data points in each set. When data variability is likely to be high, as in this case, it is necessary to have either correspondingly large data sets or a relatively large difference in their average values to demonstrate a statistically significant difference. The project team therefore advocated an approach that emphasized maximum production of useful data.

In practical terms, this approach meant the collection and analysis of samples from the maximum number of storms in each of the two wet seasons. To accomplish this within the available budget, it was necessary to focus the analyses on indicator pollutants. These pollutants were known or expected to be present in relatively high concentrations, and to be representative of the other pollutants on-site. By focusing on a subset of the expected pollutants, money was spent where it could produce the most useful data. As discussed more specifically in section 4, Monitoring, the selection of indicator pollutants was based on both the literature review and the sample results from the first three storms.

Another way to maximize the statistical validity of pre- and post-BMP comparisons is to maximize the difference in the pre- and post-BMP data. To effect this, the project team implemented a full suite of BMPs at each station, as opposed to implementing one BMP at each station. The presumption was that the combined effect of the suite of best management practices would increase the likelihood of reducing pollutants, thereby producing more statistically significant results.

Characterization of gas station runoff was also a goal of the project. Given the applied science emphasis and practical constraints on project funding, a detailed, comprehensive characterization of all possible constituents in gas station runoff was not feasible. The runoff characterization therefore also focused on a limited list of key constituents.

2.0 Background

This section describes the scientific and regulatory background to the project.

2.1 Literature Review

The objective of the literature review was to collect, compile, and review the existing information on toxic pollutant loads associated with storm water runoff from gas stations. This information was used to support subsequent project tasks. Two independent approaches were used to conduct the review: on-line database searching on DIALOG to find published information, and telephone contacts to find any additional published information. The on-line database search showed that very little had been published on the topic of storm water runoff from service stations. The most closely related studies were conducted in Europe, but most of these efforts studied wastewater, and none focused strictly on storm water. However, valuable information was obtained through discussions with researchers (Sacramento County, 1992a).

2.2 Regulatory Impetus

As a result of published studies and monitoring data from municipalities, there is growing support for regulation of fueling station discharges, both sanitary as well as storm water. The growing body of storm water monitoring data continues to indicate that vehicles are one of the most significant sources of storm water pollutants and that areas where service of vehicles is conducted may be of particular concern. In fact, several agencies, including the City of Palo Alto Regional Water Quality Control Plant (RWQCP) and the County of Orange Environmental Management Agency, have recently passed new ordinances that regulate discharges from vehicle service facilities, including fueling stations (Palo Alto RWQCP, 1993; County of Orange, 1993). These agencies require the implementation of BMPs such as secondary containment, spill controls, and employee training, to comply with their ordinances.

At the national level, bills drafted to reauthorize the Clean Water Act are focusing on vehicle service facility discharges, particularly storm water runoff. In addition, U.S. EPA has been developing options for Phase II of the federal storm water regulations, that generally include increased regulation of vehicle service facilities, including fueling stations. The overall impression from this evidence is that fueling station discharges will be regulated, and so cost-effective BMPs will be very important in not just pollution reduction, but regulatory compliance as well.

3.0 *Monitoring Plan*

This section describes issues related to the constituents that were analyzed, the quality assurance and quality control aspects of the study design, and the sampling site selection process, including gasoline fueling station selection and sampling point determination. In addition, the sampling program design is provided, including weather monitoring, storm selection, sample collection, and sample handling procedures.

3.1 Constituents

The identification of constituents to analyze focused on the constituents generally thought to be present at fueling stations. Information on the likely pollutants from vehicles and vehicle traffic were obtained from a number of sources (Shaheen, 1975; Federal Highway Administration, 1984; City of Puyallup, 1988; Pitt and Field, 1990; Sacramento County, 1992b; Washington Department of Ecology, 1992; Wisconsin Department of Natural Resources, 1992). Based on a review of these studies, the major classes of constituents analyzed in the pre-BMP phase were:

- Oil & Grease,
- Total suspended solids,
- Heavy metals,
- Polycyclic aromatic hydrocarbons, and
- Petroleum hydrocarbons.

For each constituent analyzed (see Table 3.1), the EPA test method, detection limit, sample type, sample bottle, maximum holding times, and preservative are listed. Samples were not filtered before analysis.

Based on the results from the first three storms of Phase 1, constituents not found in detectable concentrations or those found significantly below levels of concern were no longer included in the analyses after the third storm, thereby allowing the analyses to focus on pollutants regularly found in significant concentrations (i.e., indicators). This action was consistent with the project's applied science approach (see section 1, Introduction).

TABLE 3.1 - CONSTITUENTS ANALYZED							
EPA Test Method	Constituent	Event[1]	Detection Limit	Sample Type[2]	Sample Bottle[3]	Maximum Hold Time	Preservative
413.2	Oil & Grease	x	0.5 mg/l	C	B	28 days	Cool, 4°C, H_2SO_4 to pH < 2
160.2	Total Suspended Solids	x	3 mg/l	C	B	7 days	Cool, 4° C
200	Priority Metals (13)			C	B	6 months	HNO_3 to pH < 2
204.2	Antimony	x	1 ug/l				
206.2	Arsenic	x	4 ug/l				
200.7	Beryllium	x	10 ug/l				
213.2	Cadmium	x	0.1 ug/l				
218.2	Chromium	x	1 ug/l				
220.2	Copper	x(D)[5]	1 ug/l				
239.2	Lead	x(D)	1 ug/l				
245.2	Mercury	x	0.2 ug/l			28 days	
249.2	Nickel	x	1 ug/l				
270.3	Selenium	x	1 ug/l				
272.2	Silver	x	1 ug/l				
279.2	Thallium	x	1 ug/l				
289.1	Zinc	x(D)	1 ug/l				
200.7	Aluminum	x(D)	50 ug/l	C	B	6 months	HNO_3 to pH < 2
200.7	Iron	x(D)	30 ug/l				
610/8310	PAHs (16)			C	B	7/40[4]	Cool, 4°C
	Acenapthene	x	1.6 ug/l				
	Acenapthylene	x	1.6 ug/l				
	Anthracene	x	0.5 ug/l				
	Benzo (a) anthracene	x	0.2 ug/l				
	Benzo (a) pyrene	x	0.3 ug/l				
	Benzo (b) fluoranthene	x	0.3 ug/l				
	Benzo (g,h,i) perylene	x	0.4 ug/l				
	Benzo (k) fluoranthene	x	0.3 ug/l				
	Chrysene	x	0.15 ug/l				
	Dibenzo (a,h)anthracene	x	0.9 ug/l				
	Fluoranthene	x	0.9 ug/l				
	Fluorene	x	0.4 ug/l				
	Indeno (1,2,3-cd) pyrene	x	0.2 ug/l				
	Naphthalene	x	1.6 ug/l				
	Phenanthrene	x	0.15 ug/l				
	Pyrene	x	0.9 ug/l				
8015 Modified	Petroleum Hydrocarbons			C	B	14 days	Cool, 4°C
	Gas	x	0.5 mg/l				
	Diesel	x	0.5 mg/l				

1 Event = storms events sampled
2 C = composite
3 B = borosilicate
4 7/40 = 7 days for extraction and 40 days for analysis
5 (D) = Analyzed for dissolved concentration for one storm event each season.

The following pollutants were selected as indicators and were analyzed in samples from all twelve storms (6 pre- and 6 post-BMP):

- Oil & Grease;
- Total suspended solids; and
- Heavy metals -
  - Cadmium,
  - Chromium,
  - Copper,
  - Lead, and
  - Zinc.

The same suite of parameters that were analyzed in the environmental samples were also analyzed in the Quality Control (QC) samples (field duplicate, field blank, laboratory duplicate, matrix spike and matrix spike duplicate samples).

3.2 Quality Assurance / Quality Control

A Quality Assurance Project Plan (QAPP) (Sacramento County, 1993b) was prepared for the project using guidance from the *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, (U.S. EPA, 1983). The QAPP presented specific information including data quality objectives, data use objectives, procedures, organization, functional activities, and specific quality assurance (QA) and quality control activities for the project.

QA/QC Sample Collection and Handling

Strict adherence to the sampling protocols described in section 3.4 is the most important QA/QC measure to be followed in the field. Documentation of consistency in sampling and analytical procedures is important for the validation of any sampling effort. As a part of field QA/QC, the chain-of-custody for each sample was strictly maintained. Sampling points for both Field QC samples and Laboratory QC samples were located at the same point that environmental sample collection took place.

Field QC Samples

Two types of field QC samples were used for Phase 1 and 2: field duplicate samples (duplicates) and field bottle blank samples (blanks). The objective of collecting duplicates was to obtain a check on sampling and analytical precision. The objective of collecting blanks was to check for cross-contamination during sample collection, shipment, and laboratory handling.

Field duplicate samples were collected in the field using the same sample collection methodology and sampling procedures as those used for collecting environmental samples. The procedure consisted of filling two 5 liter composite sample bottles, one for the environmental sample and one for the duplicate. Each time a 1 liter aliquot was collected and poured into the first 5 liter composite bottle, a second 1 liter aliquot was collected immediately thereafter and poured into the second 5 liter composite bottle. Both composite bottles remained on ice and were covered with screw-on caps, except during sample introduction. A discussion of sampling procedures is presented in section 3.4.

Blanks were collected concurrently with the environmental samples. Contaminant free water sufficient for the specified QA/QC analyses, a separate 1 liter glass bottle, and a separate 5 liter composite bottle were brought into the field along with the environmental sample containers. Each time a runoff sample was collected at the sampling point, an aliquot of contaminant-free water was poured into the separate 1 liter bottle and then into the separate 5 liter composite bottle. Both 5 liter bottles (environmental and blank composites) remained on ice and were covered with screw-on caps, except during sample introduction.

Both duplicates and blanks were labeled, packaged and sealed in the same manner as the environmental samples. The duplicate and blank samples were submitted blind to the laboratory along with the environmental samples. Because one environmental composite sample from each gas station was collected and delivered to the laboratory for each storm event, the sample was uniquely identified by station name and date. The identity of blank and duplicate samples was disguised.

Laboratory QC Samples

Matrix spike and matrix spike duplicate analyses of field samples were conducted as a quality control check. In addition, laboratory duplicates and method blanks were analyzed as part of the laboratory's routine in-house protocols. A complete discussion of the laboratory QA/QC program is provided in the QAPP (Sacramento County, 1993b).

QA/QC Sample Collection and Analysis Frequency

Due to the unpredictable and uncontrollable nature of storms, the frequency of collecting QA/QC samples deviated from the recommended U.S. EPA (1980) collection frequency for duplicates of "one sample per week or 10% of all field samples, whichever is greater," and for blanks "one blank per day." The collection frequency for this particular project was driven by storm events. Thus, QA/QC samples were collected on an event basis for each storm sampled. One field duplicate and one field blank were collected and analyzed for each event. One matrix spike, one matrix spike duplicate, and one laboratory duplicate was collected and analyzed for each event. QA/QC samples were collected at each of the three gas stations on a rotating basis.

3.3 Sampling Site Selection

The selection of sampling sites was a two step, sequential process. The first step was identifying three gas stations with appropriate characteristics whose owners/operators were willing to participate in the study. After the sites were identified, the actual sampling points were selected.

Station Selection

The goal of the site selection process was to select three representative gasoline fueling stations whose owner/operators were willing to participate in the BMP demonstration program. The following general principles were followed in this process:

- Maximize statistical validity of pre- and post-BMP comparisons.
- Select stations that are representative of those in Sacramento County.
- Select similar sites; minimize variability that may confound pre-and post-BMP comparisons.

As noted above, one of the guiding principles in site selection was to select sites that enhanced the ability to distinguish between pre- and post-BMP implementation. To this end, the project team originally expected to select stations that have automotive service bays. During the course of the site selection process, however, it became apparent that the major oil companies are phasing out the traditional service stations that provide a mix of gasoline sales and automotive repair services, and replacing them with the modern self service/convenience store facility.

The site selection process also strove to identify stations that are representative of gasoline service stations in Sacramento County. Lists of existing retail gasoline operations in Sacramento County were obtained from the records of public agencies during the site selection phase of the project. The major oil companies operating retail gasoline outlets in Sacramento were contacted individually. A meeting of the Western

States Petroleum Association's (WSPA) Environmental Management Subcommittee was attended by a member of the consultant team. From these contacts, information was obtained regarding the types of stations which represent typical gasoline stations currently in operation in Sacramento County. This information was used in the selection of gas station sites.

The typical station is now a self service gasoline retailer with a convenience market and without automobile repair service bays. Furthermore, older stations providing repair services are being renovated and converted to the self service/convenience market type of station. This type of station was therefore selected as most representative of gasoline retail stations in Sacramento County, and the selected gas stations all conform to this set of characteristics.

Given the ongoing changes in the oil industry, it was also considered important to select stations operating under companies that appear to be stable in the Sacramento market, to provide some security that the selected stations would still be in operation at the conclusion of the project. The project team selected one station from each of the three leading gasoline retailers in Sacramento County. This decision increased the representativeness of the program and added credibility to the results.

The three selected stations were located in fairly close geographical proximity to one another (2 miles) (see Figure 3.1), and all receive an average of 19 to 20 inches of annual rainfall. The stations were located in the suburban Citrus Heights / Fair Oaks area of northeastern Sacramento County. The sites are within the Arcade Creek watershed, a 25,000 acre mixed use watershed which drains to the Sacramento River via the Natomas East Main Drainage Canal, and then into the San Francisco Bay Delta/Estuary.

All three stations were high volume gasoline retailers (over 200,000 gallons per month) that emphasized self service gasoline sales. All three stations were situated at busy, signalized intersections along major arterial roadways. Station X was the parent oil company's highest volume retail station in Sacramento County. All three stations had convenience markets; none provided automotive repair services or had automobile service bays. Station Z had a car wash, but most of the runoff from this activity flowed away from the sample collection point. Figures 3.2, 3.3, and 3.4. show the facility layout for each of the three stations.

Besides the representativeness of the selected stations, the other key selection criteria involved the selection of similar stations, to minimize station-to-station variability in the runoff chemistry data and maximize the statistical validity of the pre- and post-BMP comparison. The selected stations had the following characteristics in common:

- Geographic location (similar precipitation and atmospheric deposition)
- Local setting (land uses, traffic patterns)
- Quantity of gasoline sold (high volume sales)
- Station layout and design
- Mix of services (e.g., convenience store)
- Existing BMPs and on-site treatment

Stations also were chosen where samples could be collected effectively, safely, and securely, and where the collected runoff would include only runoff from the gasoline station, uncomplicated by runoff from off-site. Finally, and in practical terms most importantly, stations were selected where the owner/operator has pledged their full cooperation.

Sampling Points

In essentially all cases, collection of storm water runoff that includes only service station runoff requires collection of samples on the service station property. Therefore, oil company approval was required before physical modifications could be made to the site to accommodate sample collection. The WSPA members, representing the three gasoline station retail outlets, agreed to allow these physical modifications to be made.

Statistical techniques were used to determine the number of sampling locations and storm events that should be included in the project, subject to the project's budgetary, logistic, and practical constraints. The statistical methods included an ANOVA model used in conjunction with statistical power analysis, a sampling plan design tool (Cohen, 1988). This analysis concluded that a 50% change in runoff concentrations due to BMP implementation would produce a statistically significant difference in pre- and post-BMP runoff characteristics, assuming three gas stations with one sampling point and six storms each for both the pre- and post-BMP sampling.

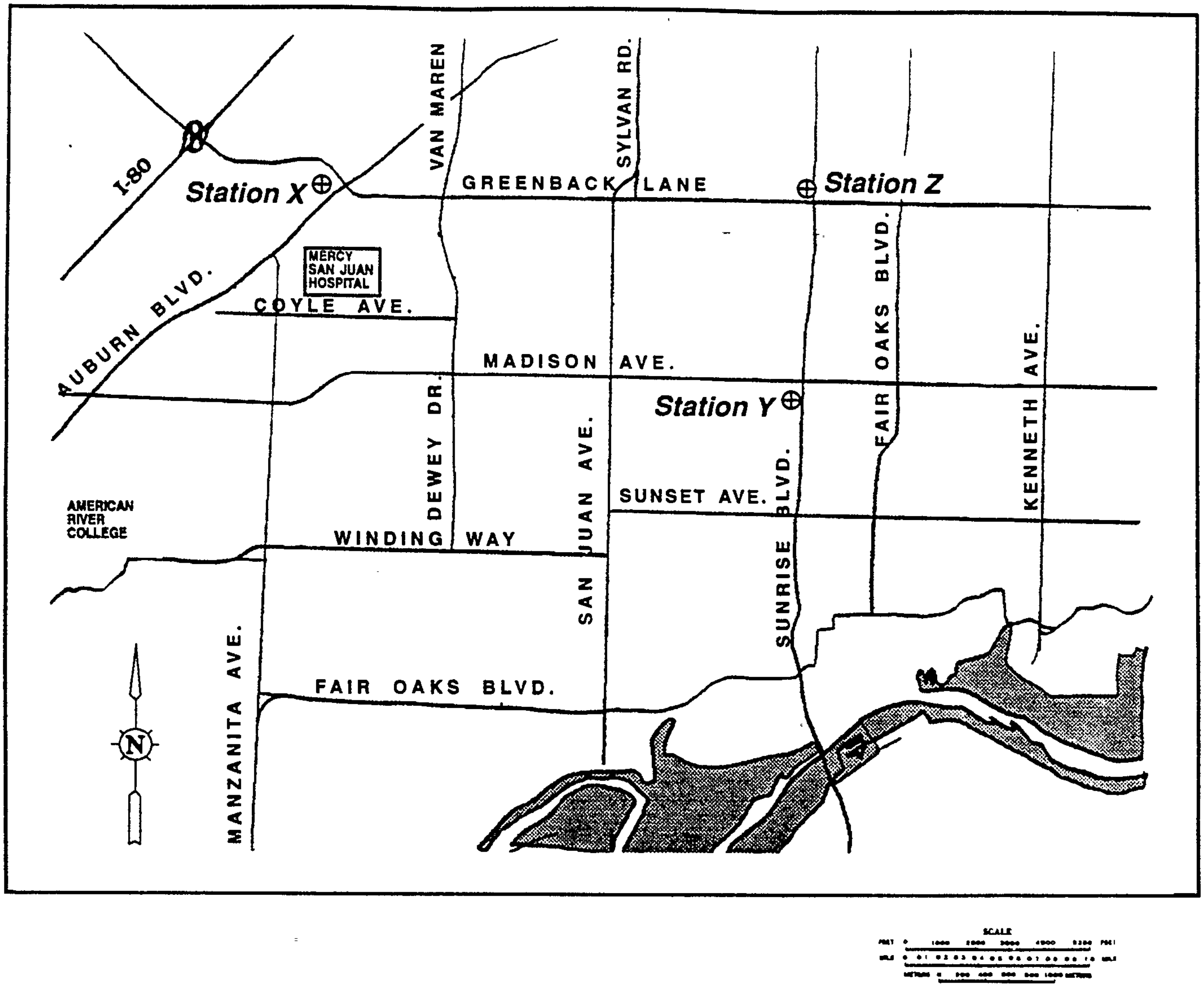

Figure 3.1

GASOLINE FUELING STATIONS

Vicinity Map

Figure 3.2

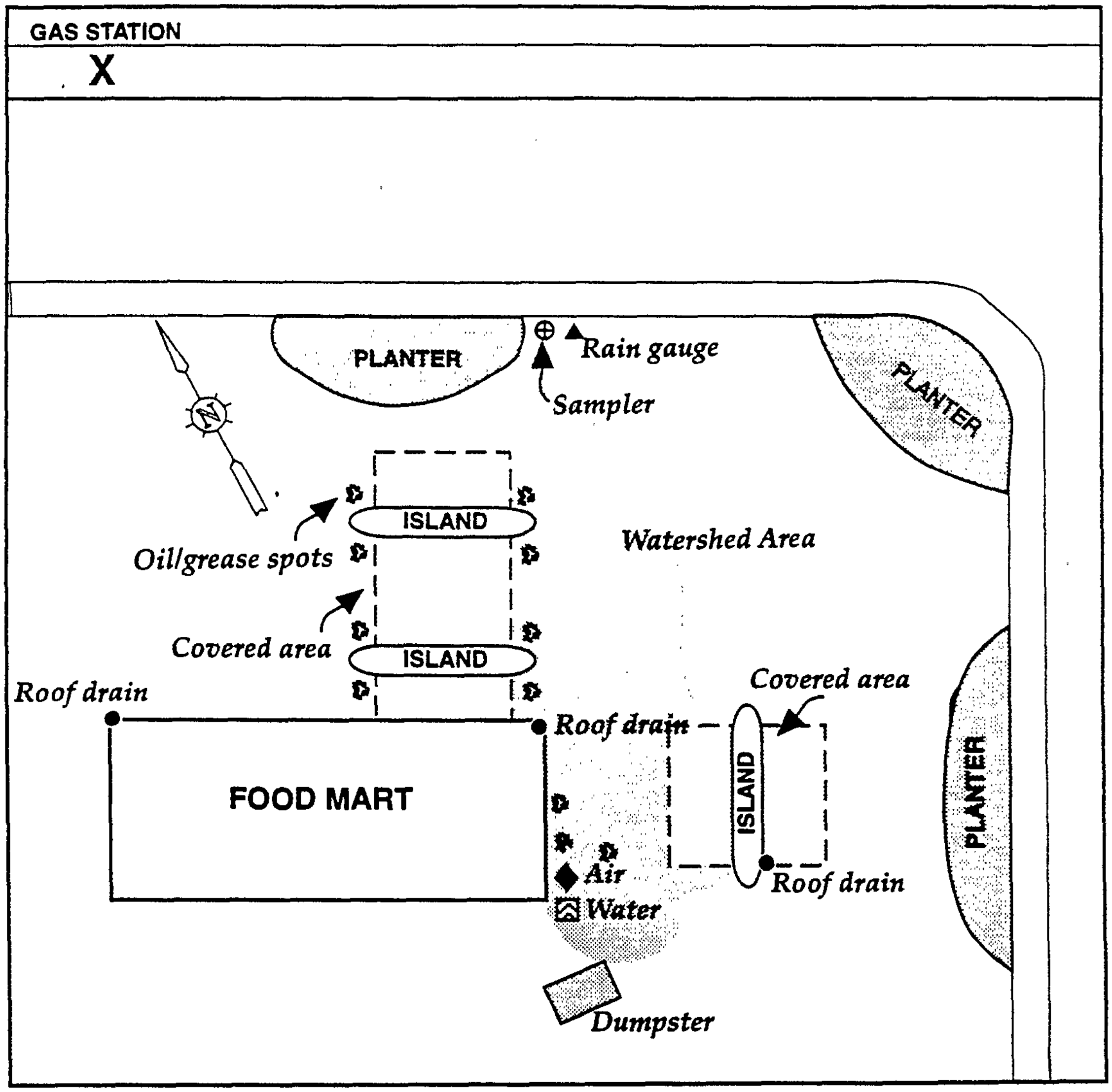

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Figure 3.3

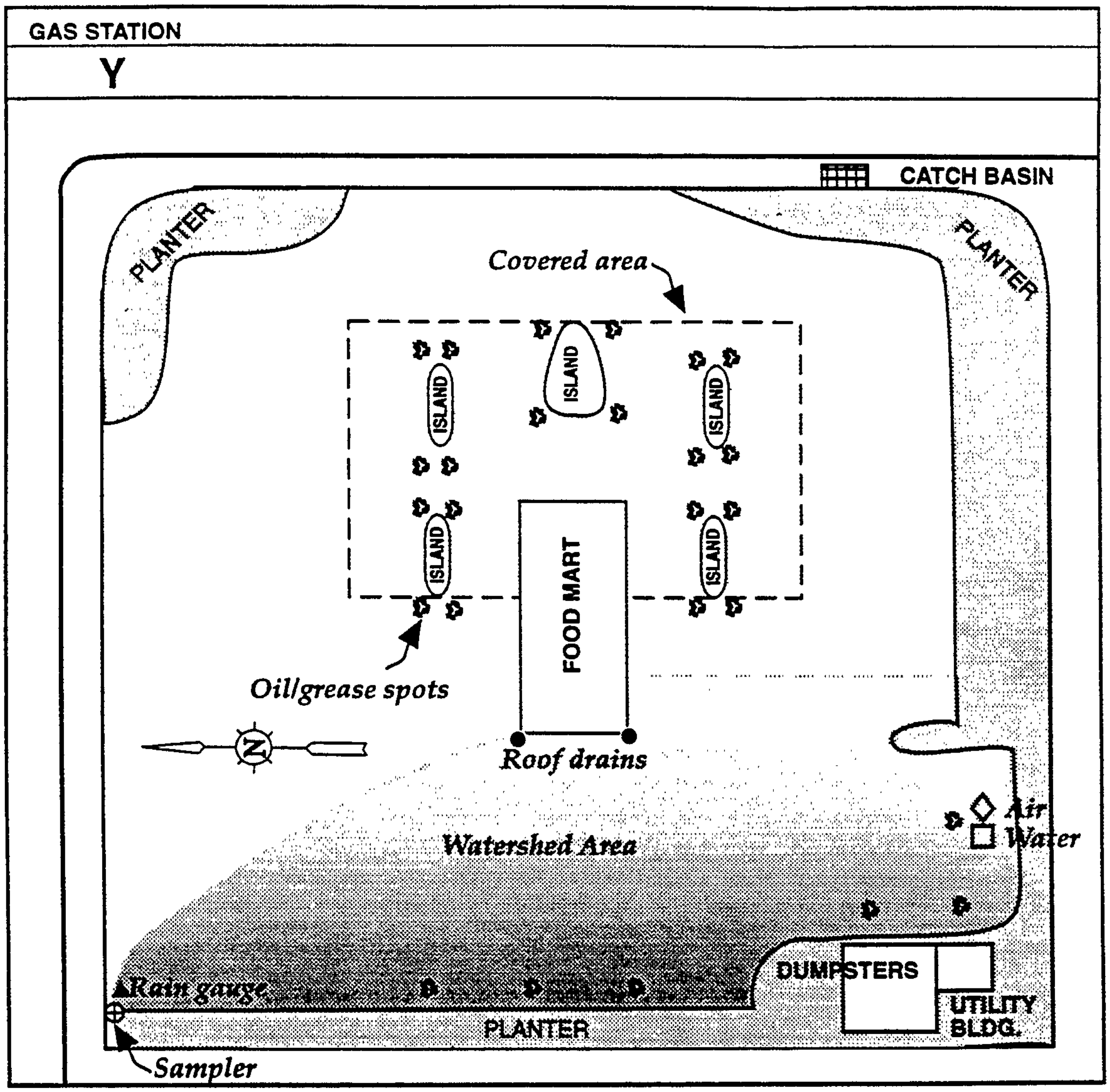

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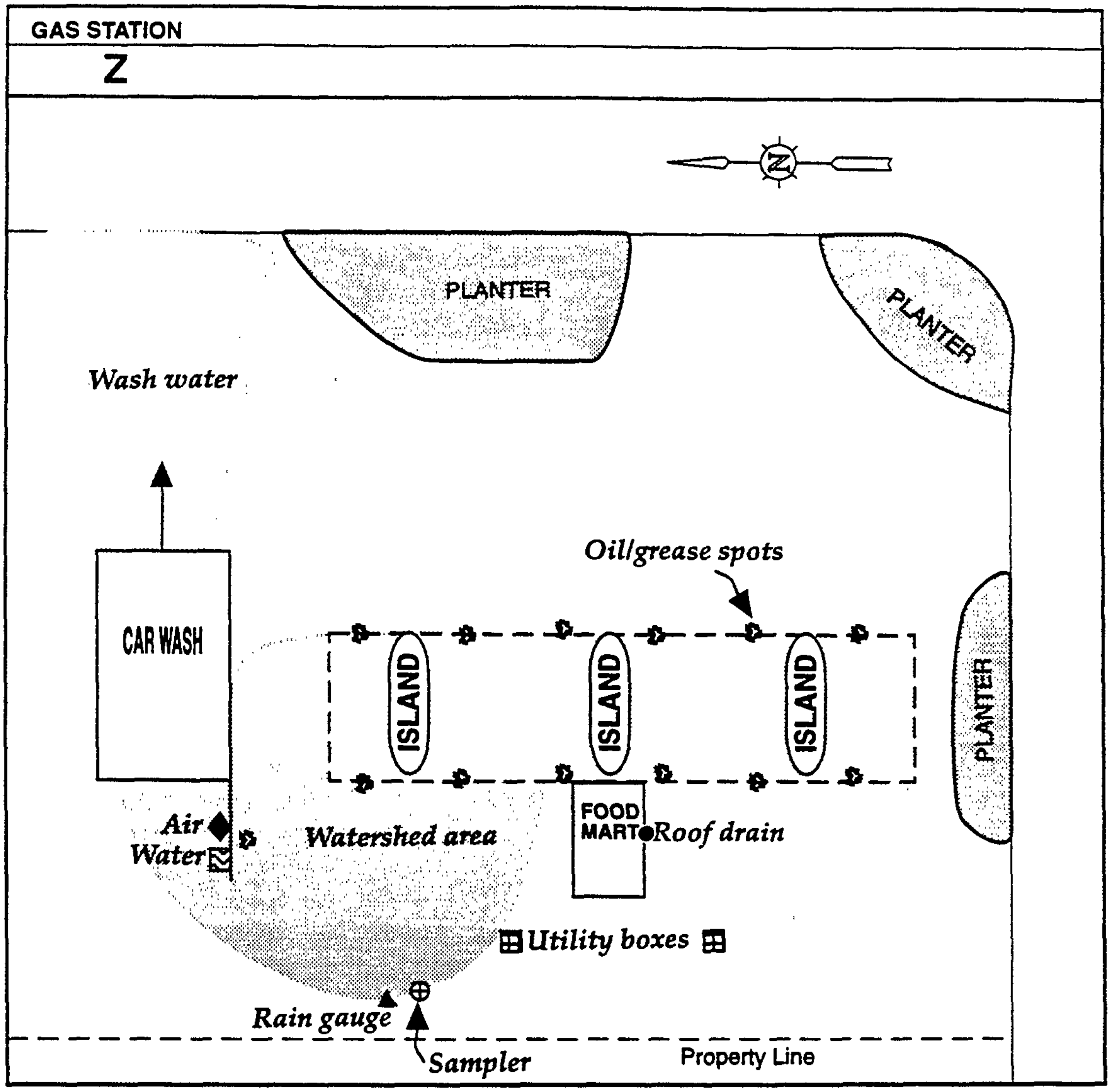
Figure 3.4



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Given the expressed wish of the participating oil companies for the project to have a minimal impact on station operations (i.e., no interference with traffic flow or services), and the project's budgetary constraints (the cost of sampling manpower and monitoring station installation); the selection of one representative sampling point at each gas station was considered adequate. Safety of field sampling personnel was also a factor in sampling point selection. Sampling points were chosen based on the following criteria:

- Minimum intrusion of off-site runoff co-mingling with the sample
- Minimum interruption of station operation
- Maximum safety for sampling crews
- Consistency among gas stations
- Locations receiving runoff representative of gasoline fueling stations, including runoff from fueling areas and air and water supply service areas

At each of the three gas stations, a sampling point was selected where station runoff left the property, where the runoff stream at the sampling point drained a significant portion of the property, and where the runoff stream at the sampling point included drainage from fueling areas and auxiliary services (especially air and water supply areas). These sampling points were selected after careful site inspection and dry weather flow testing (observation of drainage patterns by allowing water to flow from a garden hose onto the areas of interest). Subsequent storm sampling experience at the gas stations confirmed that the sampling points received runoff representative of the gas stations.

Samples were collected at each of the three selected gas stations from the sampling points indicated in Figures 3.2, 3.3, and 3.4.

3.4 Sampling Program Design

Weather Monitoring

Weather was monitored during this project to maximize the likelihood of "capturing" six storms each season, to minimize false starts, and to ensure that the sampling equipment and team was prepared in sufficient time to collect runoff samples. The incoming storms were monitored using the Weather Network on-line weather database system, as well as direct telephone contacts with Weather Network and National Weather Service forecasters. The project team accessed Weathernet's on-line database via modem through an account established for this project, thereby providing live access to Weather Network forecasters available around the clock during impending storm events.

Storm Selection

Using Weathernet information and a "phone tree," the Field Sampling Coordinator kept the project team informed as to the likelihood of sampling. As a storm approached, the Field Sampling Coordinator made a recommendation to the rest of the project team as to whether the storm was likely to be large enough for the purposes of this study. Only storms predicted to provide sufficient runoff to be sampled were selected.

Storm Events

Storm water monitoring programs in Sacramento County typically have restricted sampling events to storms expected to produce over 0.5 inch of rainfall within a 24-hour period, to achieve sufficient runoff to collect adequate samples. This guideline was adopted for the current project as well. In an average rainfall year, Sacramento County receives approximately 19-20 inches of precipitation in the area of the selected gas stations. In recent drought years (1986/87-1991/92), the annual rainfall has totaled significantly less. Given that some precipitation will occur during storms which do not meet the 0.5 inch / 24-hour intensity criteria, and given that it was not possible to predict the annual precipitation in advance, six was considered to be the number of storms that could reasonably be expected to be sampled within a wet season.

Sample Collection

Sheet flow samples were collected manually (without the use of sampling equipment) by placing a 1 liter glass bottle below grade at a sampling point (monitoring station). As shown in Figure 3.5, the monitoring station consisted of a 12 inch inside diameter by 18 inch deep reinforced concrete pipe (RCP) placed in the pavement at each location. A 3/8 inch aluminum plate was bolted in-place over the hole when sampling was not taking place. The plate was removed before sampling began.

At each station a 1 liter glass sample bottle was used to collect water for all the constituent analyses, and a 5 liter borosilicate glass bottle was used for compositing the 1 liter aliquots. During sampling, sheet flow runoff flowed over the lip of the RCP and was collected directly into the 1 liter sampling bottle. Continuous bailing was performed to keep the water level in the hole sufficiently below the mouth of the bottle to prevent cross-contamination of the collected sample. The individual 1 liter sample aliquots were composited immediately into the 5 liter borosilicate glass bottle.

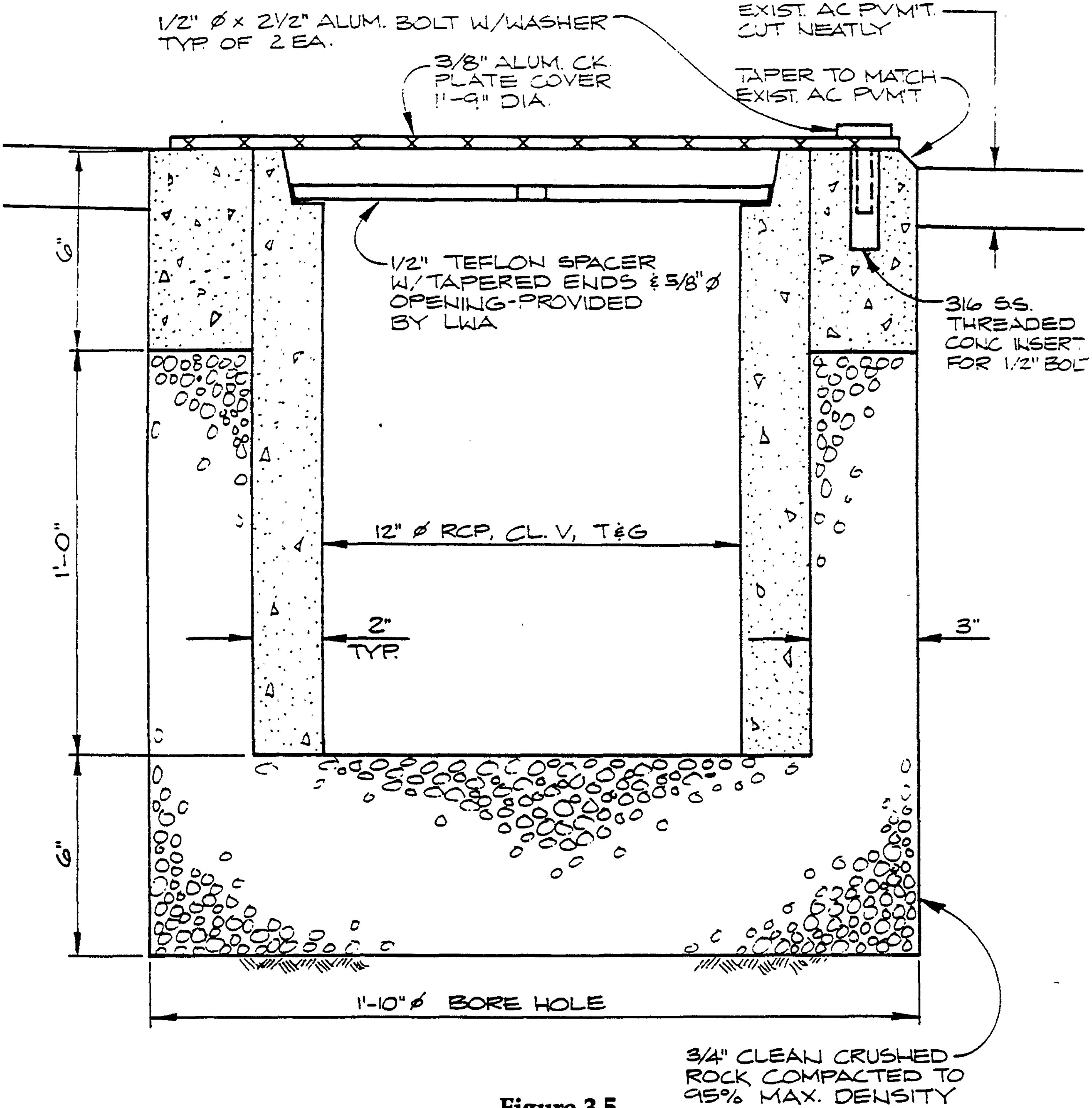

Figure 3.5

MONITORING STATION (NOT IN USE)

SCALE: 3" = 1'-0"

DRAWN BY: ENZ
DESIGNED BY: TLW
CHECKED BY: AR

LWA NO. 183.01
9/23/92

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Samples were flow weighted by collection at intervals based on a pre-determined increment of rainfall volume, equal to 0.05 inches. To accomplish this, rain gauges were used to measure rainfall volume during storm sampling. The same type of gauge was placed at each of the three stations during the sampling period to provide site-specific data. The gauges were placed in an open area on-site, away from the influence of structures or trees. The rain gauges were checked periodically, depending on the rainfall intensity, and the amount of rain in each gauge was recorded during the sampling period to yield rate information as well as total rainfall data. Upon initiation of runoff sufficient to permit sample collection, a 1 liter sample was collected every 0.05 inches of measured rainfall until the composite bottle contained 5 liters of sample.

Sample collection was initiated by the Field Sampling Coordinator. Each station had dedicated staff who covered that station for the duration of the sampling period. All field observations were recorded, including storm characteristics, runoff characteristics, activities on-site, irregularities or difficulties in the sampling procedure, the time each grab sample was taken, and unusual qualities of the runoff sample.

Sample Handling

The composite container was field preserved at approximately 4^{o} Centigrade by storage in a cooler containing ice. The filled composite sample containers were maintained on ice until delivery to the analytical laboratory. Delivery to the lab occurred within 24 hours of the completion of sampling. The composite containers remained closed with a screw on cover containing a Teflon Seal. Upon delivery to the lab, the composite was split by laboratory personnel into aliquots for the specified analyses, and preserved accordingly (see Table 3.1). Prior to pouring off aliquots from the composite for analyses, the composite sample was thoroughly shaken to ensure that representative samples were obtained.

Rainfall Monitoring

In addition to the on-site rain gauges used to measure rainfall during the sample collections, rainfall data were accessed from the closest Sacramento County ALERT system rain gauges. Figure 3.6 shows the location of three ALERT rain gauges in the vicinity of the three gas stations. The gauges are designated by numbers and nearby street names.

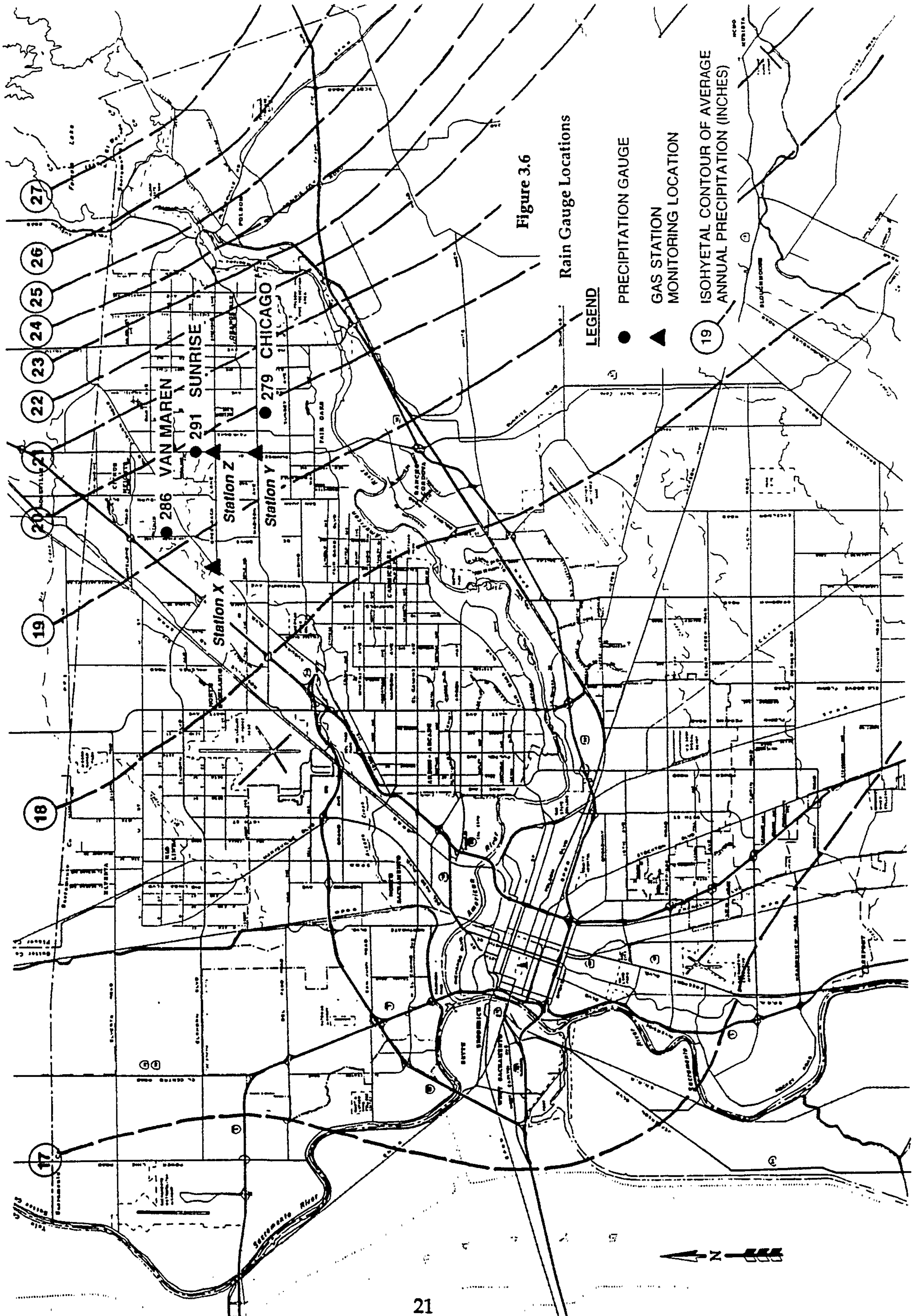

Figure 3.6
Rain Gauge Locations

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4.0 *Best Management Practices (BMPs)*

This section describes the selection and implementation of best management practices designed to reduce gas station runoff pollution.

4.1 Selection

The selection of best management practices was based on a review of appropriate BMPs described and used elsewhere for vehicle-related activities (SCVNPSPCP, 1992; U.S. EPA, 1992; Palo Alto RWQCP, 1993; California SWQTF, 1993; County of Orange, 1993). As part of Phase 1, BMPs were selected based on their effectiveness, practicality, and cost by using a semi-quantitative scoring method (Sacramento County, 1993a). The following six BMPs were selected and implemented:

- Mobile High Pressure Water Cleaning
- Public Notices
- Litter Control
- Storm Drain Stenciling
- Spill Cleanup Materials
- Employee Awareness

The above list includes all of the BMPs applicable to the stations given the physical limitations of the sites. The selected best management practices were either low in cost, and/or high in perceived effectiveness in reducing pollutants. A "potential for disruption" criterion helped guide the selection toward BMPs that were acceptable to the station owners/operators. The BMPs tended to focus on the areas of the stations with the greatest potential to generate pollutants (e.g., air/water supply area, fueling area, drive through area) as opposed to areas with less pollution potential (e.g., roof drains, landscaping). On-site treatment control BMPs were not selected because of their high relative cost and disruption to operations. Off-site BMPs (e.g., detention pond, wetlands) were not considered because the scope and budget did not allow for these to be tested. Therefore, all of the best management practices selected for implementation were source controls.

One way to maximize the statistical validity of pre- and post-BMP comparisons is to maximize the difference in the pre- and post-BMP data. To effect this, the project team implemented the full suite of BMPs at each station, as opposed to implementing one

BMP at each station. The presumption was that the combined effect of the suite of best management practices would increase the likelihood of reducing pollutants, thereby producing more statistically significant results. The need to implement a suite of BMPs is especially important with source controls, because there are a variety of pollutant sources, each requiring a best management practice. If treatment controls had been a more viable approach, it's possible that fewer BMPs would have been necessary to produce a reduction in pollutants.

4.2 Implementation

Having selected the BMPs, the project team worked with the station owners/operators to gain their final approval and to implement the BMPs. The following discussions provide some detail on the actual implementation of each of the selected best management practices.

Mobile High Pressure Water Cleaning - The entire drainage area used in Phase 1, particularly the air/water supply, fueling, and drive through areas, was cleaned an average of about twice per month using a high pressure (3,000 psi) and high temperature (210^{o}F) mobile cleaning unit (Figure 4.1). The wash water generated was collected using a "Vacu-boom," a portable, runoff collection system (Figures 4.2 and 4.3). The "Vacu-boom" includes a hollow, flexible snake that is connected to a high power wet vacuum unit. The apparatus enables sheet flow to be captured and conveyed to a sanitary sewer inlet.

Several concerns were identified and resolved before using the mobile cleaning system including: 1) potential asphalt erosion caused by the high temperature of the water, 2) wash water disposal, 3) safety of the cleaning operator and the equipment, and 4) disruption of normal station operations. To reduce the potential for erosion of the asphalt, the operator avoided persistent spraying in one area to avoid heating up the asphalt surface. Wash water disposal was handled by discharging into the sanitary sewer system via a cleanout or rest room connection. The safety and disruption issues were addressed by conducting cleaning operations late at night during slower business hours and by supplying the operator and assistant with safety orange cones and an orange vest for increased visibility.

Figure 4.1 Mobile Cleaning System

Figure 4.2 Vacu-boom

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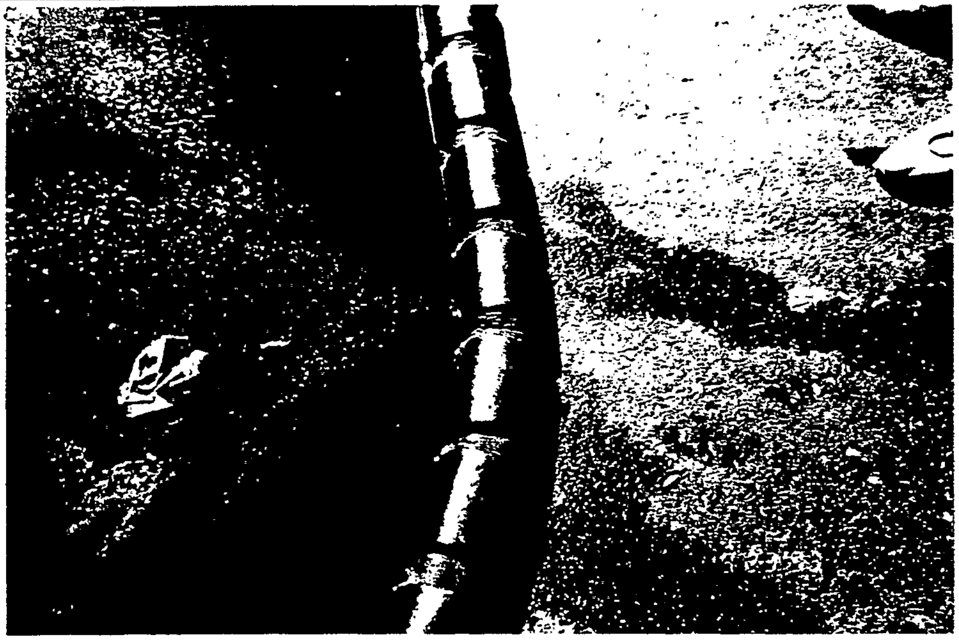


Figure 4.3 Wash water collected by Vacu-boom

The objective of the mobile cleaning BMP was to free the pollutants from the asphalt surface using high temperature and high pressure water and to transport the pollutants, in water suspension, to the Vacu-boom apparatus. The method of application that appeared to be the most effective was to initially wet the asphalt surface over the entire drainage area to the point of saturation without creating any significant runoff. The mobile cleaning took place starting from the furthest upstream point in the drainage area and working down in a back and forth line to the furthest downstream point. By initially wetting the surface, the waste stream from the mobile cleaning was able to freely travel down to the Vacu-boom without the water being "used up" in the wetting of dry asphalt. Water quality samples of the waste stream were originally going to be taken to determine the type and amount of pollutants being removed in the mobile cleaning BMP. However, since the Vacu-boom wet vacuum contained copper and brass fittings and components, project staff decided that the results would not be reliable and therefore abandoned the idea.

Table 4.1 presents data on the mobile cleanings performed during the project. The information presented in Table 4.1 relates the mobile cleaning number, dates of mobile cleaning, the stations cleaned, and the days since the previous cleaning with the storm number, the storm date, the number of days since the last cleaning, and the number of cleanings since the last storm sampled. The drainage areas at the three stations were mobile cleaned a total of ten times between late October 1993 and late March 1994.

To further explain Table 4.1, starting with the first column, the first cleaning occurred on 10/27/93 for stations Y and Z, and on 11/4/93 for station X. The second cleaning occurred on 11/9/93 for all three stations which resulted in 5 days since the last cleaning for station X and 13 days since the last cleaning for stations Y and Z (fourth column). The first storm (fifth column) was sampled on 11/29/93 (sixth column) which was 20 days since the last cleaning (seventh column) that was done on 11/9/93. The drainage areas at all the stations were mobile cleaned twice prior to this storm (eighth column).

Table 4.1 Mobile Cleaning/Sampled Storm Information

Mobile Cleaning Data				Sampled Storm Data			
Mobile Cleaning Number	Date of Mobile Cleaning	Station(s)	Days Since Previous Cleaning	Storm Number	Storm Date	Number of Days Since Last Cleaning	Cleanings Since Last Storm Sampled
1 1	10/27/93 11/4/93	Y and Z X					
2	11/9/93	All	5 (X), 13 (Y/Z)	1	11/29/93	20	2
3	12/5/93	All	26	2	12/11/93	6	1
4	12/23/93	All	18				
5	1/10/94	All	18	3	1/24/94	14	2
6	1/26/94	All	16	4	2/6/94	11	1
7	2/9/94	All	14	5	2/17/94	8	1
8	2/23/94	All	14				
9	3/9/94	All	14				
10	3/23/94	All	14	6	4/8/94	16	3

Public Notices - Signs educating the public about good housekeeping practices and what to do in the event of a spill were displayed in the air/water supply area. One sign requested that the gas station attendant be notified should a spill occur and the other sign requested that litter be properly disposed (Figure 4.4).

Litter Control - To supplement the litter control sign, the project team monitored the presence of trash receptacles in the air/water supply area (Figure 4.4).

Storm Drain Stenciling - The public is usually unaware that storm drains flow directly to a creek, river, or a bay. Storm drain stenciling conveys the message that the water that flows into the catch basin goes directly to the local rivers. The on-site, and nearby off-site storm drain inlets were stenciled to increase public awareness (Figure 4.5).

Spill Cleanup Materials - To ensure that spilled fluids are promptly removed, cleanup materials must be readily available. All three stations keep spill cleanup materials on-site. The station managers were also encouraged to, not only keep the spill materials readily available, but also to train employees in the proper use of the spill materials.

Employee Awareness - All three stations and their parent corporations have employee training programs that include material and waste management practices. This training was supplemented, as necessary, to assist the project team in understanding the conditions at each station. Because the team could not be at each of the stations most of the time, the employees were encouraged to use log sheets to record significant events (e.g., spills) that could help to interpret study results. However, the use of log sheets to monitor spills outside the fueling areas was difficult to implement because the limited staff found at these type of stations usually did not have the time to make observations.

Figure 4.4 Public Notices

Figure 4.5 Storm Drain Stenciling

5.0 *Results*

This section describes the results of the first (pre-BMP) and second (post-BMP) year's wet season's measurements, including drainage area estimates, climatological data, runoff sample analyses, and graphs.

5.1 Drainage Area Estimates

For each of the stations, the area draining to the collection point was less than the total area of the station (see Figures 4.2-4.4). Measurements of the drainage area to the sample collection point were made based on site plans provided by the County of Sacramento and field measurements, including field flow (hose) trials, made by the project team. A planimeter was used to determine the watershed areas depicted in Figure 3.2 through 3.4. The estimated dimensions of the drainage areas are provided in Table 5.1.

As shown in Table 5.1, there are several ways to calculate the area draining to the sample collection point. The project team is using the exposed paved area plus the roof drainage area (row 6 in Table 5.1) to represent the "sample area," or area draining to the collection point. This area excludes the *covered* paved drainage area because runoff normally does not flow through this area. One difference between the stations is the percent of roof area draining to the collection point, with station X having significantly more roof drainage area (29%) than either of the other two stations (Y = 4% and Z = 0%).

5.2 Sampling Results

Climatological Results

Climatological data were compiled throughout both wet seasons to aid in interpreting the storm water runoff results. These data included areawide rainfall totals from Sacramento County ALERT system rain gauges, inter-event times (time between significant storms), and rainfall intensity data recorded during sampling. Rainfall data collected at the three ALERT gauges were used to calculate the cumulative precipitation for the 1992-93 (Figure 5.1) and 1993-94 wet seasons (see Figure 5.3). Figures 5.2 and 5.4 show the daily precipitation totals for the 1992-93 and 1993-94 wet seasons, respectively.

Table 5.1 Drainage Area Estimates

	Area		Station X (sq. ft.)	Station Y (sq. ft.)	Station Z (sq. ft.)
1	**Exposed Paved Drainage Area**		**2,826**	**3,794**	**2,844**
2	Covered Paved Drainage Area (1)	+	222	149	887
3	Total Paved Drainage Area (2)	=	3,048	3,943	3,731
4	**Roof Drainage Area**	+	**1,150**	**168**	**0**
5	Total Paved + Roof Drainage Area	=	4,198	4,111	3,731
6	**Exposed Paved + Roof Drainage Area (3) = Sample Area (Row 1 + Row 4)**		**3,976**	**3,962**	**2,844**
7	Roof Drainage as Percent of Sample Area		29%	4%	0%
8	Area of Gas Station (4)		20,809	18,358	30,423
9	Sample Area as Percent of Gas Station Area		19%	22%	9%

(1) Covered paved drainage area is a potential source of pollutants but runoff normally does not flow through this area.

(2) Total paved drainage area is the sum of the exposed drainage area and the covered drainage are (covered by an overhang).

(3) Excludes covered paved drainage area.

(4) Area of gas station includes buildings, landscaping, and other facilities but excludes adjacent streets and sidewalks.

All four plots of precipitation data show when the six pre-BMP and six post-BMP sampling events took place.

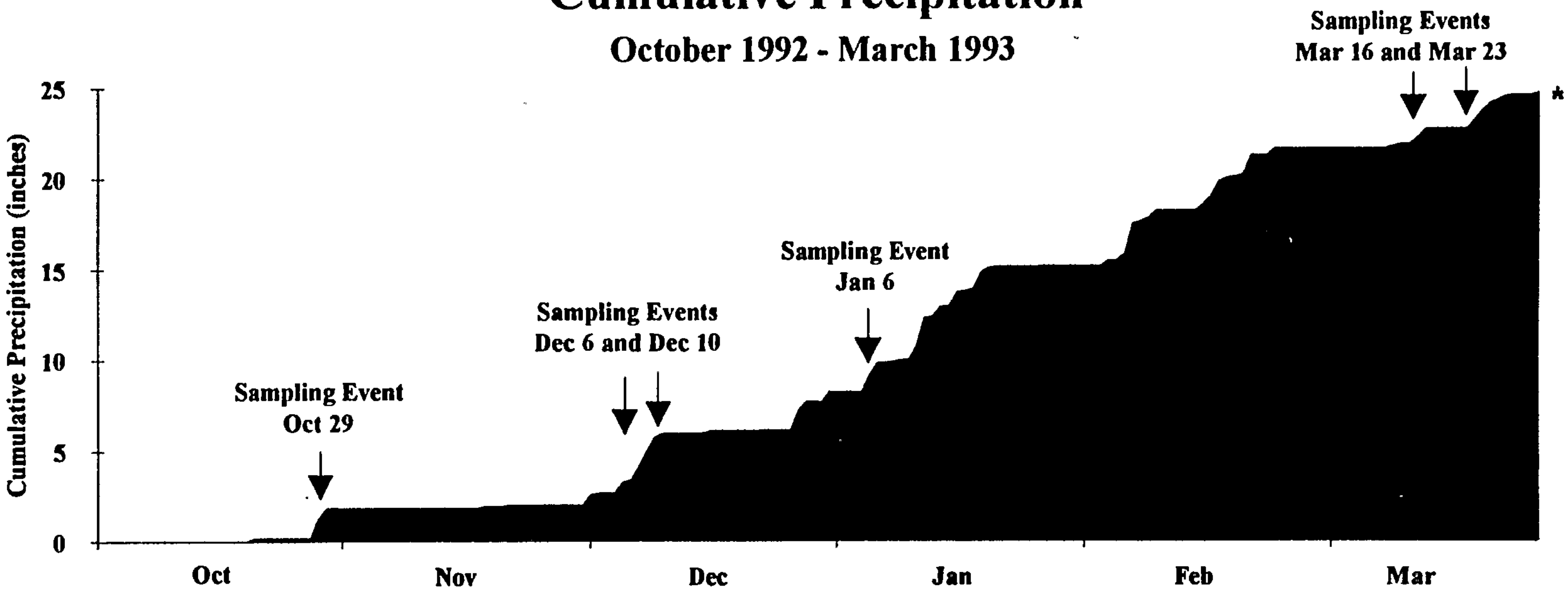
Once collected, the ALERT system rainfall data allowed for the calculation of the time between sampled storms (inter-event time). The determination of inter-event time depends on the definition of a "significant" storm. Consistent with U.S. EPA storm water regulations (40 CFR 122.26), the project team used 0.10 inches of rain as the significant storm threshold. Table 5.2 presents the inter-event data for both wet seasons.

R0008981

Figure 5.1

Cumulative Precipitation

October 1992 - March 1993



Note: Daily rainfall average is based on an unweighted average of the calculated rain gauge #291 (Sunrise) data and the recorded rainfall measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

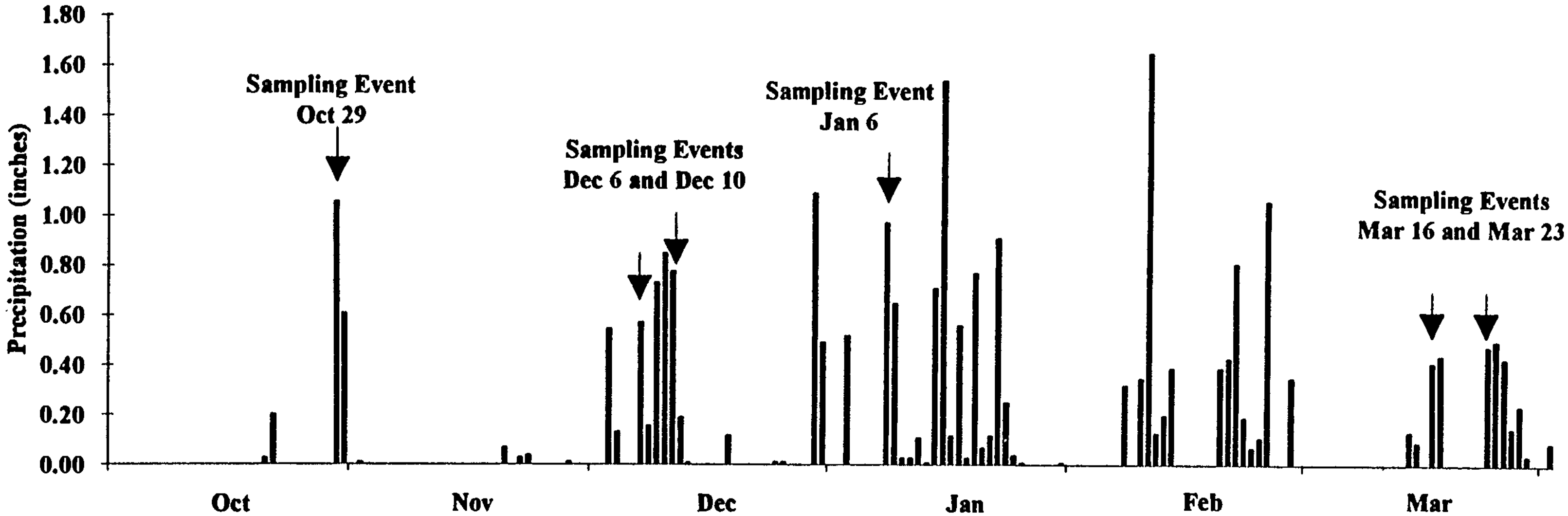
*** Total Precipitation for October 1, 1992 - March 31, 1993 = 24.69 inches.**

[redacted] [redacted]

Figure 5.2

Daily Precipitation Totals

October 1992 - March 1993

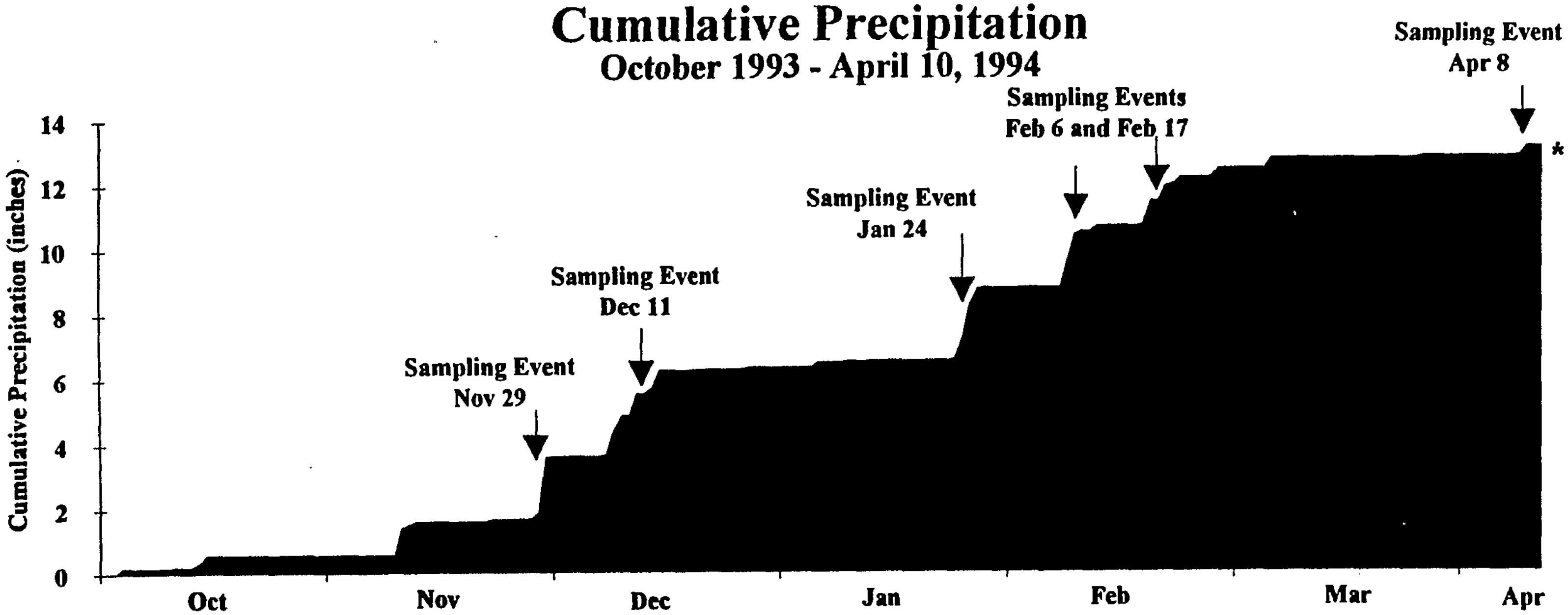


Note: Daily rainfall average is based on an unweighted average of the calculated rain gauge #291 (Sunrise) data and the recorded rainfall measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

R0008982

Figure 5.3

Cumulative Precipitation
October 1993 - April 10, 1994



Notes:

1) Rain gauge #291 (Sunrise) data was not used based on *incomplete and inconsistent* data. Calculation is based on the average of recorded measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

2) Daily rainfall average is based on an unweighted average of the calculated rain gauge #291 (Sunrise) data and the recorded rainfall measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

* Total Precipitation for Oct 1, 1993 - April 10, 1994 = 13.18 inches.

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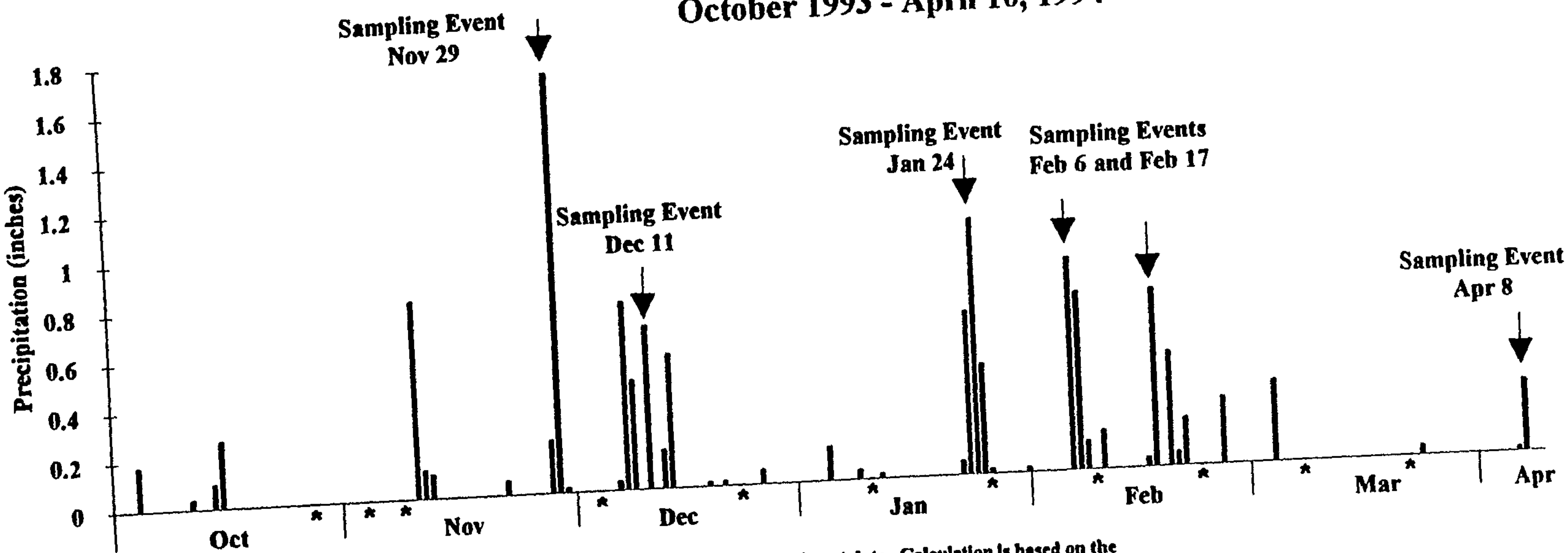
Figure 5.4

Daily Precipitation Totals

October 1993 - April 10, 1994



Notes:
1) Rain gauge #291 (Sunrise) data was not used based on incomplete and inconsistent data. Calculation is based on the average of recorded measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

2) Daily rainfall average is based on an unweighted average of the calculated rain gauge #291 (Sunrise) data and the recorded rainfall measurements from rain gauges #279 (Chicago) and #286 (VanMaren).

* Mobile Cleaning Dates: 10/27/93; 11/04/93; 11/09/93; 12/05/93; 12/23/93; 1/10/94; 1/26/94; 2/09/94; 2/23/94; 3/09/94; 3/23/94.

Table 5.2 Inter-event Time Data

		Pre-BMP Monitoring					
Storm #	Sampled Storm Date	Previous Storm Date (> 0.10")	Total Depth* (inches)	Inter-event Time (days)	Previous Storm Date (> 0.25")	Total Depth* (inches)	Inter-event Time (days)
1	29-Oct-92	21-Oct-92	0.21	8	29-Jun-92	0.35	122
2	6-Dec-92	3-Dec-92	0.13	3	2-Dec-92	0.54	4
3	10-Dec-92	9-Dec-92	0.78	1	9-Dec-92	0.78	1
4	6-Jan-93	1-Jan-93	0.52	5	1-Jan-93	0.52	5
5	16-Mar-93	14-Mar-93	0.11	2	26-Feb-93	0.34	18
6	23-Mar-93	17-Mar-93	0.39	6	17-Mar-93	0.39	6

		Post-BMP Monitoring					
Storm #	Sampled Storm Date	Previous Storm Date (> 0.10")	Total Depth** (inches)	Inter-event Time (days)	Previous Storm Date (> 0.25")	Total Depth** (inches)	Inter-event Time (days)
1	29-Nov-93	28-Nov-93	0.22	1	11-Nov-93	0.91	18
2	11-Dec-93	9-Dec-93	1.04	2	9-Dec-93	1.04	2
3	24-Jan-94	23-Jan-94	0.74	1	23-Jan-94	0.74	1
4	6-Feb-94	26-Jan-94	0.48	11	26-Jan-94	0.48	11
5	17-Feb-94	10-Feb-94	0.16	7	8-Feb-94	0.32	9
6	8-Apr-94	5-Mar-94	0.34	34	5-Mar-94	0.34	34

* = Weighted average of three closest rain gauges
** = Average of Chicago and Van Maren Cripple rain gauges

Because 1992-93 (pre-BMP) was a relatively wet year in California, with frequent storms occurring on a regular basis throughout the winter, the inter-event times were fairly short, ranging from 2 to 9 days. In 1993-94 (post-BMP), about half as much rain fell as compared to 1992-93 (approx. 13 inches versus approx. 26 inches). The inter-event times in 1993-94 reflected the drier winter, ranging from 0 up to 33 days. Because a 0.10 inch storm does not always produce a significant volume of runoff (depending on duration and intensity), inter-event times based on the previous storm of 0.25 inches or greater were also evaluated for both years.

As discussed in section 3.4, Sampling Program Design, rain gauges were used to measure rainfall volume at the three gas stations during storm sampling. The same type of gauge was placed at each of the three stations during the sampling period to give site-specific data. The gauges were placed in an open area on-site, away from the influence of structures or trees. The rain gauges were checked periodically, depending on the rainfall intensity, and the amount of rain in each gauge was recorded during the sampling period to yield rate information as well as total rainfall data.

Table 5.3 presents information for both wet seasons on observed rainfall and the period of observation as recorded during sample collection, and the calculated rainfall intensity. The intensity shown is simply the quotient of the measured rainfall divided by the total time of observation, which corresponds to the amount of time required to collect the composite sample. For the most part, the differences in the rainfall intensities represent the inherent variability caused by the geographic separation of the stations.

Runoff Water Quality Results

QA/QC Evaluation

On a quarterly basis, a review of the QA/QC program was conducted, fulfilling the requirement for such a review as described in the Quality Assurance Project Plan (Sacramento County, 1993b). The quality control data from the storms indicated that the data quality objectives, as measured by the project specific numerical goals (Sacramento County, 1993b), were generally met during the second wet season. Specifically, precision, expressed as relative percent difference, was within the goals of +/- 20% for oil & grease and metals, and within +/- 10% for TSS, except for one storm (February 17 = +11%). Percent spike recovery values were all within the 80-120% accuracy goal for metals, and 70-130% for oil & grease. In addition, the collection of samples from all six storms exceeded the completeness goal of four storms for the season.

The qualitative system audits performed during this period indicated that the measurement systems were used appropriately and that the sampling and analysis activities matched those presented in the QAPP. The performance audit data described above indicate that data of known and defensible quality were produced. During the second wet season, there was one analytical result from a field duplicate in the third storm that did not match well with its corresponding environmental sample. With this exception, no other significant QA problems occurred during the 1993-94 monitoring.

Runoff Water Quality Data

Table 5.4 presents the pre-BMP (1992-93) runoff data for analytes detected in at least 75% of analyzed samples (i.e., indicators, nickel, aluminum, and iron). Table 5.5 presents the post-BMP (1993-94) data for the indicator analytes. As expected for storm

Table 5.3 Gas Station Rainfall Intensities

Pre-BMP Monitoring

Parameter	Station X	Station Y	Station Z	Mean	Std. Dev.
29-Oct					
Rainfall (inches)*					
Time (hours)*					
Intensity (inches/hr.)*					
6-Dec					
Rainfall (inches)	0.27	0.22	0.53	0.34	0.17
Time (hours)	5.68	9.18	10.00	8.29	2.29
Intensity (inches/hr.)	0.05	0.02	0.05	0.04	0.02
10-Dec					
Rainfall (inches)	0.42	0.33	0.15	0.30	0.14
Time (hours)	0.67	0.58	0.75	0.67	0.09
Intensity (inches/hr.)	0.63	0.57	0.20	0.47	0.23
6-Jan					
Rainfall (inches)	0.27	0.20	0.25	0.24	0.04
Time (hours)	3.07	2.21	2.50	2.59	0.44
Intensity (inches/hr.)	0.09	0.09	0.10	0.09	0.01
16-Mar					
Rainfall (inches)	0.27	0.15	0.15	0.19	0.07
Time (hours)	6.25	5.42	5.25	5.64	0.54
Intensity (inches/hr.)	0.04	0.03	0.03	0.03	0.01
23-Mar					
Rainfall (inches)	0.15	0.13	0.13	0.14	0.01
Time (hours)	6.08	4.18	3.75	4.67	1.24
Intensity (inches/hr.)	0.02	0.03	0.03	0.03	0.01
Average Storm Rainfall (inches) (n=15)				0.24	0.08
Average Storm Time (hours) (n=15)				4.37	0.92
Average Storm Intensity (inches/hr.) (n=15)				0.13	0.05

* = Samples collected on October 29, 1992, were grab samples; rainfall intensity was not measured.

Post-BMP Monitoring

Parameter	Station X	Station Y	Station Z*	Mean	Std. Dev.
29-Nov					
Rainfall (inches)	1.65	1.77	1.71	1.71	0.06
Time (hours)	10.78	10.23	10.3	10.44	0.30
Intensity (inches/hr.)	0.153	0.173	0.166	0.164	0.010
11-Dec					
Rainfall (inches)	0.47	0.87	0.67	0.67	0.20
Time (hours)	11.00	11.00	8.93	10.31	1.20
Intensity (inches/hr.)	0.043	0.079	0.075	0.066	0.020
24-Jan					
Rainfall (inches)	1.46	0.63	1.045	1.05	0.42
Time (hours)	12.34	11.81	20.39	14.85	4.81
Intensity (inches/hr.)	0.118	0.053	0.051	0.074	0.038
6-Feb					
Rainfall (inches)	0.87	0.87	0.87	0.87	0.00
Time (hours)	15.27	15.00	15.27	15.18	0.16
Intensity (inches/hr.)	0.057	0.058	0.057	0.057	0.001
17-Feb					
Rainfall (inches)	0.71	0.75	0.73	0.73	0.02
Time (hours)	15.88	21.25	24.65	20.59	4.42
Intensity (inches/hr.)	0.045	0.035	0.030	0.037	0.008
8-Apr					
Rainfall (inches)	0.35	0.24	0.295	0.30	0.05
Time (hours)	10.69	11.00	6.60	9.43	2.46
Intensity (inches/hr.)	0.033	0.022	0.045	0.033	0.012
Average Storm Rainfall (inches) (n=18)				0.89	0.13
Average Storm Time (hours) (n=18)				13.47	2.22
Average Storm Intensity (inches/hr.) (n=18)				0.07	0.01

* Rainfall data from the ALERT rain gauge near Station Z was incomplete and inconsistent. Therefore, rainfall data for Station Z is the average of rainfall data measured at ALERT rain gauges near Stations X and Y.

water runoff samples, the variability was quite high in both year's data sets. Standard deviations of mean values by storm, by station, and of the pooled data were high.

Table 5.4 Fueling Station Storm Water Runoff Data
Pre-BMP Monitoring (1992/93)

Concentrations in ug/l
(Except where otherwise noted)

Constituent	Station	29-Oct	6-Dec	10-Dec	06-Jan	16-Mar	23-Mar	Station Mean	Standard Deviation	
TSS (mg/l)	X	34	110	110	130	53	38	79	42	
	Y	150	52	31	46	36	40	59	45	
	Z	26	96	9	29	36	42	40	30	
	Mean	70	86	50	68	42	40		Pooled Data Mean	59
	Std. Dev.	69	30	53	54	10	2		Std. Deviation	40
O&G (mg/l	X	2.7	15	< 0.5	5.4	12	1.9	6.3	5.9	
	Y	6.9	7.8	1.0	0.6	5.0	1.0	3.7	3.3	
	Z	1.2	14	0.8	2.0	3.9	1.2	3.9	5.1	
	Mean	3.6	12.3	0.8	2.7	7.0	1.4		Pooled Data Mean	4.6
	Std. Dev.	3.0	3.9	0.3	2.5	4.4	0.5		Std. Deviation	4.7
Cadmium	X	0.38	1.80	1.90	0.42	0.77	0.54	0.97	0.70	
	Y	1.40	0.71	0.31	0.25	0.60	0.27	0.59	0.44	
	Z	0.54	0.56	0.11	0.39	0.53	0.45	0.43	0.17	
	Mean	0.77	1.02	0.77	0.35	0.63	0.42		Pooled Data Mean	0.66
	Std. Dev.	0.55	0.68	0.98	0.09	0.12	0.14		Std. Deviation	0.50
Chromium	X	4.3	6.7	9.4	< 1.0	4.1	3.0	4.8	2.9	
	Y	11	4.1	2.6	1.8	5.5	2.6	4.6	3.4	
	Z	7.4	2.9	< 1.0	< 1.0	4.0	2.5	3.1	2.4	
	Mean	7.6	4.6	4.3	1.3	4.5	2.7		Pooled Data Mean	4.2
	Std. Dev.	3.4	1.9	4.5	0.5	0.8	0.3		Std. Deviation	2.8
Copper	X	30	26	9.7	5.2	20	13	17.3	9.7	
	Y	68	31	6.0	7.6	45	20	29.6	23.9	
	Z	9.3	26	6.0	9.2	37	85	28.8	30.1	
	Mean	35.8	27.7	7.2	7.3	34.0	39.3		Pooled Data Mean	25.2
	Std. Dev.	29.8	2.9	2.1	2.0	12.8	39.7		Std. Deviation	21.6
Lead	X	34	28	17	8.2	54	15	26.0	16.6	
	Y	150	28	17	16	63	24	49.7	52.1	
	Z	15	28	7.0	15	32	50	24.5	15.5	
	Mean	66.3	28.0	13.7	13.1	49.7	29.7		Pooled Data Mean	33.4
	Std. Dev.	73.1	0.0	5.8	4.2	15.9	18.2		Std. Deviation	32.1

Table 5.4 Fueling Station Storm Water Runoff Data
Pre-BMP Monitoring (1992/93)

Concentrations in ug/l
(Except where otherwise noted)

Constituent	Station	29-Oct	6-Dec	10-Dec	06-Jan	16-Mar	23-Mar	Station Mean	Standard Deviation	
Nickel	X	5.2	5.1	11	NA	NA	NA	7.1	3.4	
	Y	9.4	3.1	< 5.0	NA	NA	NA	5.8	3.2	
	Z	< 5.0	3.1	3.1	NA	NA	NA	3.7	1.1	
	Mean	6.5	3.8	6.4					Pooled Data Mean	5.6
	Std. Dev.	2.5	1.2	4.1					Std. Deviation	2.8
Zinc	X	690	500	430	180	430	550	463	169	
	Y	410	190	59	82	130	91	160	131	
	Z	2400	200	53	84	150	200	515	926	
	Mean	1167	297	181	115	237	280		Pooled Data Mean	379
	Std. Dev.	1077	176	216	56	168	240		Std. Deviation	525
Aluminum	X	NA	800	2300	NA	NA	940	1347	829	
	Y	NA	810	570	NA	NA	310	563	250	
	Z	NA	910	140	NA	NA	680	577	395	
	Mean		840	1003			643		Pooled Data Mean	829
	Std. Dev.		61	1143			317		Std. Deviation	614
Iron	X	NA	1300	2700	340	NA	NA	1447	1187	
	Y	NA	1000	600	110	NA	NA	570	446	
	Z	NA	1300	190	850	NA	NA	780	558	
	Mean		1200	1163	433				Pooled Data Mean	932
	Std. Dev.		173	1346	379				Std. Deviation	798

For both data sets (1992-93 and 1993-94) and for nearly all of these analytes, the number of samples was equal to or greater than five, except for chromium at station Z (n = 4) in 1992-93, and chromium at station Y (n = 3) in 1993-94. In order to increase the statistical validity of the chromium results, a distributional method was used to establish a maximum likelihood value for the non-detect results. The method used is outlined in Appendix A.

For example, the calculated values for the 1992-93 non-detected chromium values were 1.02 ug/L and 1.67 ug/L. These values were higher than the analytical detection limit, indicating a data gap between the detected values and the non-detected values. Given that the chromium values calculated to replace the non-detected values were actually slightly greater than the detection limit, it was concluded that it would be reasonable to replace the two non-detected values with the detection limit (1.0 ug/L).

Table 5.5 Fueling Station Storm Water Runoff Data
Post-BMP Monitoring (1993-94)

Concentrations in ug/l
(Except where otherwise noted)

Constituent	Station	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr	Station Mean	Standard Deviation	
TSS (mg/l)	X	30	44	80	54	46	90	57	23	
	Y	24	62	120	29	37	160	72	56	
	Z	42	84	240	32	43	250	115	102	
	Mean	32	63	147	38	42	167		Pooled Data Mean	82
	Std. Dev.	9	20	83	14	5	80		Std. Deviation	67
O&G (mg/l)	X	4.5	18	8.9	6.7	5.4	21	10.8	7.0	
	Y	5.2	2.7	13	5.7	2.2	15	7.3	5.4	
	Z	6.9	6.9	4.5	6.2	4.2	29	9.6	9.6	
	Mean	5.5	9.2	8.8	6.2	3.9	21.7		Pooled Data Mean	9.2
	Std. Dev.	1.2	7.9	4.3	0.5	1.6	7.0		Std. Deviation	7.0
Cadmium	X	0.73	0.28	0.92	0.21	0.61	0.85	0.60	0.30	
	Y	0.52	0.19	1.1	0.12	0.21	1.7	0.64	0.63	
	Z	1.2	0.48	0.42	0.22	0.81	4.5	1.27	1.62	
	Mean	0.82	0.32	0.81	0.18	0.54	2.35		Pooled Data Mean	0.84
	Std. Dev.	0.35	0.15	0.35	0.06	0.31	1.91		Std. Deviation	0.98
Chromium	X	3.5	3.2	3.7	1.3	3.2	5.9	3.5	1.5	
	Y	1.8	< 1.0	5.7	< 1.0	< 1.0	9.8	3.4	3.6	
	Z	3.9	3.9	1.3	2.6	2.5	14	4.7	4.7	
	Mean	3.1	2.7	3.6	1.6	2.2	9.9		Pooled Data Mean	3.8
	Std. Dev.	1.1	1.5	2.2	0.9	1.1	4.1		Std. Deviation	3.3
Copper	X	12	10	13	5	10	23	12	6	
	Y	17	16	58	13	8.4	350	77	135	
	Z	84	22	14	16	140	460	123	173	
	Mean	38	16	28	11	53	278		Pooled Data Mean	71
	Std. Dev.	40	6	26	6	76	227		Std. Deviation	124
Lead	X	34	7.1	20	2.9	14	32	18	13	
	Y	18	13	98	11	13	93	41	42	
	Z	210	33	18	22	70	580	156	220	
	Mean	87	18	45	12	32	235		Pooled Data Mean	72
	Std. Dev.	107	14	46	10	33	300		Std. Deviation	133
Zinc	X	270	350	440	170	380	620	372	154	
	Y	150	83	300	84	41	760	236	272	
	Z	430	200	150	100	360	1400	440	487	
	Mean	283	211	297	118	260	927		Pooled Data Mean	349
	Std. Dev.	140	134	145	46	190	416		Std. Deviation	316

Also for the 1992-93 data set, this same method was used to determine values for non-detect results on oil & grease (December 10 storm) and chromium (January 6 storm) at station X. In both cases, the values calculated to replace the non-detected values were actually slightly greater than the detection limit. So it was deemed reasonable to replace the two non-detected values with their respective detection limits (0.5 mg/L - oil & grease; 1.0 ug/L - chromium).

Appendix B presents plots of pollutant concentrations versus station for all six post-BMP storms. Where applicable, the plots include water quality objectives (SWRCB, 1991) for comparison. This comparison is very conservative because it does not consider the fate of the pollutants (e.g., adsorption) and the fact that the samples were collected upstream of the storm drain system, as well as the receiving waters for which these objectives are developed (SWRCB, 1991).

Appendix B also presents plots of post-BMP pollutant concentrations versus storm for the three stations. As in the case with the previous plots, where applicable, the plots include water quality objectives (SWRCB, 1991) for comparison. Again, this comparison is very conservative because of the reasons outlined above. As was the case with the first year's data, pooled mean concentrations of copper, lead, and zinc (Table 5.5) exceeded California Inland Surface Waters Plan water quality objectives based on a Sacramento River hardness value of 59 mg/L as $CaCo_3$.

Comparison to Related Studies

Table 5.6 presents some of the pre-BMP runoff water quality data from this study along with data from recent characterization studies. These studies have focused in whole or in part on vehicle-related sources. The studies vary in sample size (n=4 to 18), sample type (composite, grab), waste stream type (sheet flow runoff, simulated runoff, oil/grit separator water), and activity area (gas stations, fueling islands, oil/grit separators, parking, streets, vehicle service, driveways). So direct comparisons among studies is not possible. However, it does appear that the pre-BMP results from this study are comparable to results from other studies.

[redacted] [redacted]

Table 5.6 Data Comparison - Related Studies

Constituent (ug/l)	Sacramento County 1993 (this study)	WSPA 1993	Maryland DE 1993	Maryland DE 1993	Wisconsin DNR 1992			Pitt & Field 1990		
					Driveways	Parking	Streets	Vehicle Service	Parking	Streets
Aluminum	829	ND	ND	ND	ND	ND	ND	920	1550	4,000
Cadmium	0.7	ND	UND	15.29	0.5	1.0 & 0.6*	0.8 to 3.3**	8	0.72	0.76
Chromium	4.2	ND	5	17.63	2	12 & 5	5 to 23	19	18	3.3
Copper	25.2	200	72	112.63	17	41 & 15	24 to 76	8.3	20	15
Lead	33.4	ND	48	162.38	17	38 & 22	33 to 86	75	30	30
Nickel	4.7	ND	UND	ND	ND	ND	ND	35	40	3
Zinc	379	200 to 600#	373	554	107	304 & 178	220 to 575	67	30	58
Oil & grease (mg/l)	4.6	1 to 34	ND	95.51	ND	ND	ND	ND	ND	ND
TSS (mg/l)	59	10 to ?	ND	ND	173	312 & 58	233 to 763	ND	ND	ND
Number of samples	9 to 18	5	4	7	12	6 & 12	18	4	12 to 13	6
Sample type	Composite	Grab	Composite	Grab	Composite	Composite	Composite	Grab	Grab	Grab
Waste stream type	Sheet flow runoff	Simulated runoff	Water in chambers	Water in chambers	Sheet flow runoff	Sheet flow runoff	Sheet flow runoff	Sheet flow runoff	Sheet flow runoff	Sheet flow runoff
Activity area	Gas stations	Fueling	Oil/grit separator	Oil/grit separator	Residential driveways	Parking	Streets	Vehicle service	Parking	Streets

Studies are referenced in section 9.
UND = undetected; ND = no data.
# = range; * = means of two study areas; ** = range of street types (feeder, collector, arterial).

6.0 *Data Analysis*

This section describes the first and second year's data analysis, including a determination of which distribution plots (normal or log-normal) best fit the data, estimation of mass loads, analysis of station-to-station and pre- to post-BMP differences, evaluation of seasonal trends, and evaluation of high pressure water cleaning.

6.1 Descriptive Statistics

Descriptive statistics (mean, median and standard deviation) for each year for each constituent, for each station individually, and for all three stations combined, are presented in Table 6.1.

Table 6.1 Descriptive Statistics

Pre- and Post-BMP Data Combined

	TSS	O&G	O&G w/NDs	Cd	Cr	Cr w/NDs	Cu	Pb	Zn
Median	45	5.3	5.3	0.535	3.2	3.2	16.5	23	200
Mean	70.42	6.89	6.91	0.75	3.67	3.99	47.93	52.51	364.36
Standard Deviation	56.23	6.40	6.37	0.78	3.43	3.05	91.90	98.40	433.42

Pre-BMP Data Only

	TSS	O&G	O&G w/NDs	Cd	Cr	Cr w/NDs	Cu	Pb	Zn
Median	41	2.35	2.35	0.535	3.5	3.5	20	26	195
Mean	59.33	4.55	4.61	0.66	3.83	4.16	25.22	33.40	379.39
Standard Deviation	39.58	4.66	4.61	0.50	3.22	2.78	21.60	32.09	524.51

Post-BMP Data Only

	TSS	O&G	O&G w/NDs	Cd	Cr	Cr w/NDs	Cu	Pb	Zn
Median	50	6.45	6.45	0.565	3.2	3.2	16	21	285
Mean	81.50	9.22	9.22	0.84	3.52	3.83	70.63	71.61	349.33
Standard Deviation	67.18	7.02	7.02	0.98	3.62	3.29	124.08	132.68	316.48

6.2 Determination of Best Fit Distributions

The initial data analysis step involved testing the runoff water quality data to determine whether the data better fit a normal or log-normal distribution. The data were plotted using both a normal scale and a log scale for the y-axis, in each case plotted with a normal probability distribution for the x-axis. By fitting a regression line to the data plot, it can be determined how well the data fit a normal or log-normal distribution. Only those constituents with four or more detected values at each station were included in this analysis. Those constituents were total suspended solids, oil & grease, cadmium, chromium, copper, lead, and zinc. The analysis was completed for each year of data separately for each gas station, and then for the data from all three stations combined.

As discussed in section 5.2, Sampling Results, non-detected data were replaced with the appropriate values before plotting so that the true number of data points could be used on each plot. In each case the curve-fitting function in Kaleidagraph™ was used to determine the equation of the line that fit the data most closely. Kaleidagraph™ reports an "R" value, which is an indication of how well the line approximates the actual data. Curves with "R" values close to 1.0 fit best.

Plots for Data Grouped by Constituent and Station

For the pre-BMP condition, the log-normal distribution fit the majority of the data best for the individual stations. In the case of cadmium and lead, the log-normal plots had higher "R" values than the normal plots for each sampling location, indicating that the log-normal curves fit best. In the case of chromium, copper, total suspended solids, and zinc, the station Y and Z curves fit best on the log-normal plot, but the curves for X fit slightly better on the normal plot. The station X and Y curves for oil and grease also fit best on the normal plot.

Plots for Data Grouped by Constituent Only (All Stations Combined)

For the pre-BMP data, for each of the seven constituents evaluated, when the data from all three stations were combined, the log-normal curves fit best. Each of the "R" values was greater than 0.93, indicating that the curves fit the data fairly well.

For the post-BMP data, log-normal distributions provided the best curve fits for the combined data sets for all constituents tested.

Assumption of Log-normal Distribution

Based upon the preceding analysis of the distributional characteristics of the data, the log-normal curves best fit the data overall for the constituents examined in this study. The regression analysis (sections 6.5 and 6.6) therefore assumes that the data are generally log-normally distributed. The distribution plots are shown in Appendix C.

6.3 Estimation of Event Mass Loads

For each constituent and station, event mass loads (EMLs) were estimated for each storm event monitored. The EMLs were calculated from the product of the measured pollutant concentration and the estimated runoff flow volume through the gas station monitoring site drainage area. The runoff flow volume for each storm was calculated from the estimated surface area draining to the monitoring site (as described in section 5.1), and the rainfall volume measured at the ALERT system rain gauge nearest the site. The estimated mass loads for the pre-BMP and post-BMP storm events are shown in Tables 6.2 and 6.3.

6.4 Analysis of Station-to-Station Differences and Pre- to Post-BMP Differences

Statistical analyses were conducted to determine whether runoff water quality differed from station-to-station during the study, and whether post-BMP runoff quality differed from pre-BMP runoff quality.

T-tests were used to evaluate the differences in gas station runoff water quality among the stations in each of the two years of the project, and also to evaluate the differences in runoff quality between the pre-BMP and post-BMP conditions. For the station-to-station comparisons, the tests were done by pairs of stations (X:Y, Y:Z, X:Z). A robust form of the paired, two-tailed Student's t-test was used. This test compares the means of two data sets, but does not assume that the variances of the populations from which the data sets are drawn are equal. The paired sample test is appropriate for data sets where the observations are in paired sets, as in this study.

The t-test evaluates the relative difference in mean values between two data sets. The test is set up to test what is called the "null hypothesis"; that is, the hypothesis that there is no significant difference between the two data sets. Technically, the t-test determines the probability of error associated with rejecting the null hypothesis. This is essentially equivalent to the probability of error (known as the "p" value) associated with accepting the hypothesis that there is a significant difference between two data sets.

The key measure produced by the t-test is the probability (p) value. A significant difference is considered to exist between the data sets when the p-value is less than or equal to 0.05, which indicates that the probability of error associated with rejecting the null hypothesis (or with accepting the alternative hypothesis that the data sets are different) is less than five percent.

Table 6.2 Pre-BMP Event Mass Loads

All values in grams

Event	Station	TSS	Oil & Grease	Cadmium	Chromium	Copper	Lead	Zinc
10/29/92		1,719.61	136.56	0.02	0.22	1.52	1.72	34.90
12/6/92		4,105.06	559.78	0.07	0.25	0.97	1.04	18.66
12/10/92	X	4,699.21	21.36	0.08	0.40	0.41	0.73	18.37
1/6/93		8,426.17	350.01	0.03	0.06	0.34	0.53	11.67
3/16/93		2,914.79	659.95	0.04	0.23	1.10	2.97	23.65
3/23/93		1,791.30	89.56	0.03	0.14	0.61	0.71	25.93
10/29/92		3,638.87	167.39	0.03	0.27	1.65	3.64	9.95
12/6/92		1,892.21	283.83	0.03	0.15	1.13	1.02	6.91
12/10/92	Y	913.18	29.46	0.01	0.08	0.18	0.50	1.74
1/6/93		2,789.80	36.39	0.02	0.11	0.46	0.97	4.97
3/16/93		1,247.61	173.28	0.02	0.19	1.56	2.18	4.51
3/23/93		1,802.11	45.05	0.01	0.12	0.90	1.08	4.10
10/29/92		895.94	41.35	0.02	0.25	0.32	0.52	82.70
12/6/92		3,859.43	562.83	0.02	0.12	1.05	1.13	8.04
12/10/92	Z	484.58	43.07	0.01	0.05	0.32	0.38	2.85
1/6/93		2,997.95	206.76	0.04	0.10	0.95	1.55	8.68
3/16/93		1,654.04	179.19	0.02	0.18	1.70	1.47	6.89
3/23/93		3,015.18	86.15	0.03	0.18	6.10	3.59	14.36

Table 6.3 Post-BMP Event Mass Loads

All values in grams

Event	Station	TSS	Oil & Grease	Cadmium	Chromium	Copper	Lead	Zinc
11/29/93		2,430.63	364.59	0.06	0.28	0.97	2.75	21.88
12/11/93		1,015.46	415.42	0.01	0.07	0.23	0.16	8.08
1/24/94	X	5,735.30	638.05	0.07	0.27	0.93	1.43	31.54
2/6/94		2,306.89	286.22	0.01	0.06	0.21	0.12	7.26
2/17/94		1,603.72	188.26	0.02	0.11	0.35	0.49	13.25
3/6/94		1,546.76	360.91	0.01	0.10	0.40	0.55	10.66
11/29/93		1,840.23	398.72	0.04	0.14	1.30	1.38	11.50
12/11/93		2,336.67	101.76	0.01	0.03	0.60	0.49	3.13
1/24/94	Y	3,274.98	354.79	0.03	0.16	1.58	2.67	8.19
2/6/94		1,092.96	214.82	0.00	0.03	0.49	0.41	3.17
2/17/94		1,202.13	71.48	0.01	0.03	0.27	0.42	1.33
3/6/94		1,663.48	155.95	0.02	0.10	3.64	0.97	7.90
11/29/93		5,155.96	847.05	0.15	0.48	10.31	25.78	52.79
12/11/93		4,040.34	331.89	0.02	0.19	1.06	1.59	9.62
1/24/94	Z	18,004.93	337.59	0.03	0.10	1.05	1.35	11.25
2/6/94		1,998.63	387.24	0.01	0.16	1.00	1.37	6.25
2/17/94		2,253.49	220.11	0.04	0.13	7.34	3.67	18.87
3/6/94		5,294.51	614.16	0.10	0.30	9.74	12.28	29.65

Station-to-Station Differences - Pre-BMP Monitoring

The t-test p-values produced by the station-to-station comparisons of runoff pollutant concentrations for the pre-BMP condition (1992-93 monitoring) are shown in Table 6.4. In two instances, the p-value was small enough (<0.05) to warrant further investigation. The variances for these two instances were very large in comparison to the means, however, which indicates that the difference was likely an artifact rather than a significant difference. All of the other values indicate no statistically significant differences among the gas stations for the baseline monitoring, using the log-transformed values. These results allowed the data to be "pooled" or combined into a larger data set for evaluations of rainfall-related effects, and allowed the pooling of the data from the three stations in the pre-BMP analyses.

Table 6.4 p-Value Matrix; Paired t-tests
Pre-BMP (1992/93) Concentration Data

	Station Group		
Constituent	X/Y	Y/Z	X/Z
Total suspended solids	0.542	0.434	0.101
Oil & grease	0.232	0.936	0.112
Cadmium	0.349	0.345	0.155
Chromium	0.938	0.029	0.365
Copper	0.116	0.960	0.423
Lead	0.259	0.328	0.865
Zinc	0.002	0.329	0.884

Station-to-Station Differences - Post-BMP Monitoring

The t-test p-values produced by the station-to-station comparisons of runoff pollutant concentrations for the post-BMP condition (1993-94 monitoring) are shown in Table 6.5. As with the pre-BMP monitoring data, the t-test results indicate that no significant differences can be determined in post-BMP runoff water quality from one station to another. No p-values below 0.05 were obtained from the comparisons of the various station pairs. These results allowed the data to be "pooled" or combined into a larger data set for evaluations of rainfall-related effects, and allowed the pooling of the data from the three stations in the post-BMP analyses.

Table 6.5 p-Values; Paired t-tests Post-BMP (1993/94) Concentration Data*			
	Station Group		
Constituent	**X/Y**	**X/Z**	**Y/Z**
TSS	0.357	0.143	0.085
Oil and Grease	0.265	0.684	0.468
Cadmium	0.832	0.321	0.243
Chromium (ND values replaced)	0.894	0.441	0.307
Copper	0.274	0.167	0.164
Lead	0.200	0.172	0.225
Zinc	0.102	0.677	0.129

Table 6.6 p-Values; Paired t-tests Post-BMP (1993/94) Event Mass Data*			
	Station Group		
Constituent	**X/Y**	**X/Z**	**Y/Z**
TSS	0.347	0.100	0.107
Oil and Grease	<u>0.032</u>	0.498	<u>0.024</u>
Cadmium	0.108	0.184	0.063
Chromium (ND values replaced)	<u>0.032</u>	0.226	<u>0.042</u>
Copper	0.169	0.054	0.074
Lead	0.708	0.126	0.157
Zinc	<u>0.028</u>	0.445	<u>0.050</u>

* These values are the two-tail p-values from the paired t-tests performed on data for each pair of stations in the study. Each value represents the probability of error in accepting the hypothesis that there is a significant difference in the samples taken at two different gas stations.

Table 6.7 p-Values; Paired t-tests Pre-BMP (1992/93) Concentrations vs. Post-BMP (1993/94) Concentrations				
	Station			
Constituent	X	Y	Z	All
TSS	0.305	0.732	0.160	0.316
Oil and Grease (ND values replaced)	0.257	0.326	0.282	<u>0.045</u>
Cadmium	0.278	0.895	0.254	0.541
Chromium (ND values replaced)	0.342	0.614	0.494	0.770
Copper	0.313	0.453	0.172	0.121
Lead	0.390	0.798	0.185	0.259
Zinc	0.260	0.601	0.867	0.835

For the post-BMP monitoring, the EMLs were also tested for station-to-station differences. Significant differences were observed both between stations X and Y, and between stations Y and Z, for chromium, zinc, and oil and grease (see Table 6.6).

Pre-BMP to Post-BMP Differences

The lack of statistically significant differences in pollutant concentration data among the three stations for both years permits grouping of the data from the three stations in the pre- and post-BMP analyses, as well as use of the combined data sets in evaluations of rainfall-related effects for each year.

T-tests were again used to compare the pre-BMP monitoring results to those of the post-BMP conditions. The tests were run for each station individually and for data from the three stations combined, in each case comparing the pre-BMP data to the post-BMP data. The comparisons were done for both concentrations and mass loadings.

The results of the concentration data comparisons are shown in Table 6.7. A significance level of p=0.05 was again used to determine whether statistically significant differences exist. The only statistically significant difference in the pre- to post-BMP comparisons was found in the combined stations data sets for oil and grease. For the EML comparisons (Table 6.8), no statistically significant differences were found between the pre- and post-BMP data. This indicates that, generally speaking, gas station runoff quality was not significantly different before and after implementation of BMPs. A complete set of the paired t-test results is presented in Appendix D.

Table 6.8 p-Values; Paired t-tests
Pre-BMP (1992/93) Masses vs. Post-BMP (1993/94) Masses

	Station			
Constituent	X	Y	Z	All
TSS	0.233	0.826	0.217	0.498
Oil and Grease (ND values replaced)	0.659	0.297	0.130	0.069
Cadmium	0.324	0.778	0.178	0.531
Chromium (ND values replaced)	0.123	0.111	0.093	0.443
Copper	0.176	0.601	0.093	0.110
Lead	0.510	0.458	0.182	0.248
Zinc	0.173	0.775	0.908	0.508

6.5 Evaluation of Seasonal Trends

Regression analysis was used to evaluate the effects of precipitation patterns on gas station runoff chemistry for each of the two study years. A regression analysis provides an evaluation of the best-fit line drawn through a data plot. The "p" value indicates the likelihood that the observed relationship is due to chance. A p-value of ≤ 0.05 is generally considered to indicate a statistically significant relationship. The "r" value indicates the relative "goodness of fit", or strength of the relationship. An r value of 1 equals a perfect positive correlation between the data points; -1 equals a perfect negative correlation.

For the pre-BMP data, regressions were performed on the runoff concentration data vs. four rainfall parameters: rainfall intensity during the period of sampling, cumulative precipitation to date, days since last storm of 0.1" or greater, and days since last storm of 0.25" or greater.

For the post-BMP runoff concentration data, additional precipitation parameters were added: sampled storm depth (volume), intensity of storm (overall intensity during the entire storm event, from the ALERT rain gauge data), and elapsed rainfall before start of sampling. For the post-BMP event mass data, regressions were run on a smaller subset of precipitation parameters: cumulative precipitation to date, and days since last storm of 0.25" or greater.

The regressions were run for each station individually and for the combined stations data set. The log-transformed pollutant concentration values were used in all cases.

Pre-BMP Concentration Data

The statistically significant regression relationships for the pre-BMP data are shown in Table 6.9. The highest number of statistically significant regression relationships ($p \leq 0.05$) was found with the "days since last storm >0.25 inch" parameter. Four different constituents at station Y (chromium, lead, zinc, and TSS) and one constituent at station Z (zinc) were significantly correlated with this parameter. For the pooled data set (all stations combined), chromium and zinc were again significantly correlated with this parameter, although the r values were relatively low.

For the "days since last storm >0.10 inch" parameter, the station X regression of cadmium concentration was statistically significant, and had a fair r value, but the slope is negative, indicating that cadmium concentration decreases as the inter-event time gets longer, which is counterintuitive. It is likely that this result was an artifact due to chance. The pooled zinc data set was positively correlated with days since last storm >0.10 inch, although the r value was marginal.

At station Z, cadmium, lead, and zinc showed decreasing concentrations in relation to increasing rainfall intensity, which is plausible due to the diluting effect of more intense rainfall. For the pooled data set, oil and grease showed a similar inverse relationship to intensity, but the r value was weak.

Overall, the regressions of pre-BMP runoff concentrations versus rainfall parameters indicated that zinc (and possibly other metals) appeared to exhibit a build-up effect during dry periods at the fueling stations. Zinc concentration tended to decrease as the inter-event time decreased.

Table 6.9 Significant* Regressions
Rainfall Parameters vs. Concentrations**
Pre-BMP (1992/93) Monitoring

Station	Independent Variable	Dependent Variable**	"r" value
Y	Days Since Last Storm >0.25"	Chromium	0.84
Y	Days Since Last Storm >0.25"	Lead	0.88
Y	Days Since Last Storm >0.25"	Zinc	0.84
Y	Days Since Last Storm >0.25"	TSS	0.94
Z	Days Since Last Storm >0.25"	Zinc	0.93
Pooled	Days Since Last Storm >0.25"	Chromium	0.50
Pooled	Days Since Last Storm >0.25"	Zinc	0.65
X	Days Since Last Storm >0.10"	Cadmium	-0.82
Pooled	Days Since Last Storm >0.10"	Zinc	0.49
Z	Rain Intensity	Cadmium	-0.96
Z	Rain Intensity	Lead	-0.96
Z	Rain Intensity	Zinc	-0.93
Pooled	Rain Intensity	Oil & Grease	-0.54

* = $p < 0.05$
** = log-transformed concentrations
Pooled = Combined data from all stations

Table 6.10 Regression p-Values (Post-BMP)

Concentrations

		Cumulative Precipitation to Date	Sampled Storm Depth	Days Since Last Storm > 0.1"	Days Since Last Storm > 0.25"	Intensity of Storm	Intensity During Sampling	Elapsed Rainfall Before Start of Sampling (in.)	Days Since Last Cleaning
Log(TSS)	***X***	0.1103	0.4896	0.1886	0.6909	0.4444	0.7692	0.1718	0.9969
	Y	0.2697	0.0597	0.3056	0.7321	0.2022	0.9972	**0.0174**	0.9515
	Z	0.5125	0.3946	0.4381	0.7572	0.5205	0.9441	**0.0325**	0.7092
	All	0.0649	**0.0339**	0.0663	0.5144	0.0814	0.8208	**0.0002**	0.7225
Log(O&G) w/NDs	***X***	0.5161	0.1186	0.2646	0.6480	0.2190	0.6564	**0.0387**	0.6438
	Y	0.5560	0.4440	0.3036	0.3841	0.6970	0.7292	0.5601	0.1719
	Z	0.4010	0.3102	**0.0185**	**0.0301**	0.9382	0.0824	0.5521	0.4701
	All	0.1581	**0.0419**	**0.0065**	**0.0424**	0.3347	0.4158	0.0661	0.2716
Log(Cd)	***X***	0.8448	0.5016	0.7631	0.5149	0.4218	0.3148	0.5219	0.2005
	Y	0.6521	0.5450	0.3988	0.3354	0.8459	0.7577	0.4460	0.1565
	Z	0.5223	0.6106	0.1429	**0.0405**	0.8763	0.3971	0.6570	0.3249
	All	0.3630	0.6338	0.0747	**0.0197**	0.7761	0.7500	0.2161	**0.0199**
Log(Cr) w/NDs	***X***	0.8021	0.8168	0.5073	0.4131	0.9546	0.7840	0.1533	0.5075
	Y	0.6004	0.3965	0.2983	0.3654	0.7170	0.8315	0.3202	0.2258
	Z	0.5153	0.3644	0.0518	**0.0276**	0.9081	**0.0392**	0.7521	0.6132
	All	0.3268	0.1963	**0.0264**	**0.0247**	0.8257	0.6968	0.1012	0.1122
Log(Cu)	***X***	0.6899	0.8122	0.3435	0.2766	0.9624	0.7645	0.1669	0.3769
	Y	0.3235	0.2144	0.0914	0.1959	0.4657	0.7271	0.2557	0.3623
	Z	0.3454	0.5407	0.1301	**0.0365**	0.9403	0.2945	0.9371	0.5180
	All	0.1762	0.1760	**0.0211**	**0.0171**	0.5163	0.4651	0.2725	0.1964
Log(Pb)	***X***	0.9029	0.5647	0.7351	0.3467	0.3970	0.4848	0.5808	0.1370
	Y	0.4545	0.2792	0.3979	0.5548	0.5129	0.6343	0.2344	0.3422
	Z	0.6796	0.8260	0.1639	**0.0115**	0.6139	0.3024	0.9301	0.2417
	All	0.5688	0.6648	0.1307	**0.0357**	0.7680	0.9682	0.4358	**0.0480**
Log(Zn)	***X***	0.4276	0.5366	0.3879	0.5603	0.6730	0.8652	0.0529	0.8553
	Y	0.5956	0.4430	0.2074	0.2352	0.7733	0.9900	0.4260	0.1765
	Z	0.4890	0.5753	0.1400	**0.0395**	0.9116	0.3483	0.7036	0.3931
	All	0.2344	0.2870	**0.0290**	**0.0222**	0.8112	0.8248	0.1406	0.1071

Note: p-values below 0.05 are shaded and **bold**.

Post-BMP Concentration Data

The regression results for the concentration data are shown in Table 6.10. The statistically significant regression relationships are indicated by shading. Plots of the significant regressions are presented in Appendix E. There were several significant relationships but, as was the case with the pre-BMP data, the highest number of statistically significant regression relationships ($p \leq 0.05$) was found with the "days since last storm >0.25 inch" parameter. All five metal constituents and oil & grease, both at station Z and for the pooled data set (all stations combined), were significantly correlated with this parameter. Only TSS did not show any significant correlation with the "days since last storm >0.25 inch" parameter.

Concentrations of three of the five metals and oil & grease, in the pooled data set, were also significantly correlated with the "days since last storm >0.10 inch" parameter. Pooled data set concentrations of TSS showed statistically significant regression relationships with two parameters, elapsed rainfall before start of sampling and sampled storm depth. Both these parameters relate to volume of the sampled storm.

Post-BMP Event Mass Load Data

The regression results for the event mass load data are shown in Table 6.11. The statistically significant regression relationships are indicated by shading. Plots of the significant regressions are presented in Appendix F. In contrast to the post-BMP concentration data, there were no statistically significant regression relationships with the parameter "days since last storm of 0.25" or greater."

6.6 Evaluation of Effects of Mobile Cleaning

Despite the result, discussed in pre- to post-BMP Differences (section 6.4) that, overall, gas station runoff quality was not significantly different after implementation of BMPs, there were statistically significant regression relationships ($p \leq 0.05$) between both the post-BMP concentration and event mass load data, and the "days since last cleaning" parameter. The pooled concentration data set for two metals, cadmium and lead, showed a significant correlation with "days since last cleaning." The event mass load data showed a number of statistically significant regression relationships with the "days since last cleaning" parameter. The pooled data sets for three metals (cadmium, chromium, and zinc) and oil & grease showed that the event mass loads of these constituents decreased with decreasing number of days since last cleaning.

Table 6.11 Regression p-Values (Post-BMP)

Event Mass Loadings

Constituent	Station	Cumulative Precipitation to Date	Days Since Last Storm > 0.25"	Days Since Last Cleaning
TSS	X	0.7658	0.4513	0.5112
	Y	0.5454	0.3378	0.8371
	Z	0.8233	0.5012	0.5805
	All	0.7037	0.3187	0.4481
O&G w/ NDs	X	0.5140	0.4863	0.6343
	Y	0.2371	0.9747	0.0613
	Z	0.4292	0.1619	**0.0219**
	All	0.1679	0.5502	**0.0169**
Cd	X	0.3253	0.7476	0.1647
	Y	0.2985	0.7547	**0.0301**
	Z	0.5579	0.1510	**0.0402**
	All	0.2249	0.2727	**0.0069**
Cr w/ NDs	X	0.2471	0.8642	0.1221
	Y	0.6132	0.7392	**0.0447**
	Z	0.3543	0.1961	0.0927
	All	0.1374	0.3442	**0.0087**
Cu	X	0.2864	0.9401	0.0903
	Y	0.4059	0.0854	0.2210
	Z	0.8915	0.0635	0.2028
	All	0.7823	0.0757	0.1462
Pb	X	0.1708	0.8207	0.0532
	Y	0.7035	0.7094	0.2837
	Z	0.4141	0.1994	**0.0458**
	All	0.3274	0.2335	0.0516
Zn	X	0.4824	0.5991	0.3023
	Y	0.4341	0.4368	**0.0065**
	Z	0.4766	0.2153	0.0616
	All	0.2818	0.3637	**0.0194**

Note: p-values below 0.05 are shaded and **bold.**

R0009004

7.0 *Discussion and Recommendations*

This section discusses the results of Phase 1 and Phase 2 and makes recommendations for further research.

7.1 Discussion

One of the goals of the project was to compare pre-BMP data to post-BMP data for a quantitative evaluation of BMP effectiveness. As discussed in section 4, Best Management Practices, the project team implemented the full suite of BMPs at each station, as opposed to implementing one BMP at each station. The presumption was that the combined effect of the suite of best management practices would increase the likelihood of reducing pollutants, thereby producing more statistically significant results.

Based on observations by project personnel and best professional judgment about the efficacy of source controls, it is highly likely that of the six BMPs implemented at the gas stations, the one BMP with the most significant chance to affect runoff quality was mobile high pressure water cleaning. The combined effect of the other five source controls:

public notices,
litter control,
storm drain stenciling,
spill cleanup materials, and
employee awareness,

seems likely to have a much less significant impact on the primary sources of pollution at the stations, namely, high volume vehicle traffic and leaks and spills of vehicle fluids. In addition, some of the other source controls (litter control, spill cleanup, and employee training) were in place, to some extent, during the pre-BMP period. Consequently, the study can be considered in large part a pilot test of mobile cleaning as a best management practice. The discussion of BMP effectiveness therefore focuses on mobile cleaning.

Climatological Differences

In discussing the differences between the pre-BMP and post-BMP data, it is important to note the large difference in the climatology of the two wet seasons. In 1993-94 (post-BMP), about half as much rain fell compared to the pre-BMP wet season (1992-93) (approx. 13 inches versus approx. 26 inches). Because 1992-93 (pre-BMP) was a relatively wet year in California, with frequent storms occurring on a regular basis throughout the winter, the inter-event times were fairly short, ranging from 1 to 8 days. The inter-event times in 1993-94 reflected the drier winter, ranging from 1 to 34 days. Average inter-event time for pre-BMP sampling events was four days, compared to over nine days for post-BMP samples. As discussed below, both pre-BMP and post-BMP runoff quality was significantly affected by the inter-event time period (number of days since last storm).

Research by others including Pitt (1987), indicates that rain depth and intensity significantly affect particulate residue washoff from impervious surfaces. Normal rains, up to about one inch, typically remove only about 10-20 percent of the particulate residue on a surface. So it is possible that during the post-BMP wet season, when total rainfall was one-half of the pre-BMP wet season, that relatively less particulate residue was washed off the asphalt surfaces at the gas stations by storm events.

Summary of Pre-BMP to Post-BMP Differences

When all the data from the pre-BMP condition is combined and compared against all the post-BMP condition data, the only statistically significant difference in the pre- to post-BMP concentrations was for oil and grease, and it was higher after the BMPs were implemented. For the event mass loading comparisons, no statistically significant differences were found between the pre- and post-BMP data. This indicates that, generally speaking, gas station runoff quality was not significantly different before and after implementation of BMPs.

However, these results must be interpreted in light of the sample size data variability and climatological effects, as follows:

1. Although the sample size for both years (n=18, 3 stations x 6 storms) is reasonable, given the logistical challenges of storm water monitoring; statistically, it is a relatively small sample size, particularly considering the inherently large variability in storm water data.

2. A review of the data from both years (Tables 5.4 and 5.5) confirms the high degree of variability in the pooled data. Standard deviations were generally as large as the means.

Effects of Climatology on Pre-BMP and Post-BMP Concentration Data

Overall, the regressions of pre-BMP runoff concentrations versus rainfall parameters indicated that zinc (and possibly other metals) appeared to exhibit a buildup effect during dry periods at the fueling stations. Zinc concentration tended to decrease as the inter-event time decreased. Similarly, for post-BMP data, the highest number of statistically significant regression relationships ($p \leq 0.05$) was found with the "days since last storm >0.25 inch" parameter (all five metal constituents and oil & grease), and with the "days since last storm >0.10 inch" parameter (three of the five metals and oil & grease).

This buildup or accumulation effect has been documented in other studies (U.S. EPA, 1979; U.S. EPA, 1985; Pitt and McLean, 1986) for particulates. It appears from this study that many of the heavy metals and oil & grease exhibit a similar effect. These data also seem to indicate that the accumulation of these pollutants translates into higher concentrations in the runoff, that is, that what accumulates tends to wash off.

For the post-BMP data, the only constituent that did not show any significant correlation with either of the "days since last storm" parameters was TSS. The concentration of total suspended solids in runoff did not increase with increasing time between significant storms. The potential explanations for this result are discussed below in relation to the effects of mobile cleaning.

Effects of Mobile Cleaning on Concentration and Mass Load Data

Although overall gas station runoff quality was not significantly different after implementation of BMPs, the length of time between cleanings and sampled storm events seems to have affected runoff quality. There were statistically significant regression relationships ($p \leq 0.05$) between both the post-BMP concentration and event mass load data for some metals and oil & grease, and the "days since last cleaning" parameter. This result appears to parallel the correlations found between the post-BMP concentration data and the "days since last storm" parameters. It seems that, in general, measured runoff concentrations for some metals and oil & grease increase with increasing time since the previous "washoff" event, whether that event was natural (storm) or artificial (cleaning).

In contrast to metals and oil & grease, the post-BMP concentrations and event mass loads of total suspended solids in runoff did not increase with increasing time between cleanings. Again, this result appears to parallel the correlations found between the post-BMP TSS concentration and load data and the "days since last storm" parameters. There are a couple of potential explanations for these results in relation to the effects of mobile cleaning.

One potential reason that post-BMP TSS concentrations and loads did not increase with increasing time between either storms or cleanings is that the cleanings were effective at removing available particulate residue and possibly even reducing the total residue lodged in the spaces of the asphalt surface. It is possible that the cleanings were much more effective at removing TSS, which did not exhibit a buildup effect, than in removing oil & grease and heavy metals, which did show an accumulation effect. It is likely that oil & grease have a strong affinity for asphalt surfaces because of the similarities in their chemical composition. This affinity would make the separation of oil & grease from asphalt difficult, even under the high pressure and temperature conditions created by the cleanings. As for the heavy metals, although they have been shown to be bound to particulates, it is likely that a significant amount of metals are also bound to oil & grease.

Another potential reason that post-BMP TSS data did not correlate with the "days since last ..." parameters may relate to the fact that the post-BMP concentrations of TSS showed statistically significant regression relationships with two completely different parameters than the other constituents: elapsed rainfall before start of sampling and sampled storm depth. Both these parameters relate to volume of the sampled storm. This result is consistent with the research of Pitt (1987), discussed previously, that indicates that rain depth and intensity significantly affect residue washoff from impervious surfaces, and that the accumulation of particulates on paved surfaces does not necessarily translate into those particulates being washed off by storm runoff. This study's results may indicate that, when total rainfall was significantly reduced during the post-BMP wet season, very little particulate residue was washed off the asphalt surfaces at the gas stations by storm events.

The point could be made that although total rainfall was significantly reduced during the post-BMP wet season, it would seem that the ten mobile cleanings that took place during this time would have, in a sense, "made up for" the lower frequency and volume of storms, and washed off much of the particulates. However, the timing of the cleanings was such that they may have had little impact on TSS buildup. Although the mobile cleanings occurred interspersed throughout the wet season (see Figure 5.4), only the last two mobile cleanings occurred after a significant storm (greater than 0.1 inch) and before the sampled storm (#6), and therefore, shortened the number of days, and presumably the TSS accumulation, since a significant event, either storm or cleaning.

Effectiveness of Mobile Cleaning

Although visual observations (see Figure 4.3) confirmed that a significant amount of pollutants were removed with each cleaning, it is likely that the cleanings may have made more pollutants, particularly oil & grease, "available" for washoff in the next event, either storm or cleaning, by freeing up pollutants and allowing them to redeposit on the pavement surface. There are several reasons for this observation.

1. Pollutant deposition - The asphalt at gas stations, particularly the high sales volume stations used in this study, is subject to very high pollutant deposition rates. The sources include not only the vehicles themselves traveling over the surface for routine services (e.g., fueling), but episodic sources like fluid spills in the air/water supply area, and local sources like the resuspension and deposition of airborne pollutants from vehicles stopping at the intersections and traveling on the major streets adjacent to the stations. The net effect is an essentially continuous deposition of pollutants at such locations. The cleaning effort may not have been sufficient for the level of pollutant deposition occurring at the gas stations.

2. Surface texture - Asphalt is a relatively rough and porous surface. Because of its texture, it has innumerable miniature storage spaces that receive and detain pollutants as they are deposited on its surface. These spaces act as pollutant sources when it rains or when the surface is cleaned. The ability of high pressure cleaning to efficiently remove pollutants from porous surfaces is questionable.

3. Pollutant buildup - A relatively long-term buildup of pollutants may have occurred on the outside pavement surfaces of these stations because of the significantly reduced volumes of rain that fell during the six year drought period preceding the study. In addition, because of drought restrictions, the use of water to clean asphalt surfaces at these stations was prohibited by local ordinance during much of this period. The high pressure cleanings may have loosened up the long-term buildup of pollutants which otherwise would not have been available for washoff during normal rainfall conditions.

4. Water accumulation before runoff - Because of the innumerable miniature storage spaces in asphalt, a significant amount of water must fall, in the case of a storm, or be applied, in the case of a cleaning, before these spaces are "filled" and runoff occurs. Observations by the mobile cleaning crew confirmed that the asphalt had to be wetted first before actual cleaning could start. This phenomena means that when cleaning time is restricted, as it was at the stations because of high traffic volumes, it is difficult to tell if the spray application rate is sufficient to overcome the necessary wetting and create a constant sheet flow toward the wash water collection device.

5. Incomplete washoff after cleaning - The mobile cleaning crew reported that although visual observations indicated that the cleanings removed a significant amount of pollutants, they also probably left behind a significant amount for a couple of reasons:
   a) The asphalt seemed to contain more pollution than the crew had time to remove.
   b) The limited coverage of the cleaning wand meant that even when the crew was able to remove significant quantities of the pollutants from the asphalt and suspend them in the sheet flow, as soon as the wand was moved to another area, pollutants started settling out of the sheet flow back into the asphalt, resulting in a redistribution rather than removal of some pollutants.

   It's likely that some of the pollutants left behind or redistributed were previously not available to be washed off, but were made available by mobile cleaning to be washed off in the next significant storm.

All-in-all, it appears that this pilot test of mobile cleaning asphalt surfaces, at high sales volume gas stations, near busy intersections on major streets, was probably a worst case scenario for this potential best management practice. The cost of mobile cleaning used by the fueling stations for this study was estimated to be about $600 per station per wash down, which is equivalent to $1,300 per acre of paved surface. Therefore, the cost of mobile cleaning a significant portion of the areas in a watershed exposed to vehicle traffic, on a regular basis, would be quite high.

Because the results were inconclusive, this study cannot recommend the implementation of the mobile cleaning BMP on a large scale. However, field observations and study results seem to indicate that, given the right conditions, mobile cleaning may have the potential to remove sources of storm water pollution. The discussion below provides some ideas on the focus of future studies.

7.2 Recommendations for Conduct of Future Studies

Monitoring results for the pre- and post-BMP study showed that constituent concentrations in runoff from the fueling stations are similar to those found in storm water monitoring data on streets, parking lots, driveways, oil/grit separators, and other areas that have significant exposure to vehicle traffic. In this study, the potential for interference with gas station activities and the resulting disruption to business constrained implementation of mobile cleaning. Because runoff from other areas significantly exposed to vehicles is likely to be representative of gas stations, it may be more appropriate to conduct future investigations of source control effectiveness on paved surfaces exposed to vehicle traffic that are not subject to the logistical constraints at high volume fueling stations. The discussion below is intended to provide insight on how to improve investigations of BMP effectiveness.

Existing Source Controls

Because existing source controls such as spill cleanup, litter control ,and employee education were being implemented at the fueling stations on a regular basis in the pre- and post-BMP study periods, their effectiveness could not be quantified. However, their ability to prevent potential sources of contamination is high and should be emphasized in all commercial and industrial areas where outdoor spills may occur.

New Construction Source Controls

Methods of source control not used in this study because of the high costs of retrofit include those that could normally be built as part of new facility construction. These BMPs include isolating runoff, redirecting runoff from areas with high pollution potential, or substituting cement for asphalt because it is easier to clean. Many of these best management practices may be cost-effective over the long-term in reducing storm water pollution.

Further Study of Mobile Cleaning

In this study, the potential for interference with gas station activities precluded extensive quantitative monitoring of the mobile cleaning method itself. Application rates varied over the drainage areas because of traffic, operator judgment, and time constraints. To reduce variability, a controlled application could be done by monitoring the amount and rate of application of high pressure/high temperature water. Other parameters to monitor might be use of soaps and detergents, use of different cleaning apparatus, and application on different pavement surfaces (e.g., cement concrete).

Because of the high cost of mobile cleaning, its practical use may be limited to spot cleaning specific areas with evidence of spills or staining such as behind restaurants, around vehicle service areas, and on heavily stained areas of parking lots. The important elements of mobile cleaning are that it be preventative and that the wash water be collected and disposed of properly.

Improvement in Pre- and Post-BMP Study Design

One of the advantages of this study's two-year time frame was that it allowed ample time after the pre-BMP monitoring to select and implement best management practices before the post-BMP monitoring began. The disadvantages of this time span were that climatological and site conditions changed between the pre-BMP and post-BMP monitoring. One alternative to this method is to conduct the study in the same wet season by monitoring a large number of vehicle traveled areas and service facilities of similar characteristics for the first few storms to verify that the data can be pooled, and then to implement the BMPs at some sites for the remaining storms to achieve a direct comparison on a per storm basis. This method may reduce climatological differences and differences in sites that occur from year to year. However, it would be necessary to statistically account for the effects of seasonal variation on runoff quality.

Use of Larger Watershed Treatment Controls

This study has attempted to demonstrate the effectiveness of BMPs, and source controls in particular, in reducing pollutant loadings from gasoline fueling station runoff. It is clear from this study and others that it is not just gas station runoff, but runoff from any area where vehicles travel, park, or are serviced that is of concern. Unfortunately, this description includes most of the area in urban watersheds and much of the area in suburban watersheds. The success and the practicality of implementing all but the most restrictive source controls (e.g., product reformulations - unleaded gasoline) over such a large area is questionable. In addition, measuring the effectiveness of less restrictive source controls is complicated by the inherent variability in runoff data. As a result, regional treatment such as detention basins, which have been used successfully elsewhere, may warrant a closer look in California.

8.0 Public Participation

This section describes the public participation process for the project. One of the goals of the project is to disseminate the results to a wide audience. To effect this goal, three presentations were made as part of the Phase 1 effort. The first presentation was an open house hosted by Sacramento County, a second presentation was made to WSPA at the beginning of the project, and, near the end of Phase 1, a third presentation was made to the American Public Works Association (APWA) California Stormwater Quality Task Force, a consensus building group of about 100 representatives from regulatory agencies, municipalities, industry, construction, and consulting firms.

A final presentation was made after Phase 2, also to the APWA California Stormwater Quality Task Force. Members of the project team presented preliminary results from the analysis of the post-BMP data as part of a larger presentation on monitoring results from a number of projects statewide, including the WSPA study of gas stations and parking lots (WSPA, 1993).

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Appendix A

Distributional Method to Determine Non-detect Values

Distributional Method to Determine Non-detect Values

Example: Chromium concentration at station Z, December 10, 1992 and January 6, 1993.

1. Assign ranks to each of the results in ascending order of concentration, beginning with the two non-detected values. The first non-detected value was rank one and the greatest concentration (7.4 ug/L) was assigned a rank of 6.

2. Assign probabilities to each value in the data set using the Hazen (1930) method:

   $p_i = (i - 0.5 / n) * 100\%$

   where i is the rank of the given data point, p_i is the probability assigned to the i^{th} data point, and n is the number of data points.

3. Create a probability plot with the percent probability along the x-axis and the concentration on a log scale along the y-axis.

4. Using the curve fitting function of Kaleidagraph™, generate an exponential curve that closely matches the actual data curve:

   concentration = $2.6757e^{0.69726z}$

   where z is the standard normal deviate, or Z-statistic, corresponding to the specific cumulative probability (in percent).

5. Use the equation just derived, calculate values for the same probabilities as the original data points. The points with 8.33% and 25.00% probability correspond to the on-detected values.

6. The calculated values for the non-detects were 1.02 ug/L and 1.67 ug/L. These values were higher than the analytical detection limit, indicating a data gap between the detected values and the non-detected values.

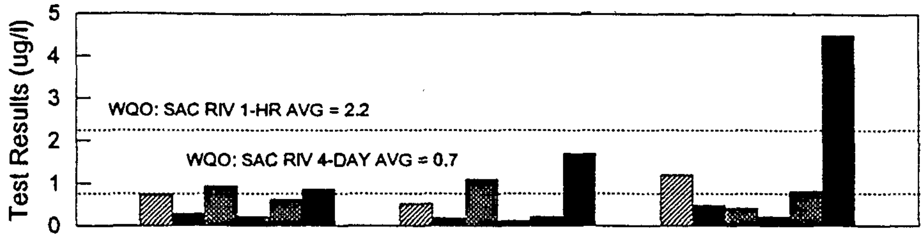
7. Replace the non-detected values with the detection limit. (1.0 ug/L) since the values calculated to replace the non-detected values were actually slightly greater than the detection limit.

Appendix B

Post-BMP Data Plots

CADMIUM

Gas Station Stormwater Runoff Sampling

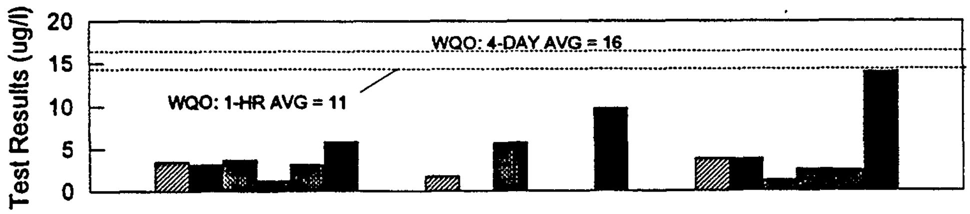


	Station X	Station Y	Station Z
▨ 29-Nov	0.73	0.52	1.2
■ 11-Dec	0.28	0.19	0.48
■ 24-Jan	0.92	1.1	0.42
■ 06-Feb	0.21	0.12	0.22
■ 17-Feb	0.61	0.21	0.81
■ 08-Apr	0.85	1.7	4.5

Note: Method Detection Limit for Cadmium is 0.10 ug/l

CHROMUIM

Gas Station Stormwater Runoff Sampling

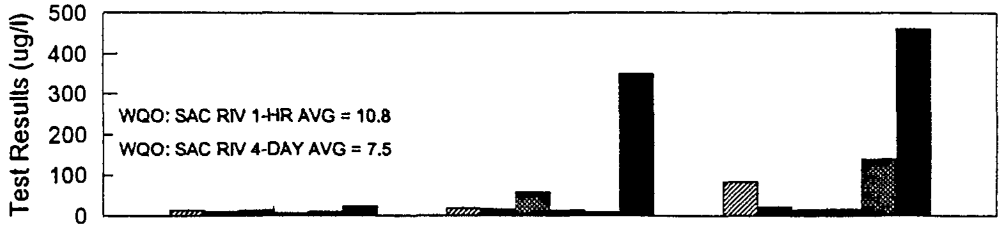


	Station X	Station Y	Station Z
▨ 29-Nov	3.5	1.8	3.9
■ 11-Dec	3.2	ND	3.9
■ 24-Jan	3.7	5.7	1.3
■ 06-Feb	1.3	ND	2.6
■ 17-Feb	3.2	ND	2.5
■ 08-Apr	5.9	9.8	14

Note: Method Detection Limit for Chromium is 1.0 ug/l

COPPER

Gas Station Stormwater Runoff Sampling

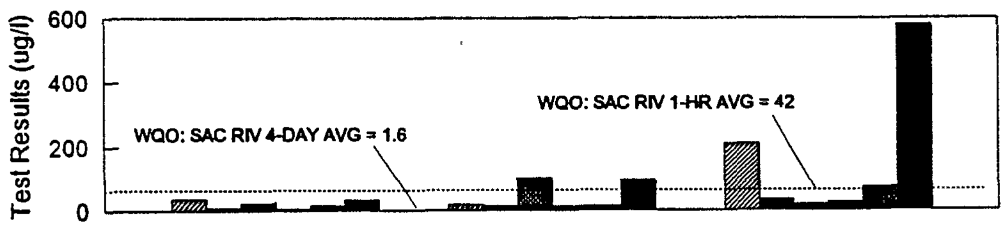


	Station X	Station Y	Station Z
29-Nov	12	17	84
11-Dec	10	16	22
24-Jan	13	58.0	14.0
06-Feb	5	13	16
17-Feb	10	8.4	140
08-Apr	23	350	460

Note: Method Detection Limit for Copper is 1.0 ug/l

LEAD

Gas Station Stormwater Runoff Sampling

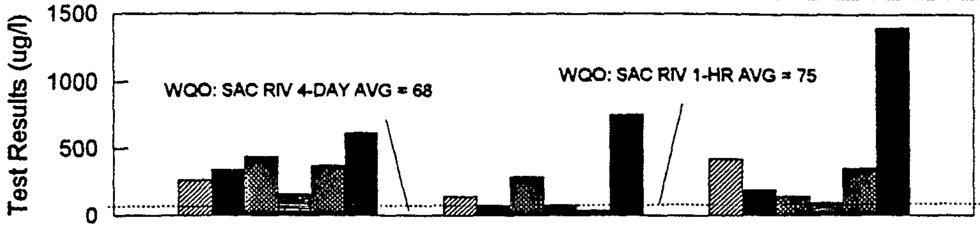


	Station X	Station Y	Station Z
29-Nov	34	18	210
11-Dec	7.1	13	33
24-Jan	20	98	18.0
06-Feb	2.9	11	22
17-Feb	14	13	70
08-Apr	32	93	580

Note: Method Detection Limit for Lead is 1.0 ug/l

ZINC

Gas Station Stormwater Runoff Sampling



	Station X	Station Y	Station Z
29-Nov	270	150	430
11-Dec	350	83	200
24-Jan	440	300	150
06-Feb	170	84	100
17-Feb	380	41	360
08-Apr	620	760	1400

Note: Method Detection Limit for Zinc is 1.0 ug/l

TOTAL SUSPENDED SOLIDS

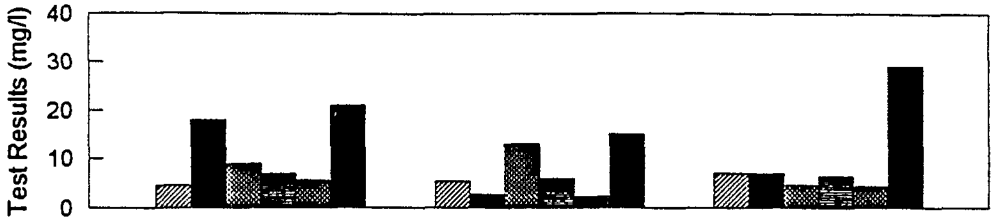
Gas Station Stormwater Runoff Sampling

	Station X	Station Y	Station Z
29-Nov	30	24	42
11-Dec	44	62	84
24-Jan	80	120	240
06-Feb	54	29	32
17-Feb	46	37	43
08-Apr	90	160	250

Note: Method Detection Limit for TSS is 3.0 mg/l

OIL & GREASE

Gas Station Stormwater Runoff Sampling

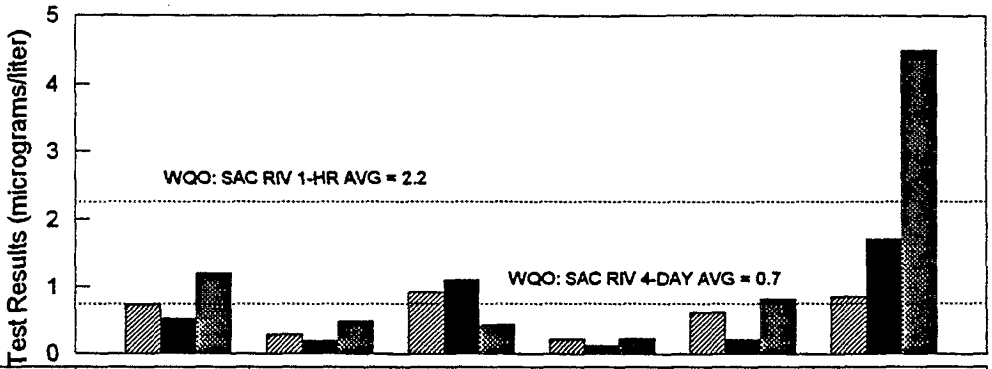


	Station X	Station Y	Station Z
29-Nov	4.5	5.2	6.9
11-Dec	18	2.7	6.9
24-Jan	8.9	13.0	4.5
06-Feb	6.7	5.7	6.2
17-Feb	5.4	2.2	4.2
08-Apr	21	15.0	29

Note: Method Detection Limit for Oil & Grease is 0.5 mg/l

CADMIUM

Gas Station Stormwater Runoff Sampling

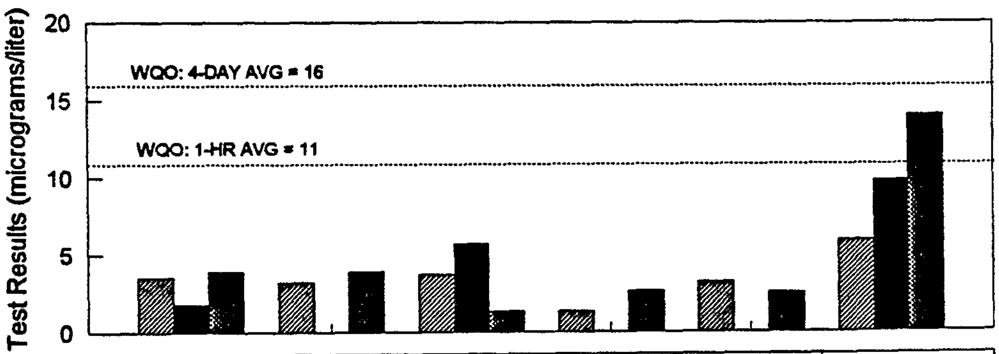


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	0.73	0.28	0.92	0.21	0.61	0.85
■ Station Y	0.52	0.19	1.1	0.12	0.21	1.7
■ Station Z	1.2	0.48	0.42	0.22	0.81	4.5

Note: Method Detection Limit for Cadmium is 0.10 ug/l

CHROMIUM

Gas Station Stormwater Runoff Sampling

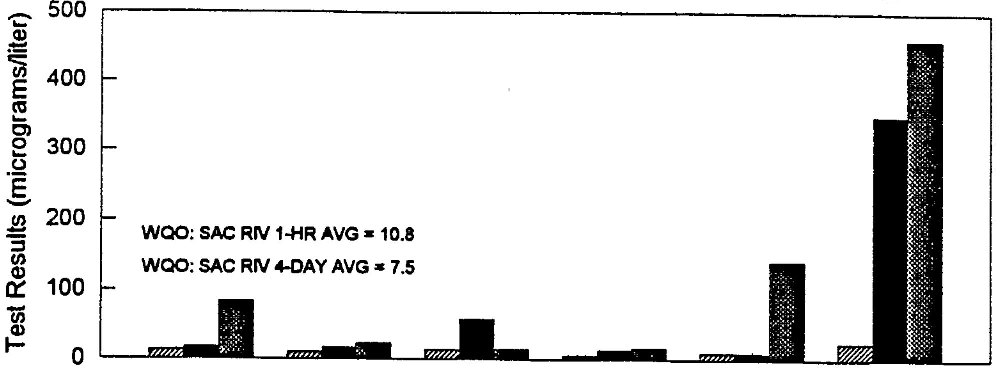


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	3.5	3.2	3.7	1.3	3.2	5.9
■ Station Y	1.8	ND	5.7	ND	ND	9.8
■ Station Z	3.9	3.9	1.3	2.6	2.5	14

Note: Method Detection Limit for Chromium is 1.0 ug/l

COPPER

Gas Station Stormwater Runoff Sampling

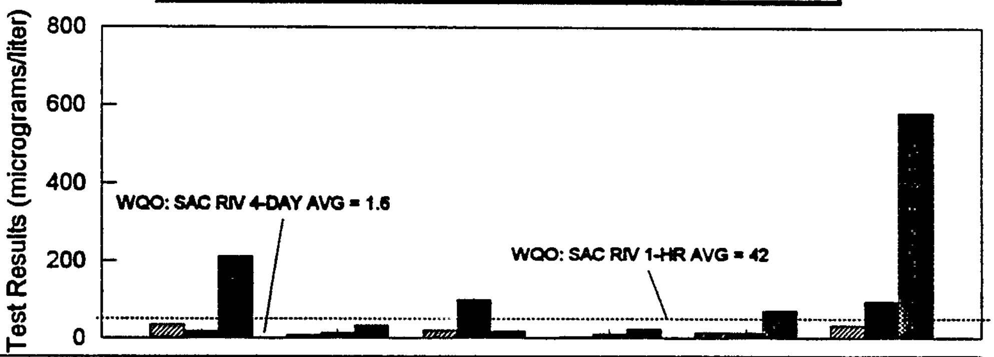


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	12	10	13	5	10	23
■ Station Y	17	16	58.0	13	8.4	350
■ Station Z	84	22	14.0	16	140	460

Note: Method Detection Limit for Copper is 1.0 ug/l

LEAD

Gas Station Stormwater Runoff Sampling

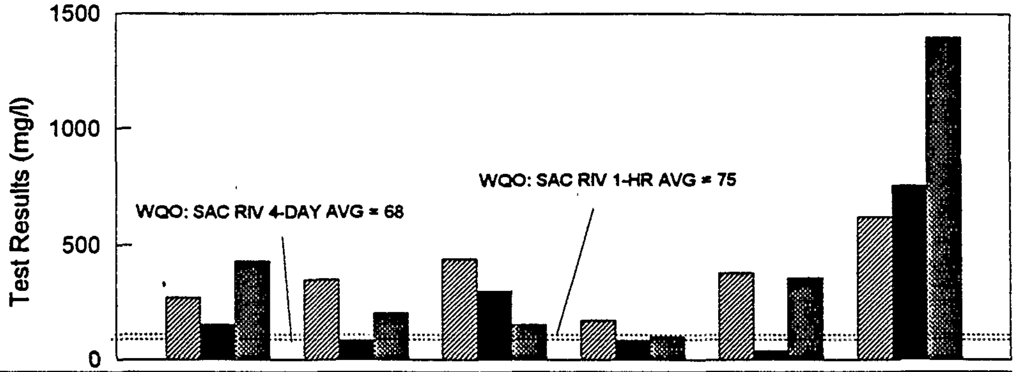


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	34	7.1	20	2.9	14	32
■ Station Y	18	13	98	11	13	93
■ Station Z	210	33	18.0	22	70	580

Note: Method Detection Limit for Lead is 1.0 ug/l

ZINC

Gas Station Stormwater Runoff Sampling

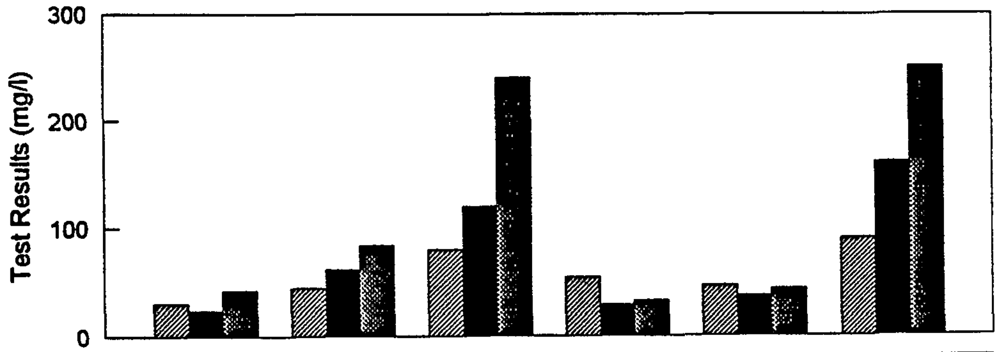


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	270	350	440	170	380	620
■ Station Y	150	83	300	84	41	760
■ Station Z	430	200	150	100	360	1400

Note: Method Detection Limit for Zinc is 1.0 ug/l

TOTAL SUSPENDED SOLIDS

Gas Station Stormwater Runoff Sampling

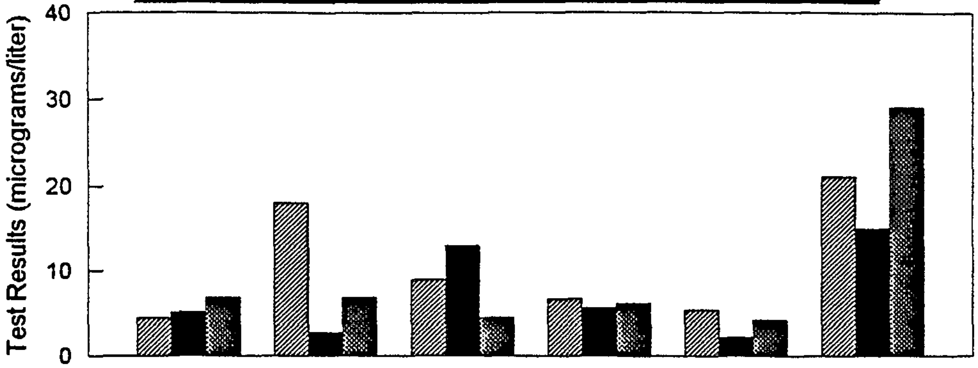


	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	30	44	80	54	46	90
■ Station Y	24	62	120	29	37	160
■ Station Z	42	84	240	32	43	250

Note: Method Detection Limit for TSS is 3.0 mg/l

OIL & GREASE

Gas Station Stormwater Runoff Sampling



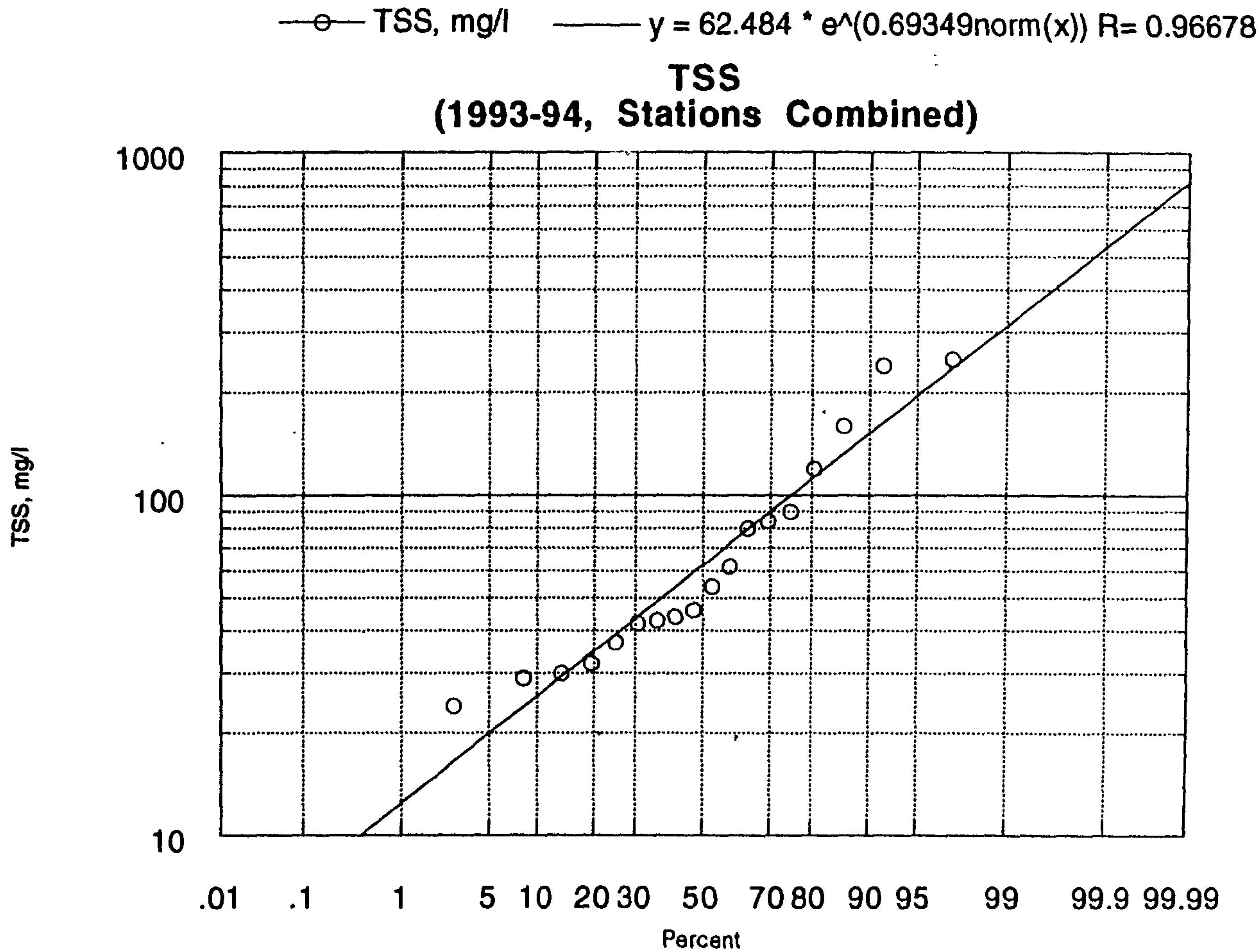
	29-Nov	11-Dec	24-Jan	06-Feb	17-Feb	08-Apr
▨ Station X	4.5	18	8.9	6.7	5.4	21
■ Station Y	5.2	2.7	13.0	5.7	2.2	15.0
■ Station Z	6.9	6.9	4.5	6.2	4.2	29

Note: Method Detection Limit for Oil and Grease is 0.5 mg/l

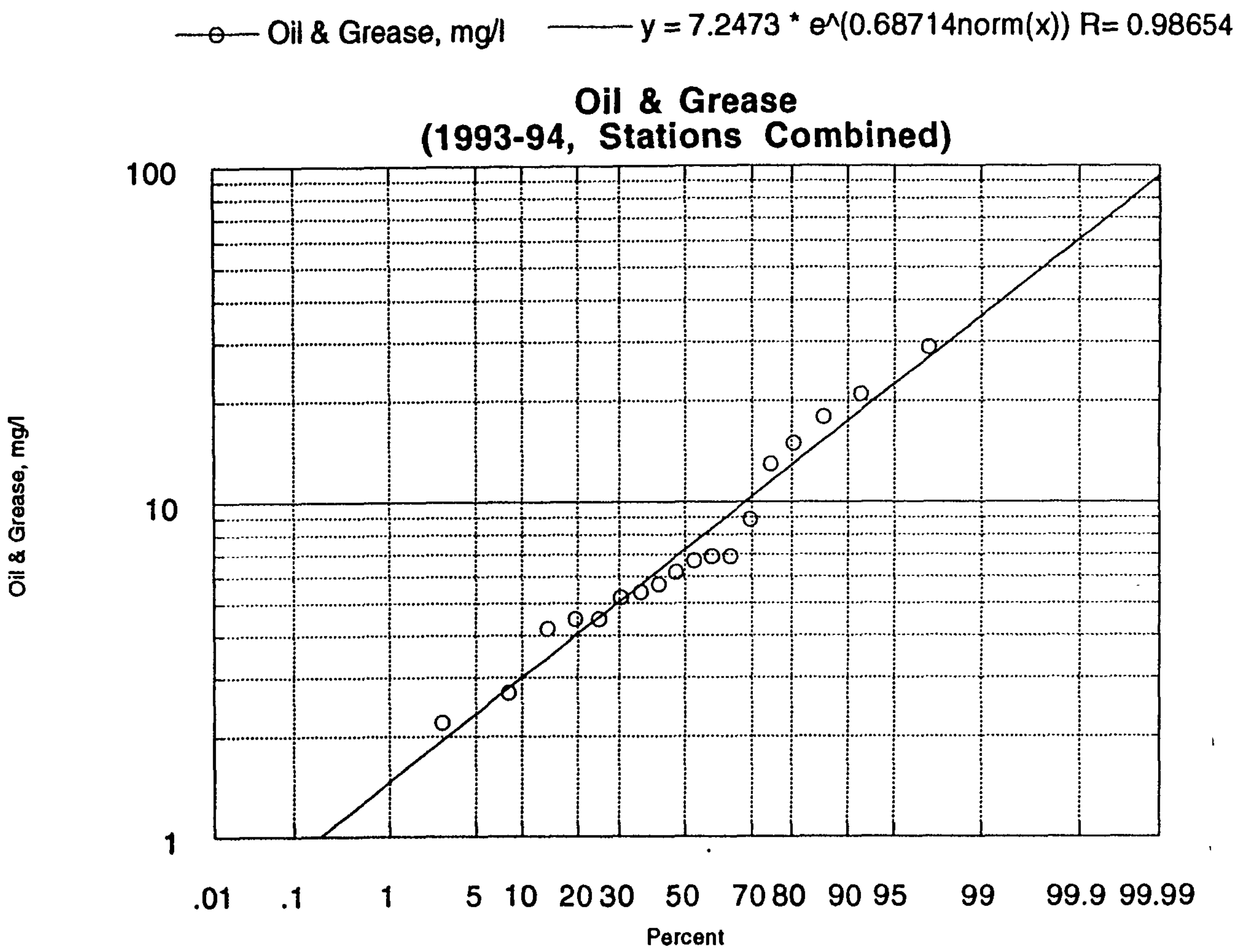
Appendix C

Distribution Plots

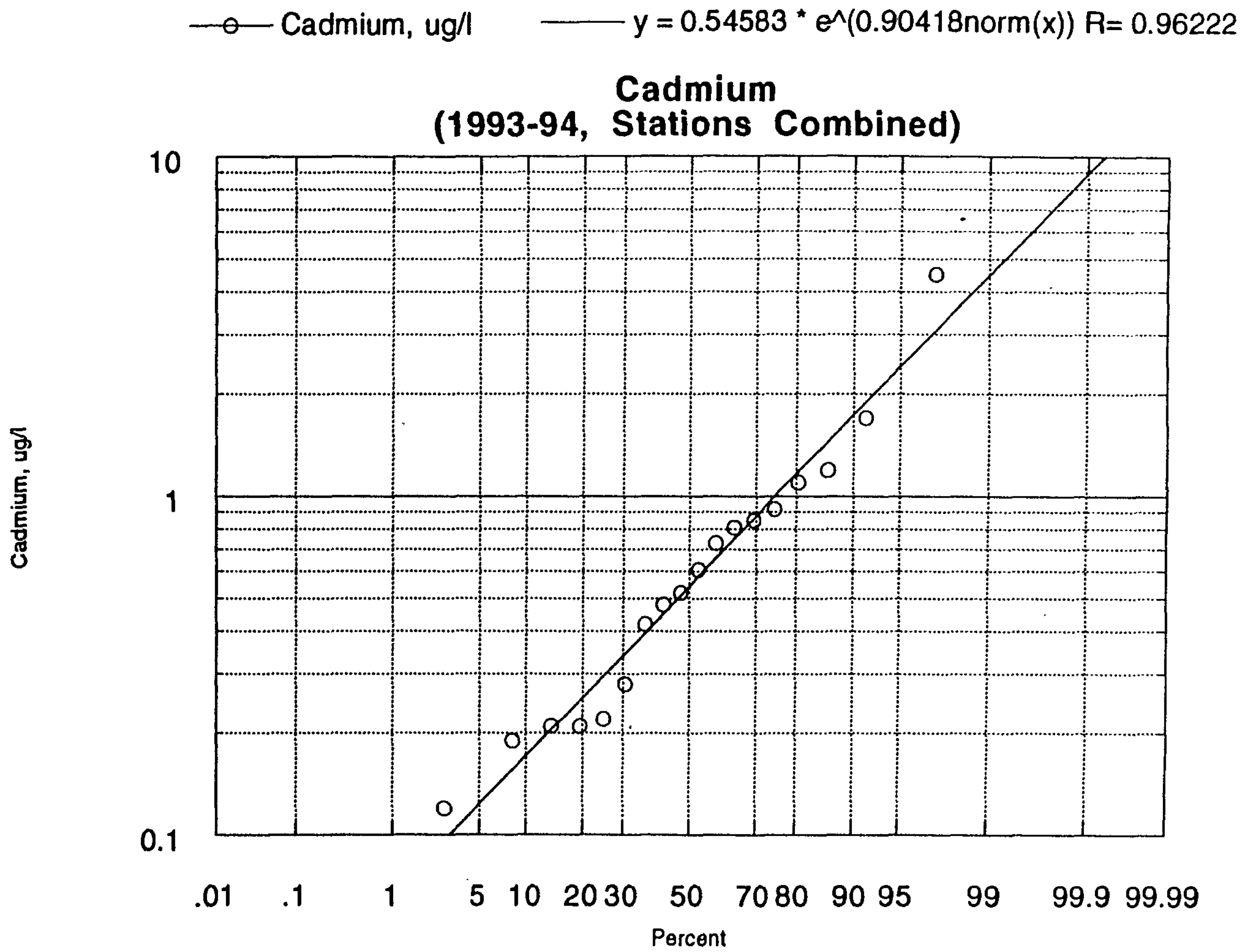
[redacted]



R0009029

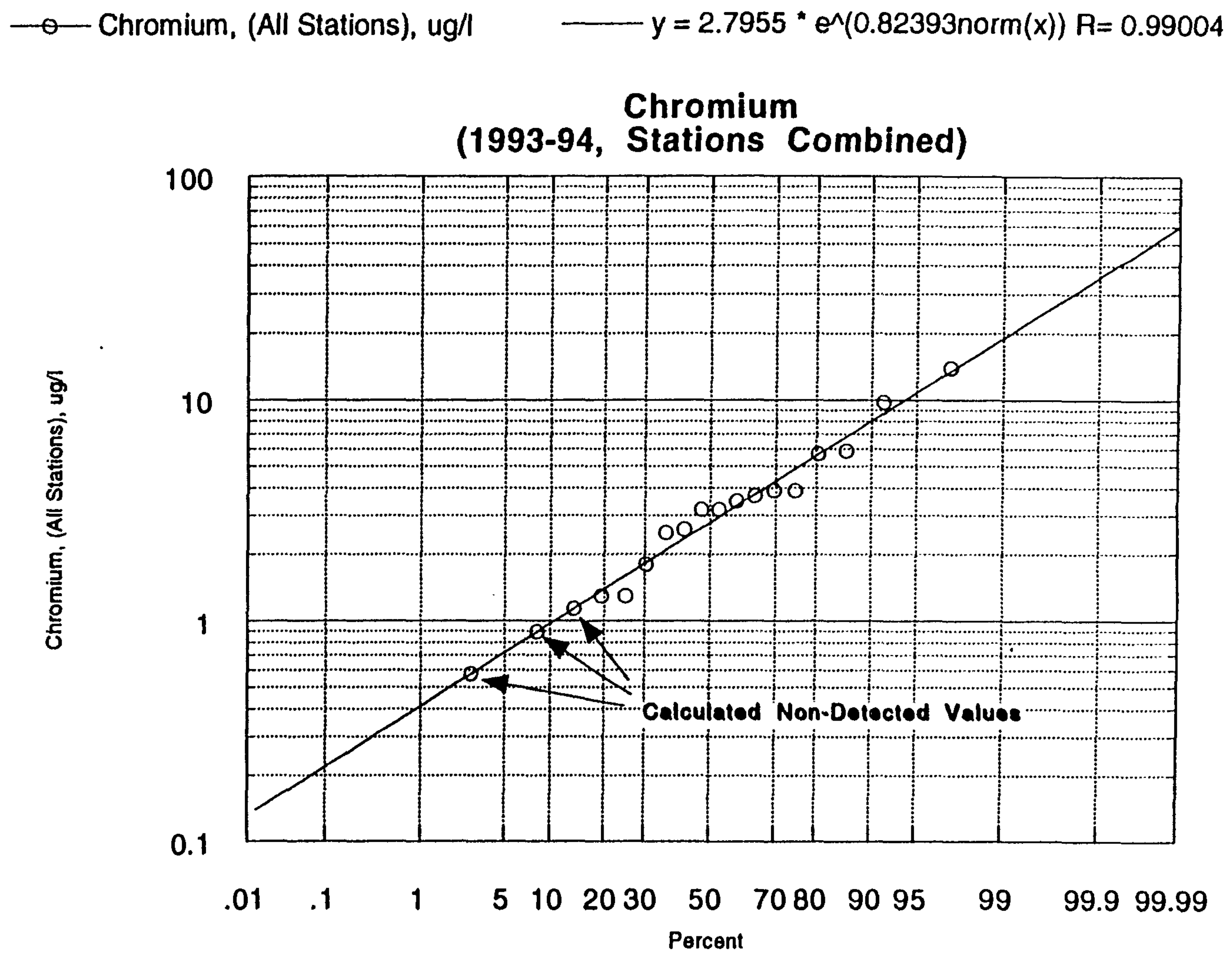

Oil & Grease, mg/l
y = 7.2473 * e^(0.68714norm(x)) R= 0.98654
Oil & Grease
(1993-94, Stations Combined)
100
10
1
Oil & Grease, mg/l
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

R0009030

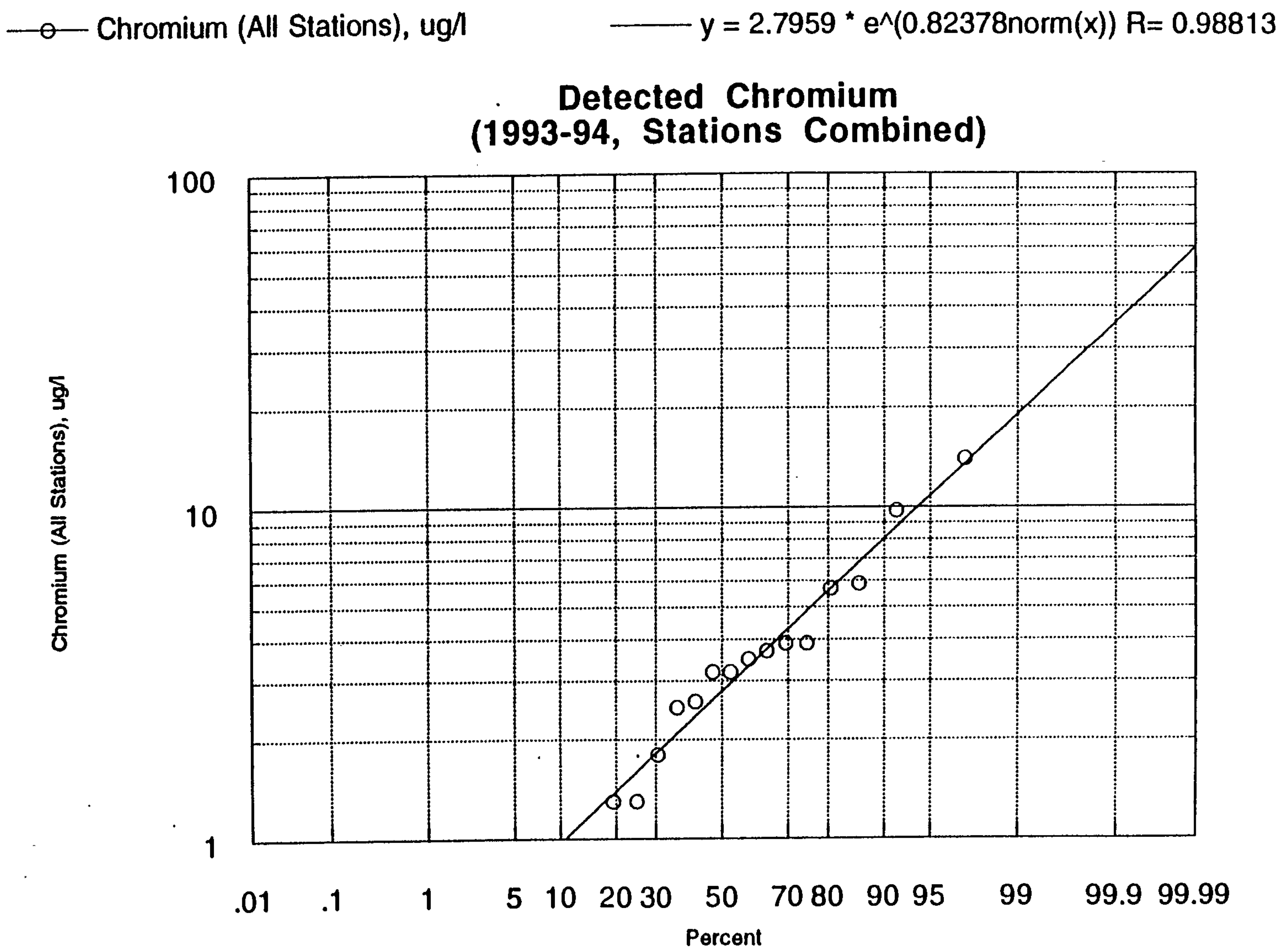


Cadmium, ug/l
y = 0.54583 * e^(0.90418norm(x)) R= 0.96222
Cadmium
(1993-94, Stations Combined)
10
1
0.1
Cadmium, ug/l
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

R0009031

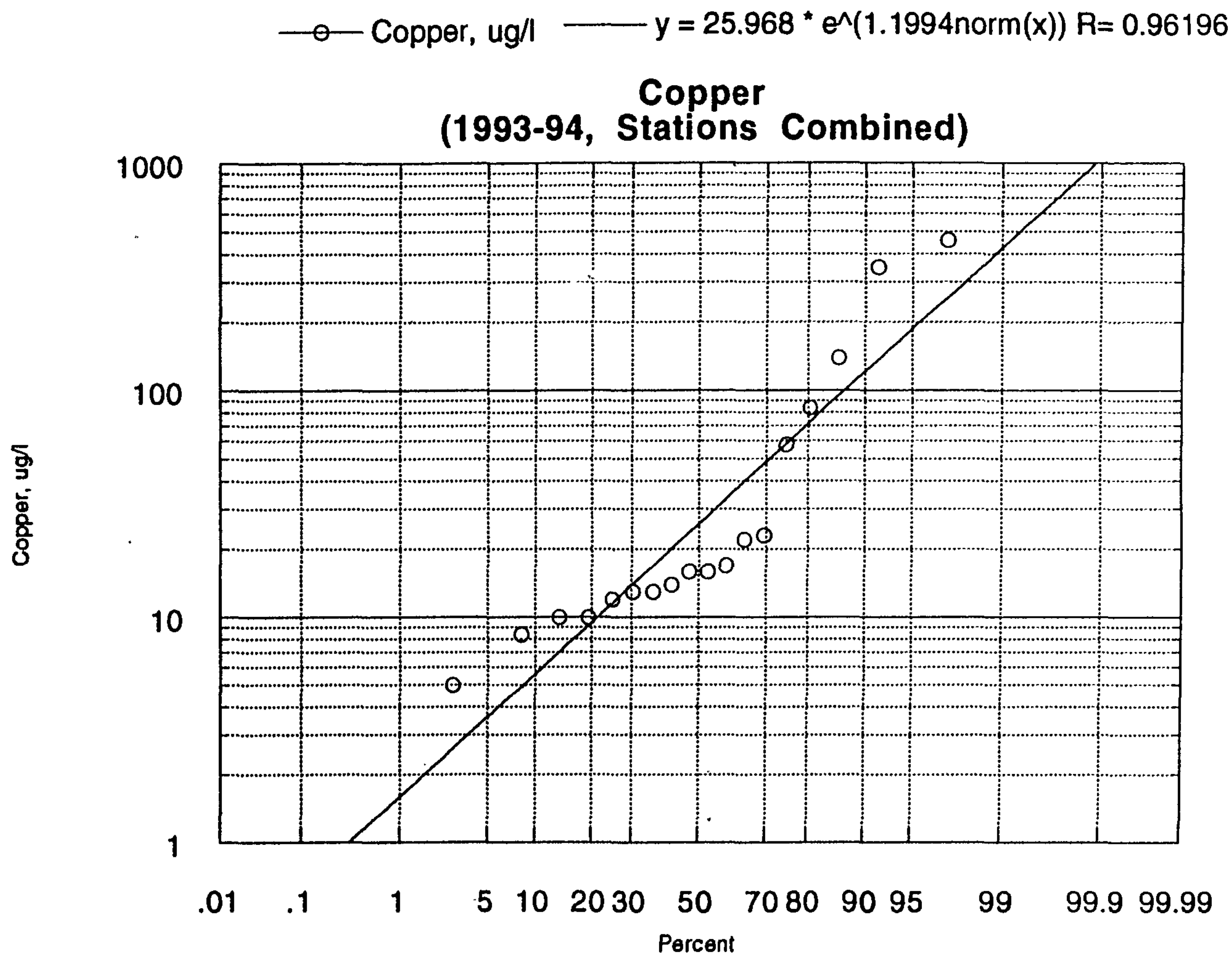

—o— Chromium, (All Stations), ug/l
—— y = 2.7955 * e^(0.82393norm(x)) R= 0.99004
Chromium
(1993-94, Stations Combined)
100
10
1
0.1
Chromium, (All Stations), ug/l
Calculated Non-Detected Values
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent

R0009032



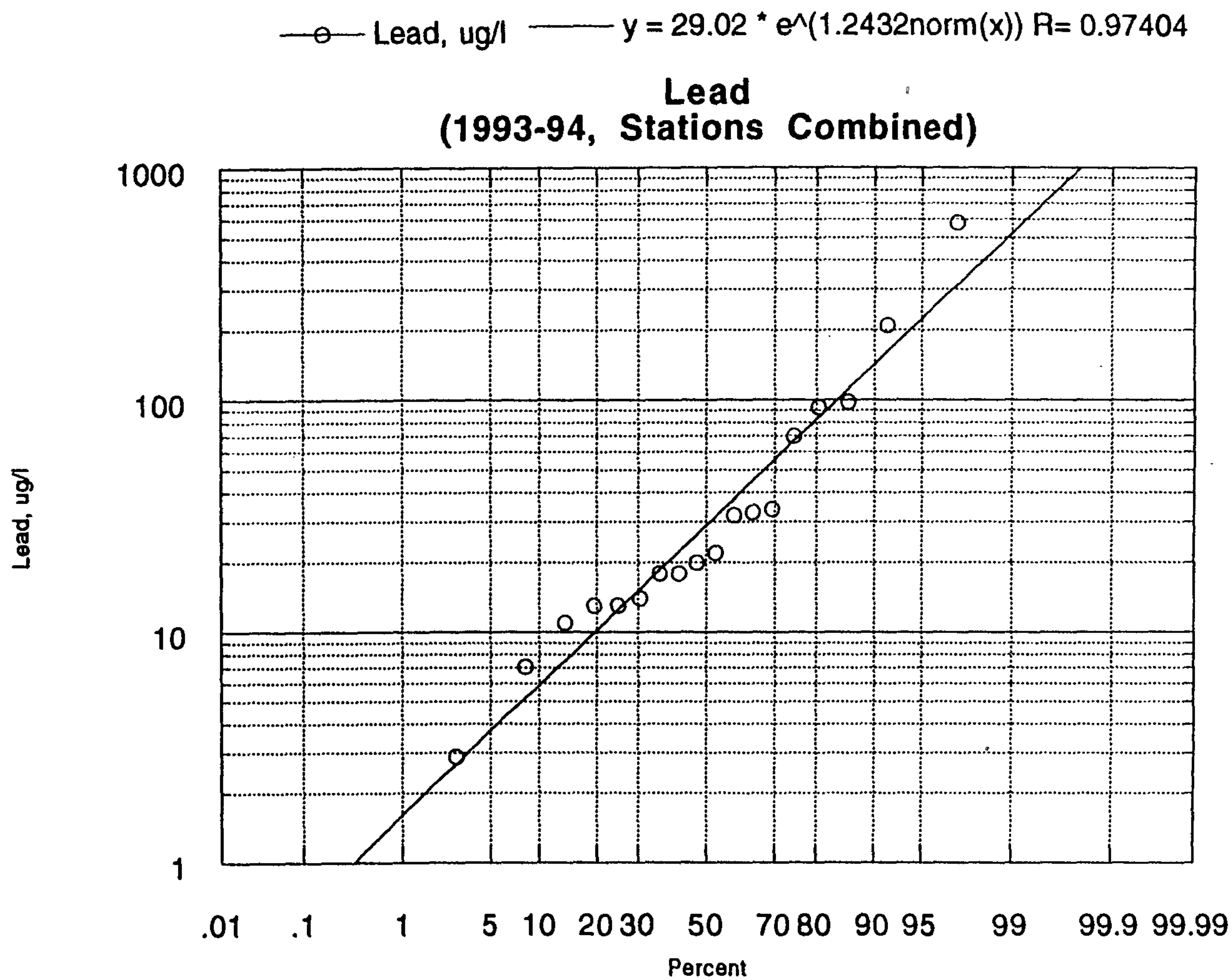
Chromium (All Stations), ug/l
y = 2.7959 * e^(0.82378norm(x)) R= 0.98813
Detected Chromium
(1993-94, Stations Combined)
100
10
1
Chromium (All Stations), ug/l
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent

R0009033



Copper, ug/l
y = 25.968 * e^(1.1994norm(x)) R= 0.96196
Copper
(1993-94, Stations Combined)
1000
100
10
1
Copper, ug/l
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

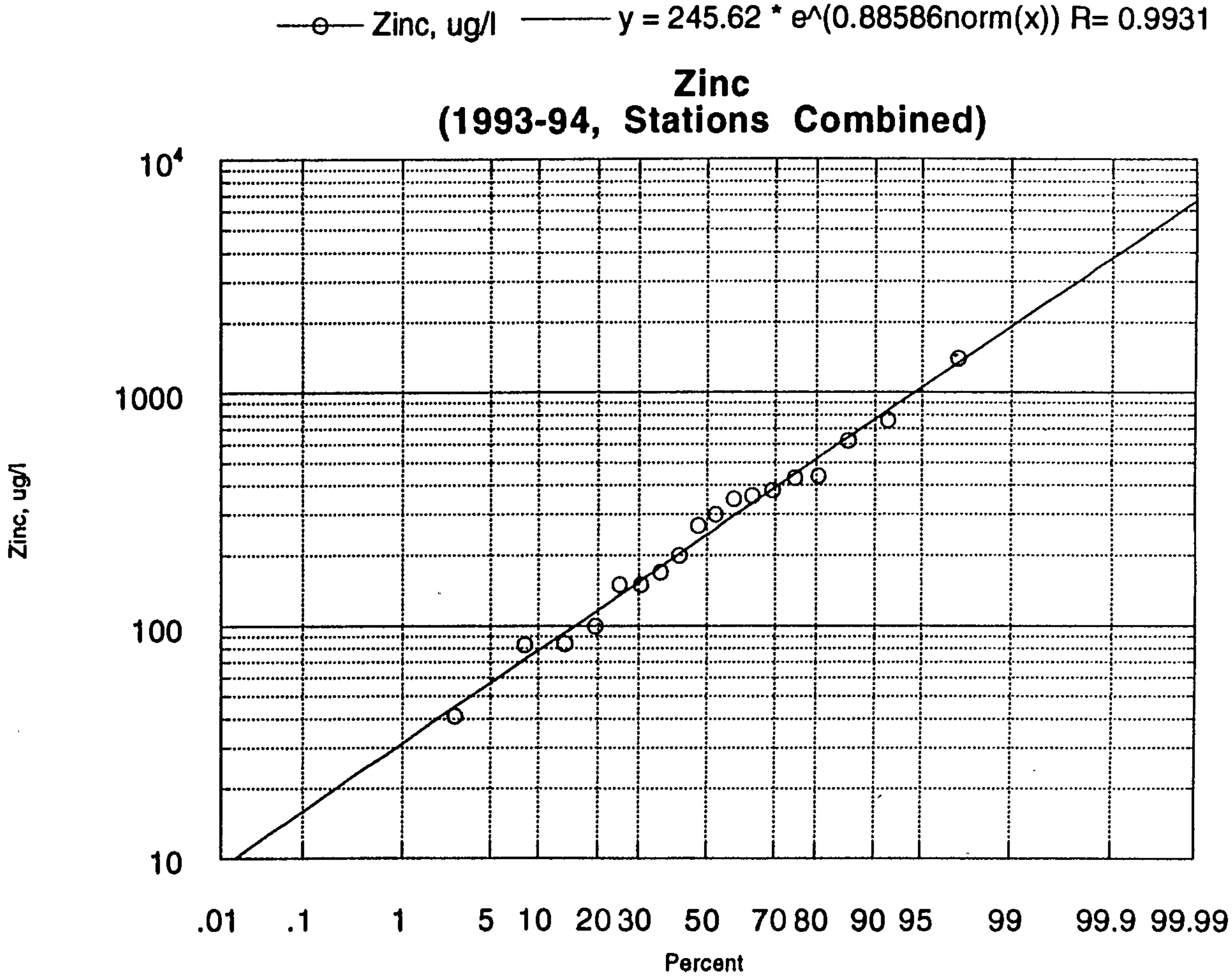
R0009034



Lead, ug/l
y = 29.02 * e^(1.2432norm(x)) R= 0.97404
Lead
(1993-94, Stations Combined)
1000
100
10
1
Lead, ug/l
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

R0009035

Zinc
(1993-94, Stations Combined)



R0009036

Appendix D

Paired t-test Results

t-Test Results, 1993-94 Data

Cadmium

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	0.6	0.64	0.6	1.271667	0.64	1.271667
Variance	0.08728	0.40148	0.08728	2.619697	0.40148	2.619697
Observations	6	6	6	6	6	6
Pearson Correlation	0.7896668		0.495263		0.807468	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-0.2229575		-1.10091		-1.32434	
P(T<=t) one-tail	0.4161954		0.160545		0.121347	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.8323908		0.32109		0.242693	
t Critical two-tail	2.5705776		2.570578		2.570578	

Chromium with ND values replaced

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	3.4666667	3.319308	3.466667	4.7	3.319308	4.7
Variance	2.1626667	13.621	2.162667	21.716	13.621	21.716
Observations	6	6	6	6	6	6
Pearson Correlation	0.8416022		0.792638		0.770473	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	0.1399916		-0.83741		-1.13782	
P(T<=t) one-tail	0.4470656		0.22027		0.153381	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.8941311		0.440539		0.306762	
t Critical two-tail	2.5705776		2.570578		2.570578	

Copper

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	12.166667	77.06667	12.16667	122.6667	77.06667	122.6667
Variance	35.766667	18202.59	35.76667	29781.87	18202.59	29781.87
Observations	6	6	6	6	6	6
Pearson Correlation	0.9149217		0.874993		0.929898	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-1.2278878		-1.61722		-1.63231	
P(T<=t) one-tail	0.1370678		0.083377		0.081771	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.2741355		0.166754		0.163543	
t Critical two-tail	2.5705776		2.570578		2.570578	

Lead

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	18.333333	41	18.33333	155.5	41	155.5
Variance	163.63067	1790	163.6307	48443.1	1790	48443.1
Observations	6	6	6	6	6	6
Pearson Correlation	0.4967467		0.726924		0.489949	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-1.4755		-1.5925		-1.3833	
P(T<=t) one-tail	0.1000493		0.086076		0.112576	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.2000986		0.172151		0.225152	
t Critical two-tail	2.5705776		2.570578		2.570578	

Oil & Grease

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	10.75	7.3	10.75	9.616667	7.3	9.616667
Variance	49.027	29.184	49.027	91.53367	29.184	91.53367
Observations	6	6	6	6	6	6
Pearson Correlation	0.4331416		0.741144		0.663174	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	1.2536065		0.43217		-0.78568	
P(T<=t) one-tail	0.1327039		0.341811		0.233817	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.2654077		0.683621		0.467634	
t Critical two-tail	2.5705776		2.570578		2.570578	

TSS

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	57.333333	72	57.33333	115.1667	72	115.1667
Variance	529.06667	3105.2	529.0667	10442.57	3105.2	10442.57
Observations	6	6	6	6	6	6
Pearson Correlation	0.9281132		0.914248		0.9758	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-1.0140833		-1.73408		-2.14296	
P(T<=t) one-tail	0.1785367		0.071718		0.042499	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.3570733		0.143436		0.084999	
t Critical two-tail	2.5705776		2.570578		2.570578	

Zinc

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	371.66667	236.3333	371.6667	440	236.3333	440
Variance	23576.667	74121.07	23576.67	237080	74121.07	237080
Observations	6	6	6	6	6	6
Pearson Correlation	0.8400584		0.783004		0.889155	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	2.0003495		-0.44174		-1.81603	
P(T<=t) one-tail	0.050947		0.338564		0.064534	
t Critical one-tail	2.0150492		2.015049		2.015049	
P(T<=t) two-tail	0.101894		0.677128		0.129067	
t Critical two-tail	2.5705776		2.570578		2.570578	

t-Test Results for 1992-93 Data vs. 1993-94 Data

Copper

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	17.31667	12.16667	29.6	77.06667	28.75	122.6667	25.22222	70.63333
Variance	93.38567	35.76667	569.36	18202.59	903.551	29781.87	493.8901	16300.26
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.024166		-0.26156		0.952472		0.508859	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.122225		-0.81293		-1.59496		-1.63376	
P(T<=t) one-tail	0.156374		0.226606		0.085803		0.060345	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.312747		0.453212		0.171607		0.12069	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Lead

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	26.03333	18.33333	49.66667	41	24.5	155.5	33.4	71.61111
Variance	274.1667	163.6307	2714.667	1790	241.1	48443.1	1090.48	18638.89
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.085846		-0.3866		0.7556		0.04735	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	0.94137		0.269411		-1.53817		-1.16686	
P(T<=t) one-tail	0.194868		0.399189		0.09231		0.129687	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.389737		0.798378		0.18462		0.259374	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Zinc

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	463.3333	371.6667	160.3333	236.3333	514.5	440	379.3889	349.3333
Variance	28546.67	23576.67	17069.07	74121.07	856820.7	237080	291288.5	106048.1
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.402936		-0.28679		0.028431		0.099938	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.270849		-0.55728		0.176559		0.211876	
P(T<=t) one-tail	0.129849		0.300681		0.433392		0.417361	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.259698		0.601362		0.866783		0.834723	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Total Suspended Solids

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	79.16667	57.33333	59.16667	72	39.66667	115.1667	59.33333	81.5
Variance	1780.967	529.0667	2034.567	3105.2	886.6667	10442.57	1658.353	4778.265
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.062773		-0.47344		-0.20492		-0.32603	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.143288		-0.3625		-1.6491		-1.03402	
P(T<=t) one-tail	0.152344		0.365897		0.080021		0.157807	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.304689		0.731794		0.160042		0.315615	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Oil & Grease w/ ND values replaced

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	6.25	10.75	3.716667	7.3	3.85	9.616667	4.605556	9.222222
Variance	34.987	49.027	10.58567	29.184	25.959	91.53367	22.4735	52.10771
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.117611		-0.72176		-0.2055		-0.1128	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	-1.27901		-1.08751		-1.2045		-2.15904	
P(T<=t) one-tail	0.128517		0.163217		0.141148		0.022715	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.257034		0.326433		0.282296		0.045431	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Cadmium

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	0.968333	0.6	0.59	0.64	0.43	1.271667	0.662778	0.837222
Variance	0.485857	0.08728	0.1934	0.40148	0.02868	2.619697	0.262162	1.014457
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.058565		-0.32062		0.162128		-0.12772	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.217654		-0.13925		-1.28866		-0.62364	
P(T<=t) one-tail	0.13884		0.447343		0.126959		0.27057	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.27768		0.894687		0.253919		0.541139	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Chromium w/ ND values replaced

t-Test: Paired Two Sample for Means	X		Y		Z		Combined Stations	
	Pre-BMP	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*	*Pre-BMP*	*Post-BMP*
Mean	4.75	3.466667	4.6	3.319308	3.133333	4.7	4.161111	3.828658
Variance	8.635	2.162667	11.572	13.621	5.702667	21.716	8.183693	11.43509
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.21243		-0.35106		0.01276		-0.15038	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.050076		0.537935		-0.7367		0.297168	
P(T<=t) one-tail	0.170882		0.306847		0.247199		0.384969	
t Critical one-tail	2.015049		2.015049		2.015049		1.739606	
P(T<=t) two-tail	0.341764		0.613693		0.494398		0.769939	
t Critical two-tail	2.570578		2.570578		2.570578		2.109819	

Event Mass Load t-Test Results, 1993-94 Data

Cadmium

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	0.029402	0.017679	0.029402	0.0589	0.017679	0.0589
Variance	0.00069	0.000209	0.00069	0.002697	0.000209	0.002697
Observations	6	6	6	6	6	6
Pearson Correlation	0.89988		0.435162		0.738288	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	1.956887		-1.54062		-2.38196	
P(T<=t) one-tail	0.053858		0.09202		0.031506	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.107716		0.184039		0.063012	
t Critical two-tail	2.570578		2.570578		2.570578	

Chromium (ND values replaced)

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	0.14853	0.081587	0.14853	0.22563	0.081587	0.22563
Variance	0.009935	0.003331	0.009935	0.019982	0.003331	0.019982
Observations	6	6	6	6	6	6
Pearson Correlation	0.884403		0.399032		0.397664	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	2.949519		-1.38207		-2.7202	
P(T<=t) one-tail	0.015952		0.112753		0.020882	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.031903		0.225505		0.041765	
t Critical two-tail	2.570578		2.570578		2.570578	

Copper

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	0.515424	1.315192	0.515424	5.083091	1.315192	5.083091
Variance	0.119316	1.549172	0.119316	20.65311	1.549172	20.65311
Observations	6	6	6	6	6	6
Pearson Correlation	0.210564		0.274093		0.479886	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-1.60628		-2.50734		-2.25354	
P(T<=t) one-tail	0.084561		0.027002		0.036974	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.169122		0.054003		0.073948	
t Critical two-tail	2.570578		2.570578		2.570578	

R0009043

Lead

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	0.919055	1.058088	0.919055	7.673873	1.058088	7.673873
Variance	1.031839	0.77322	1.031839	96.36701	0.77322	96.36701
Observations	6	6	6	6	6	6
Pearson Correlation	0.598228		0.794486		0.121589	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	-0.39687		-1.83217		-1.66227	
P(T<=t) one-tail	0.353919		0.063207		0.078674	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.707837		0.126414		0.157347	
t Critical two-tail	2.570578		2.570578		2.570578	

Zinc

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	15.44389	5.869411	15.44389	21.40359	5.869411	21.40359
Variance	89.90706	15.32678	89.90706	306.2017	15.32678	306.2017
Observations	6	6	6	6	6	6
Pearson Correlation	0.625462		0.259557		0.743803	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	3.058509		-0.82915		-2.56761	
P(T<=t) one-tail	0.014075		0.222392		0.02509	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.02815		0.444784		0.05018	
t Critical two-tail	2.570578		2.570578		2.570578	

Oil and Grease

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	375.5769	216.2529	375.5769	456.3391	216.2529	456.3391
Variance	22777.25	18038.49	22777.25	53546.74	18038.49	53546.74
Observations	6	6	6	6	6	6
Pearson Correlation	0.571564		0.044051		0.604081	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	2.937986		-0.73095		-3.18764	
P(T<=t) one-tail	0.016166		0.248804		0.012165	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.032332		0.497608		0.024329	
t Critical two-tail	2.570578		2.570578		2.570578	

Total Suspended Solids

t-Test: Paired Two Sample for Means	X	Y	X	Z	Y	Z
Mean	2439.793	1901.743	2439.793	6124.645	1901.743	6124.645
Variance	2880667	655819.6	2880667	35824573	655819.6	35824573
Observations	6	6	6	6	6	6
Pearson Correlation	0.700161		0.918534		0.895821	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t Stat	1.038118		-2.01611		-1.96198	
P(T<=t) one-tail	0.173394		0.049933		0.053508	
t Critical one-tail	2.015049		2.015049		2.015049	
P(T<=t) two-tail	0.346788		0.099865		0.107016	
t Critical two-tail	2.570578		2.570578		2.570578	

Pre vs. Post Mass Load t-tests

t-Test: Paired Two Sample for Means

Cadmium

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	0.043764	0.029401587	0.019508389	0.017678846	0.024002988	0.05890011	0.02909192	0.03532684
Variance	0.000632	0.000689909	8.62242E-05	0.000209282	0.000138686	0.002696945	0.000369591	0.00137613
Observations	6	6	6	6	6	6	18	1
Pearson Correlation	0.218226		0.252249851		-0.120555782		0.024306728	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.094217		0.296963471		-1.565063687		-0.63949312	
P(T<=t) one-tail	0.161875		0.389217723		0.089170462		0.265513024	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.323750		0.778435446		0.178340923		0.531026048	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Chromium

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	0.216800	0.148530145	0.151590723	0.081586926	0.1486771	0.225630003	0.172356104	0.15191569
Variance	0.012820	0.009934909	0.004684991	0.00333066	0.005112094	0.019981786	0.007699412	0.01344618
Observations	6	6	6	6	6	6	18	1
Pearson Correlation	0.647592		0.018351801		0.831296879		0.441116309	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.853733		1.932820566		-2.070219608		0.786137203	
P(T<=t) one-tail	0.061479		0.055544006		0.046606801		0.221303935	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.122957		0.111088012		0.093213603		0.442607871	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Copper

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	0.825292	0.515423911	0.979318237	1.315191758	1.7403333	5.0830913	1.181647863	2.30456899
Variance	0.205539	0.119316491	0.34540771	1.549171681	4.831563593	20.65311243	1.752522862	10.7652097
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.294728		-0.187945287		0.491365956		0.520393643	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.573978		-0.558556531		-2.068597701		-1.684693495	
P(T<=t) one-tail	0.088153		0.300276328		0.046703025		0.055158082	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.176306		0.600552655		0.09340605		0.110316164	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Lead

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	1.283191	0.919055338	1.565580703	1.058088231	1.438312749	7.673872928	1.42902819	3.217005499
Variance	0.859791	1.031838764	1.34033225	0.773220436	1.342924806	96.36700661	1.056191013	39.39360736
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.165165		-0.13916701		0.017782937		0.014328101	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	0.709484		0.802934227		-1.548398626		-1.195458884	
P(T<=t) one-tail	0.254865		0.229231934		0.091103527		0.124159076	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.509729		0.458463868		0.182207055		0.248318151	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Zinc

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	22.194818	15.44389429	5.362713165	5.869411439	20.58829657	21.40359172	16.04860929	14.23896582
Variance	63.074839	89.90705886	7.807071533	15.32678374	939.6433079	306.2017395	358.1214241	164.3633444
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.295417		0.284081185		0.910169474		0.810780488	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.587618		-0.301744757		-0.121667111		0.675798178	
P(T<=t) one-tail	0.086618		0.387496909		0.453950603		0.25412927	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.173236		0.774993818		0.907901206		0.50825854	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Oil & Grease

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	302.870881	375.5769152	122.5663992	216.252874	186.5582928	456.3391489	203.9985244	349.389646
Variance	69627.98147	22777.25343	10538.3196	18038.49327	38760.09752	53546.73652	40876.38627	38288.74305
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	-0.651861		-0.373226942		-0.447903126		-0.279773765	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	-0.468788		-1.164000961		-1.811211964		-1.938054309	
P(T<=t) one-tail	0.329475		0.148470771		0.064934827		0.034703861	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.658949		0.296941543		0.129869654		0.069407722	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Total Suspended Solids

	X		Y		Z		Stations Combined	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Mean	3942.690113	2439.793209	2047.297842	1901.743023	2151.187498	6124.644622	2713.725151	3488.726951
Variance	6265496.9	2880667.445	1018859.208	655819.5721	1796392.012	35824573.38	3472312.582	15306256.1
Observations	6	6	6	6	6	6	18	18
Pearson Correlation	0.210292		-0.417260084		-0.609082071		-0.257836891	
Hypothesized Mean Difference	0		0		0		0	
df	5		5		5		17	
t Stat	1.357015		0.232240146		-1.413793011		-0.692598496	
P(T<=t) one-tail	0.116411		0.412778922		0.108276809		0.24895719	
t Critical one-tail	2.015049		2.015049176		2.015049176		1.739606432	
P(T<=t) two-tail	0.232821		0.825557845		0.216553618		0.49791438	
t Critical two-tail	2.570578		2.570577635		2.570577635		2.109818524	

Appendix E

Significant Regression Plots - Concentration

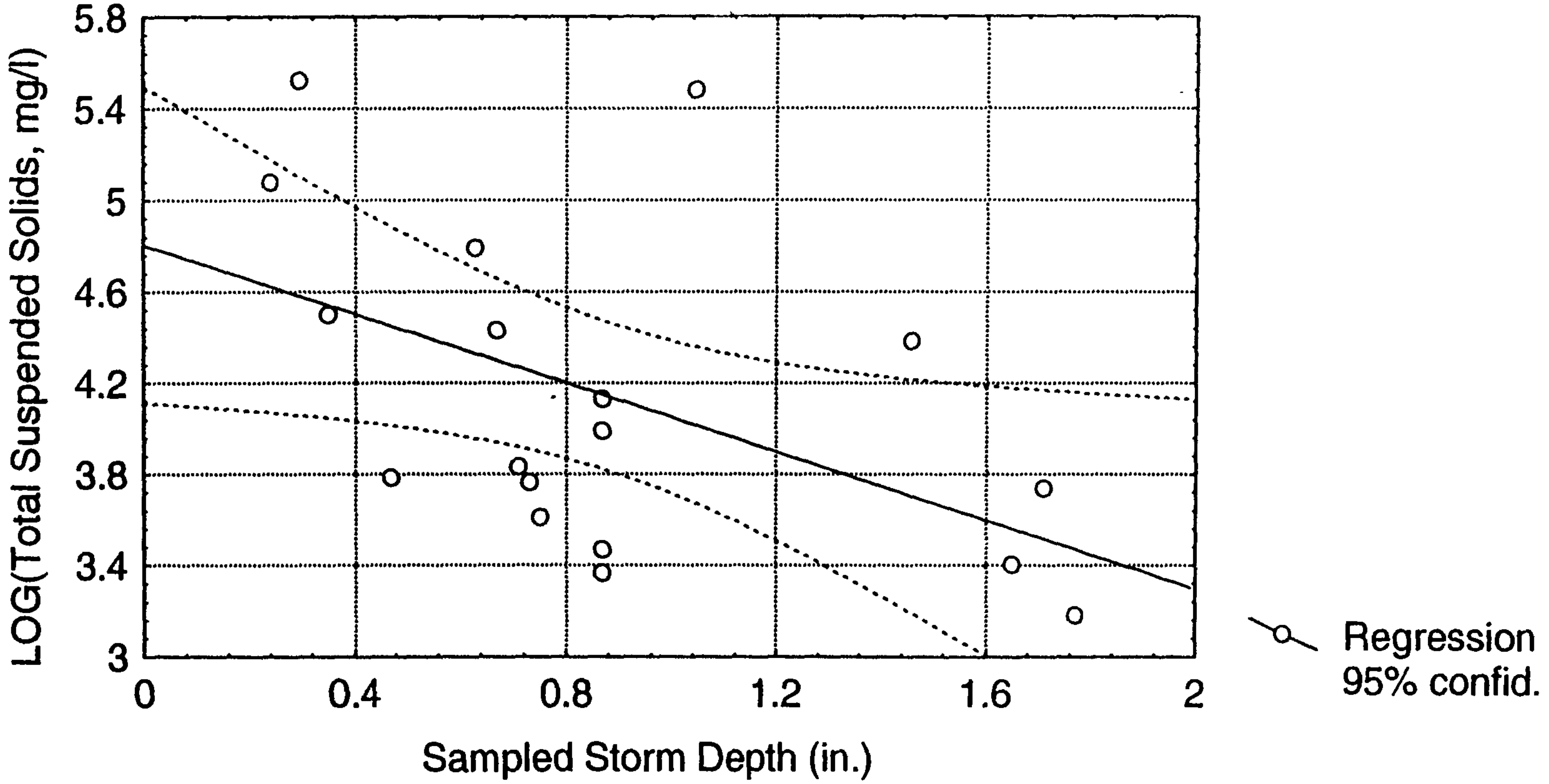
[redacted]

Sampled Storm Depth vs. LOG(TSS)

LOG_TSS = 4.8038 - .7544 * DEPTH

Correlation: r = -.5016

p=0.033946

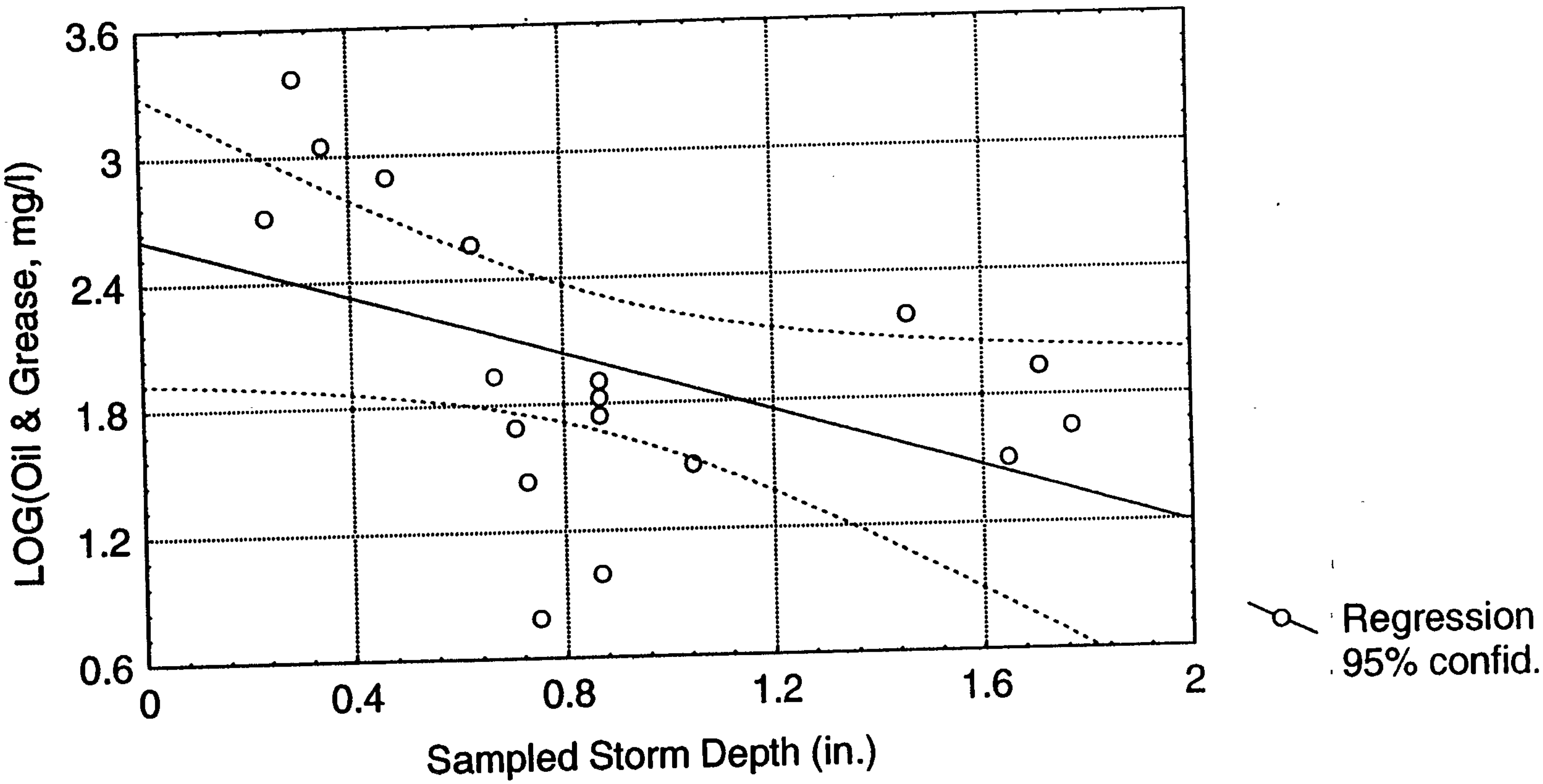


Sampled Storm Depth vs. LOG(Oil & Grease)

LOG_O_G = 2.6110 - .7109 * DEPTH

Correlation: r = -.4838

P=0.041929



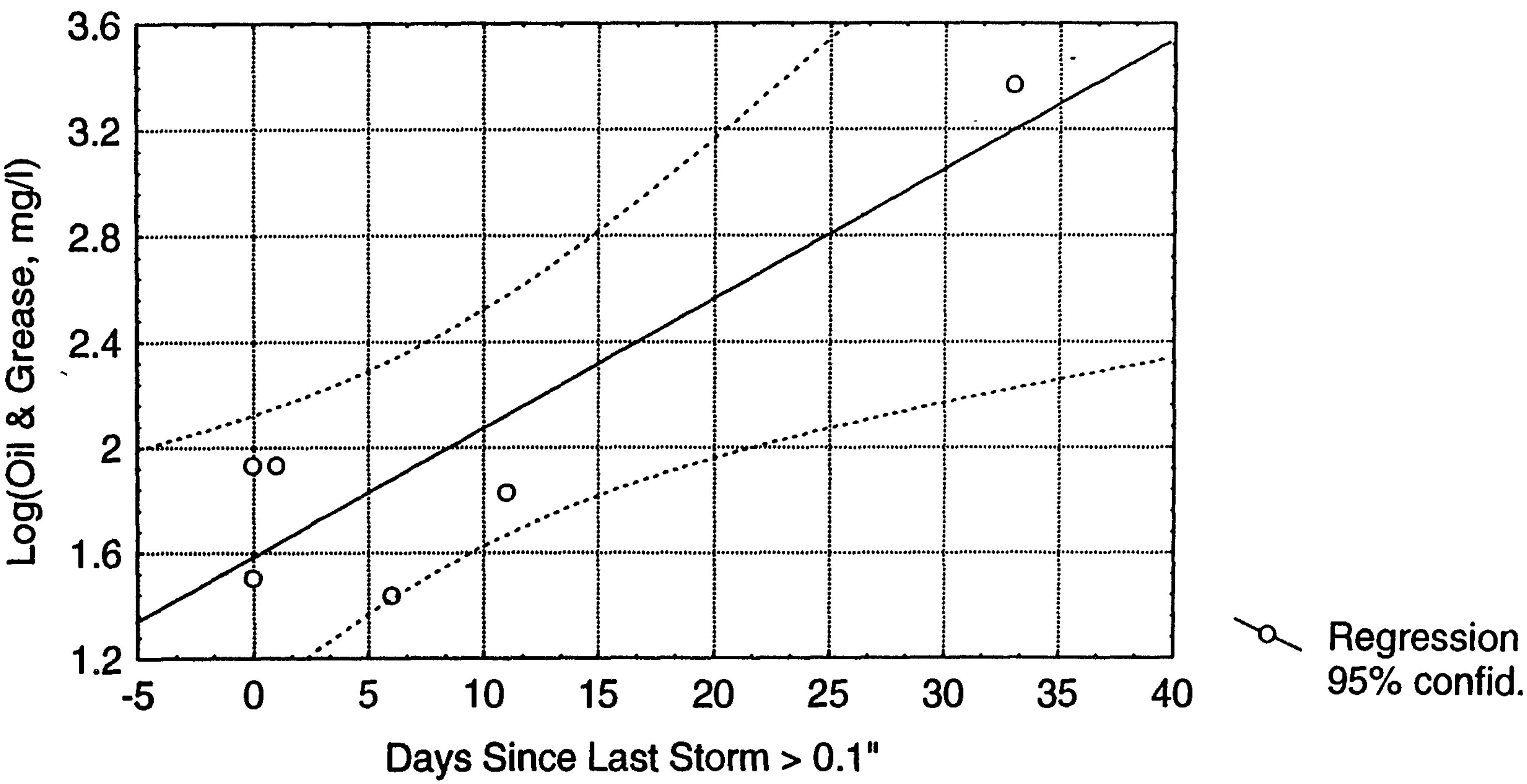
R0009050

Days Since Last Storm > 0.1" vs. Log(Oil & Grease), Station Z

LOG_O_G = 1.5833 + .04890 * DSLS_10

Correlation: r = .88667

p=0.018539



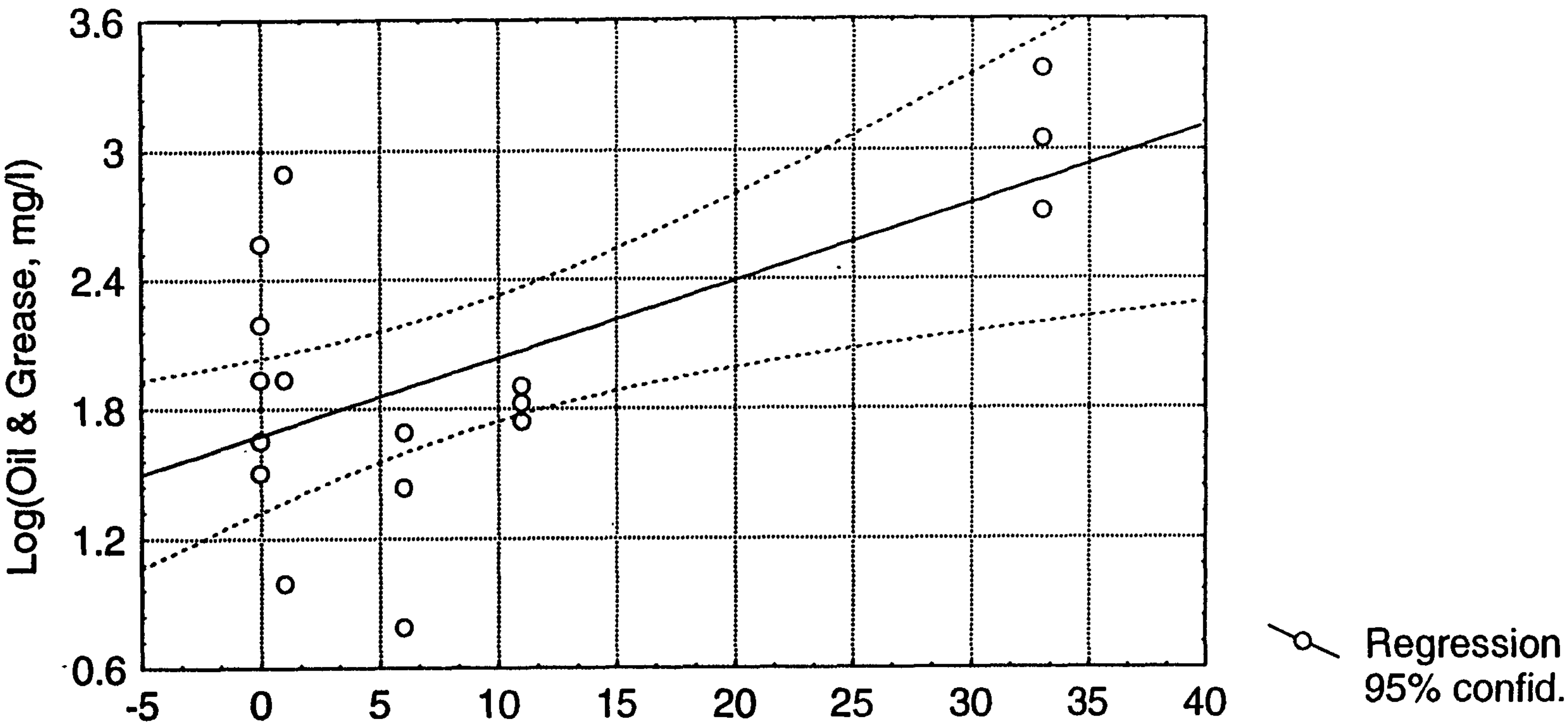
R0009051

Days Since Last Storm > 0.1" vs. Log(Oil & Grease)

LOG_O_G = 1.6765 + .03578 * DSLS_10

Correlation: r = .61611

p=0.006477



Days Since Last Storm > 0.1"

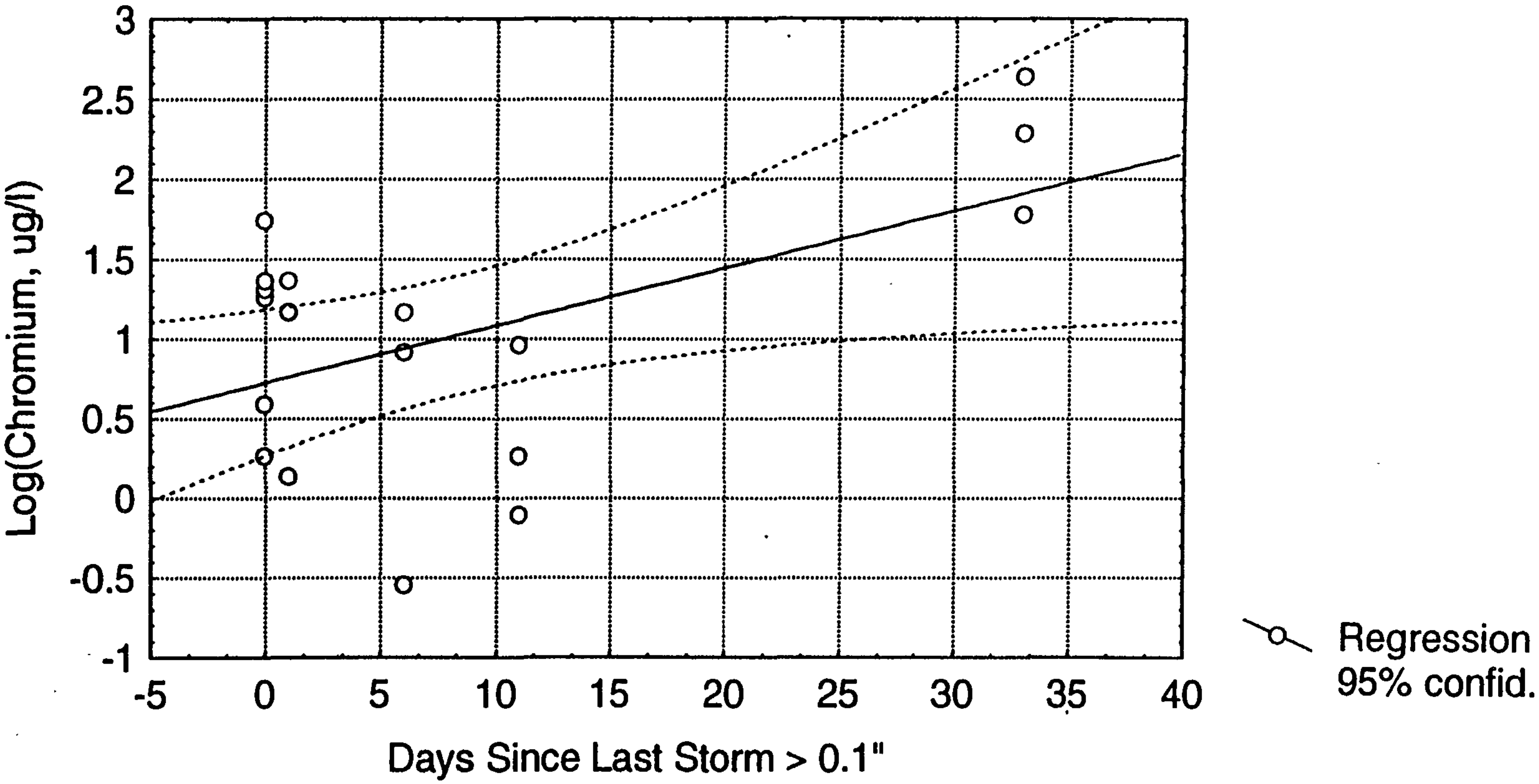
R0009052

Days Since Last Storm > 0.1" vs. Log(Chromium)

LOG_CR = .72258 + .03594 * DSLS_10

Correlation: r = .52158

p=0.026422



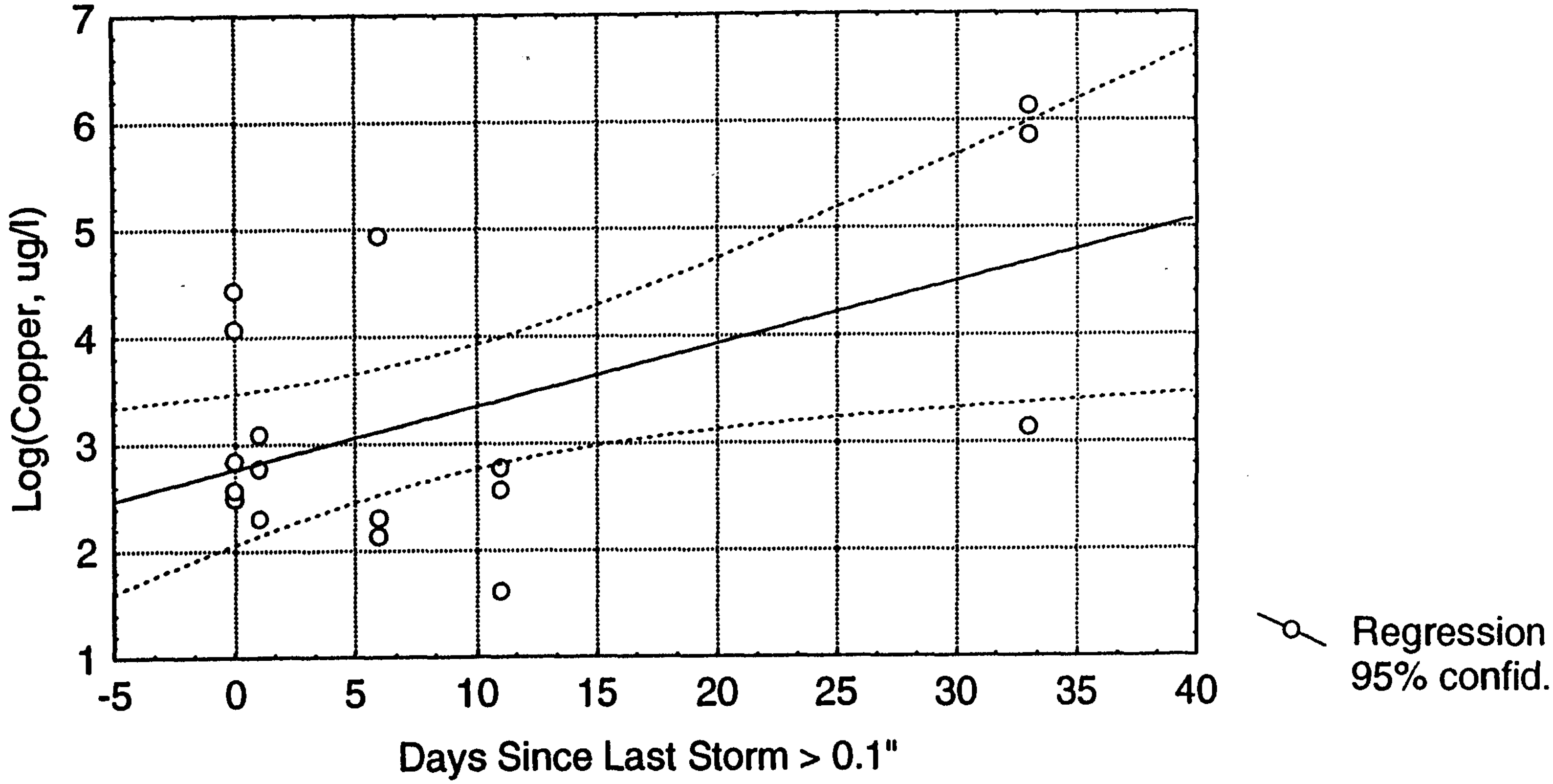
R0009053

Days Since Last Storm > 0.1" vs. Log(Copper)

LOG_CU = 2.7636 + .05803 * DSLS_10

Correlation: r = .53868

p=0.021081



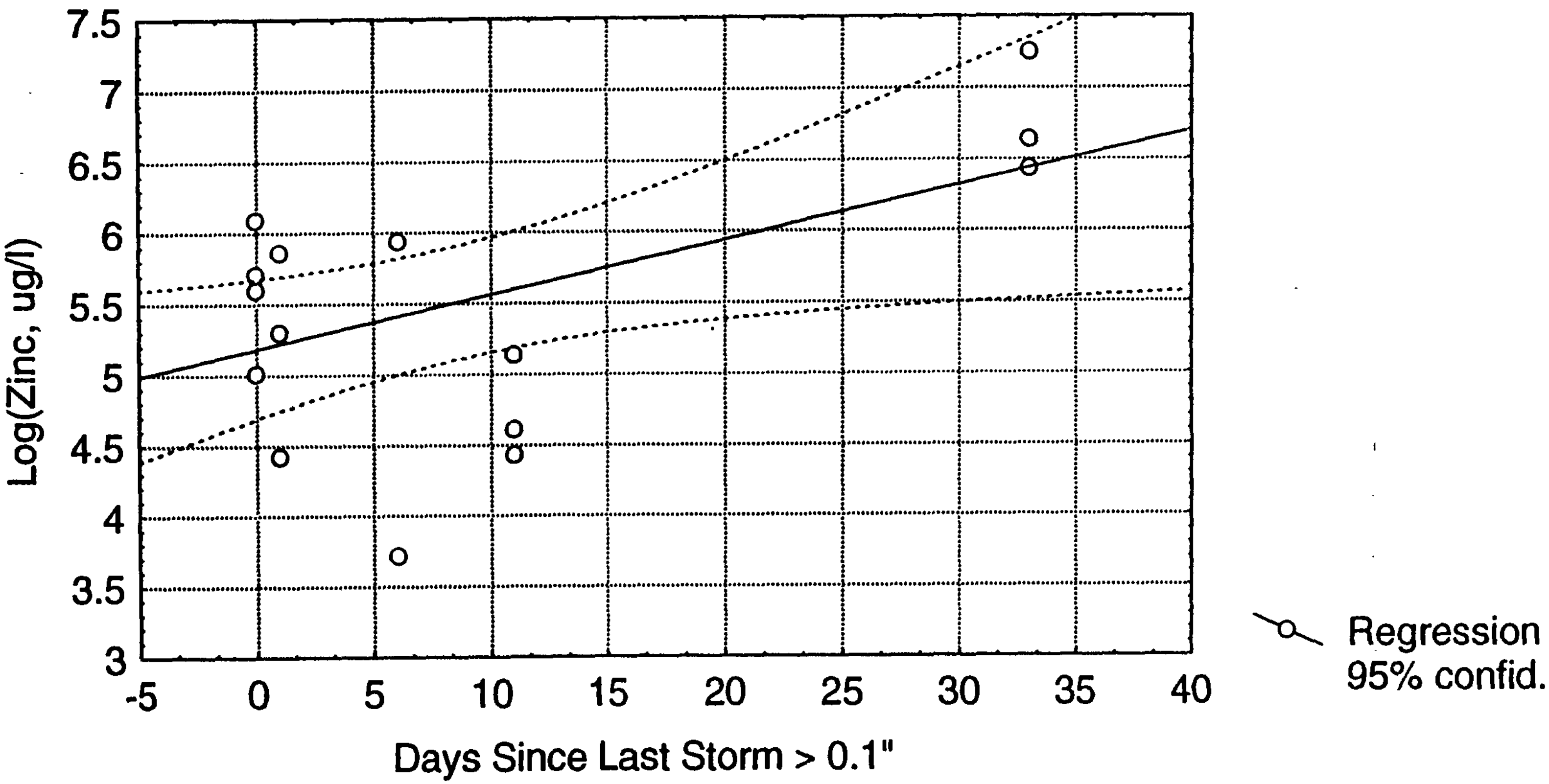
R0009054

Days Since Last Storm > 0.1" vs. Log(Zinc)

LOG_ZN = 5.1807 + .03801 * DSLS_10

Correlation: r = .51429

p=0.028995



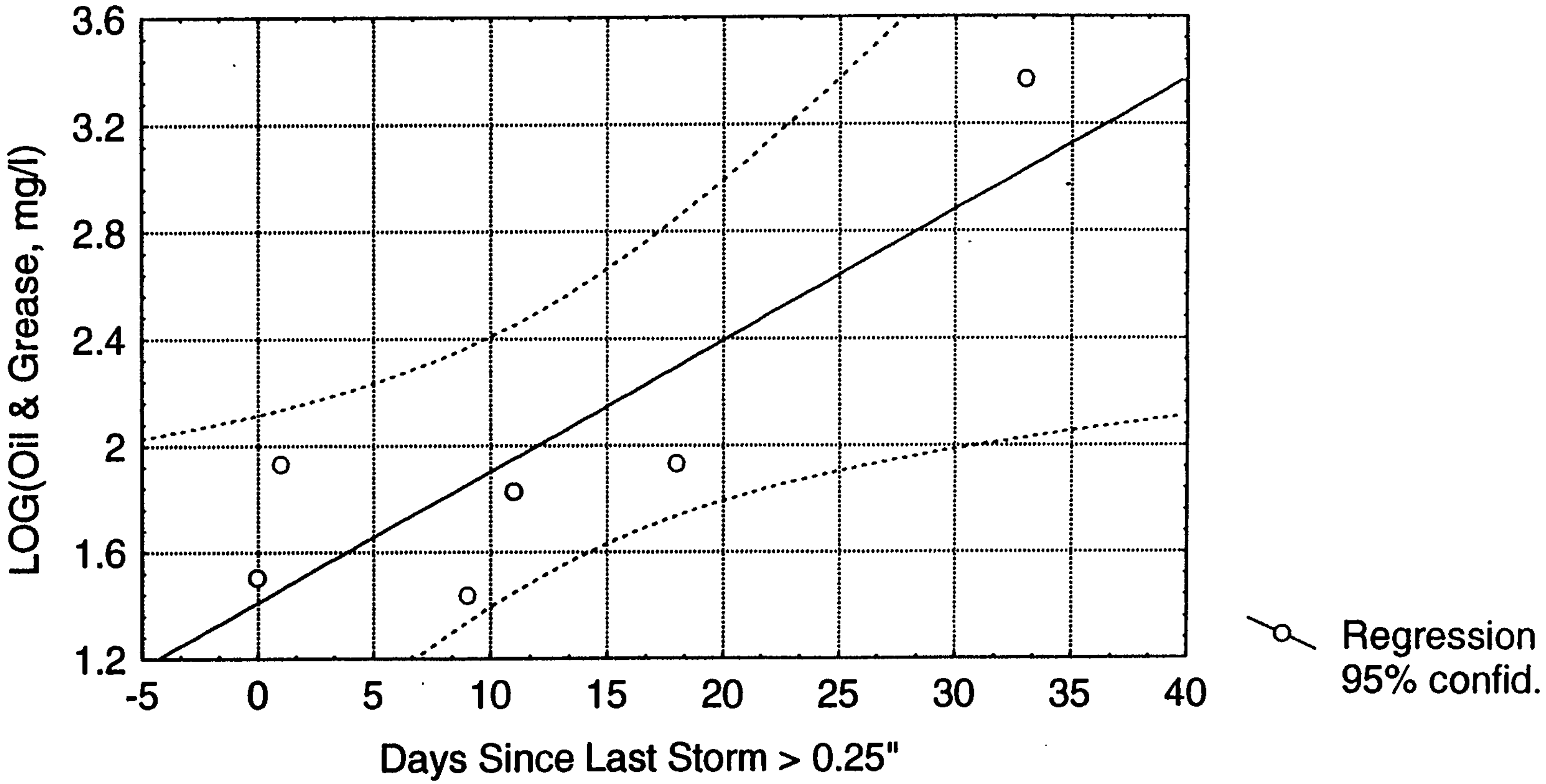
R0009055

Days Since Last Storm > 0.25" vs. LOG(Oil & Grease), Station Z

LOG_O_G = 1.4105 + .04904 * DSLS_25

Correlation: r = .85483

p=0.030080



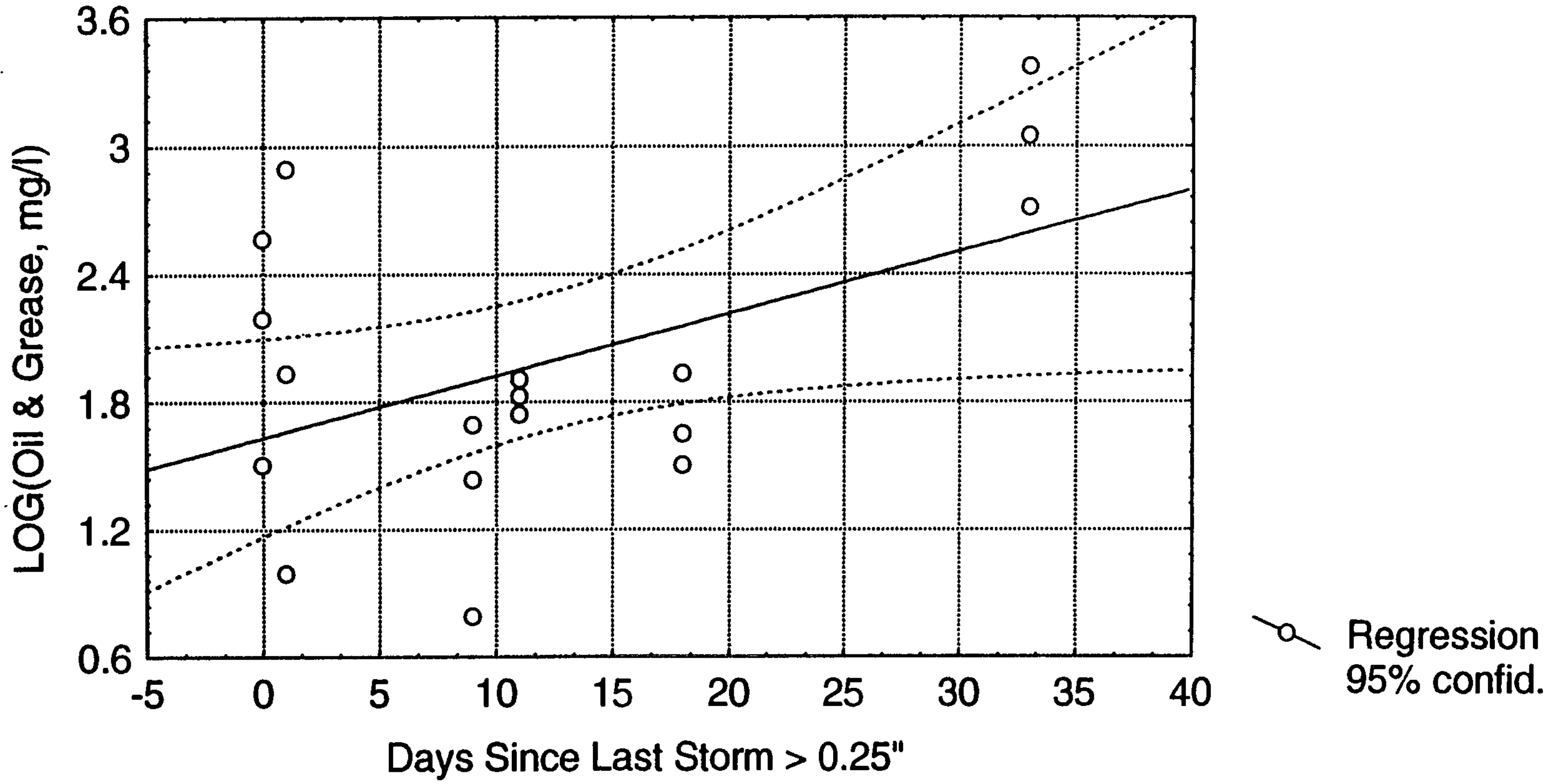
R0009056

Days Since Last Storm > 0.25" vs. LOG(Oil & Grease)

LOG_O_G = 1.6306 + .02917 * DSLS_25

Correlation: r = .48280

p=0.042412



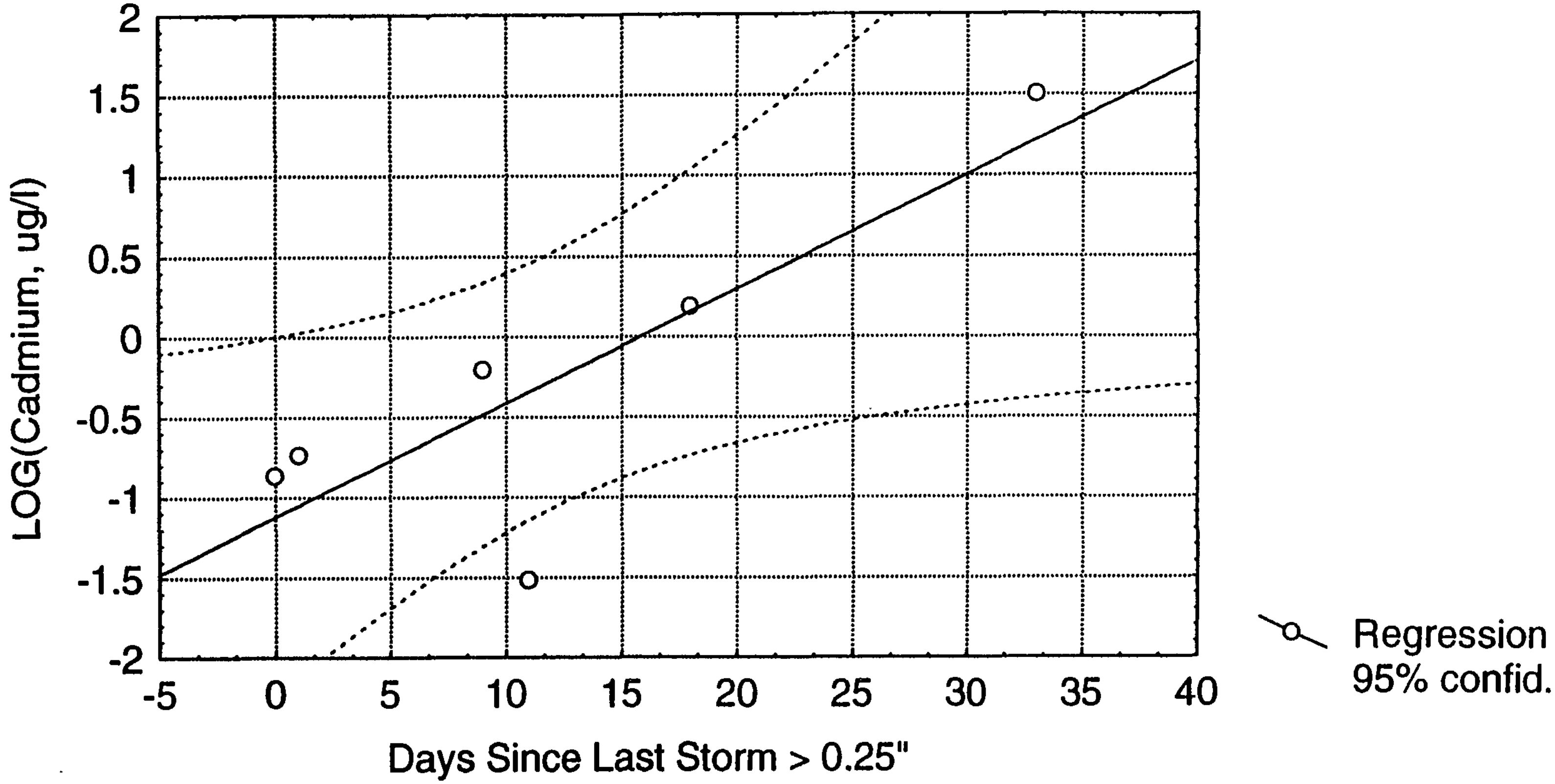
R0009057

Days Since Last Storm > 0.25" vs. LOG(Cadmium), Station Z

LOG_CD = -1.124 + .07089 * DSLS_25

Correlation: r = .83077

p=0.040533

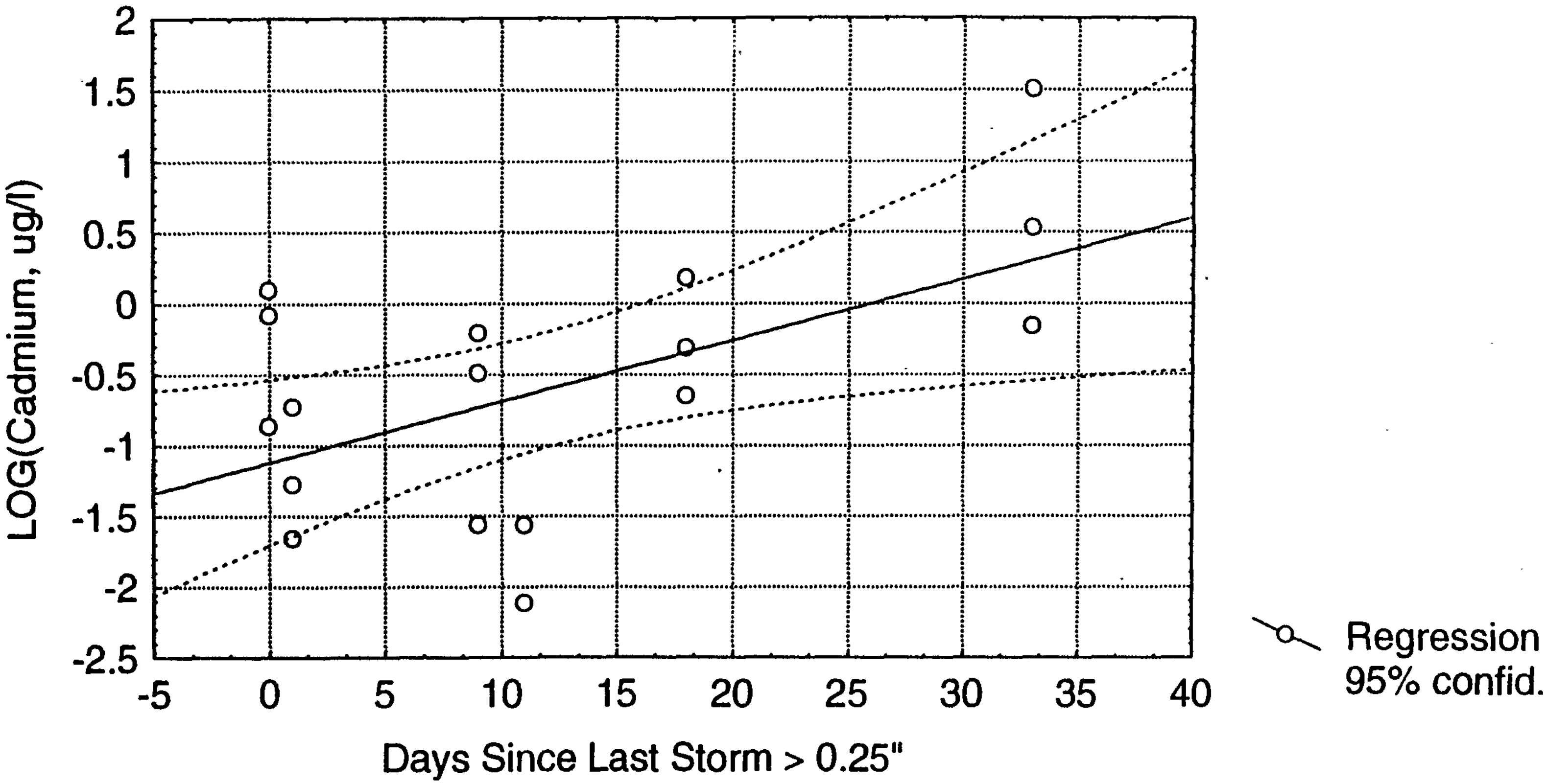


Days Since Last Storm > 0.25" vs. LOG(Cadmium)

LOG_CD = -1.122 + .04309 * DSLS_25

Correlation: r = .54373

p=0.019679



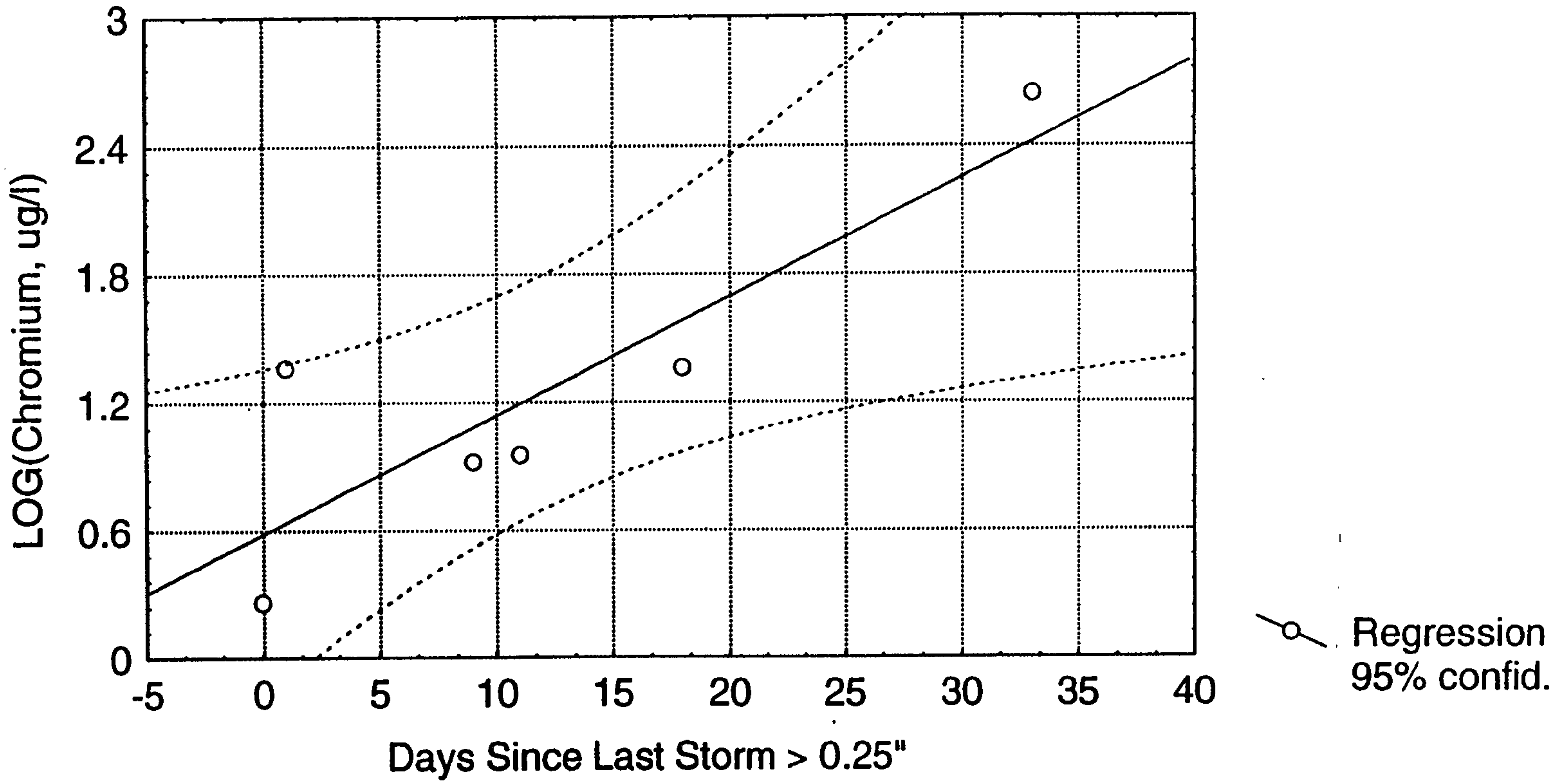
R0009059

Days Since Last Storm > 0.25" vs. LOG(Chromium), Station Z

LOG_CR = .58277 + .05554 * DSLS_25

Correlation: r = .86114

p=0.027586



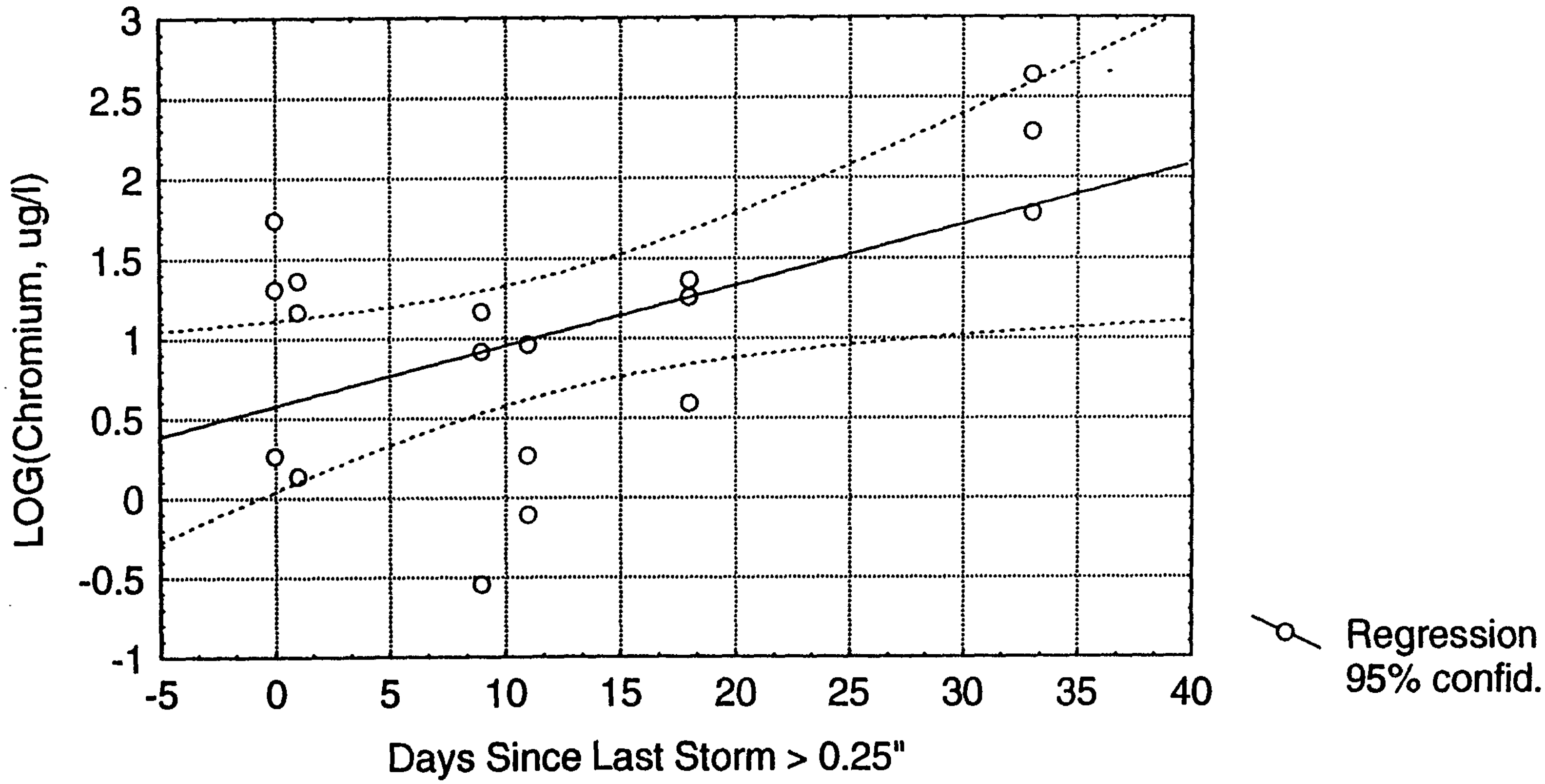
R0009060

Days Since Last Storm > 0.25" vs. LOG(Chromium)

LOG_CR = .57506 + .03775 * DSLS_25

Correlation: r = .52674

p=0.024711



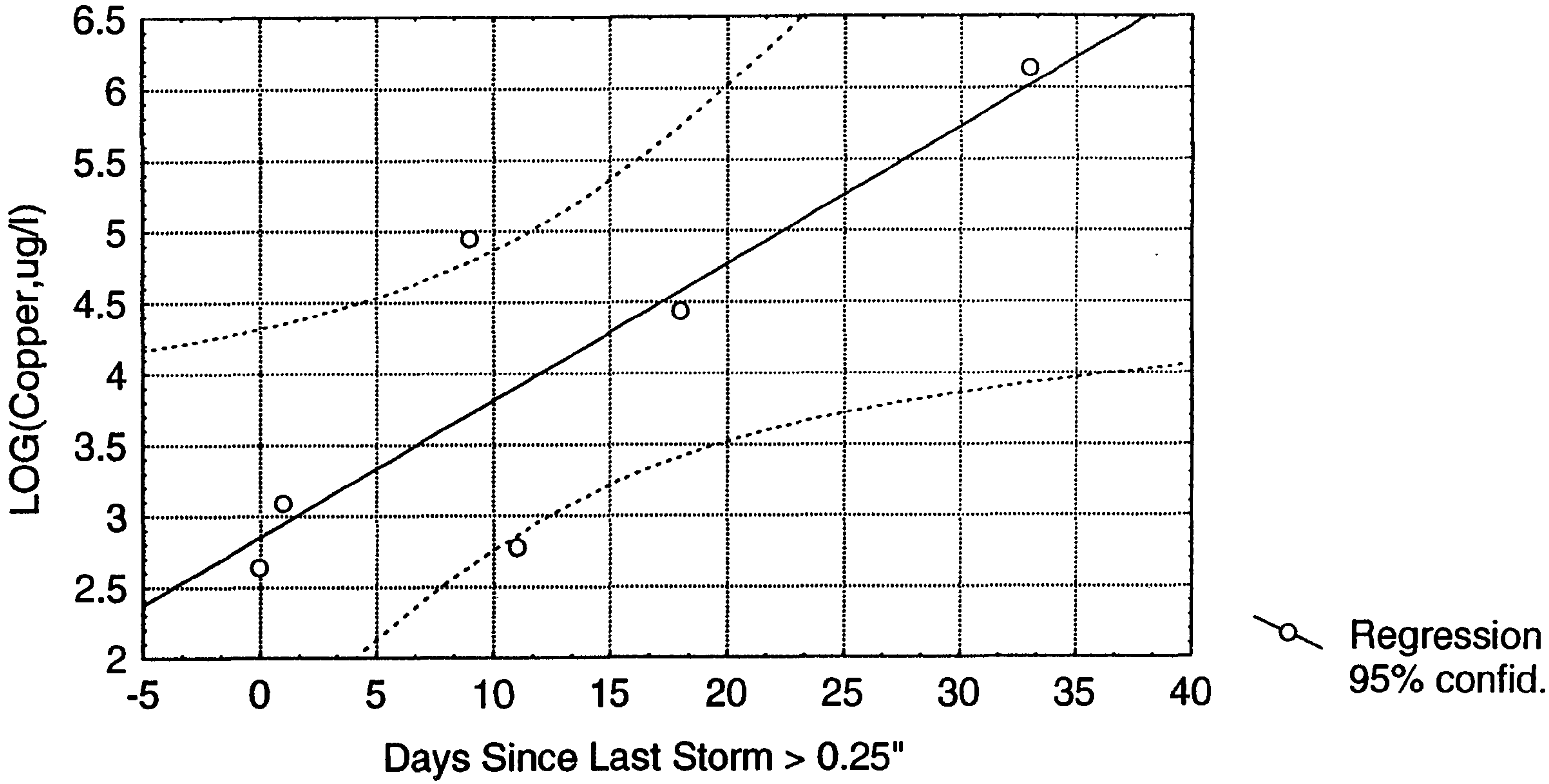
R0009061

Days Since Last Storm > 0.25" vs. LOG(Copper), Station Z

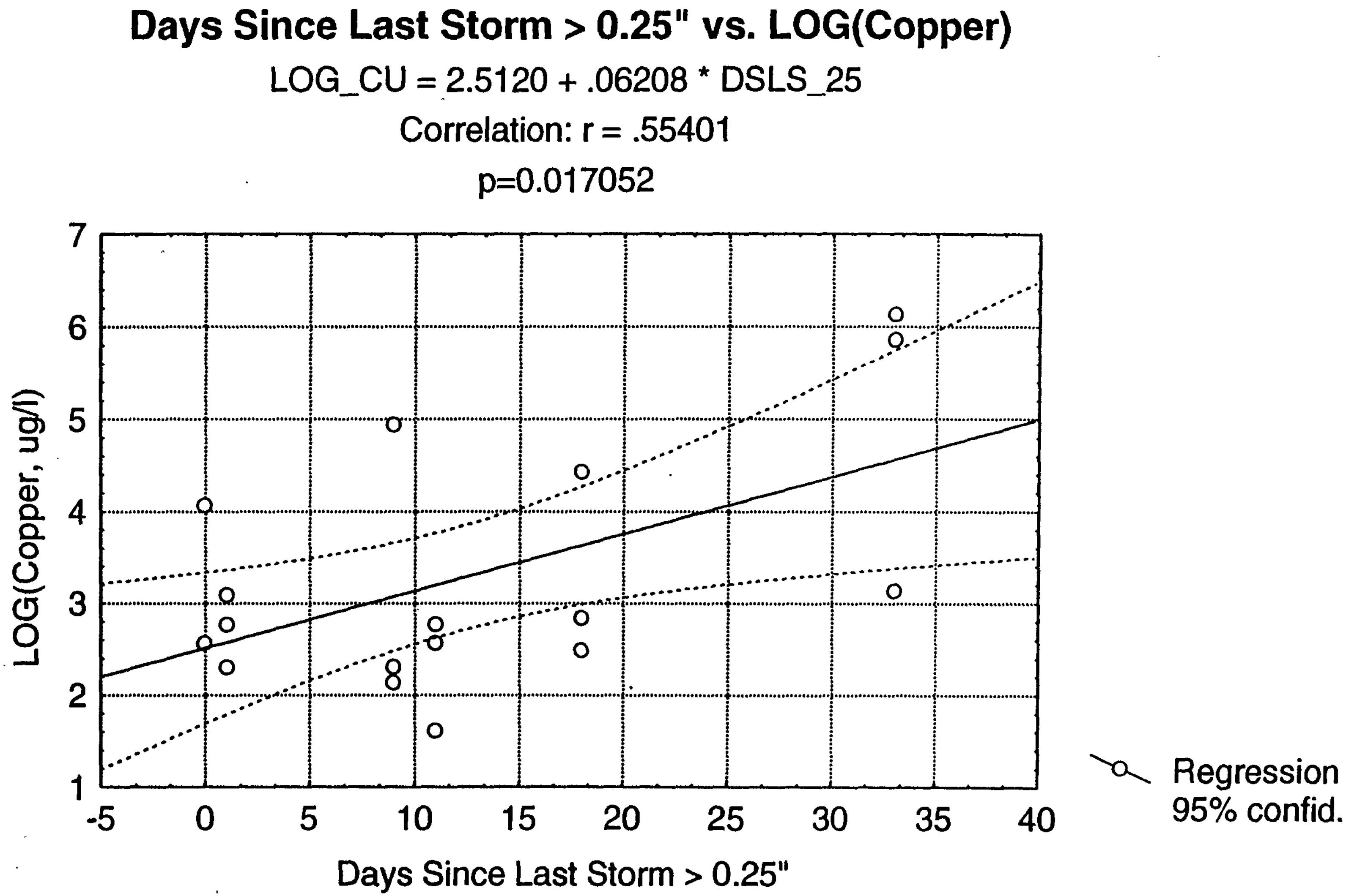
LOG_CU = 2.8510 + .09584 * DSLS_25

Correlation: r = .83959

P=0.036535



R0009062


Days Since Last Storm > 0.25" vs. LOG(Copper)
LOG_CU = 2.5120 + .06208 * DSLS_25
Correlation: r = .55401
p=0.017052
LOG(Copper, ug/l)
Days Since Last Storm > 0.25"
Regression
95% confid.
-5
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6
7

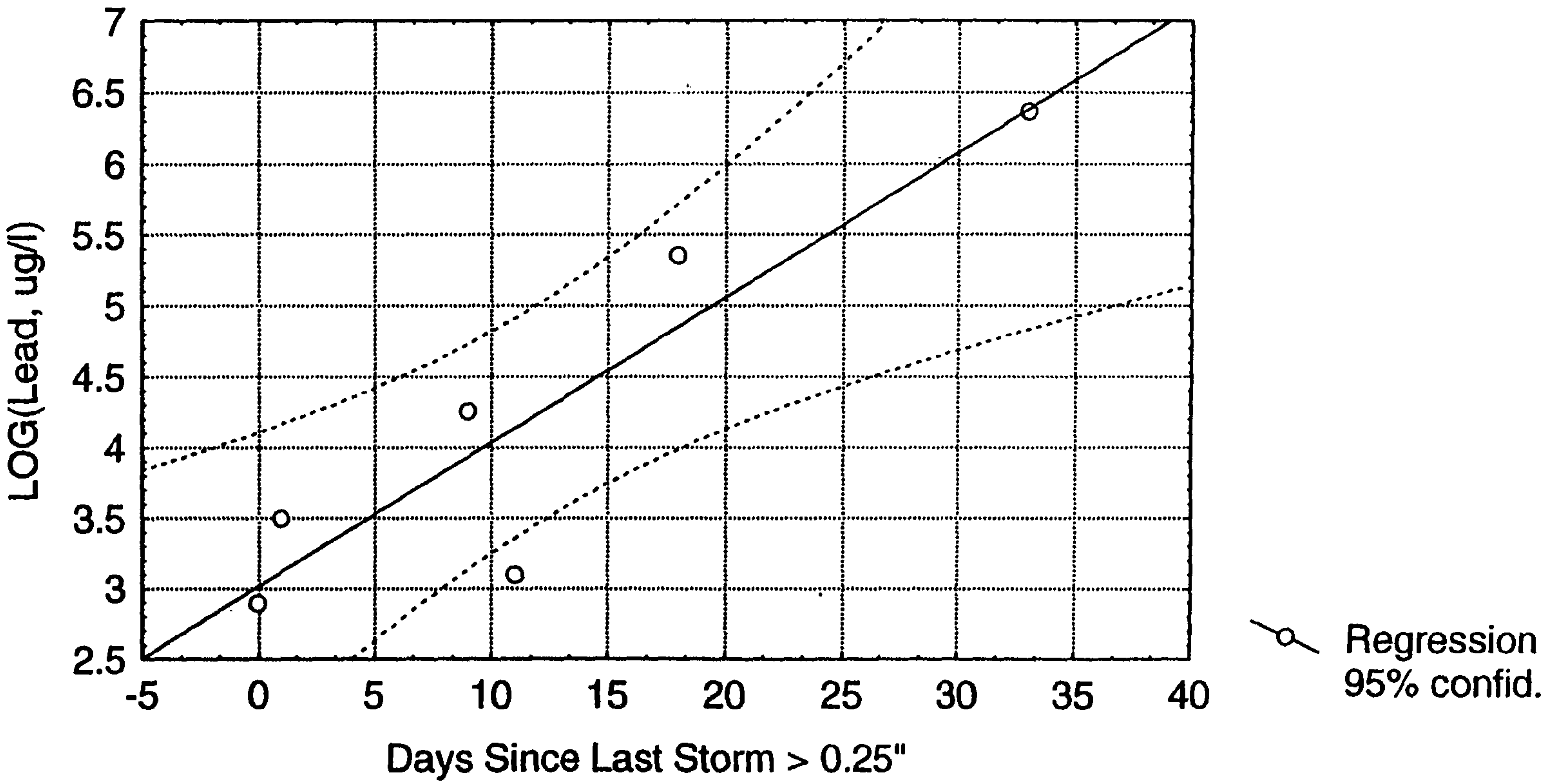
R0009063

Days Since Last Storm > 0.25" vs. LOG(Lead), Station Z

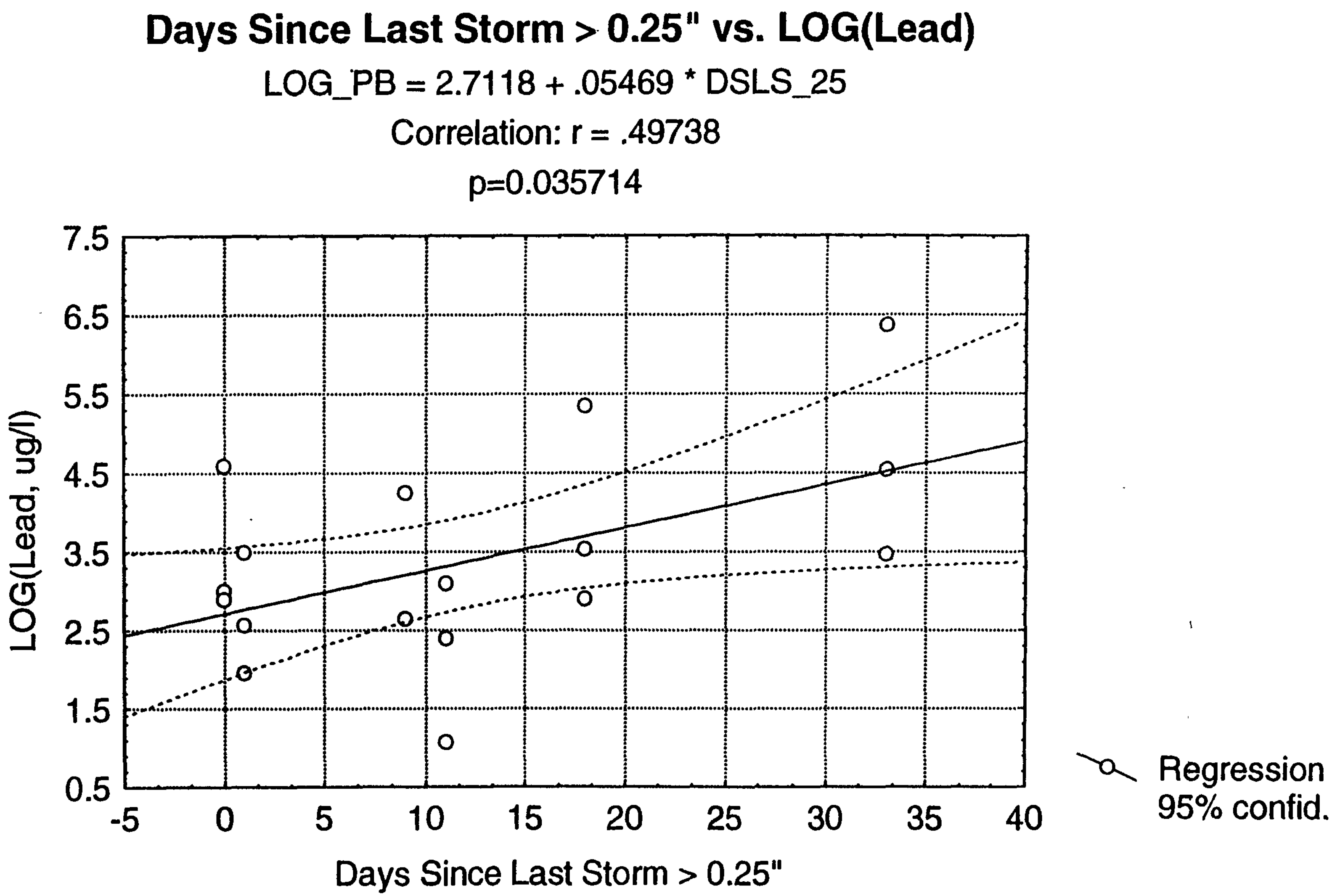
LOG_PB = 3.0151 + .10203 * DSLS_25

Correlation: r = .91122

p=0.011472



R0009064


Days Since Last Storm > 0.25" vs. LOG(Lead)
LOG_PB = 2.7118 + .05469 * DSLS_25
Correlation: r = .49738
p=0.035714
LOG(Lead, ug/l)
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-5
0
5
10
15
20
25
30
35
40
Days Since Last Storm > 0.25"
Regression
95% confid.

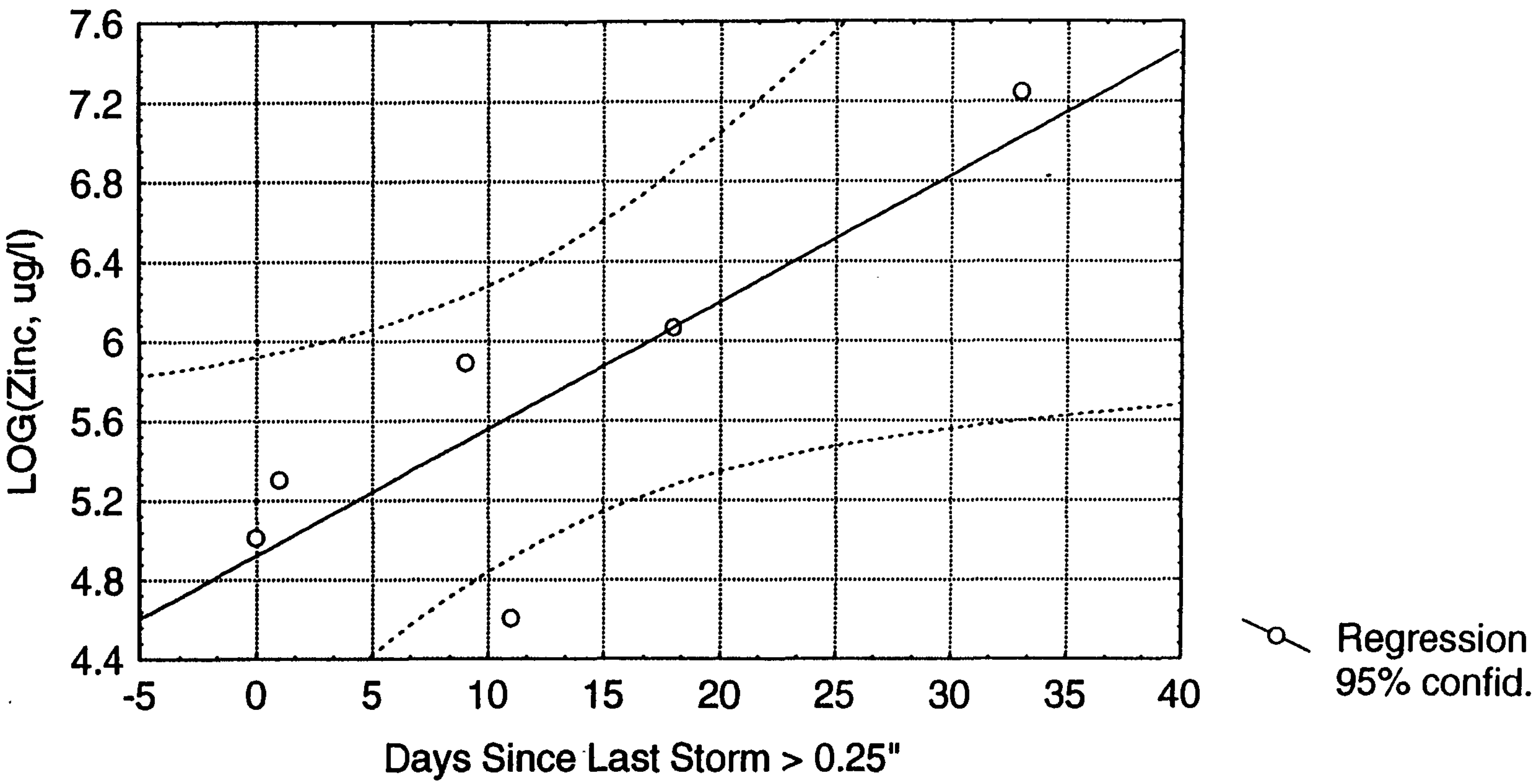
R0009065

Days Since Last Storm > 0.25" vs. LOG(Zinc), Station Z

LOG_ZN = 4.9213 + .06362 * DSLS_25

Correlation: r = .83304

p=0.039486



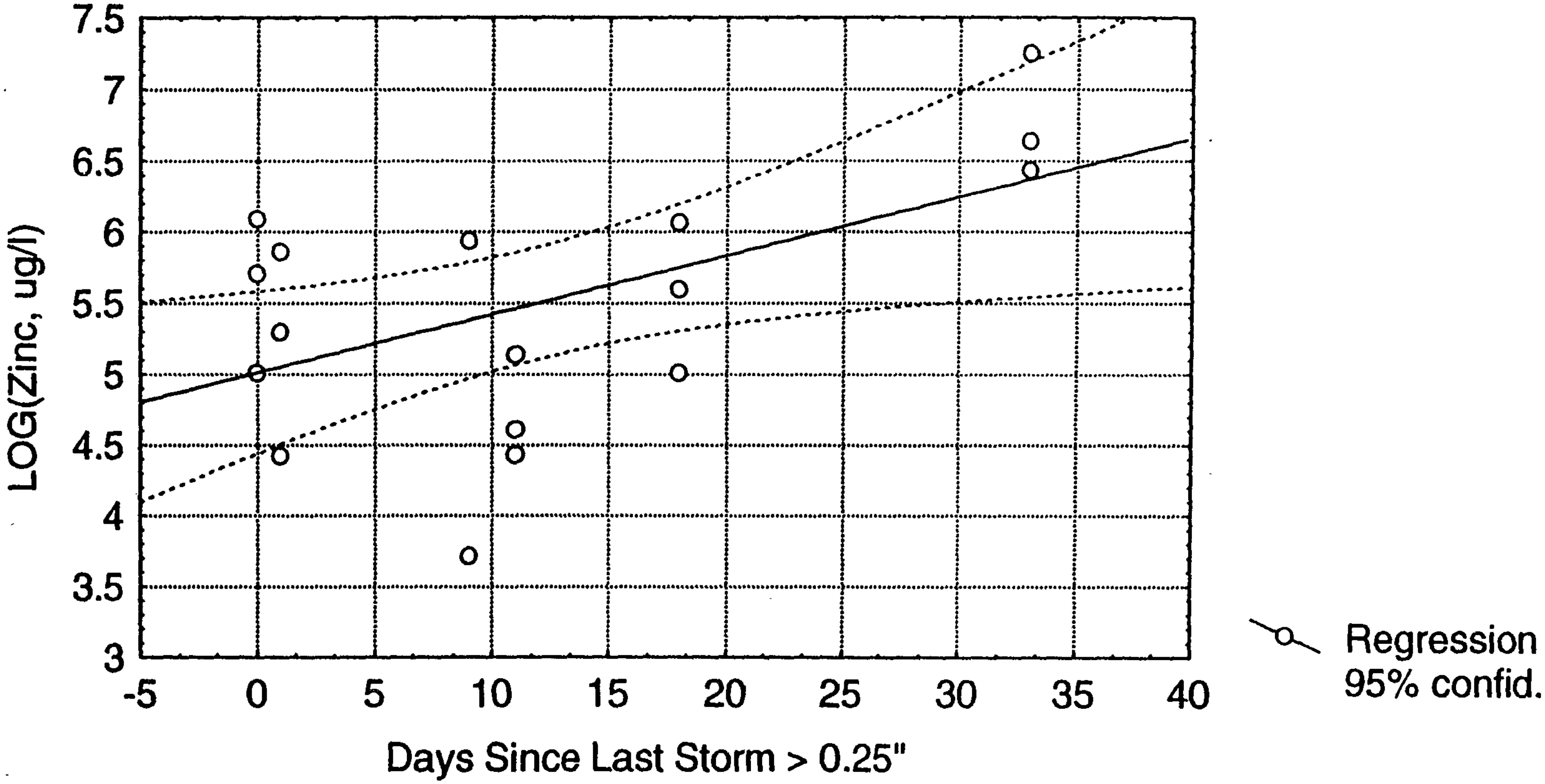
R0009066

Days Since Last Storm > 0.25" vs. LOG(Zinc)

LOG_ZN = 5.0104 + .04112 * DSLS_25

Correlation: r = .53486

p=0.022193



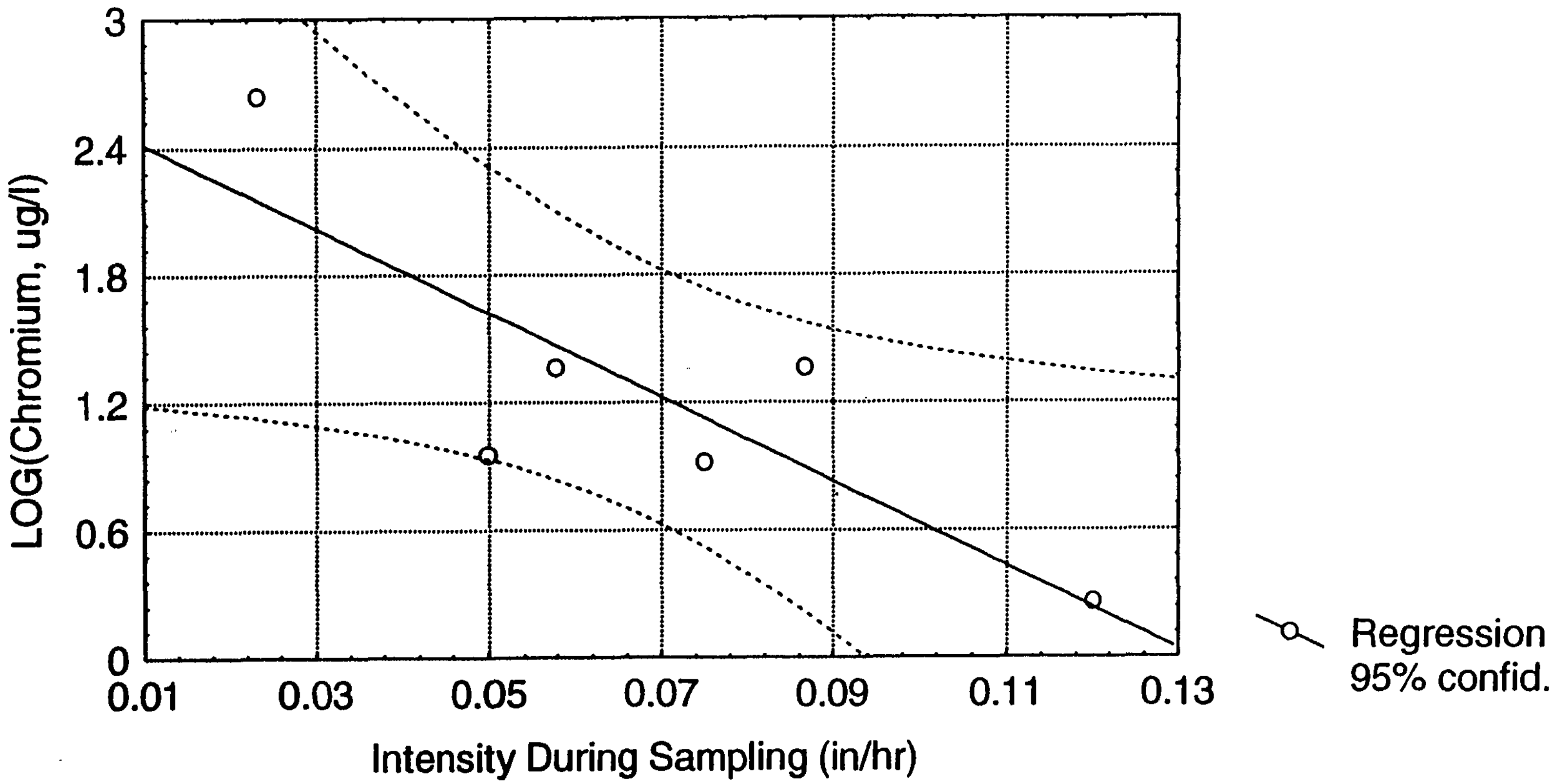
R0009067

Intensity During Sampling vs. LOG(Chromium), Station Z

LOG_CR = 2.6126 - 19.82 * INT_SAMP

Correlation: r = -.8336

p=0.039210



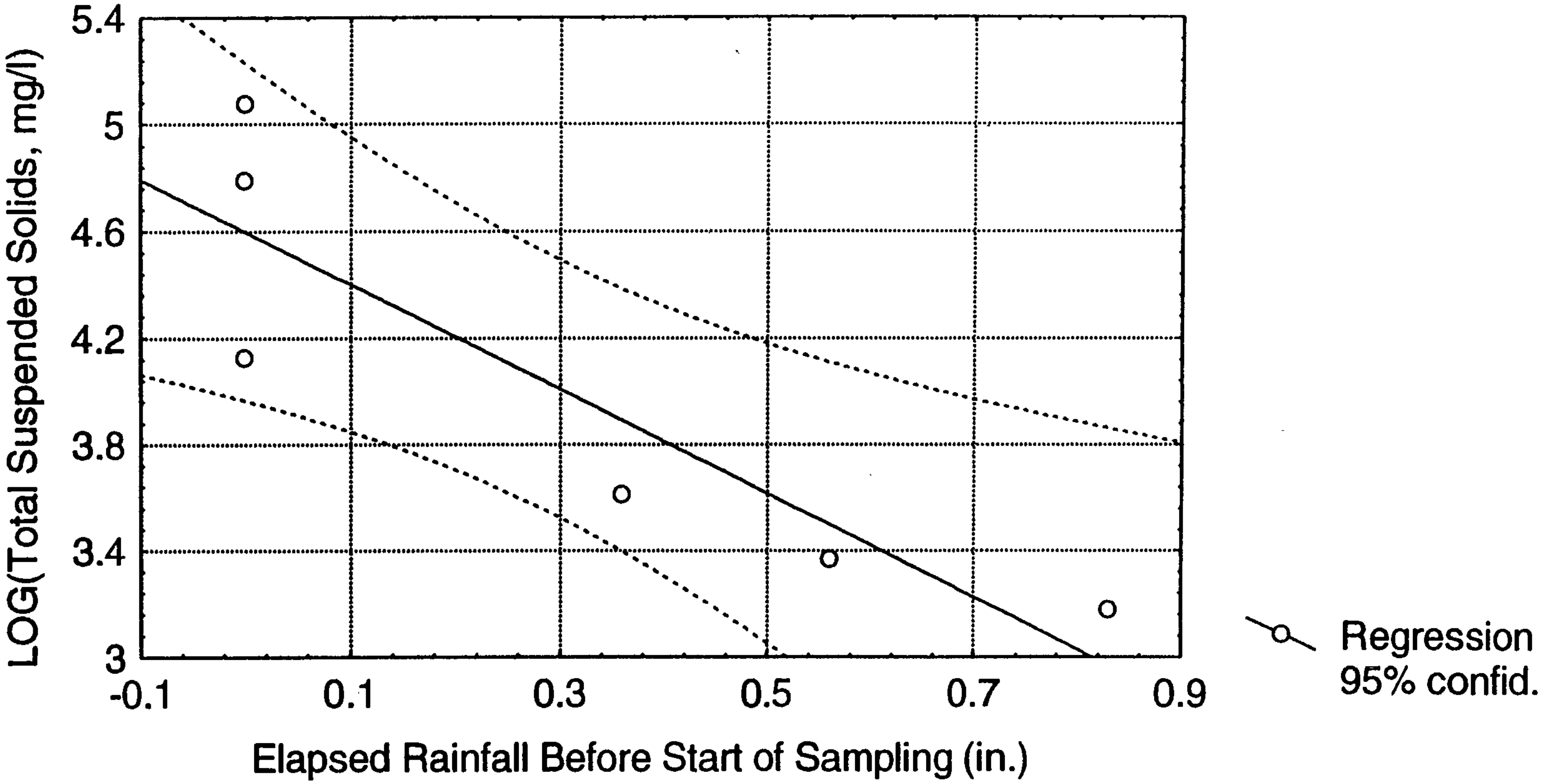
R0009068

Elapsed Rainfall Before Sampling vs. LOG(TSS), Station Y

LOG_TSS = 4.5963 - 1.961 * MISSED

Correlation: r = -.8904

p=0.017368



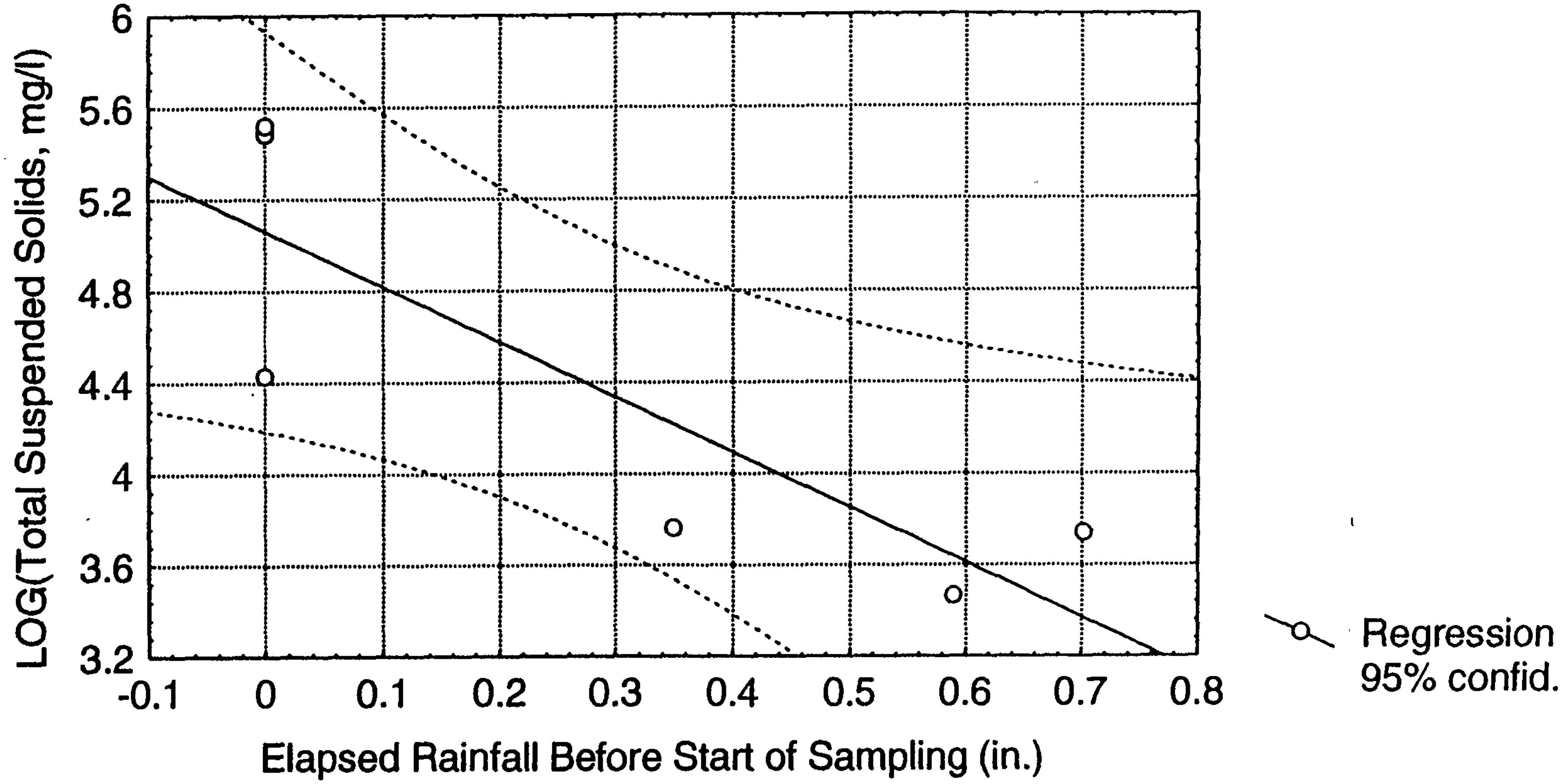
R0009069

Elapsed Rainfall Before Sampling vs. LOG(TSS), Station Z

LOG_TSS = 5.0594 - 2.412 * MISSED

Correlation: r = -.8489

p=0.032524



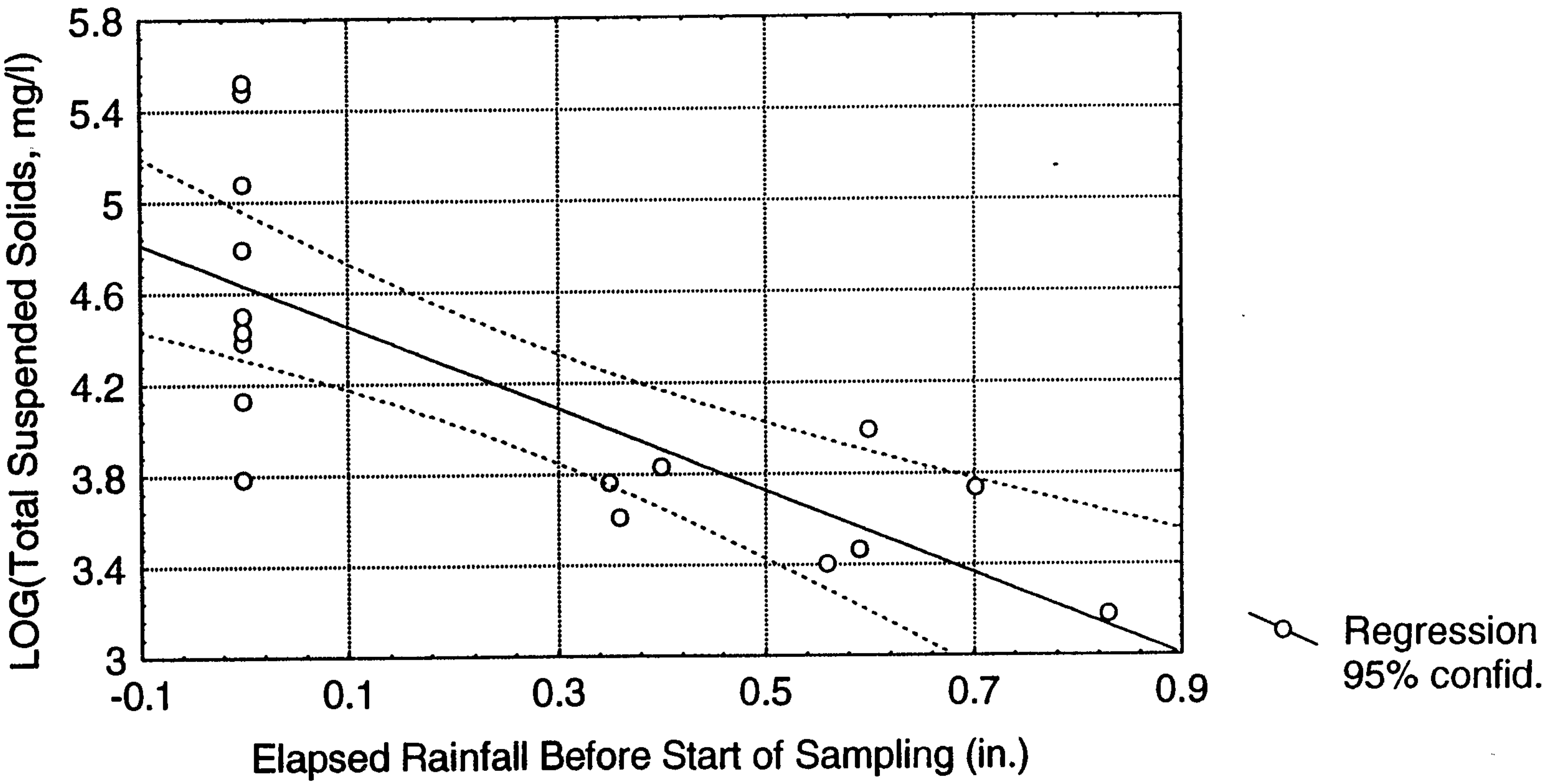
R0009070

Elapsed Rainfall Before Sampling vs. LOG(TSS)

LOG_TSS = 4.6333 - 1.812 * MISSED

Correlation: r = -.7721

p=0.000174



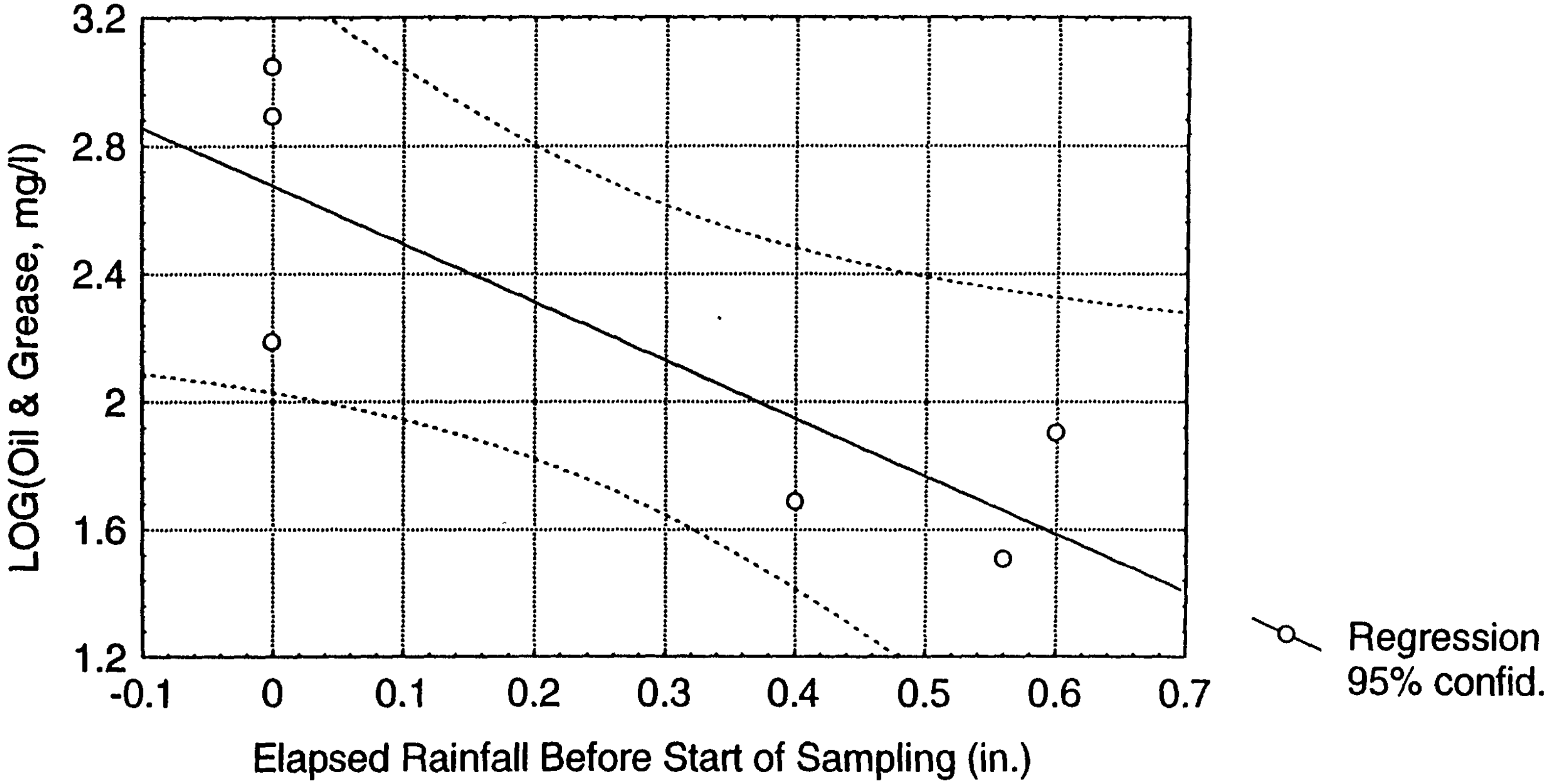
R0009071

Elapsed Rainfall Before Sampling vs. LOG(O&G), Station X

LOG_O_G = 2.6745 - 1.816 * MISSED

Correlation: r = -.8347

p=0.038737



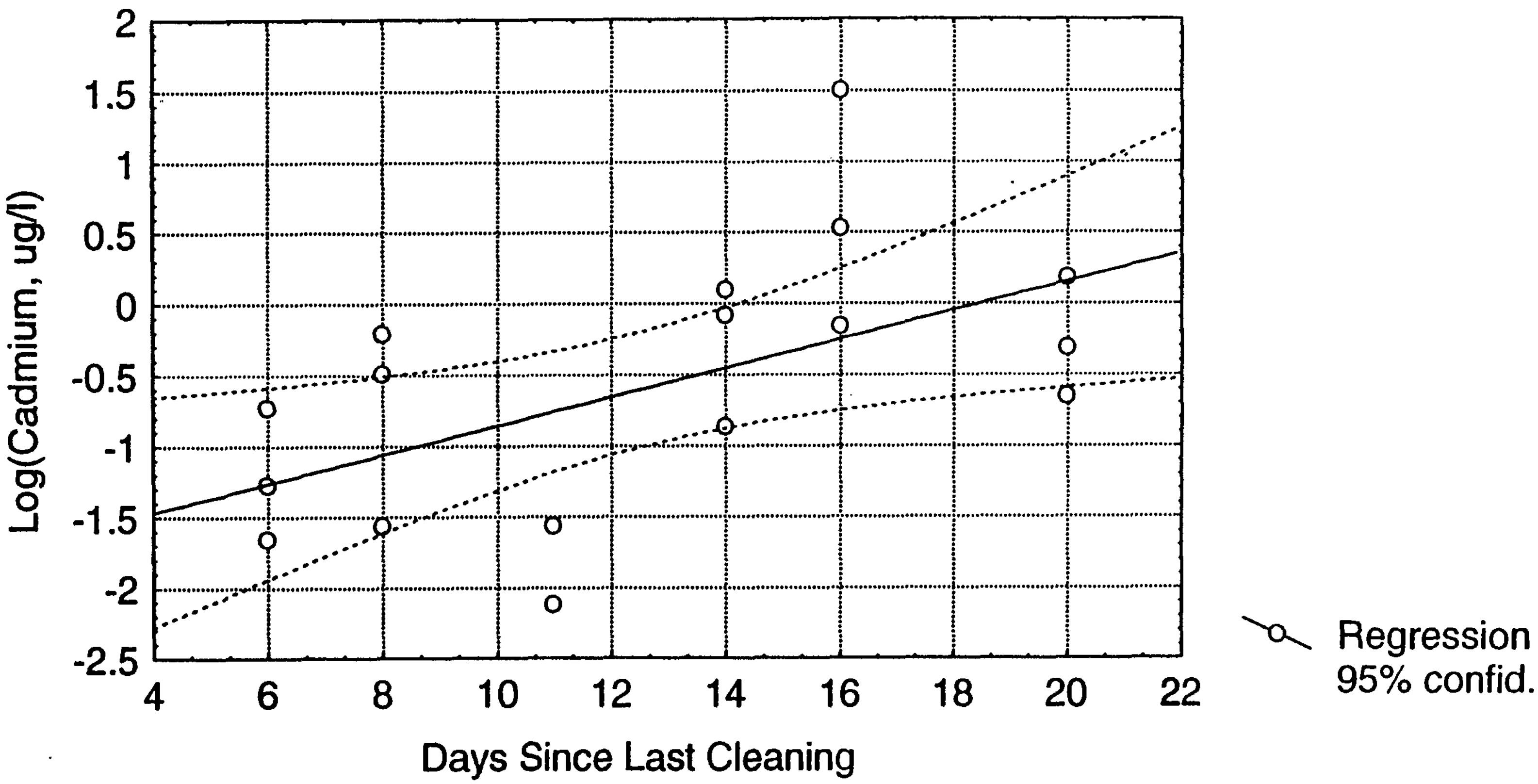
R0009072

Days Since Last Cleaning vs. Log(Cadmium)

LOG_CD = -1.872 + .10135 * L_CLEAN

Correlation: r = .54293

p=0.019895



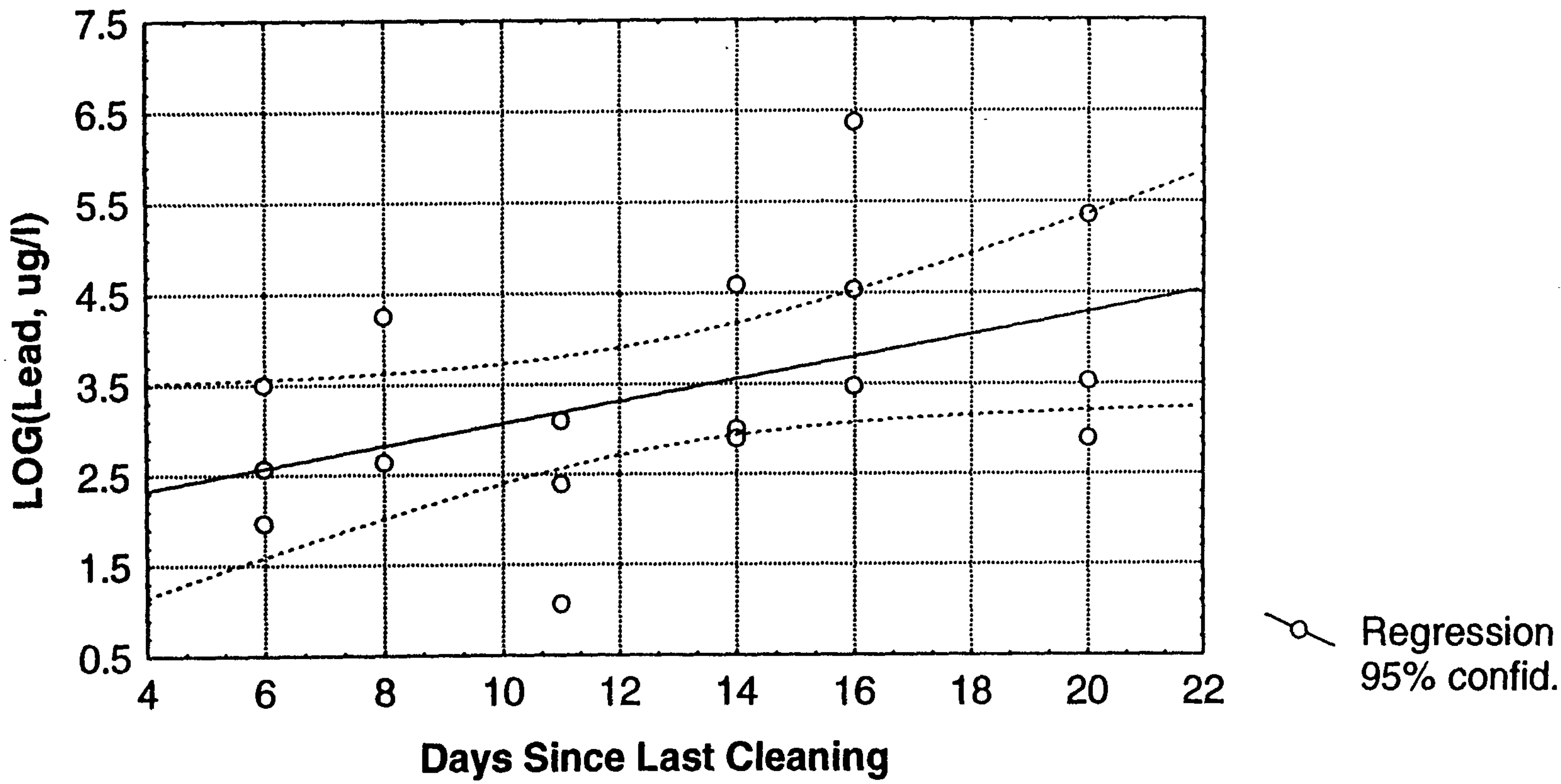
R0009073

Days Since Last Cleaning vs. LOG(Lead)

LOG_PB = 1.8399 + .12225 * L_CLEAN

Correlation: r = .47197

p=0.047983



R0009074

Appendix F

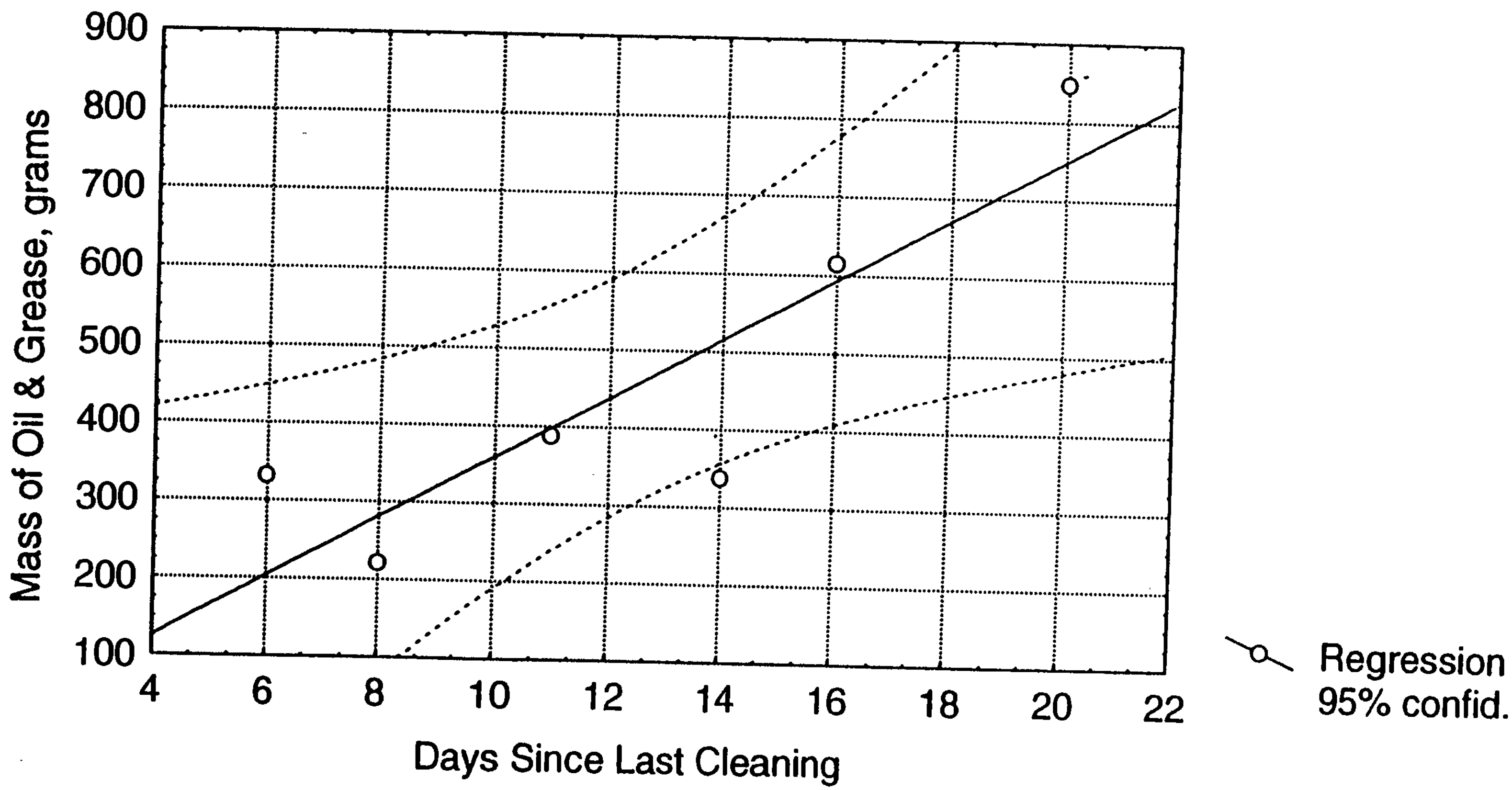
Significant Regression Plots - Event Mass Loads

Days Since Last Cleaning vs. Mass of Oil & Grease, Station Z

MASS_O_G = -30.77 + 38.969 * L_CLEAN

Correlation: r = .87666

p=0.021880



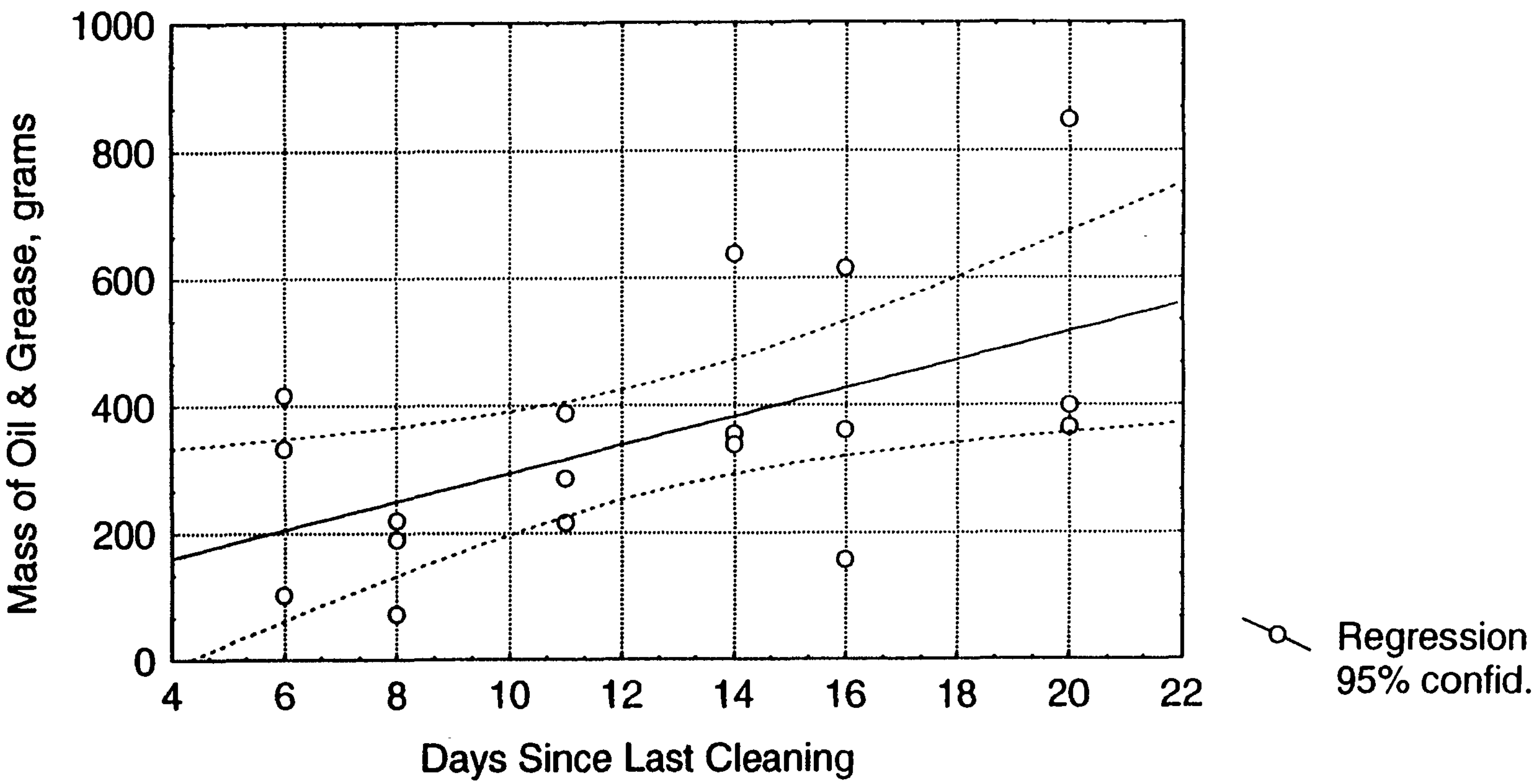
R0009076

Days Since Last Cleaning vs. Mass of Oil & Grease

MASS_O_G = 71.981 + 22.193 * L_CLEAN

Correlation: r = .55460

p=0.016909



R0009077

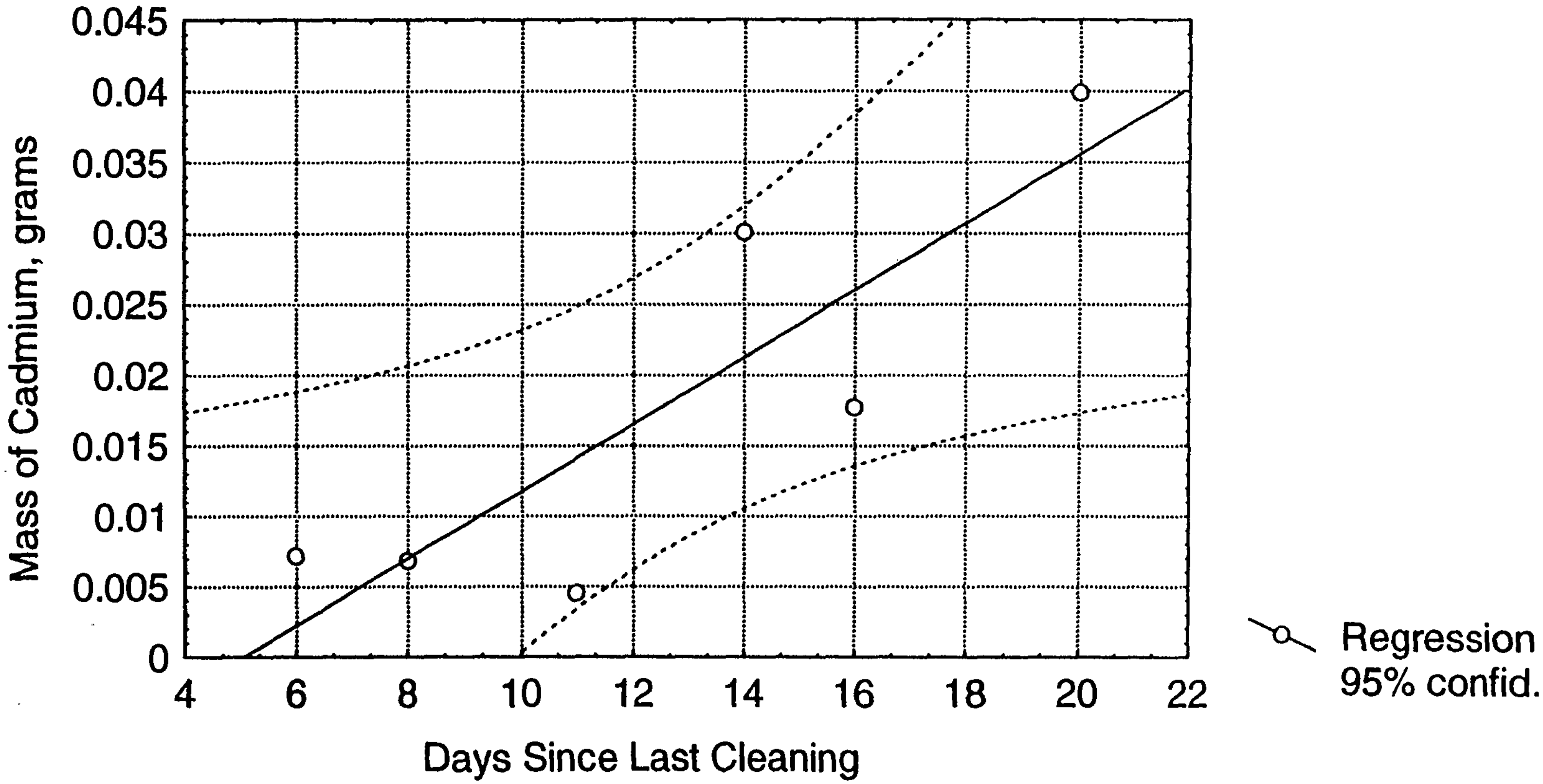
[redacted] [redacted]

Days Since Last Cleaning vs. Mass of Cadmium, Station Y

MASS_CD = -.0120 + .00238 * L_CLEAN

Correlation: r = .85486

p=0.030068



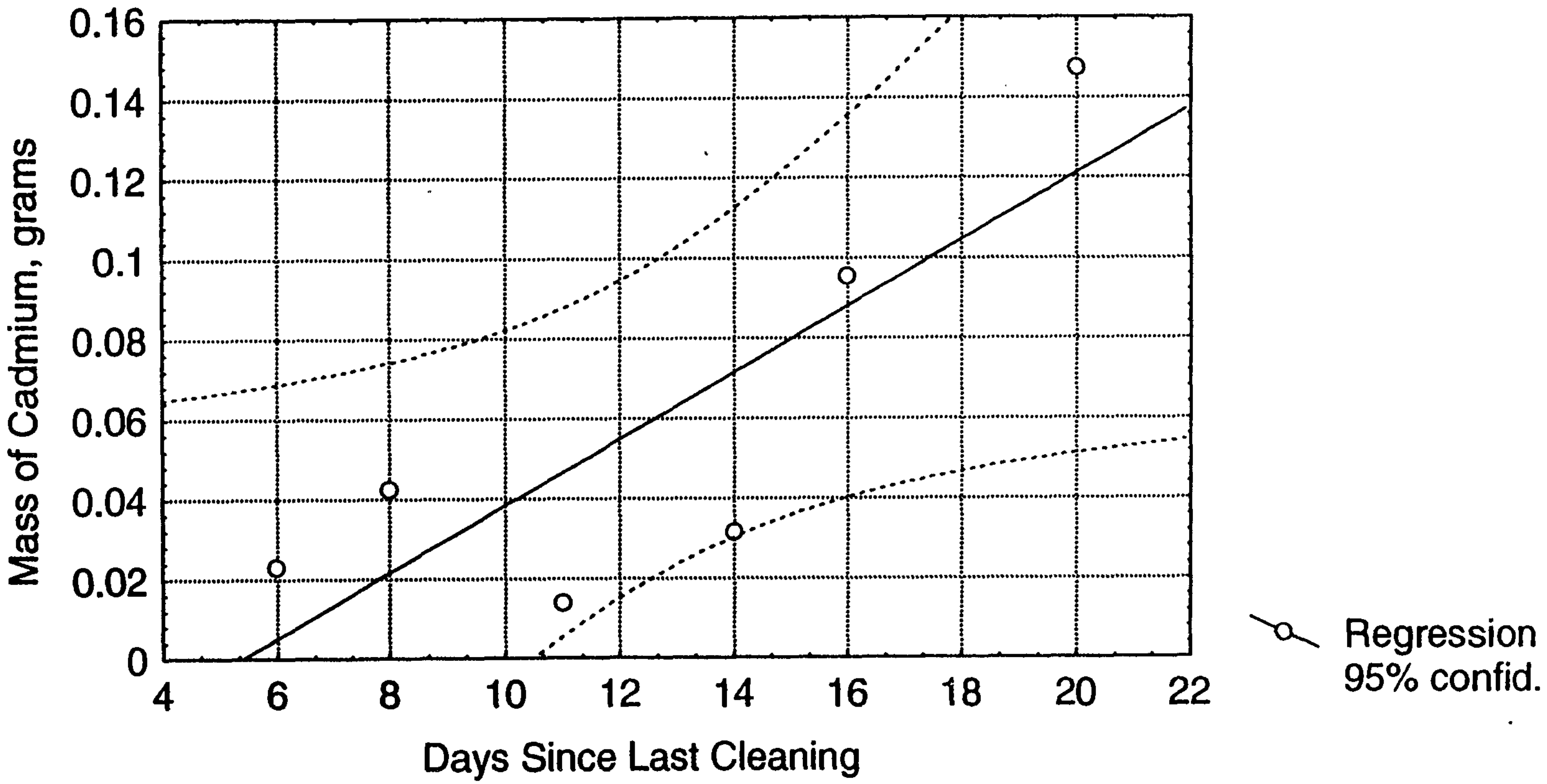
R0009078

Days Since Last Cleaning vs. Mass Load of Cadmium, Station Z

MASS_CD = -.0448 + .00829 * L_CLEAN

Correlation: r = .83150

p=0.040197



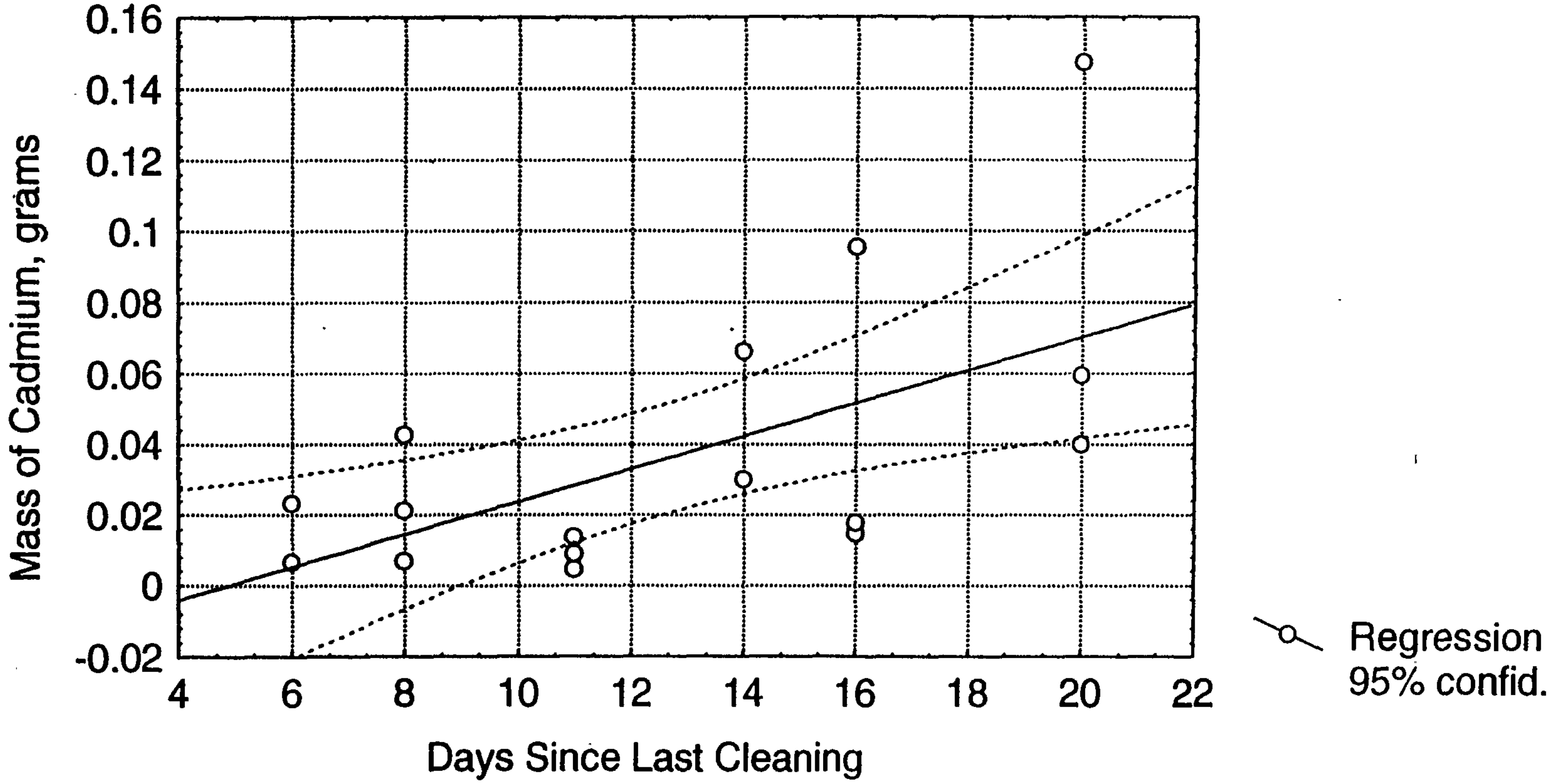
R0009079

Days Since Last Cleaning vs. Mass of Cadmium

MASS_CD = -.0227 + .00465 * L_CLEAN

Correlation: r = .61235

p=0.006906

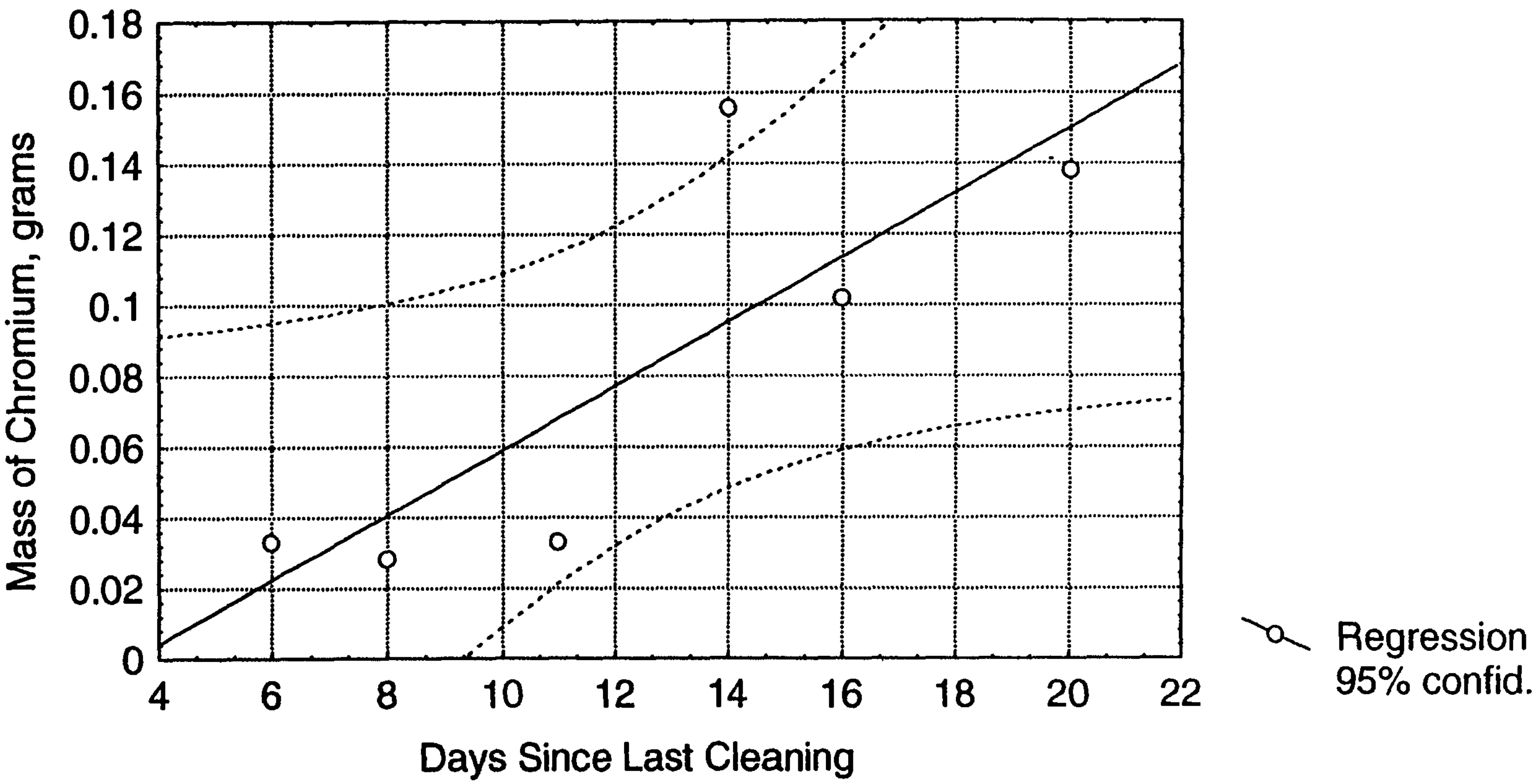


Days Since Last Cleaning vs. Mass of Chromium, Station Y

MASS_CR = -.0323 + .00911 * L_CLEAN

Correlation: r = .82194

p=0.044734



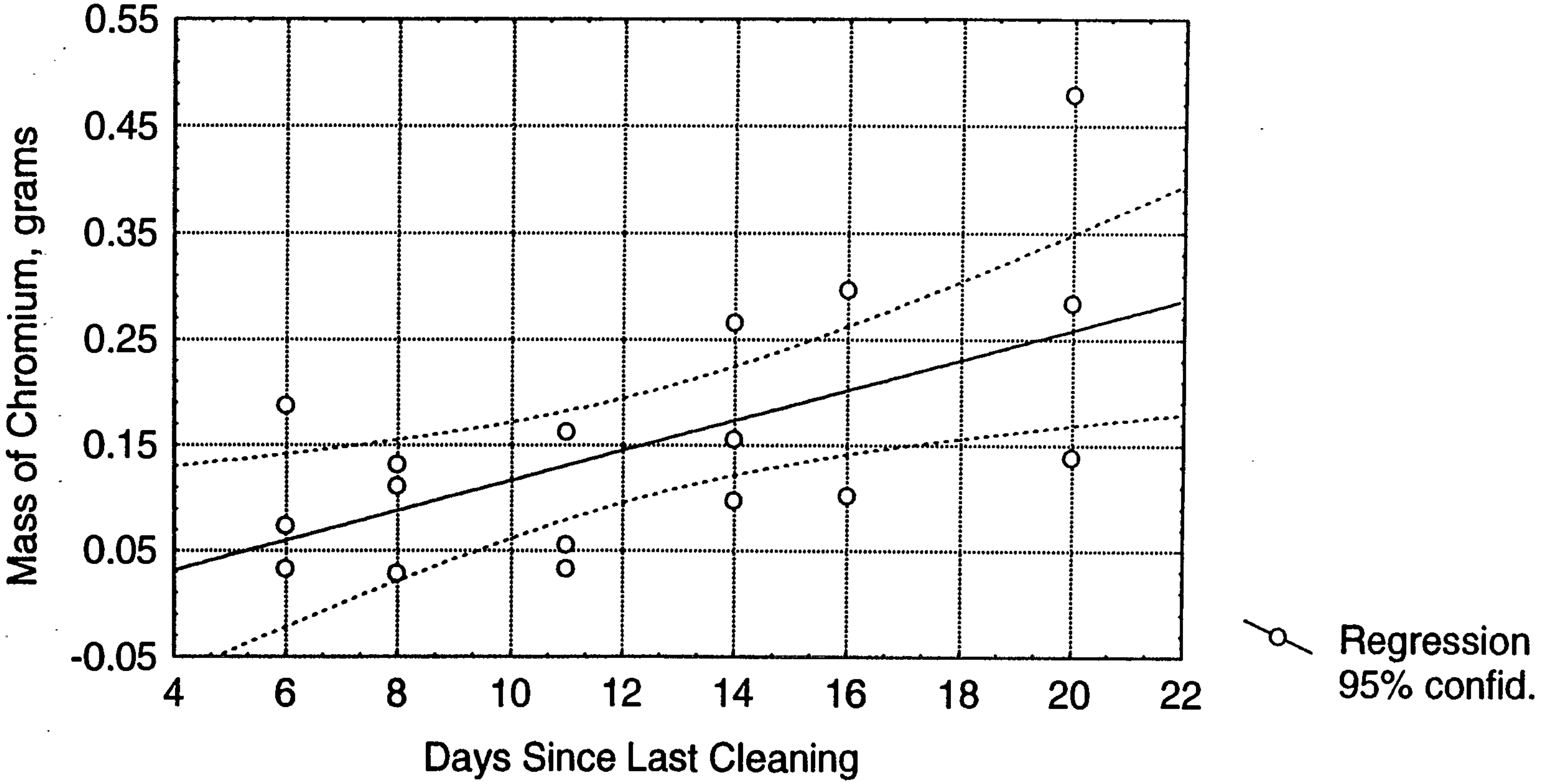
R0009081

Days Since Last Cleaning vs. Mass of Chromium

MASS_CR = -.0256 + .01420 * L_CLEAN

Correlation: r = .59870

p=0.008660

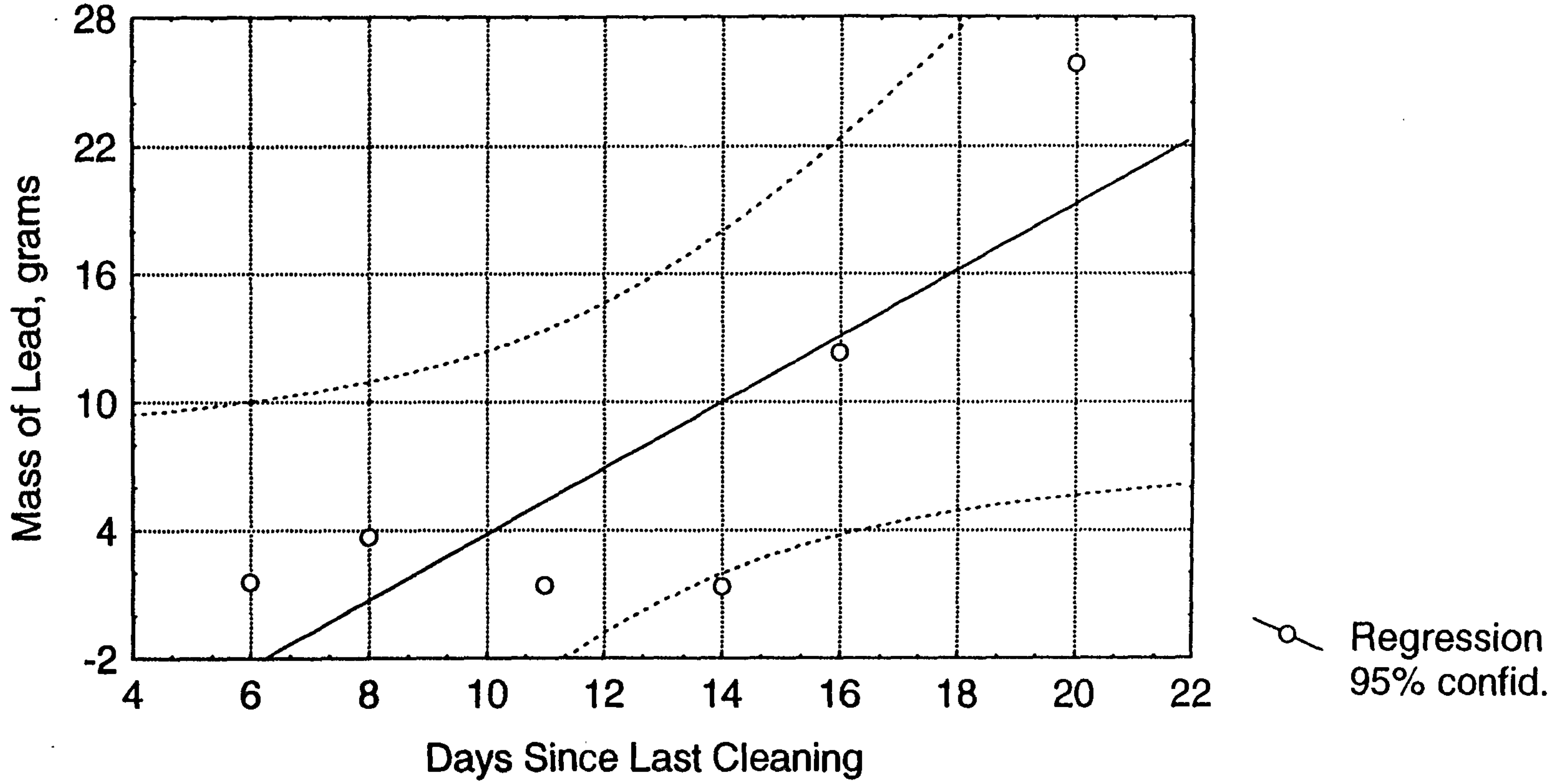


Days Since Last Cleaning vs. Mass of Lead, Station Z

MASS_PB = -11.65 + 1.5460 * L_CLEAN

Correlation: r = .81983

P=0.045770



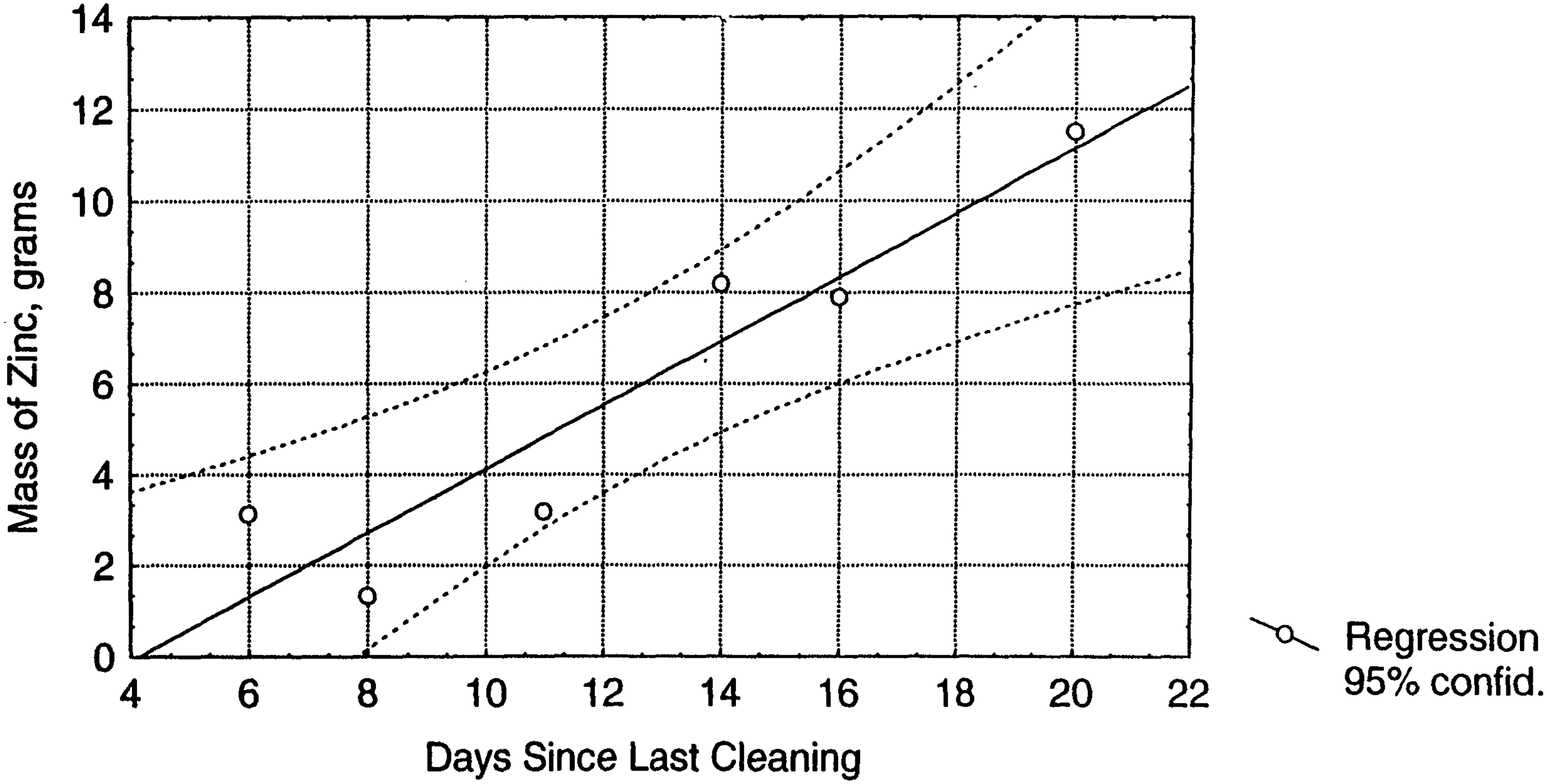
R0009083

Days Since Last Cleaning vs. Mass of Zinc, Station Y

MASS_ZN = -2.906 + .70200 * L_CLEAN

Correlation: r = .93346

p=0.006493

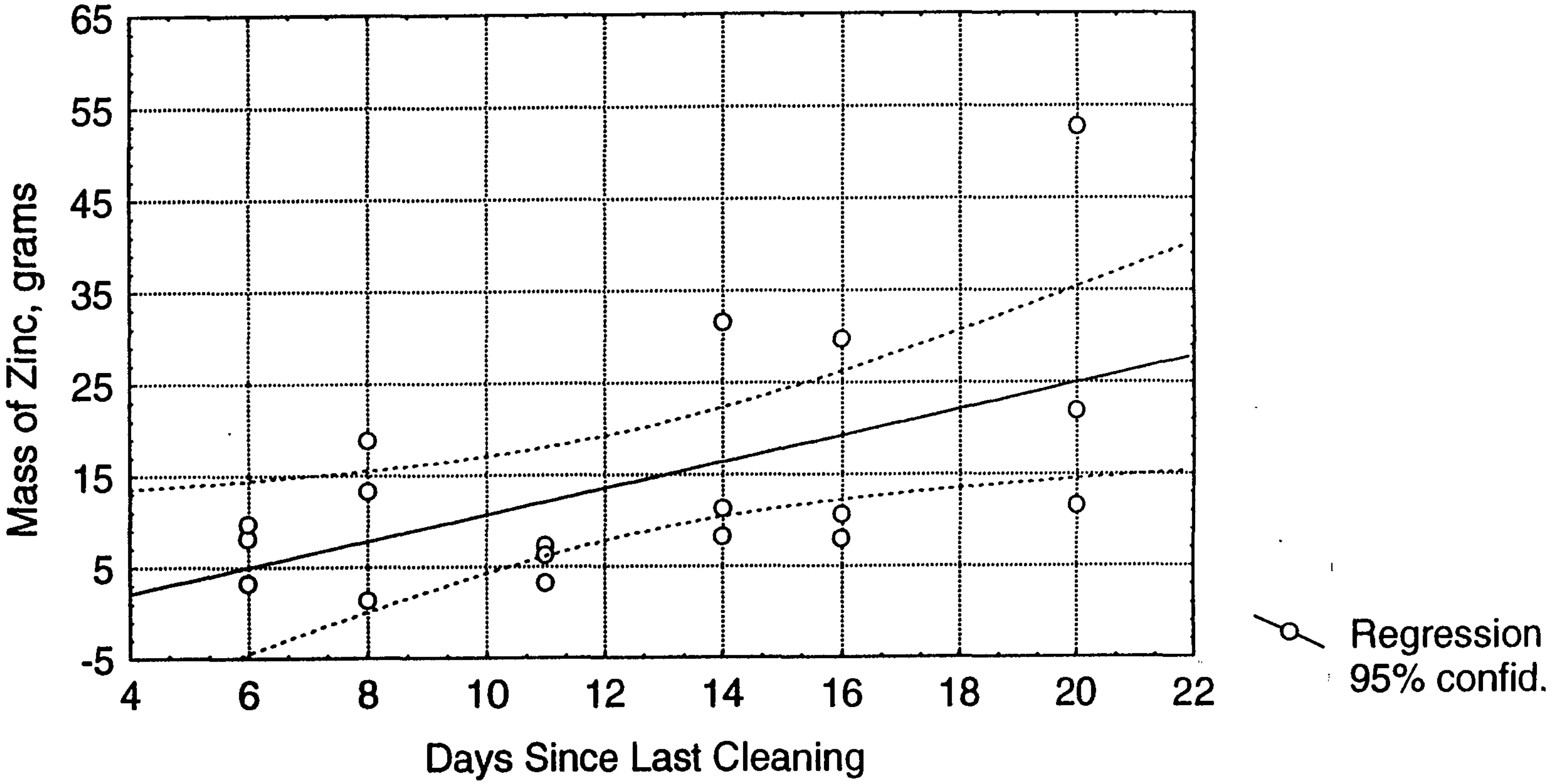


Days Since Last Cleaning vs. Mass of Zinc

MASS_ZN = -3.613 + 1.4282 * L_CLEAN

Correlation: r = .54473

p=0.019411



R0009085

GEOMATRIX

RESULTS OF A RETAIL GASOLINE OUTLET AND COMMERCIAL PARKING LOT STORM WATER RUNOFF STUDY

Prepared For:
Western States Petroleum Association
and
American Petroleum Institute

Prepared By:
Geomatrix Consultants, Inc.
Newport Beach, California

Project No. S2498
September 26, 1994

Geomatrix Consultants

GEOMATRIX

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report presents the results of a two-part study of constituents present in simulated storm water runoff from six retail gasoline outlets (RGOs) and four commercial parking lots. The objective of the study is to characterize storm water runoff from RGOs and to compare the results with runoff from commercial parking lots and published urban "background" values. The study was funded by the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API).

The study demonstrates that for the constituents analyzed, median event mean concentrations (EMCs) in storm water runoff from normally operated and maintained RGOs are no higher than those in runoff from commercial parking lots. Additionally, median EMCs of total suspended solids, copper, lead, and zinc in runoff from RGOs and parking lots are no higher than background levels present in urban runoff as established by the National Urban Runoff Program. Furthermore, there are no significant differences in median EMCs in runoff from RGO pump islands and driveways for the constituents analyzed. These results indicate that fueling activities at normally operated and maintained RGOs do not contribute additional significant concentrations of measured constituents in storm water runoff.

In 1987, Section 402(p) was added to the Clean Water Act to establish a framework for addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Storm water discharges from commercial facilities, such as RGOs and parking lots, are not included under the initial regulations. However, regulations are now being promulgated that are expected to increase the number and types of dischargers required to obtain NPDES permit coverage for storm water discharges. EPA, in a report to Congress (EPA, 1993), identified several business categories that are not currently regulated by NPDES permits. Automotive service facilities, including RGOs, are included on EPA's list of potential Phase II permittees.

This study used a simulated rainfall method to induce runoff from representative RGO and parking lot test sites. The RGO and commercial parking lots used as test sites provide a variety of site and operational conditions. Simulated runoff was collected at two areas within each test site. These areas include pump islands and driveways at RGOs and high-use and moderate-use areas within commercial parking lots. Both discrete and composite runoff samples were collected during the 45-minute test. The collected samples were analyzed in accordance with appropriate EPA methods for a variety of constituents including California Code of Regulations Title 26 Metals, total suspended solids, oil and grease, total petroleum hydrocarbons as gasoline (TPHg), and benzene, toluene, ethyl benzene, and total xylenes (BTEX).

GEOMATRIX

RESULTS OF A RETAIL GASOLINE OUTLET AND COMMERCIAL PARKING LOT STORM WATER RUNOFF STUDY

1.0 INTRODUCTION

This report presents the results of a two-part study of simulated storm water runoff from six retail gasoline outlets (RGOs) and four commercial parking lots. Part I was conducted by Hart Crowser and characterized simulated storm water runoff from five RGOs. Part II was conducted by Geomatrix Consultants, Inc. (Geomatrix) and characterized simulated storm water runoff from four commercial parking lots and one RGO. The study was funded by the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API).

1.1 Objective

The objective of this study is to characterize storm water runoff from RGOs and to compare the results with runoff from commercial parking lots and published urban "background" values.

1.2 Background

In 1972, the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) was amended to provide that any discharge of pollutants from a point source to Waters of the United States is effectively prohibited unless it is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Although this technically prohibits the discharge of pollutants in storm water, the focus at that time was on the bigger problems of industrial waste and sewage treatment.

As more significant sources of water pollution were brought under control, the impact of pollutants in storm water became more noticeable. Water quality studies conducted in the 1970s and 1980s identified urban runoff as a diffuse, or nonpoint source of pollution. In response to these studies, the

1987 amendments to the Water Quality Act added Section 402(p). This section established a comprehensive two-phased approach for the U.S. Environmental Protection Agency (EPA) to follow in addressing storm water discharges. Five types of storm water discharges are covered under the Phase I program. Dischargers within these five categories, listed below, were required to obtain permit coverage before October 1, 1992:

A) A discharge for which a permit has been issued prior to February 4, 1987;

B) A discharge associated with industrial activities;

C) A discharge from a municipal separate storm sewer system serving a population of 250,000 or more;

D) A discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000; or

E) A storm water discharge determined by the EPA Administrator or the State to contribute to a violation of a water quality standard or to be a significant contributor of pollutants to the waters of the United States.

Discharges from commercial facilities, such as RGOs and parking lots, are not included under the Phase I regulations. However, Phase II regulations now being promulgated are expected to increase the numbers and types of dischargers that are required to obtain NPDES permit coverage for storm water discharges. EPA, in a draft Phase II report to Congress (EPA, 1993), identified several business categories that are not currently regulated by NPDES permits. Automotive service facilities, including RGOs, are included on EPA's list of potential Phase II permittees. It should be noted that, according to the EPA draft Phase II report, the list of potential permittees was created using limited reliable data on storm water problems associated with Phase II sources nationwide. In order to provide data regarding storm water runoff from potential Phase II facilities, WSPA and API commissioned this study.

1.3 Other Studies

This study utilized the results from a recently published RGO runoff study titled *Action Plan Demonstration Project, Demonstration of Gasoline Fueling Station Best Management Practices, Phase 1 Report* (September, 1993), prepared by Uribe & Associates and Larry Walker Associates for the County of Sacramento, Water Resources Division. Another storm water runoff study used for the WSPA/API study described herein is the *Final Report of the Nationwide Urban Runoff Program* (December 30, 1983) prepared by the Water Planning Division of EPA. These storm water studies are described in the following sections.

1.3.1 Sacramento County's Action Plan Demonstration Project

Sacramento County's Action Plan Demonstration Project characterized storm water runoff from RGOs and identified potential best management practices (BMPs) to reduce storm water runoff pollution. EPA provided funding of the study by a grant through the San Francisco Estuary Project and the Sacramento County Water Resources Division. The report presents the analytical results of samples collected from storm water runoff from three RGOs in Sacramento County.

The Sacramento County project selected high-volume (over 200,000 gallons per month), self-service RGOs with convenience markets and without automobile repair service bays for the study. The selected RGOs are located less than 2 miles apart.

Within each RGO, a single representative sampling point was selected where station runoff leaves the property and includes drainage from the fueling and auxiliary services areas. Uribe collected samples during six storm events during the 1992/93 wet season. For five of the storms, the sample collection procedure consisted of placing a 1 liter sampling bottle into a below-grade concrete sump. A portion of the storm water discharge flowed over the lip of the sump directly into a sampling bottle. Samples were collected in this manner for each 0.05 inch increment of measured rainfall. The samples were composited immediately into a 5-liter borosilicate bottle until the 5-liter bottle was filled. The one exception to this sample collection method occurred during the first storm event, when only grab samples were collected.

The initial analytical program for the collected samples included analyses for oil and grease, total suspended solids, metals (13 EPA priority pollutant metals plus aluminum and iron), polycyclic aromatic hydrocarbons (PAHs), and petroleum hydrocarbons. However, some of the metals, petroleum hydrocarbons, and PAHs were consistently not detected in samples collected from the first three storm events. On the basis of these results, the following parameters were selected for the final three sampling events:

- oil and grease
- total suspended solids
- heavy metals (cadmium, chromium, copper, lead, and zinc)

Pertinent results of Sacramento County's Action Plan Demonstration Project are discussed in Sections 3 and 4 of this report.

1.3.2 National Urban Runoff Program

The National Urban Runoff Program (NURP) was conducted from 1978 through 1983 with funding and guidance provided by EPA. NURP characterized the chemicals present in discharges from separate storm sewers that drain residential, commercial, and light industrial areas. NURP included 28 projects across the nation, conducted separately at the local level, but centrally reviewed, coordinated, and guided. The overall objective of the program was to collect information from a national perspective that could be used to characterize urban runoff, assess the impact of non-point source urban runoff on the quality of the receiving waters, and assist decision makers in developing control measures to limit its impact. The results of NURP provide insight on what can be considered background levels for urban runoff.

The resultant NURP data represent a cross section of regional climates, land use types, and ground surface conditions. The sites sampled during NURP included 81 sites that were unaffected by hydraulic devices, such as detention basins, that would modify runoff. A total of more than 2300 separate storm events were sampled from these sites during the project. Samples collected from these sites were tested for the following standard pollutants:

- total suspended solids
- biochemical oxygen demand
- chemical oxygen demand
- total phosphorus
- soluble phosphorus
- total Kjeldahl nitrogen
- nitrite and nitrate as N
- heavy metals (copper, lead, and zinc)

Pertinent results of NURP are discussed in Sections 3 and 4 of this report.

2.0 WSPA/API PART I AND PART II STORM WATER RUNOFF STUDIES

This section describes both parts of the WSPA/API runoff study. Part I, conducted by Hart Crowser, characterized simulated storm water runoff from five RGOs. Part II, conducted by Geomatrix, characterized simulated storm water runoff from four commercial parking lots and one RGO.

2.1 Literature Search

As part of this WSPA/API study, Hart Crowser conducted a literature search to assess whether analytical results from prior RGO runoff studies were available for this study. The search was conducted using the Dialog Information Database and included a search of the following databases:

NTIS (National Technical Information Service)
COMPENDEX (Engineering Information Inc.)
APILIT (American Petroleum Institute)
Pollution Abstracts/Cambridge Scientific Abstracts
Water Resources Abstracts
WATERNET (American Water Works Association)
CA SEARCH (Chemical Abstracts)

The database search did not disclose prior RGO storm water runoff studies.

2.2 Selection of RGOs and Test Sites

In selecting the RGOs to be used for the study, the following characteristics were evaluated for a number of potential RGO sites:

- monthly throughput
- site location
- anticipated level of use by commercial vehicles
- age and general appearance
- types of ancillary services provided including on-site vehicle service, car washes, or convenience stores
- on-site drainage patterns and adjacent property usage.

On the basis of this evaluation, six RGOs, all located in Southern California, were selected for the study. The six RGOs provide a representative cross section of typical RGOs in Southern California. Site characteristics for each RGO are summarized in Table 1. Each of the selected RGOs was considered "normally operated and maintained". For the purposes of this study, "normally operated and maintained" signifies that the RGOs utilize Best Management Practices (BMPs) to minimize the buildup of potential storm water contaminants on exposed areas. These BMPs include regular sweeping of exposed areas, regular site inspections, and standardized spill response procedures.

Hart Crowser and Geomatrix conducted the simulated rainfall application and sample collection at a pump island and driveway approach area within each RGO. These areas were selected to provide results that are representative of discharge from the entire RGO. A summary of pavement types and conditions of each test site location is presented in Table 2.

A simulated gasoline spill was performed at RGO 5 to provide data regarding the effectiveness of standardized spill response procedures. One quart of regular unleaded gasoline from a pump nozzle was discharged onto the pump island pavement. Absorbent material was applied to the spill after one minute. The absorbent material was then swept up after it appeared to have absorbed the spilled liquid, and the simulated runoff test was conducted.

2.3 Selection of Parking Lots and Test Sites

Commercial parking lots for the second part of the study were evaluated using the following criteria:

- site use
- relative parking duration
- traffic and parking volume
- pavement type, condition, and visual appearance
- cleaning methods and frequency
- on-site drainage patterns.

On the basis of this evaluation, Geomatrix and WSPA selected four commercial parking lots, all located in Southern California, for the study. The selected parking lots were associated with a grocery store, bank, office complex, and restaurant.

Simulated rainfall was applied and samples were collected at two locations at each of the four parking lots for a total of eight test sites. The test locations included one high-use and one moderate-use parking area. The high-use area was generally closer to the commercial facility entrance, and was occupied more frequently than the moderate-use area. Each of the parking lots used scheduled sweeping as a good housekeeping BMP. Parking lot test locations, conditions, and BMPs are summarized in Table 3.

2.4 Testing Methodology

To minimize test variability caused by differing rainfall intensities and durations, both parts of the WSPA/API runoff study used a simulated rainfall method to induce runoff from the study sites. The water-dispensing system and sampling procedures were identical for both the RGO and commercial parking lot sites. The water-dispensing system was designed to apply water uniformly over the test area and create sheet flow.

During the test, potable water was distributed uniformly over an approximate 400-square-foot area using a network of perforated 1-inch-diameter, schedule 80 polyvinyl chloride (PVC) pipes elevated approximately 4 feet above the pavement surface. A schematic of the simulated rainfall system is shown on Figure 1.

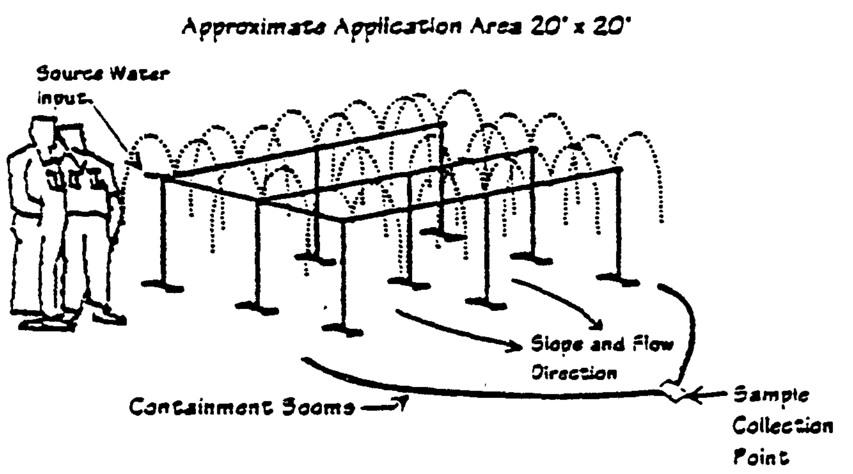


Figure 2. Schematic of Simulated Rainfall System

The water was applied at a rate of approximately 2.0 gallons per minute (gpm) for the duration of the 45-minute test. This rate represents a rainfall rate of approximately 0.008 inch per minute or 0.12 inch every 15 minutes over the test application area.

The runoff from the simulated rainfall application was channeled by gravity and sand-filled polyethylene tubing containment berms to a collection point. The runoff was diverted into a stainless steel collection trough and was pumped into a poly-lined 55-gallon steel drum.

2.5 Sampling Procedures

Sampling procedures for both Part I and II studies follow the sampling protocol established by SW-846, "Test Methods for Evaluating Solid Waste" (including surface and groundwater).

The following samples were collected at each test site.

- A discrete grab sample from the collection trough every 15 minutes during the 45 minute test
- One composite sample from the runoff pumped into the 55-gallon drum.

In addition to these samples, a background sample of the on-site water supply was collected at the point of discharge from the simulated rainfall application apparatus, and a duplicate oil and grease sample was collected at each test site. Samples were obtained using cleaned sampling equipment and were placed into laboratory-supplied and certified "clean" sampling containers. Collected samples were labeled, placed on ice in a cooler, and maintained under proper chain-of-custody procedures. A trip blank sample was included in each of the sample coolers used for this study.

2.6 Analytical Testing

GTEL Environmental Laboratories, a state-certified analytical laboratory located in Torrance, California analyzed samples from RGOs 1 through 5. Del Mar Analytical, a state-certified laboratory located in Irvine, California analyzed samples from RGO 6 and all four parking lots.

Laboratory analyses were conducted in accordance with appropriate EPA methods. The constituents, analytical test methods, and detection limits used for the WSPA/API study are listed in Table 4.

2.7 Quality Assurance and Quality Control

Both parts of the WSPA/API study described herein developed and implemented field and laboratory quality assurance/quality control (QA/QC) procedures. Field QA/QC includes following strict sampling protocols as specified in the project work plans and standard operating procedures. These procedures include an evaluation of cross-contamination through the analysis of trip blanks. Laboratory QA/QC addressed the following:

- Accuracy (analysis of matrix spike recoveries on each batch of samples and regular analysis of certified samples)
- Precision (analysis of matrix spike duplicates)
- Contamination (analysis of method and filter blanks)
- Holding Time (specified holding times associated with each chemical method)
- Certified Methods of Analysis (EPA or State certified methods of analysis).

3.0 RESULTS AND DISCUSSION

The following sections present the results of the WSPA/API simulated runoff study and provide summaries of analytical data from Sacramento County's Action Plan Demonstration Project and NURP. Also presented are data plots that provide comparisons between the pump islands and driveway RGO results and between RGOs, parking lots, and NURP.

3.1 Analytical Results

The analytical results of simulated runoff samples collected from RGOs as part of this study are summarized in Tables 5a and 5b. These tables present the results of both the Part I study conducted by Hart Crowser (RGOs 1 through 5) and the Part II study conducted by Geomatrix (RGO 6). Tables 6a and 6b summarize the results of laboratory analyses of simulated runoff samples from commercial parking lots. Tables 7 and 8, respectively, summarize the results from Sacramento County's Action Plan Demonstration Project and median concentrations reported in NURP.

3.2 Data Comparisons

This report compares analytical data from the WSPA/API RGOs and parking lots, the Action Plan Demonstration Project, and NURP using a series of box plots, Figures 3 through 24. Box plots are a simple and useful method of data comparison because they effectively describe the characteristics of single groups of data and reveal differences between groups. The components of a typical box plot are presented on Figure 2. Shown on this figure are the 25th and 75th percentiles of the data, which form the top and bottom of the box. Therefore, by definition, 25 percent of the data have a value equal to or less than the bottom line of the box, and 75 percent have a value equal to or less than the top of the box. The middle horizontal line within the box is the median, or 50th percentile (one-half of the data values are equal to or less than the median, and one-half are equal to or greater). Lines (called whiskers) extend vertically from the top and bottom of each box to the maximum and minimum data values.

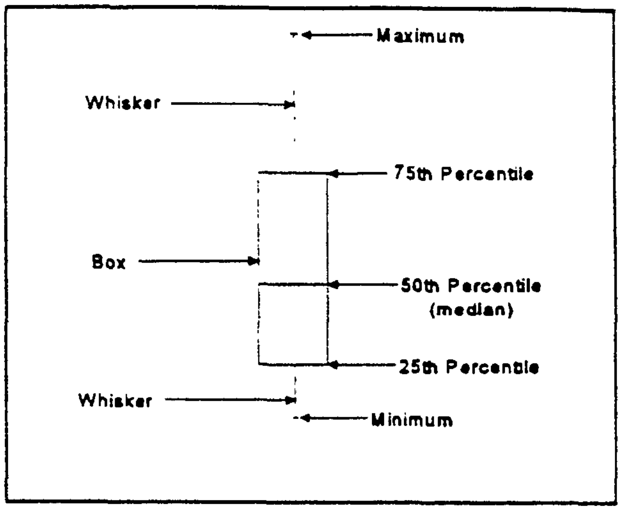


Figure 2. Components of a Typical Box Plot

In many cases, the boxes shown on Figures 3 through 24 are collapsed into a single horizontal line without a whisker extending to the minimum value. The principal reason for the shape of these plots is the presence of a large number of non-detect values in the data set. When this occurs, a single horizontal line is drawn at the detection limit, and the whisker and box segments below the reporting limit are masked.

Although Hart Crowser and Geomatrix collected and analyzed both discrete and composite samples for this study, only the composite results are used for comparison purposes in this report. Composite results are normally considered more meaningful than individual discrete results when evaluating pollutant loading in storm water discharges. It should be noted that the composite sampling methodology used for the WSPA/API study is equivalent to the event mean concentration (EMC) reported in NURP (EPA, 1983), which is defined as the total constituent mass discharged divided by the total runoff volume. In addition, the flow weighted sampling method used for the Action Plan Demonstration Project (Uribe, 1993) provides an estimate of EMC. To provide consistency in comparisons between these studies, the EMC will be used when describing composite discharge concentrations for the remainder of this report.

The following sections discuss comparisons between the pump island and driveway results from the WSPA/API RGOs, and between the RGOs, parking lots, and NURP.

3.2.1 Comparison of Results from RGO Pump Islands and Driveways

Figures 3 through 9 present box plots that compare EMC results between the pump islands and driveways from the WSPA/API RGOs for total suspended solids, oil and grease, total petroleum hydrocarbons as gasoline (TPHg) and benzene, toluene, ethyl benzene, and total xylenes (BTEX). On the basis of these box plots, there is no significant difference in median EMCs in runoff from pump islands and driveways for these constituents. In each case, the median EMCs from pump islands and driveways are either at or very near the detection limit. Toluene, ethyl benzene, and total xylenes were detected more frequently in samples from pump islands, primarily the result of the simulated spill on the RGO 5 pump island. However, the EMCs of these chemicals were significantly below the Maximum Contaminant Levels (MCLs) for drinking water established by EPA and California Department of Health Services (Marshack, 1993).

3.2.2 Comparison of Results from RGOs, Parking Lots, and NURP

Figures 10 through 24 present box plots that compare the EMC results for RGOs and parking lots. The median EMC results from NURP are also presented on the data plots for total suspended solids, copper, lead, and zinc (Figures 10, 20, 22, and 24, respectively). On the basis of these box plots, there is no significant difference in median EMCs between RGOs and parking lots for these constituents. In addition, the box plots for total suspended solids, copper, and zinc indicate that for these constituents, there is no significant difference in median EMCs between RGOs, parking lots, and background runoff levels established by NURP. The box plots for lead, Figure 22 indicate that the median and range of EMCs from RGOs and parking lots are significantly less than the background values reported in NURP.

4.0 CONCLUSIONS

The results of this study demonstrate that for the constituents analyzed in this report, median EMCs in storm water runoff from normally operated and maintained RGOs are no higher than those in runoff from commercial parking lots. Additionally, median EMCs of total suspended solids, copper, lead, and zinc in runoff from RGOs and parking lots are no higher than background levels present in urban runoff as established by NURP. Furthermore, there are no significant differences in median EMCs in runoff from RGO pump islands and driveways for the constituents analyzed. In all cases, the fueling related constituents (TPHg and BTEX) from pump islands were either not detected or below applicable Maximum Contaminant Levels (MCLs). These results indicate that fueling activities at normally operated and maintained RGOs do not contribute additional significant concentrations of measured constituents in storm water runoff.

GEOMATRIX

5.0 REFERENCES

U.S. Environmental Protection Agency, 1993. Storm Water Discharges Potentially Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program, Report to Congress, dated October, 1993.

Uribe & Associates and Larry Walker Associates, 1993. Action Plan Demonstration Project Demonstration of Gàsoline Fueling Station Best Management Practices, Phase 1 Report, dated September 1993.

U.S. Environmental Protection Agency, Water Planning Division, 1983. Final Report of the Nationwide Urban Runoff Program, dated December 30, 1983.

Marshack, 1993. A Compilation of Water Quality Goals, Staff Report of the California Regional Water Quality Control Board Central Valley Region, dated May, 1993.

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TABLES

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TABLE 2
SUMMARY OF RETAIL GASOLINE OUTLET TEST LOCATIONS AND SURFACE CONDITIONS
WSPA/API STORM WATER RUNOFF STUDY

Test Site	Location	Pavement Type	Pavement Condition	Surface Condition
RGO 1	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 1	Driveway Approach	Portland Cement Concrete	Good	No Staining
RGO 2	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 2	Driveway Approach	Portland Cement Concrete	Good	Moderate Staining
RGO 3	Pump Island	Portland Cement Concrete	Degraded	Heavy Staining
RGO 3	Driveway Approach	Asphaltic Concrete	Degraded	Heavy Staining
RGO 4	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 4	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining
RGO 5	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 5	Driveway Approach	Asphaltic Concrete	Degraded	Moderate Staining
RGO 6	Pump Island	Portland Cement Concrete	Good	Moderate Staining
RGO 6	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining

TABLE 3
SUMMARY OF PARKING LOT TEST LOCATIONS, CONDITIONS, AND BEST MANAGEMENT PRACTICES
WSPA/API STORM WATER RUNOFF STUDY

Test Site	Site Use	Location and Traffic/Parking Condition	Traffic/Parking Frequency	Pavement Type and Condition	Best Management Practices
TS-1	Grocery Store Parking Lot	Near Store Entrance	High Volume of Traffic/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-2	Grocery Store Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Area Used For Overflow Parking, Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-3	Bank Parking Lot	Near Bank Entrance/Parking	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-4	Bank Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-5	Office Complex Parking Lot	Near Office Entrance	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-6	Office Complex Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume/Spaces Normally Filled During Business Hours	Asphaltic Concrete, Slightly Degraded Condition	Daily Sweeping
TS-7	Restaurant Parking Lot	Near Restaurant Entrance	High Traffic Volume/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown
TS-8	Restaurant Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown

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TABLE 5a

Summary of Analytical Results for Non-metal Constituents of Simulated Runoff from Retail Gasoline Outlets
WSPA/API Storm Water Runoff Study

RGO Designation	Location	Sample Type	Sampling Date	pH	Conductance (umhos/cm)	Total Suspended Solids (mg/l)	Oil and Grease (mg/l)	TPH (ug/l)	Benzene (ug/l)	Toluene (ug/l)	Ethyl Benzene (ug/l)	Total Xylenes (ug/l)
RGO 1	Source	Background	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Pump Island	15 minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	0.5	ND(0.3)	0.7
RGO 1	Pump Island	30 Minute	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.6	ND(0.3)	0.8
RGO 1	Pump Island	45 Minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	0.8	ND(0.3)	1.4
RGO 1	Pump Island	Composite	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.8	ND(0.3)	1.3
RGO 1	Driveway	15 minute	09/04/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	30 Minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	45 Minute	09/04/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	Composite	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Source	Background	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	15 minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	30 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	45 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	Composite	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	15 minute	09/10/92	NA	NA	ND(10)	1	ND(100)	1.5	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	30 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	45 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	Composite	09/10/92	NA	NA	ND(10)	1	ND(100)	0.4	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Source	Background	09/03/92	NA	NA	11	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Pump Island	15 minute	09/03/92	NA	NA	13	8	ND(1000)	ND(3)	7.9	ND(3)	20
RGO 3	Pump Island	30 Minute	09/03/92	NA	NA	ND(10)	3	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Pump Island	45 Minute	09/03/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	0.4	ND(0.3)	1.1
RGO 3	Pump Island	Composite	09/03/92	NA	NA	ND(10)	3	ND(100)	ND(0.3)	0.3	ND(0.3)	1.1
RGO 3	Driveway	15 minute	09/03/92	NA	NA	ND(10)	1	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 3	Driveway	30 Minute	09/03/92	NA	NA	ND(10)	ND(1)	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 3	Driveway	45 Minute	09/03/92	NA	NA	ND(10)	1	ND(100)	0.5	4.5	1.1	12
RGO 3	Driveway	Composite	09/03/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.8	ND(0.3)	3.4
RGO 4	Source	Background	09/09/92	NA	NA	14	15	ND(100)	ND(0.3)	0.3	ND(0.3)	7.1
RGO 4	Pump Island	15 minute	09/09/92	NA	NA	ND(10)	4	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Pump Island	30 Minute	09/09/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Pump Island	45 Minute	09/09/92	NA	NA	ND(10)	8	ND(100)	ND(0.3)	0.4	ND(0.3)	1.5
RGO 4	Pump Island	Composite	09/09/92	NA	NA	13	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	1.4
RGO 4	Driveway	15 minute	09/09/92	NA	NA	11	2	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 4	Driveway	30 Minute	09/09/92	NA	NA	10	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Driveway	45 Minute	09/09/92	NA	NA	12	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Driveway	Composite	09/09/92	NA	NA	ND(10)	ND(1)	130	ND(0.3)	ND(0.3)	ND(0.3)	ND(.6)
RGO 5	Source	Background	09/17/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 5	Pump Island	15 minute	09/17/92	NA	NA	ND(10)	9	ND(1000)	ND(3)	9.5	ND(3)	19
RGO 5	Pump Island	30 Minute	09/17/92	NA	NA	ND(10)	7	ND(1000)	ND(3)	14	5	37
RGO 5	Pump Island	45 Minute	09/17/92	NA	NA	ND(10)	9	180	1	13	6.3	41
RGO 5	Pump Island	Composite	09/17/92	NA	NA	ND(10)	34	ND(1000)	ND(3)	9.5	3.4	22
RGO 5	Driveway	15 minute	09/17/92	NA	NA	ND(10)	9	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 5	Driveway	30 Minute	09/17/92	NA	NA	ND(10)	11	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 5	Driveway	45 Minute	09/17/92	NA	NA	13	6	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 5	Driveway	Composite	09/17/92	NA	NA	ND(10)	29	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 6	Driveway	Source	05/04/94	7.6	960	ND(5)	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Driveway	15 minute	05/04/94	7.8	1000	28	2.1	NA	NA	NA	NA	NA
RGO 6	Driveway	30 Minute	05/04/94	7.8	990	14	1.7	NA	NA	NA	NA	NA
RGO 6	Driveway	45 Minute	05/04/94	7.9	1000	13	ND(1)	NA	NA	NA	NA	NA
RGO 6	Driveway	Composite	05/04/94	7.9	1000	19	2.6	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Driveway	Duplicate	05/04/94	NA	NA	NA	6	NA	NA	NA	NA	NA
RGO 6	Driveway	Trip Blank	05/04/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	15 minute	05/04/94	8.0	1000	21	3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	30 Minute	05/04/94	8.1	1000	ND(5)	3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	45 Minute	05/04/94	8.1	960	ND(5)	1.7	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	Composite	05/04/94	8.1	1000	16	9.6	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	Duplicate	05/04/94	NA	NA	NA	4.8	NA	NA	NA	NA	NA
RGO 6	Pump Island	Trip Blank	05/04/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)

NA Not analyzed.
ND(10) Not detected at specified detection limit.
Note: Increased analytical method detection limit was caused by matrix effect (foaming).

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TABLE 5b
Summary of Analytical Results for Metal Constituents of Simulated Runoff from Retail Gasoline Outlets
WSPA/API Storm Water Runoff Study

RGO Designation	Location	Sample Type	Sampling Date	Aluminum (mg/l)	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)	Cadmium (mg/l)	Chromium (VI) (mg/l)	Chromium (mg/l)	Cobalt (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Mercury (mg/l)	Molybdenum (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Silver (mg/l)	Thallium (mg/l)	Vanadium (mg/l)	Zinc (mg/l)
RGO 1	Pump Island	15 minute	08/04/92	NA	ND(04)	ND(1)	0 13	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	ND(1)
RGO 2	Pump Island	15 minute	08/10/92	NA	ND(04)	ND(1)	ND(02)	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	ND(1)
RGO 3	Pump Island	15 minute	08/03/92	NA	ND(04)	ND(1)	0 06	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 2
RGO 4	Pump Island	15 minute	08/09/92	NA	ND(04)	ND(1)	0 06	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 2
RGO 5	Pump Island	15 minute	08/17/92	NA	ND(04)	ND(1)	0 08	ND(01)	ND(03)	NA	ND(04)	ND(02)	0 2	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 6
RGO 6	Driveway	Source	05/04/94	ND(5)	ND(005)	ND(01)	0 11	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0 009	ND(05)	0 004	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 027
RGO 6	Driveway	15 minute	05/04/94	ND(5)	NA	NA	NA	NA	ND(005)	NA	ND(005)	NA	0 017	0 41	0 008	NA	NA	ND(05)	NA	NA	NA	NA	0 2
RGO 6	Driveway	30 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	45 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	Composite	05/04/94	ND(5)	NA	NA	NA	NA	ND(005)	NA	ND(005)	NA	0 028	0 5	0 008	NA	NA	ND(05)	NA	NA	NA	NA	0 18
RGO 6	Driveway	Duplicate	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	Test Blank	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	15 minute	05/04/94	ND(5)	ND(005)	ND(01)	0 098	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0 014	0 21	0 004	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 18
RGO 6	Pump Island	30 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	45 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	Composite	05/04/94	ND(5)	ND(005)	ND(01)	0 1	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0 012	0 27	0 006	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 16
RGO 6	Pump Island	Duplicate	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	Test Blank	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA — Not analyzed
ND(10) — Not detected at specified detection limit
Note. — Increased analytical method detection limit was caused by matrix effect (foaming)

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TABLE 6a
Summary of Analytical Results for Non-metal Constituents of Simulated Runoff from Parking Lots
WSPA/API Storm Water Runoff Study

Test Site	Sample Type	Sampling Date	pH	Total Suspended Solids (mg/l)	Conductance (umhos/cm)	Oil and Grease (mg/l)	TPH (8015-G) (ug/l)	Benzene (ug/l)	Toluene (ug/l)	Ethyl benzene (ug/l)	Total Xylenes (ug/l)
TS-1	Source	01/12/94	7.8	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	15	01/12/94	7.5	250	1200	820	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
TS-1	30	01/12/94	7.8	10	1100	23	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	45	01/12/94	7.8	10	1100	24	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	Composite	01/12/94	7.7	6	1200	11	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	Duplicate (20)	01/12/94	NA	NA	NA	230	NA	NA	NA	NA	NA
TS-1	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-2	15	01/12/94	7.7	170	1200	13	NA	NA	NA	NA	NA
TS-2	30	01/12/94	7.4	46	1200	7.4	NA	NA	NA	NA	NA
TS-2	45	01/12/94	7.8	25	1100	3.5	NA	NA	NA	NA	NA
TS-2	Composite	01/12/94	7.7	77	1200	7	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-2	Duplicate (20)	01/12/94	NA	NA	NA	24	NA	NA	NA	NA	NA
TS-2	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-3	15	01/12/94	7.7	110	1100	24	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	0.74
TS-3	30	01/12/94	7.9	13	1100	6.2	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-3	45	01/12/94	7.8	ND (5)	1100	5.3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-3	Composite	01/12/94	7.9	14	1100	4.1	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
TS-3	Duplicate (20)	01/12/94	NA	NA	NA	25	NA	NA	NA	NA	NA
TS-3	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-4	Source	01/12/94	7.8	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-4	15	01/12/94	7.7	290	1200	3.7	NA	NA	NA	NA	NA
TS-4	30	01/12/94	7.8	53	1100	2.5	NA	NA	NA	NA	NA
TS-4	45	01/12/94	7.8	55	1100	2.9	NA	NA	NA	NA	NA
TS-4	Composite	01/12/94	7.7	90	1200	2.2	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-4	Duplicate (20)	01/12/94	NA	NA	NA	7.1	NA	NA	NA	NA	NA
TS-4	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-5	Source	01/13/94	7.9	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-5	15	01/13/94	7.8	140	1100	3.8	ND(50)	ND(0.3)	0.45	ND(0.3)	0.63
TS-5	30	01/13/94	7.8	180	1100	11	ND(50)	ND(0.3)	0.36	ND(0.3)	ND(0.6)
TS-5	45	01/13/94	7.9	52	1100	5.1	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-5	Composite	01/13/94	7.8	62	1100	4.1	ND(50)	ND(0.3)	0.4	ND(0.3)	ND(0.5)
TS-5	Duplicate (20)	01/13/94	NA	NA	NA	3.5	NA	NA	NA	NA	NA
TS-5	Trip Blank (20)	01/13/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-6	15	01/13/94	7.7	63	1200	3.2	NA	NA	NA	NA	NA
TS-6	30	01/13/94	7.7	17	1100	1.8	NA	NA	NA	NA	NA
TS-6	45	01/13/94	7.8	13	1100	1.6	NA	NA	NA	NA	NA
TS-6	Composite	01/13/94	7.8	39	1100	1.9	ND(50)	ND(0.3)	0.33	ND(0.3)	ND(0.6)
TS-6	Duplicate (20)	01/13/94	NA	NA	NA	3.5	NA	NA	NA	NA	NA
TS-6	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-7	Source	01/17/94	7.7	ND (5)	780	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-7	15	01/17/94	7.9	27	830	4.3	NA	NA	NA	NA	NA
TS-7	30	01/17/94	7.9	23	810	NA	NA	NA	NA	NA	NA
TS-7	45	01/17/94	7.9	25	800	4	NA	NA	NA	NA	NA
TS-7	Composite	01/17/94	7.9	86	830	6.3	ND(50)	ND(0.3)	0.46	ND(0.3)	ND(0.6)
TS-7	Duplicate (20)	01/17/94	NA	NA	NA	4.5	NA	NA	NA	NA	NA
TS-8	15	01/17/94	7.9	120	740	7.9	ND(50)	ND(0.3)	0.31	ND(0.3)	ND(0.6)
TS-8	30	01/17/94	7.9	79	700	9.4	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-8	45	01/17/94	8.0	62	690	12	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-8	Composite	01/17/94	8.0	120	720	5.1	ND(50)	ND(0.3)	0.31	ND(0.3)	ND(0.6)
TS-8	Duplicate (20)	01/17/94	NA	NA	NA	6.8	NA	NA	NA	NA	NA

ND(.001) Not detected at specified detection limit.
NA Not analyzed.

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TABLE 6b
Summary of Analytical Results for Metal Constituents of Simulated Runoff from Parking Lots
WSPA/API Storm Water Runoff Study

Test Site	Sample Type	Sampling Date	Aluminum (mg/l)	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)	Cadmium (mg/l)	Chromium (VI) (mg/l)	Chromium (mg/l)	Cobalt (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Mercury (mg/l)	Molybdenum (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Silver (mg/l)	Thallium (mg/l)	Vanadium (mg/l)	Zinc (mg/l)
TS-1	Source	01/12/94	ND(0.5)	ND(0.005)	ND(0.01)	0.14	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.011	ND(0.05)	ND(0.001)	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	ND(0.001)
TS-1	15	01/12/94	2	ND(0.005)	ND(0.01)	0.13	ND(0.001)	0.062	ND(0.025)	0.011	ND(0.05)	0.032	2.3	0.026	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.02)	ND(0.05)	ND(0.001)	ND(0.05)	0.66
TS-1	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	Composite	01/12/94	0.63	ND(0.005)	ND(0.01)	0.13	ND(0.001)	ND(0.005)	ND(0.025)	0.006	ND(0.05)	0.021	0.38	0.004	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.35
TS-1	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	15	01/12/94	2.8	NA	NA	NA	NA	ND(0.005)	NA	0.007	NA	0.028	3.1	0.02	NA	NA	ND(0.1)	NA	NA	NA	NA	0.25
TS-2	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	Composite	01/12/94	1.7	NA	NA	NA	NA	ND(0.005)	NA	0.008	NA	0.026	1.9	0.016	NA	NA	ND(0.1)	NA	NA	NA	NA	0.17
TS-2	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	15	01/12/94	2.3	ND(0.005)	ND(0.01)	0.18	ND(0.001)	ND(0.005)	ND(0.025)	0.009	ND(0.05)	0.056	2.8	0.026	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.45
TS-3	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	Composite	01/12/94	0.63	ND(0.005)	ND(0.01)	0.12	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.021	0.51	0.005	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.1
TS-3	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Source	01/12/94	ND(0.5)	ND(0.005)	ND(0.01)	0.12	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.02	ND(0.05)	0.002	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	ND(0.001)
TS-4	15	01/12/94	2.8	NA	NA	NA	NA	ND(0.005)	NA	0.009	NA	0.021	3.8	0.026	NA	NA	ND(0.1)	NA	NA	NA	NA	0.25
TS-4	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Composite	01/12/94	2.1	NA	NA	NA	NA	ND(0.005)	NA	0.006	NA	0.021	ND(0.05)	0.015	NA	NA	ND(0.1)	NA	NA	NA	NA	0.21
TS-4	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Source	01/13/94	ND(0.5)	ND(0.005)	ND(0.01)	0.14	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.021	ND(0.05)	0.002	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	ND(0.001)
TS-5	15	01/13/94	2.4	ND(0.005)	ND(0.01)	0.15	ND(0.001)	ND(0.005)	ND(0.025)	0.008	ND(0.05)	0.034	3	0.017	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.2
TS-5	30	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	45	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Composite	01/13/94	1.7	ND(0.005)	ND(0.01)	0.14	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.028	2.3	0.011	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.17
TS-5	Duplicate (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Trip Blank (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	15	01/13/94	1.5	NA	NA	NA	NA	ND(0.005)	NA	ND(0.005)	NA	0.024	1.8	0.011	NA	NA	ND(0.1)	NA	NA	NA	NA	0.12
TS-6	30	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	45	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	Composite	01/13/94	1.3	NA	NA	NA	NA	ND(0.005)	NA	ND(0.005)	NA	0.018	1.2	0.007	NA	NA	ND(0.1)	NA	NA	NA	NA	0.072
TS-6	Duplicate (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	Source	01/17/94	ND(0.5)	ND(0.005)	ND(0.01)	0.11	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.018	ND(0.05)	ND(0.001)	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	ND(0.001)
TS-7	15	01/17/94	0.81	NA	NA	NA	NA	ND(0.005)	NA	ND(0.005)	NA	0.015	1.1	0.0054	NA	NA	ND(0.1)	NA	NA	NA	NA	0.21
TS-7	30	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	45	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	Composite	01/17/94	1.4	NA	NA	NA	NA	ND(0.005)	NA	ND(0.005)	NA	0.012	1.6	0.008	NA	NA	ND(0.1)	NA	NA	NA	NA	0.22
TS-8	15	01/17/94	3.7	ND(0.005)	ND(0.01)	0.15	ND(0.001)	ND(0.005)	ND(0.025)	0.008	ND(0.05)	0.034	5.8	0.033	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.46
TS-8	30	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-8	45	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-8	Composite	01/17/94	1.7	ND(0.005)	ND(0.01)	0.092	ND(0.001)	ND(0.005)	ND(0.025)	ND(0.005)	ND(0.05)	0.017	2.1	0.012	ND(0.002)	ND(0.1)	ND(0.1)	ND(0.01)	ND(0.05)	ND(0.001)	ND(0.05)	0.24

ND(.001) Not detected at specified detection limit.
NA Not analyzed

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Table 7

Analytical Results reported in "Action Plan Demonstration Project, Phase 1 Report"

Station	Date Sampled	Oil and Grease (mg/l)	Aluminum (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Nickel (mg/l)	Zinc (mg/l)
X	10/29/92	2.7	NA	0.00038	0.0043	0.03	NA	0.034	0.0052	0.69
Y	10/29/92	6.9	NA	0.0014	0.011	0.068	NA	0.15	0.0094	0.41
Z	10/29/92	1.2	NA	0.00054	0.0074	0.0093	NA	0.015	ND(.001)	2.4
X	12/06/92	15	0.8	0.0018	0.0067	0.026	1.3	0.028	0.0051	0.5
Y	12/06/92	7.8	0.81	0.00071	0.0041	0.031	1	0.028	0.0031	0.19
Z	12/06/92	14	0.91	0.00056	0.0029	0.026	1.3	0.028	0.0031	0.2
X	12/10/92	ND(.5)	2.3	0.0019	0.0094	0.0097	2.7	0.017	0.011	0.43
Y	12/10/92	1	0.57	0.00031	0.0026	0.006	0.6	0.017	ND(.001)	0.059
Z	12/10/92	0.8	0.14	0.00011	ND(.001)	0.006	0.19	0.007	0.0031	0.053
X	01/06/93	5.4	NA	0.00042	ND(.001)	0.0052	0.34	0.0082	NA	0.18
Y	01/06/93	0.6	NA	0.00025	0.0018	0.0076	0.11	0.016	NA	0.082
Z	01/06/93	2	NA	0.00039	ND(.001)	0.0092	0.85	0.015	NA	0.084
X	03/16/93	12	NA	0.00077	0.0041	0.02	NA	0.054	NA	0.43
Y	03/16/93	5	NA	0.0006	0.0055	0.045	NA	0.063	NA	0.13
Z	03/16/93	3.9	NA	0.00053	0.004	0.037	NA	0.032	NA	0.15
X	03/23/93	1.9	0.94	0.00054	0.003	0.013	NA	0.015	NA	0.55
Y	03/23/93	1	0.31	0.00027	0.0026	0.02	NA	0.024	NA	0.091
Z	03/23/93	1.2	0.68	0.00045	0.0025	0.085	NA	0.05	NA	0.2

ND(.001) Not detected at specified detection limit.
NA Not analyzed.

Source: Uribe & Associates, Larry Walker Associates (1993), Action Plan Demonstration Project Demonstration of Gasoline Fueling Stat Best Management Practices, September, Table 5.5 and 3.1.

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TABLE 8

Analytical Results Reported in NURP
Event Mean Concentrations (Median Results)

Category	Site	Total Suspended Solids (mg/l)	Copper (ug/l)	Lead (ug/l)	Zinc (ug/l)
Residential	1	265	25	137	151
	2	129	20	143	165
	3	232	22	210	158
	4	39	--	--	151
	5	30	33	200	106
	6	38	27	--	76
	7	122	63	191	--
	8	1247	81	128	596
	9	29	--	--	--
	10	45	88	592	573
	11	26	296	69	113
	12	63	20	77	81
	13	86	34	218	340
	14	32	--	--	--
	15	57	--	52	
	16	88	--	27	312
	17	196	--	144	327
	18	150	--	--	--
	19	101	--	136	114
	20	243	--	77	63
	21	141	--	90	69
	22	34	6	53	55
	23	82	--	--	--
	24	208	--	200	--
	25	42	15	123	81
	26	43	34	184	48
	27	119	--	--	--
	28	138	33	169	--
	29	482	52	376	354
	30	100	21	159	107
	31	211	36	396	--
	32	16	7	26	38
	33	14	25	--	76
	34	380	45	351	295
	35	200	43	227	189
	36	128	104	225	236
	37	135	33	182	138
	38	39	72	160	210
	39	38	28	130	75
Urban Open and Nonurban	1	551	55	159	160
	2	341	25	39	91
	3	113	--	11	306
	4	6	--	8	--
	5	22	--	22	--
	6	51	--	18	322
	7	26	--	--	--
	8	149	--	--	--
Mixed	1	208	45	147	525
	2	43	61	178	112
	3	199	37	380	--
	4	52	13	75	110
	5	48	25	227	138
	6	302	--	424	303
	7	154	100	307	225
	8	30	96	143	174
	9	98	76	91	200
	10	43	--	11	--
	11	134	--	47	--
	12	48	48	--	99
	13	61	--	50	--
	14	131	13	99	140
	15	59	--	--	--
	16	1004	--	254	--
	17	171	65	351	231
	18	23	6	35	78
	19	27	5	65	37
	20	354	59	278	471
Commercial	1	122	25	167	247
	2	107	61	296	474
	3	112	--	42	517
	4	161	--	148	34
	5	38	103	152	430
	6	39	36	140	289
	7	167	--	98	125
	8	34	39	--	368
	9	14	10	32	28
	10	298	--	310	234

Source: US Environmental Protection Agency (1983) Final Report of the Nationwide Urban Runoff Program, Table 6-1, 6-8, 6-9, and 6-10.

GEOMATRIX

FIGURES
(Figures 1 and 2 Presented in Text)

GEOMATRIX

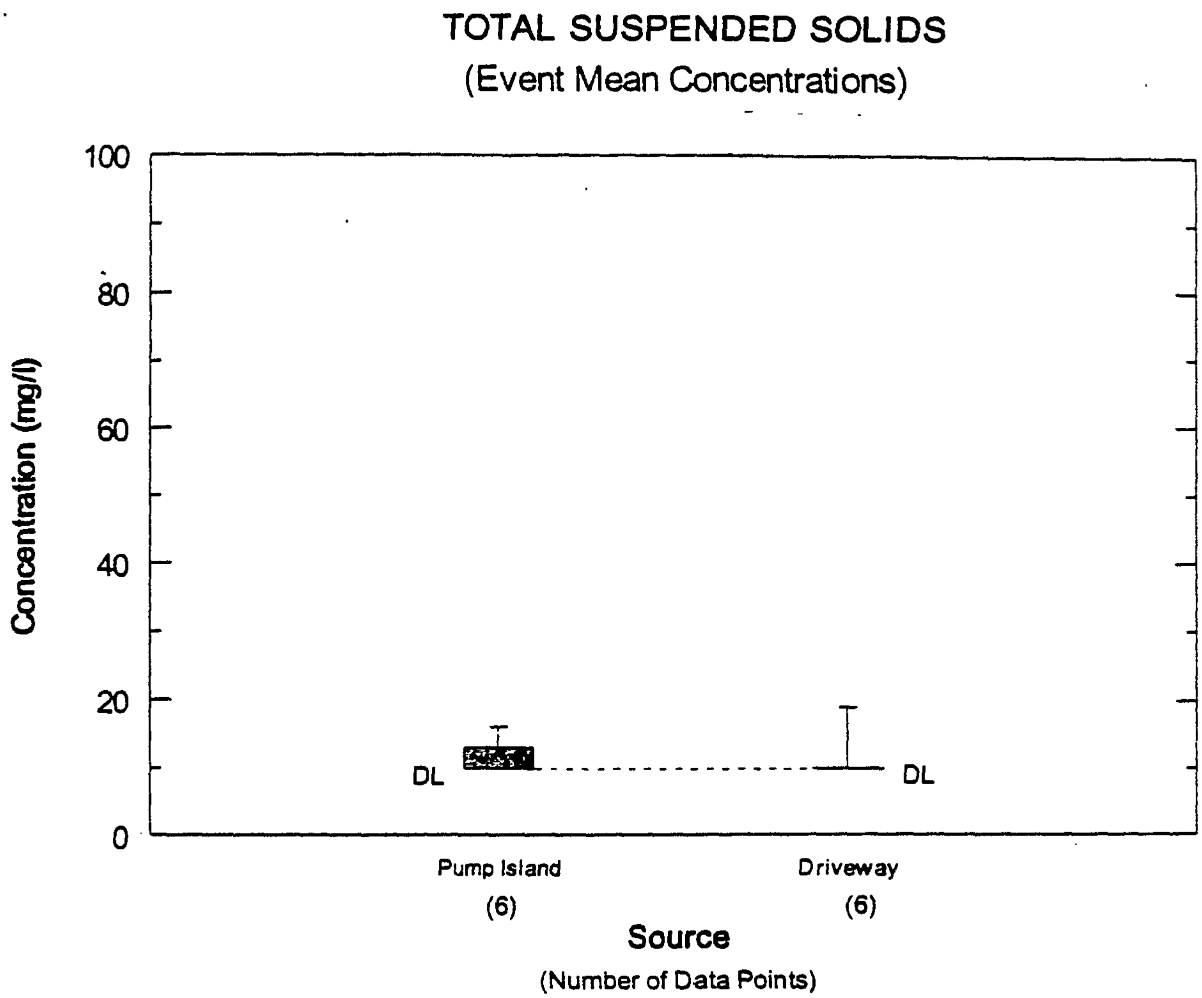


FIGURE 3

R0009114

GEOMATRIX

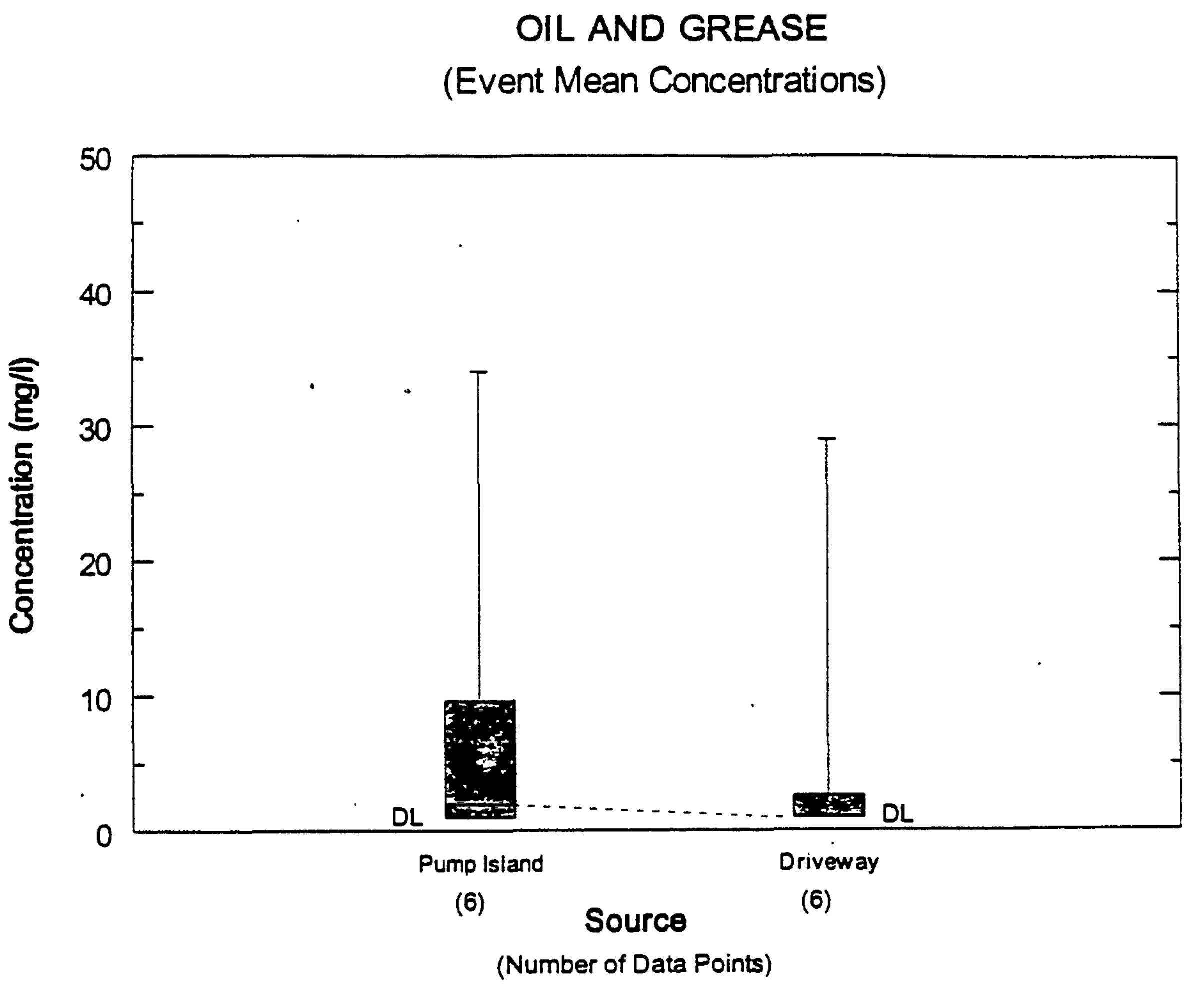
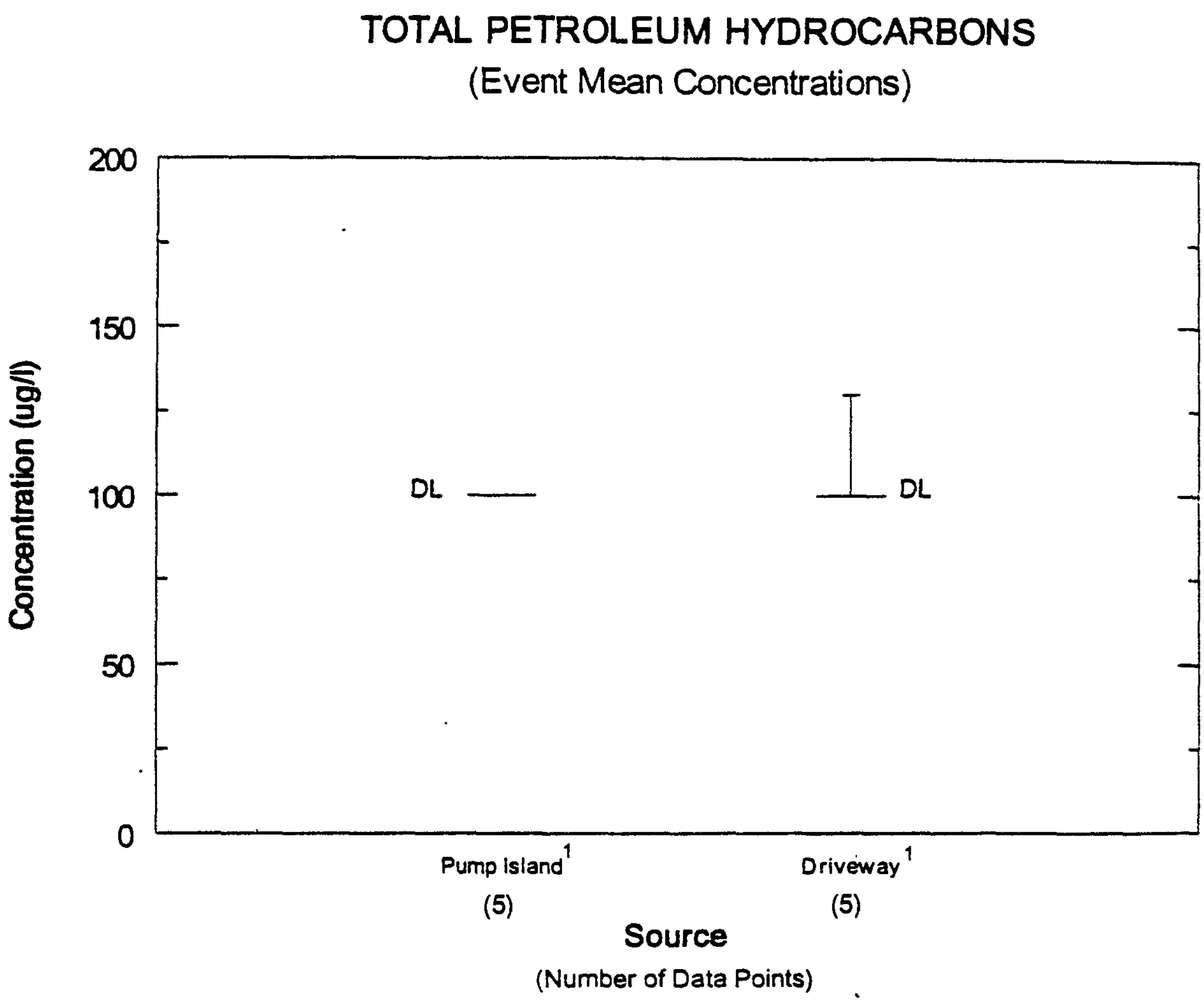


FIGURE 4

GEOMATRIX

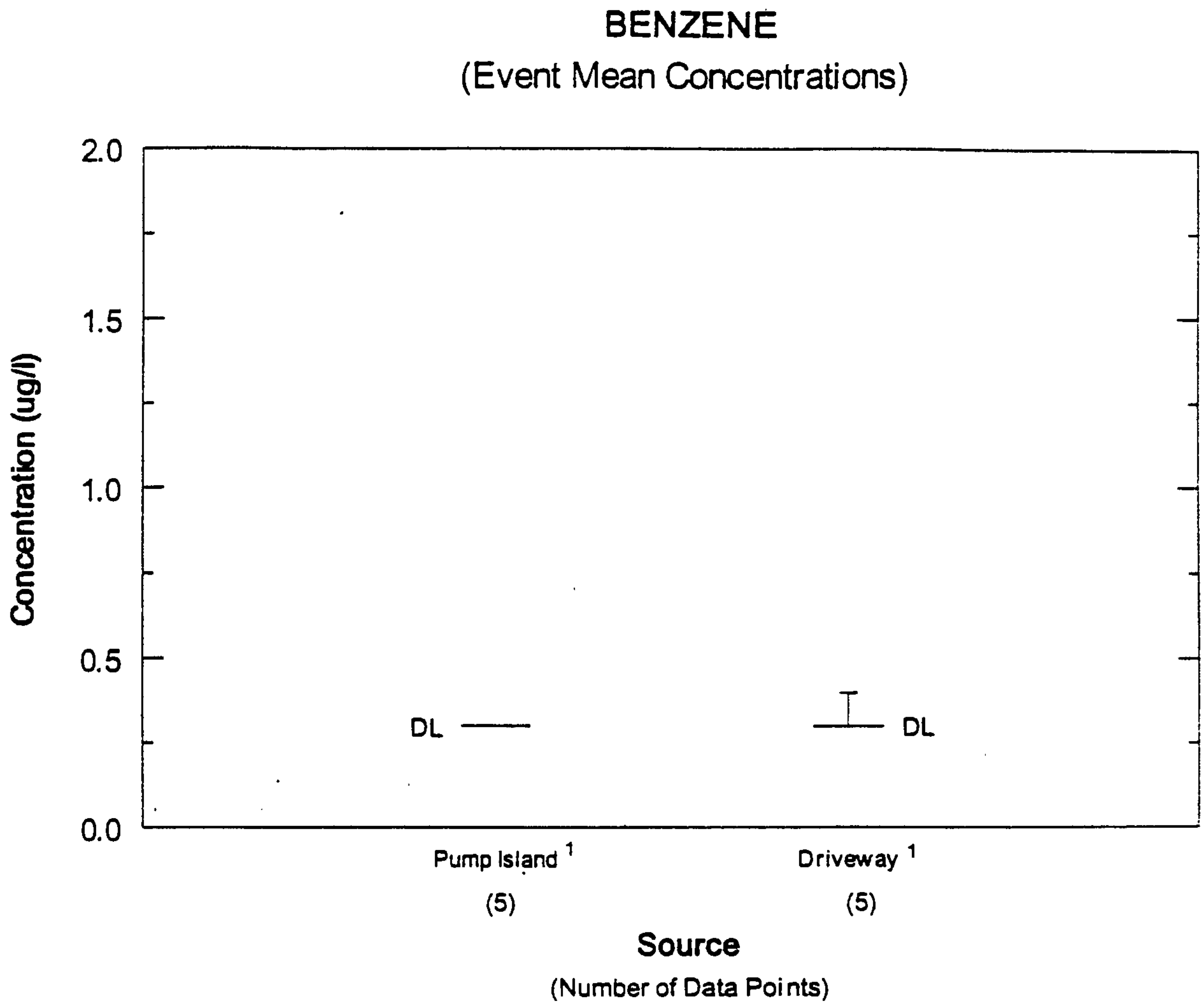


[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 5

R0009116

GEOMATRIX

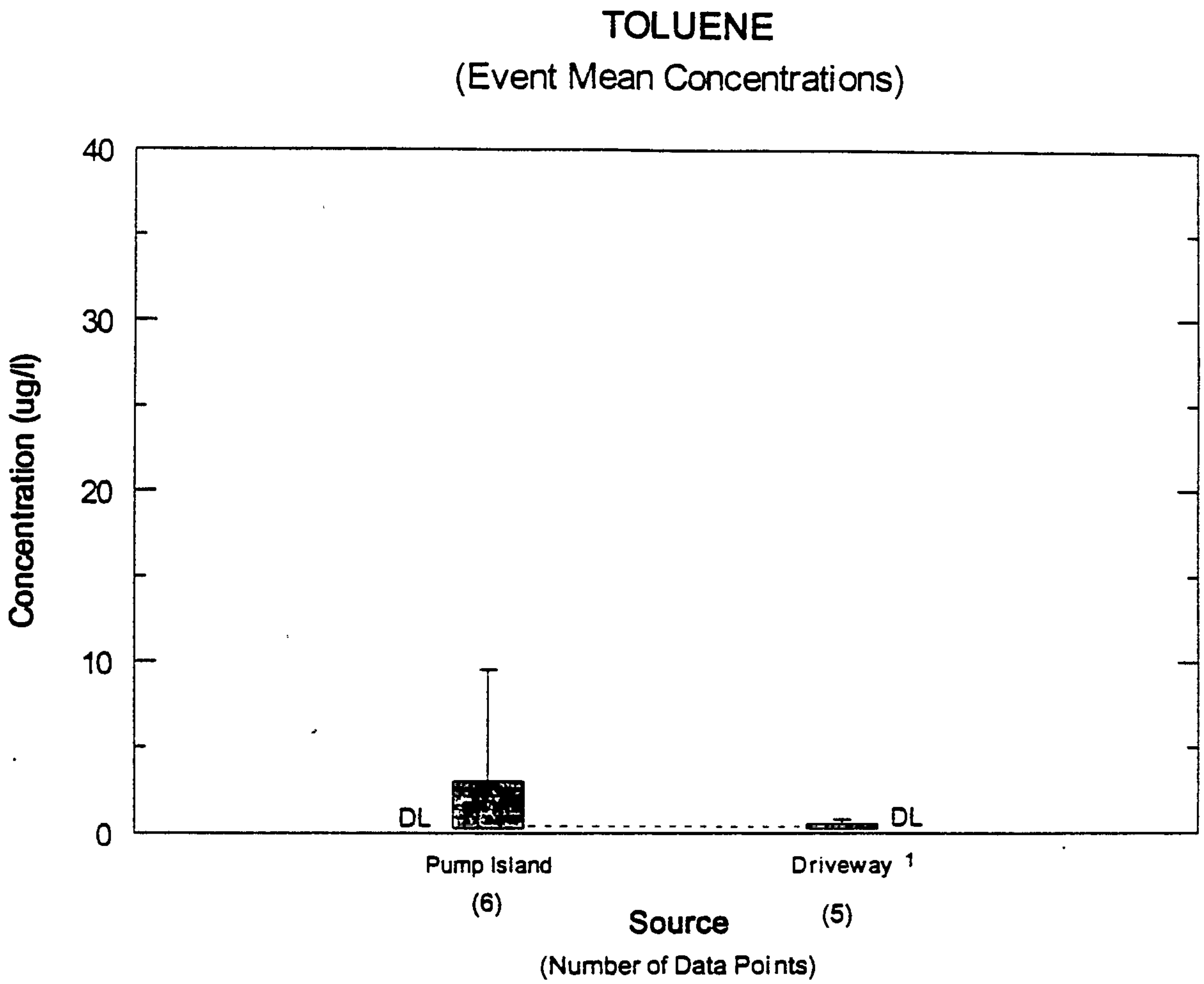


[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 6

R0009117

GEOMATRIX

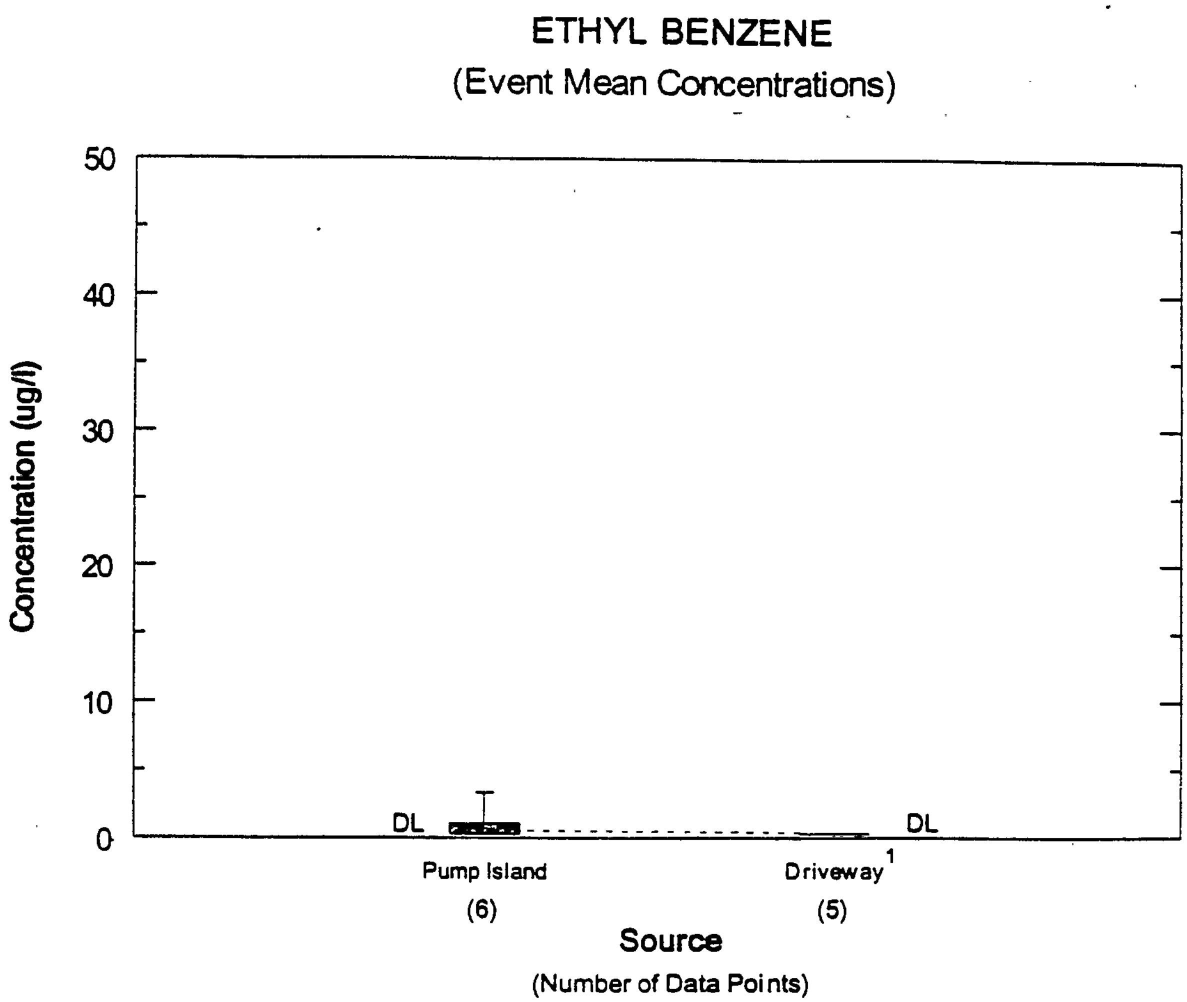


[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 7

R0009118

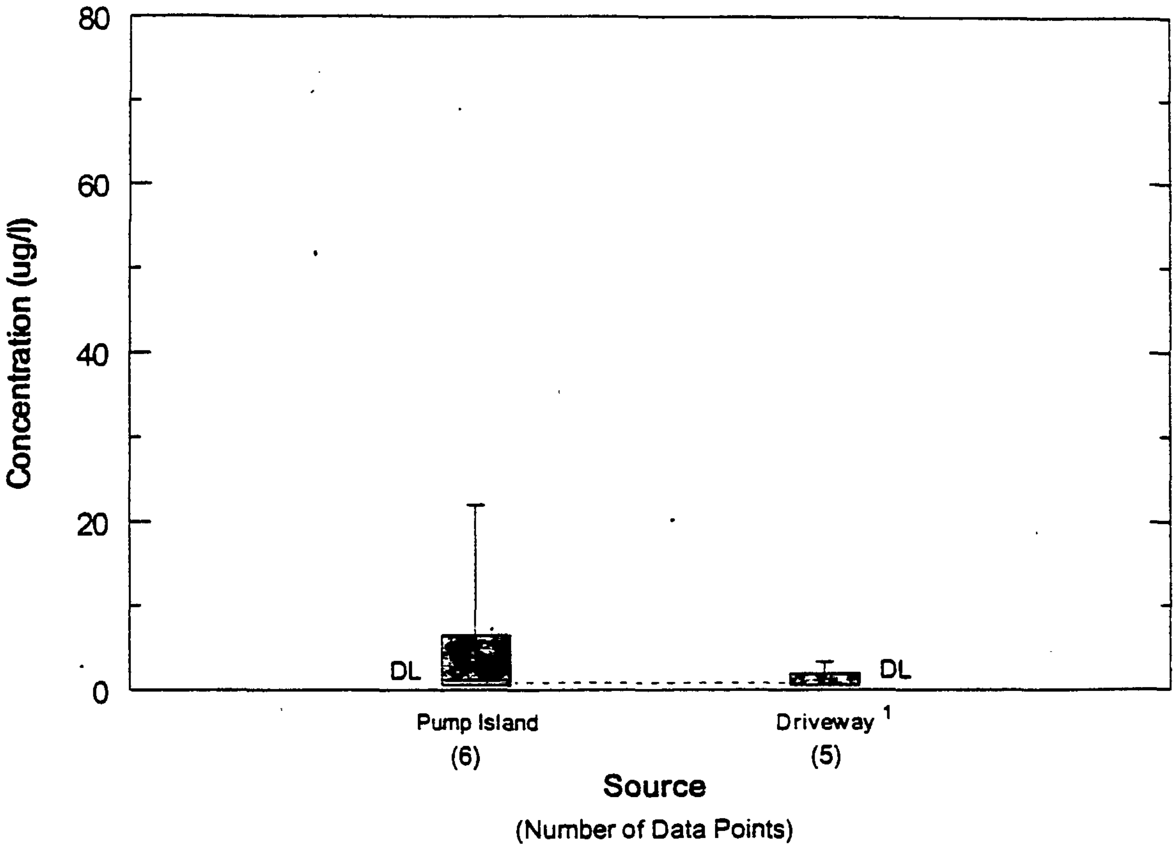
GEOMATRIX



[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 8

TOTAL XYLENES
(Event Mean Concentrations)



[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 9

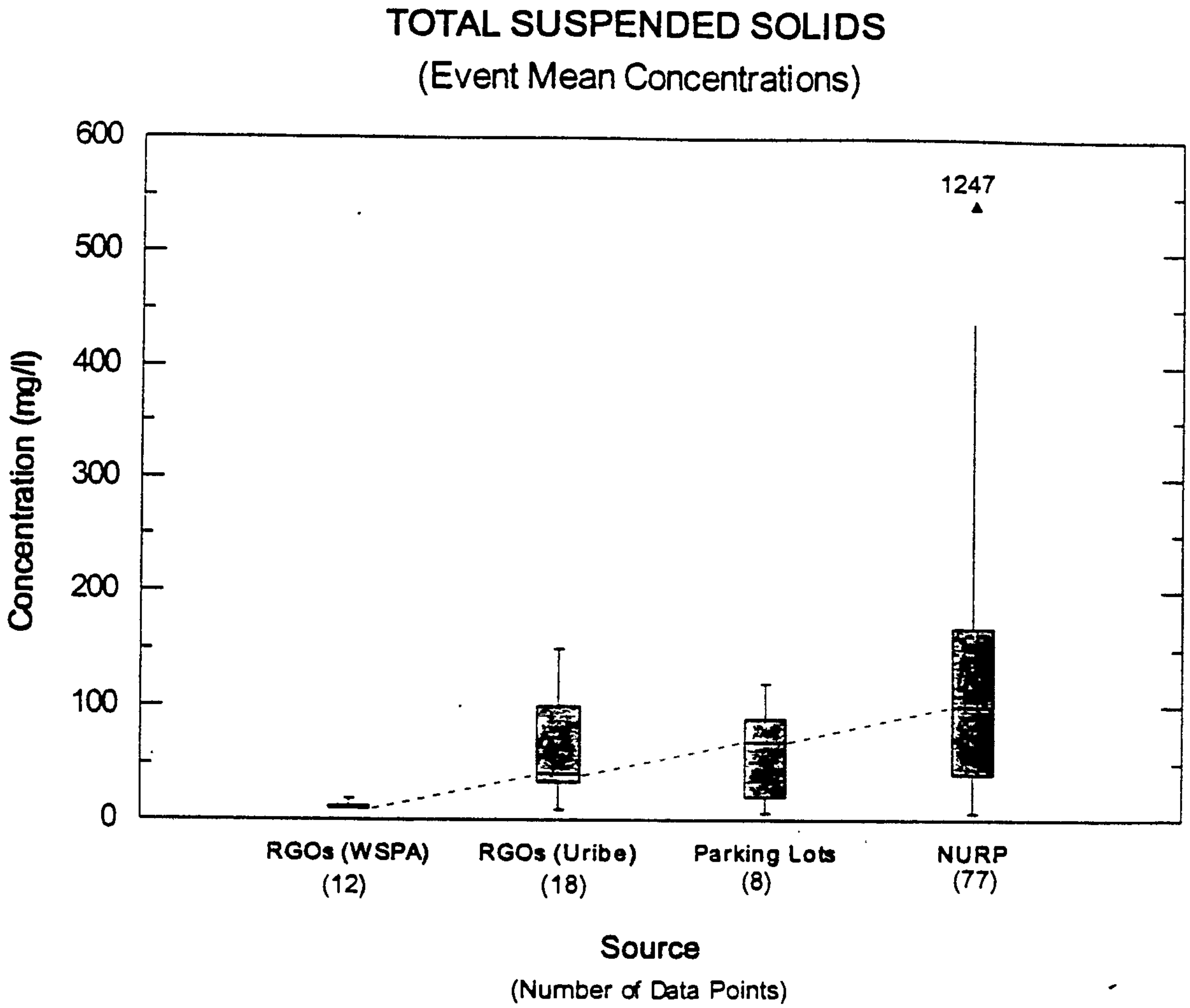

TOTAL SUSPENDED SOLIDS
(Event Mean Concentrations)
Concentration (mg/l)
600
500
400
300
200
100
0
1247
RGOs (WSPA)
(12)
RGOs (Uribe)
(18)
Parking Lots
(8)
NURP
(77)
Source
(Number of Data Points)

FIGURE 10

GEOMATRIX

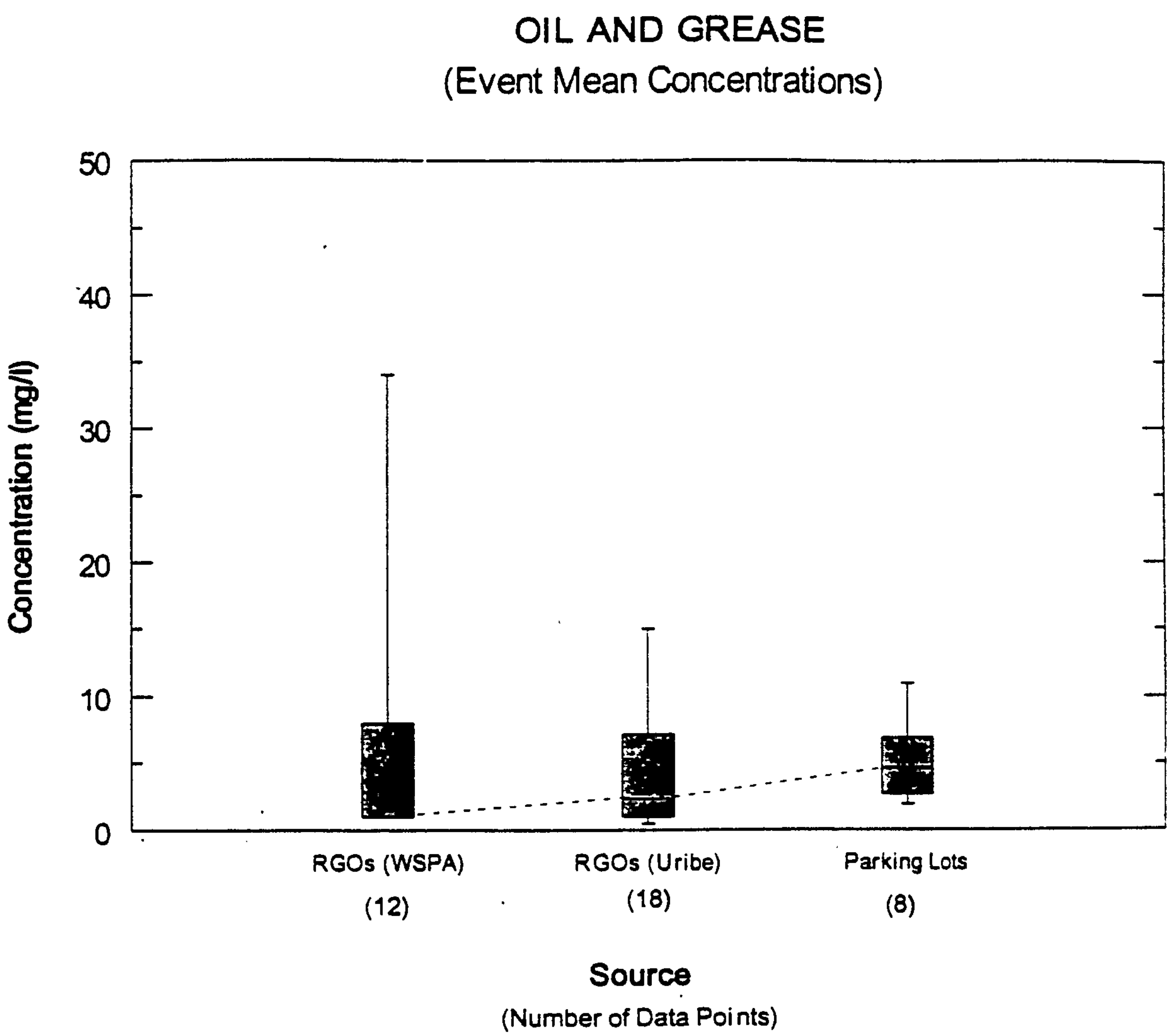
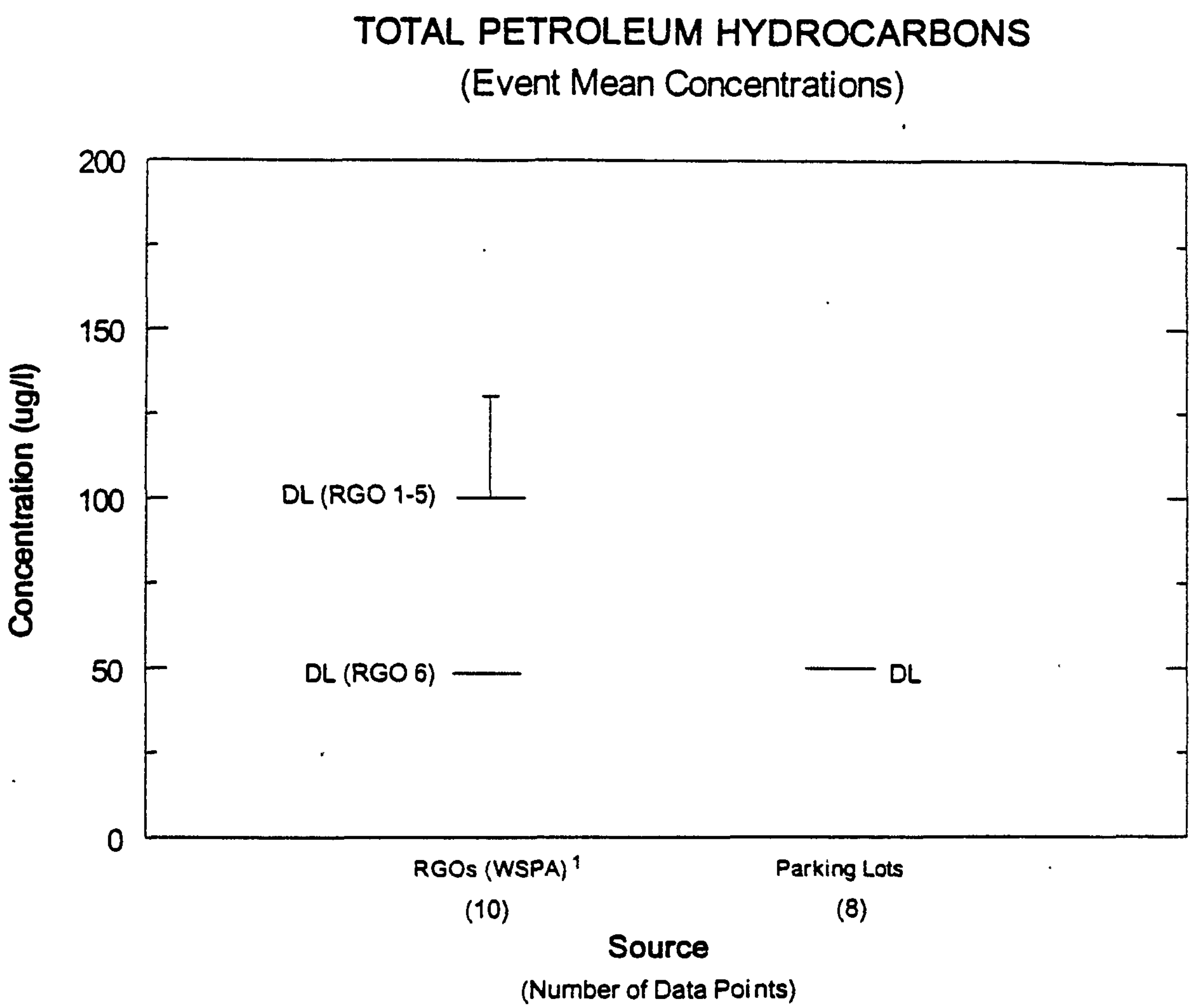


FIGURE 11

GEOMATRIX

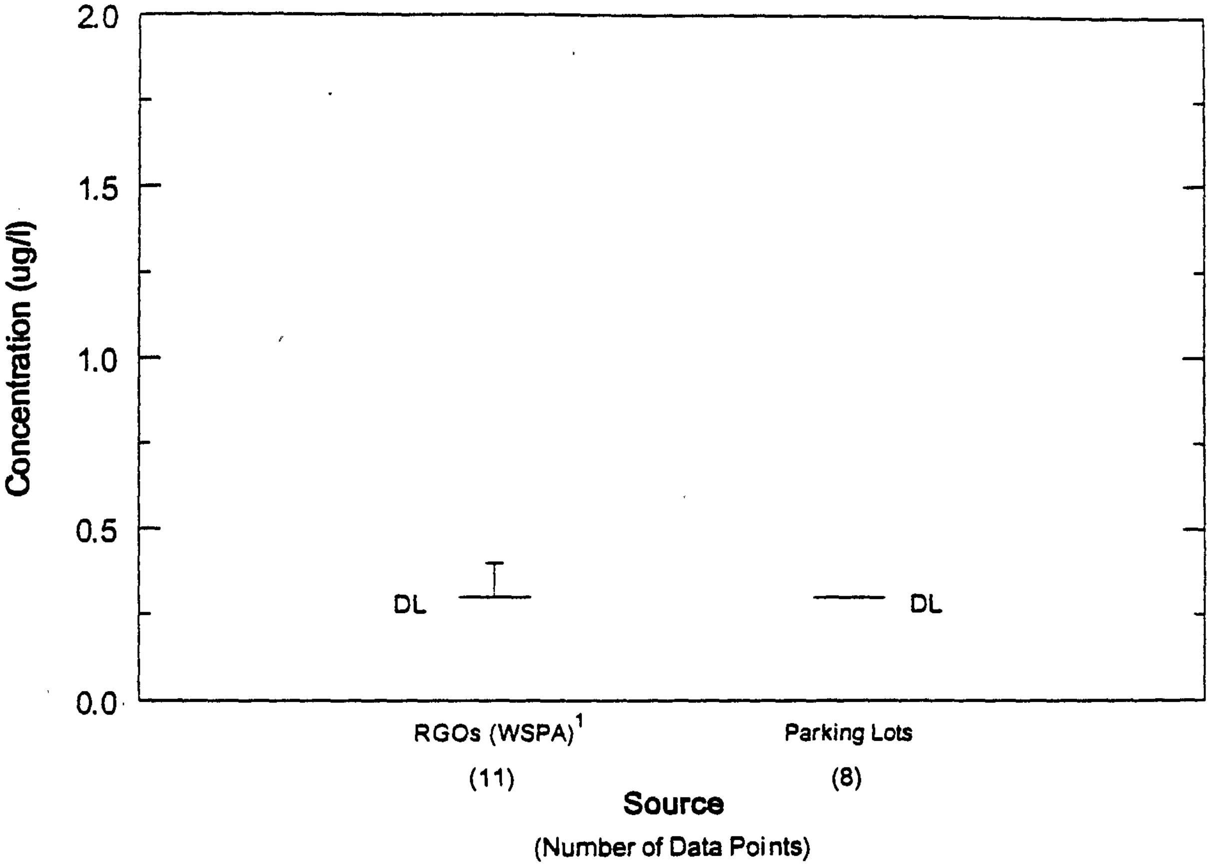


[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 12

R0009123

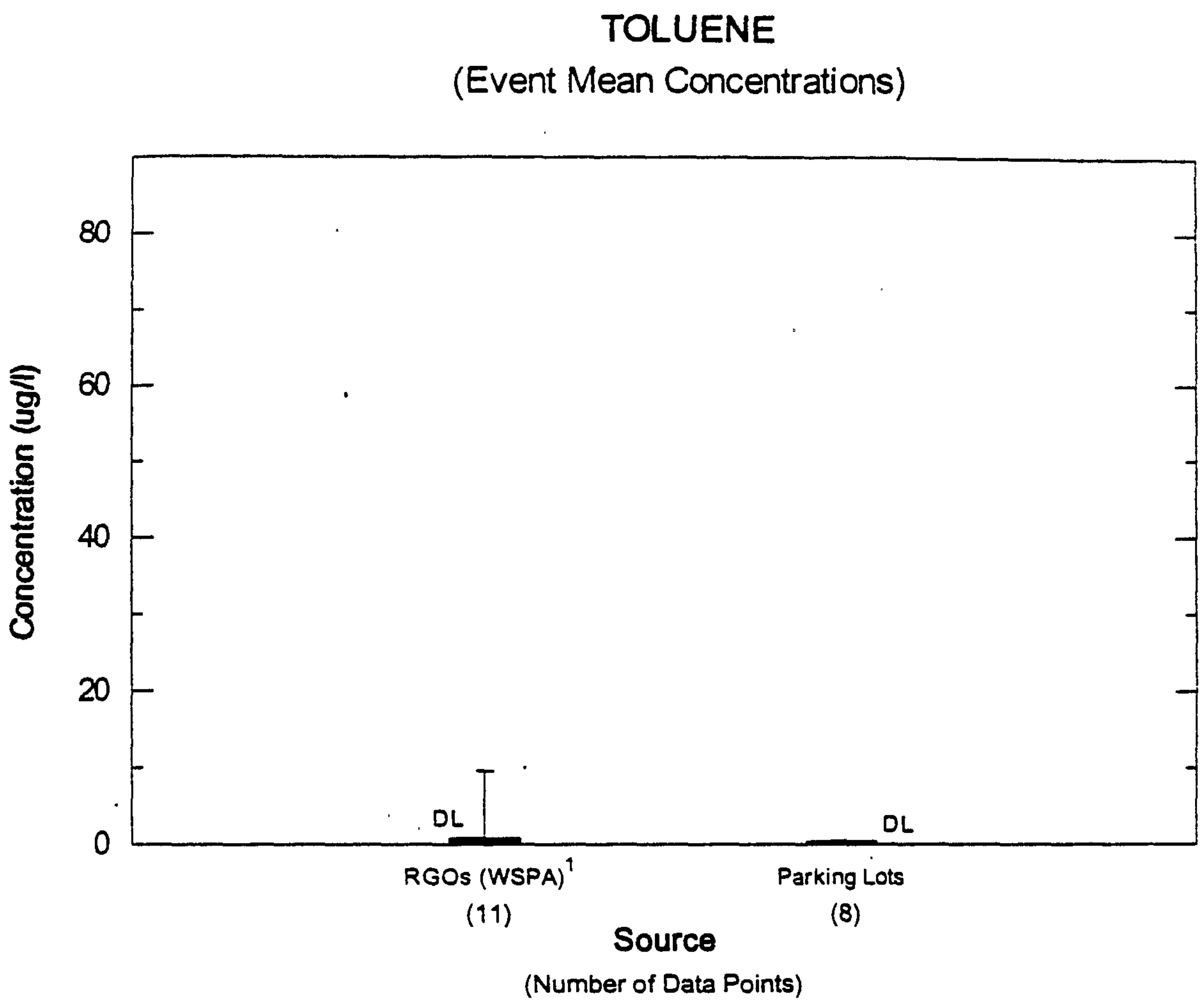
BENZENE
(Event Mean Concentrations)



[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 13

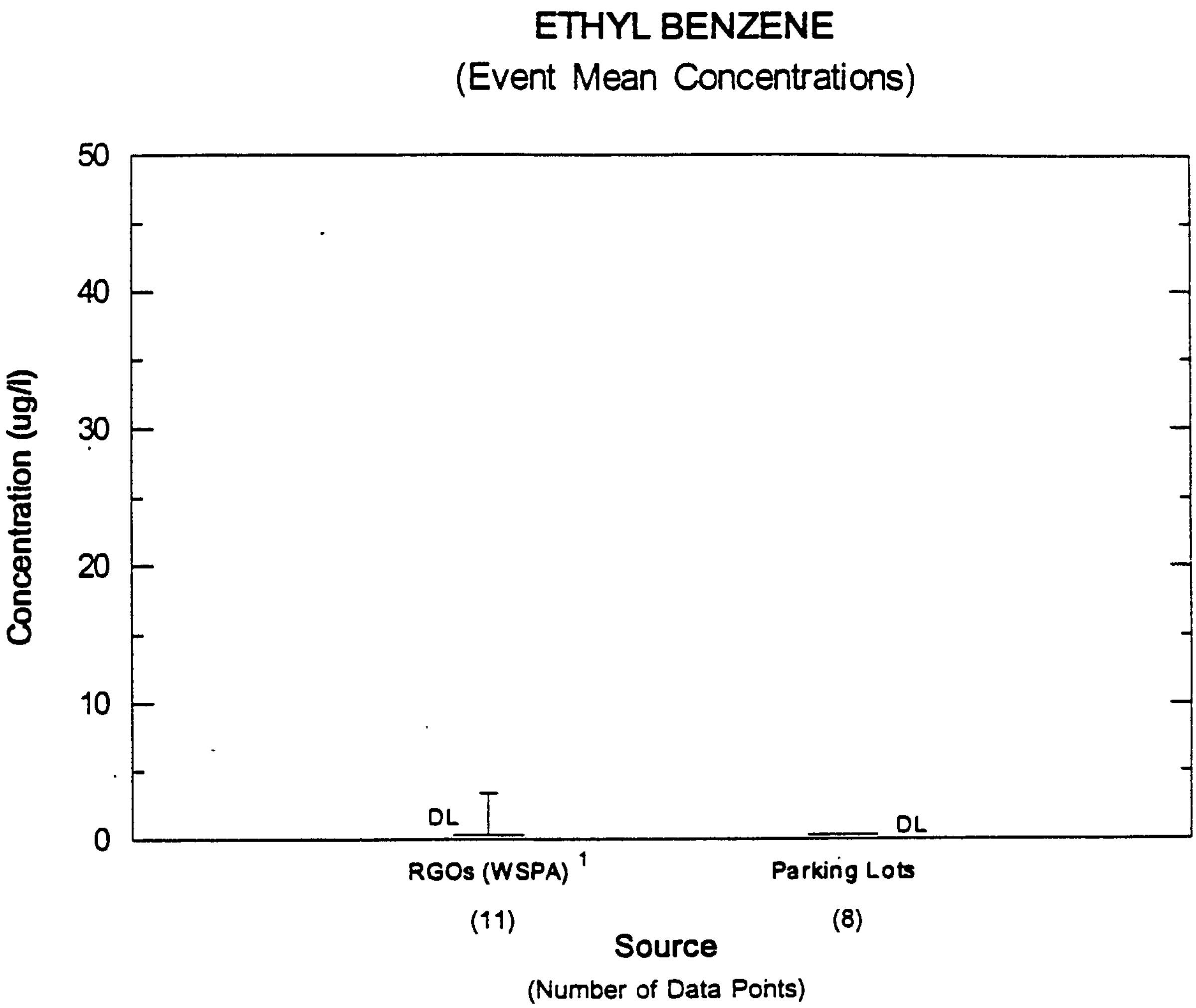
GEOMATRIX



[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 14

GEOMATRIX

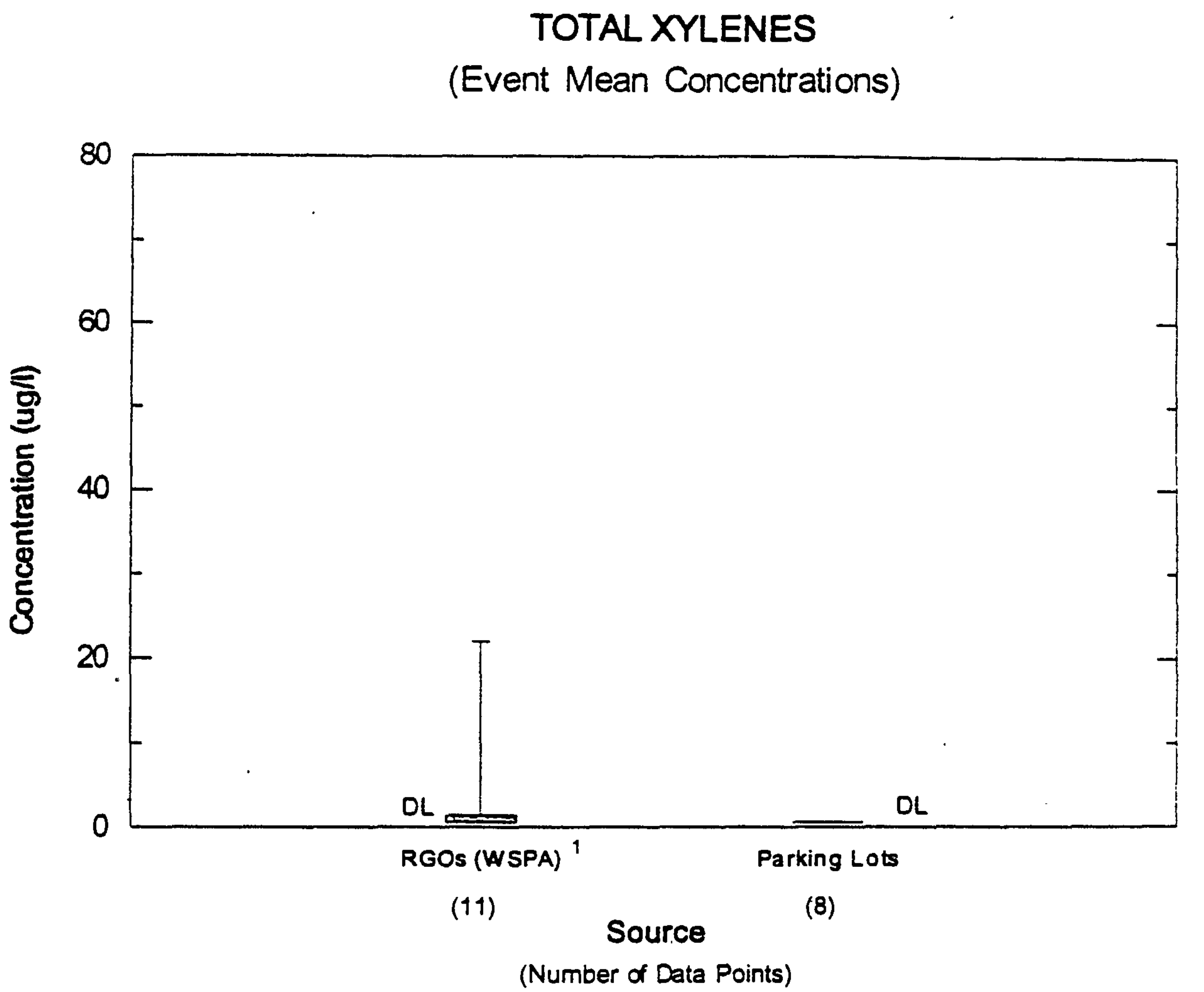


[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 15

R0009126

GEOMATRIX



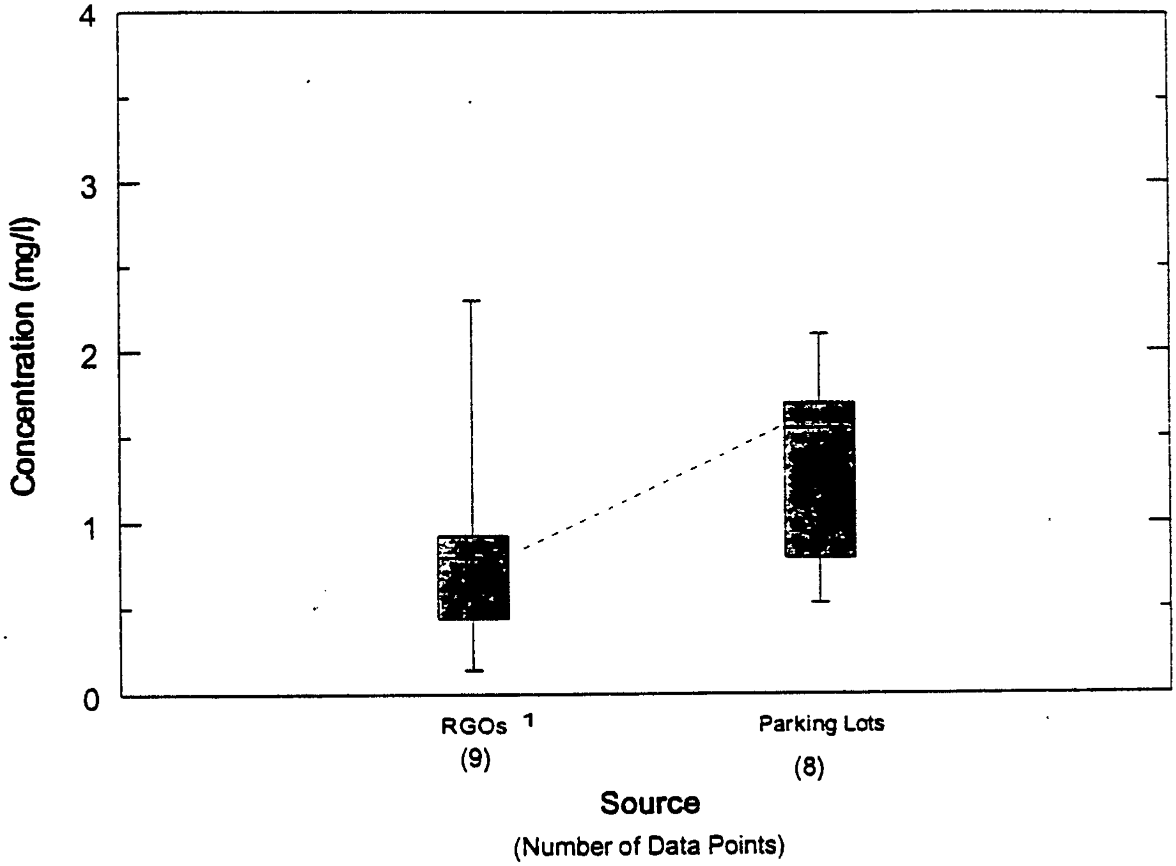
[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 16

R0009127

GEOMATRIX

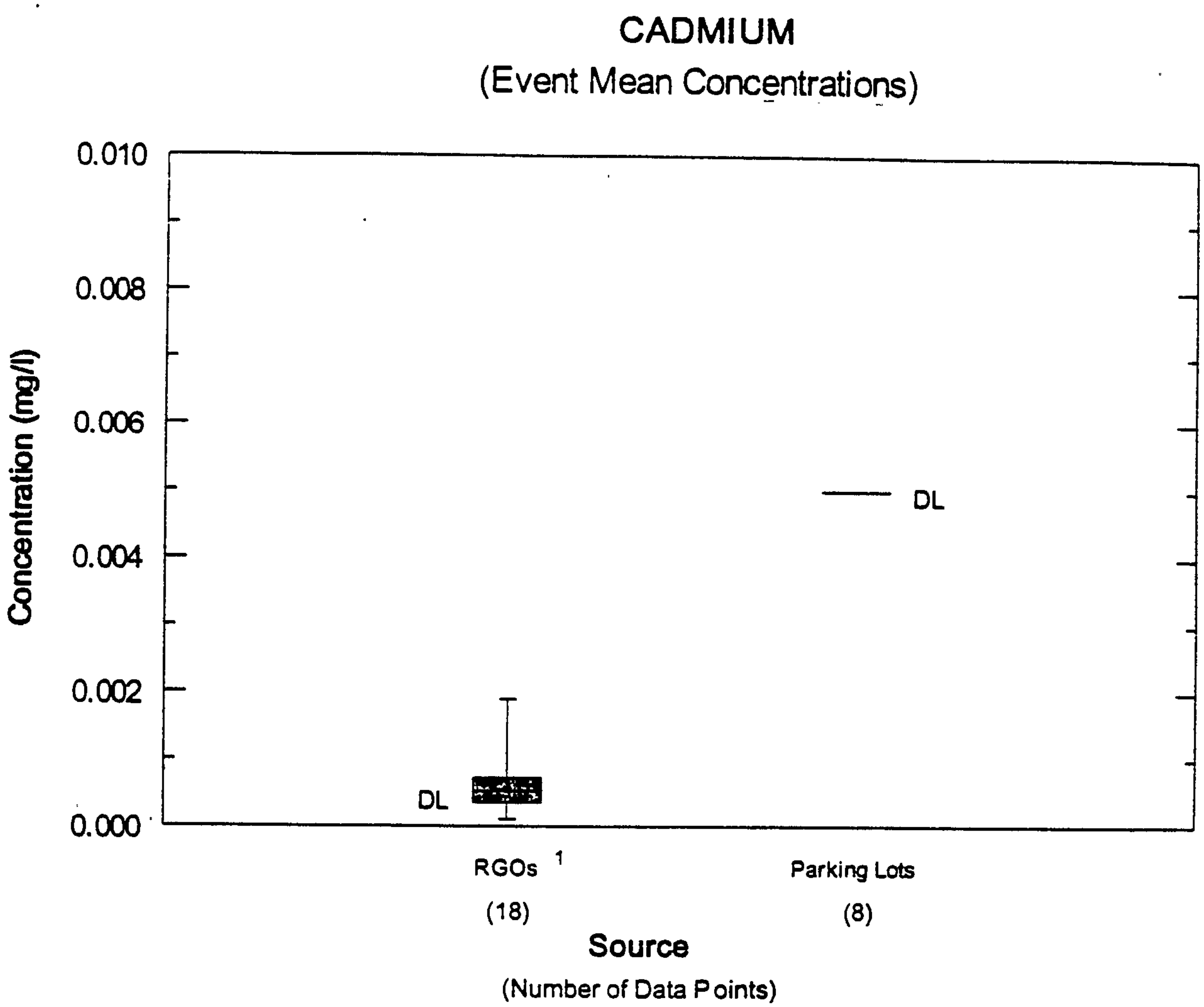
ALUMINUM
(Event Mean Concentrations)



[1] Results from Uribe (1993) only.

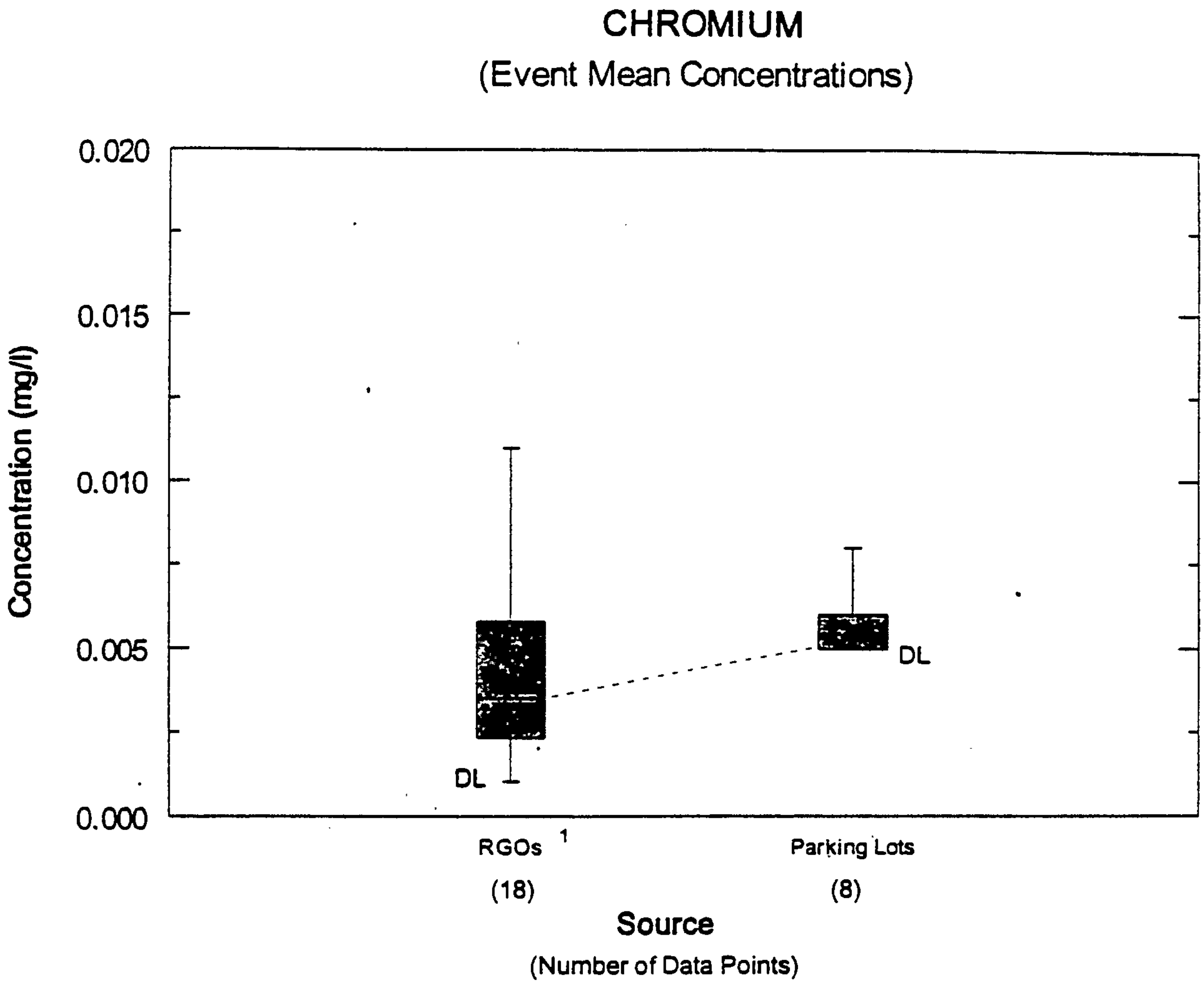
FIGURE 17

R0009128



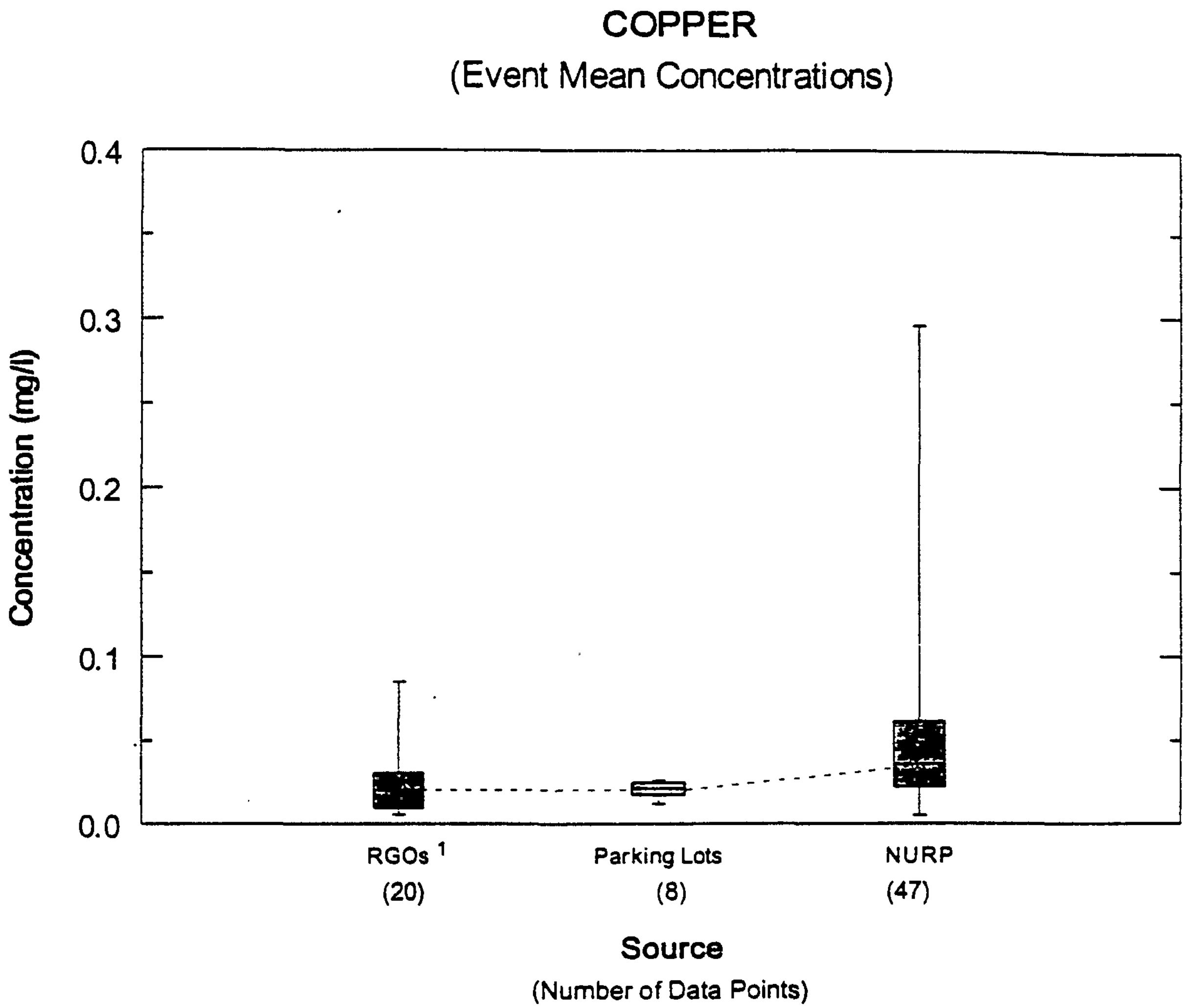
[1]Results from Uribe (1993) only.

FIGURE 18



[1]Results from Uribe (1993) only.

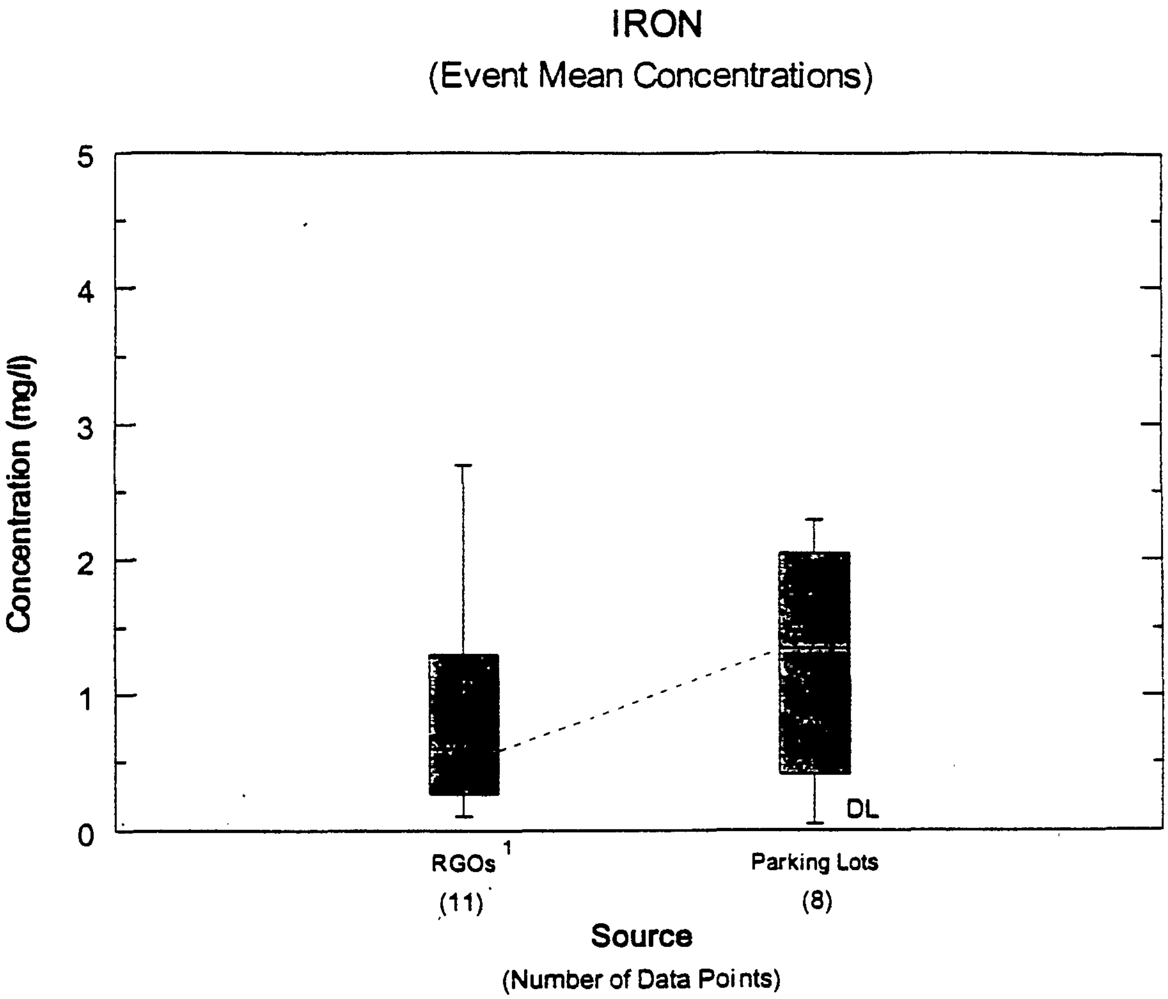
FIGURE 19



[1] Includes WSPA and Uribe (1993) results.

FIGURE 20

GEOMATRIX

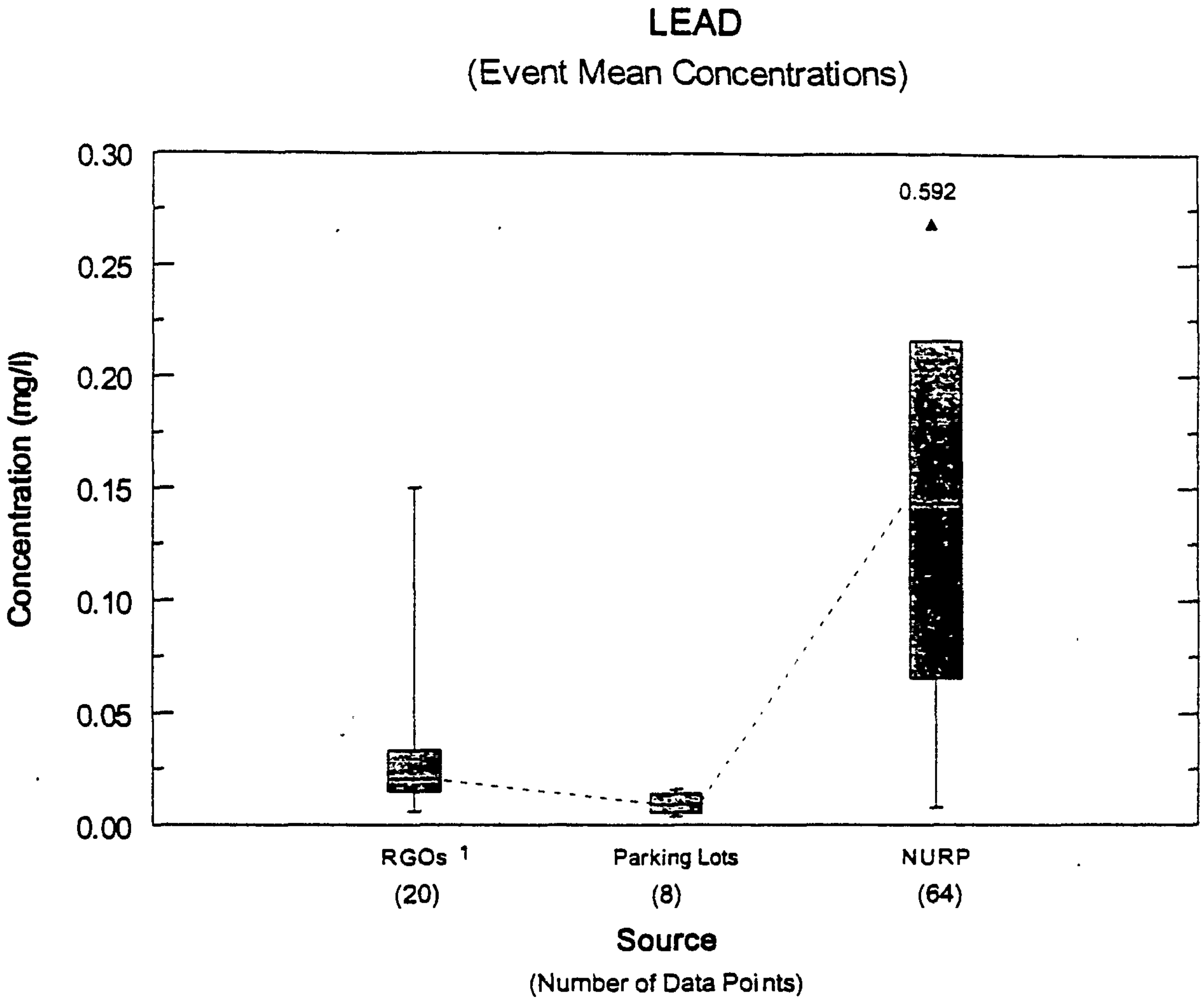


[1] Includes WSPA and Uribe (1993) results.

FIGURE 21

R0009132

GEOMATRIX

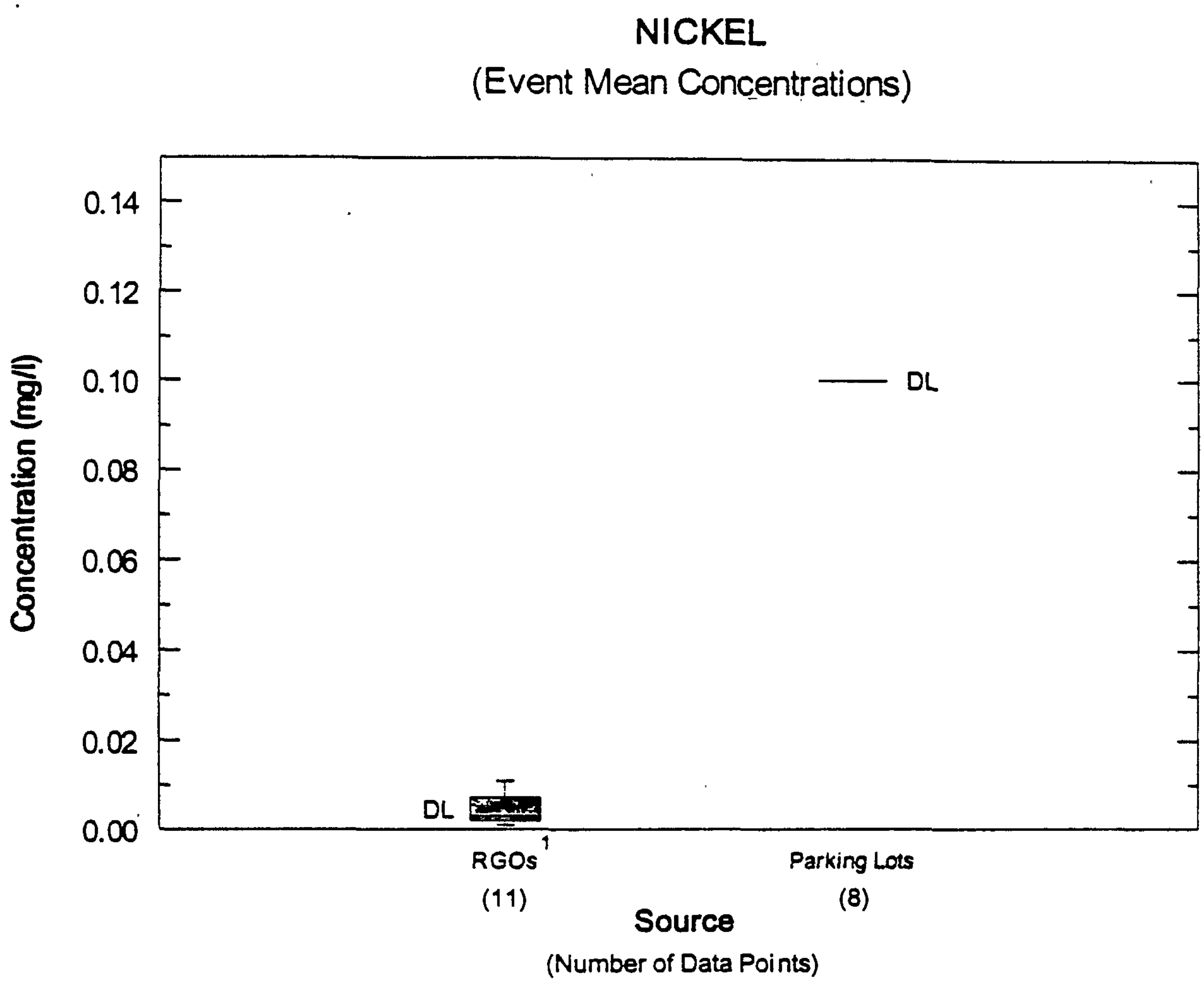


[1] Includes WSPA and Uribe (1993) results.

FIGURE 22

R0009133

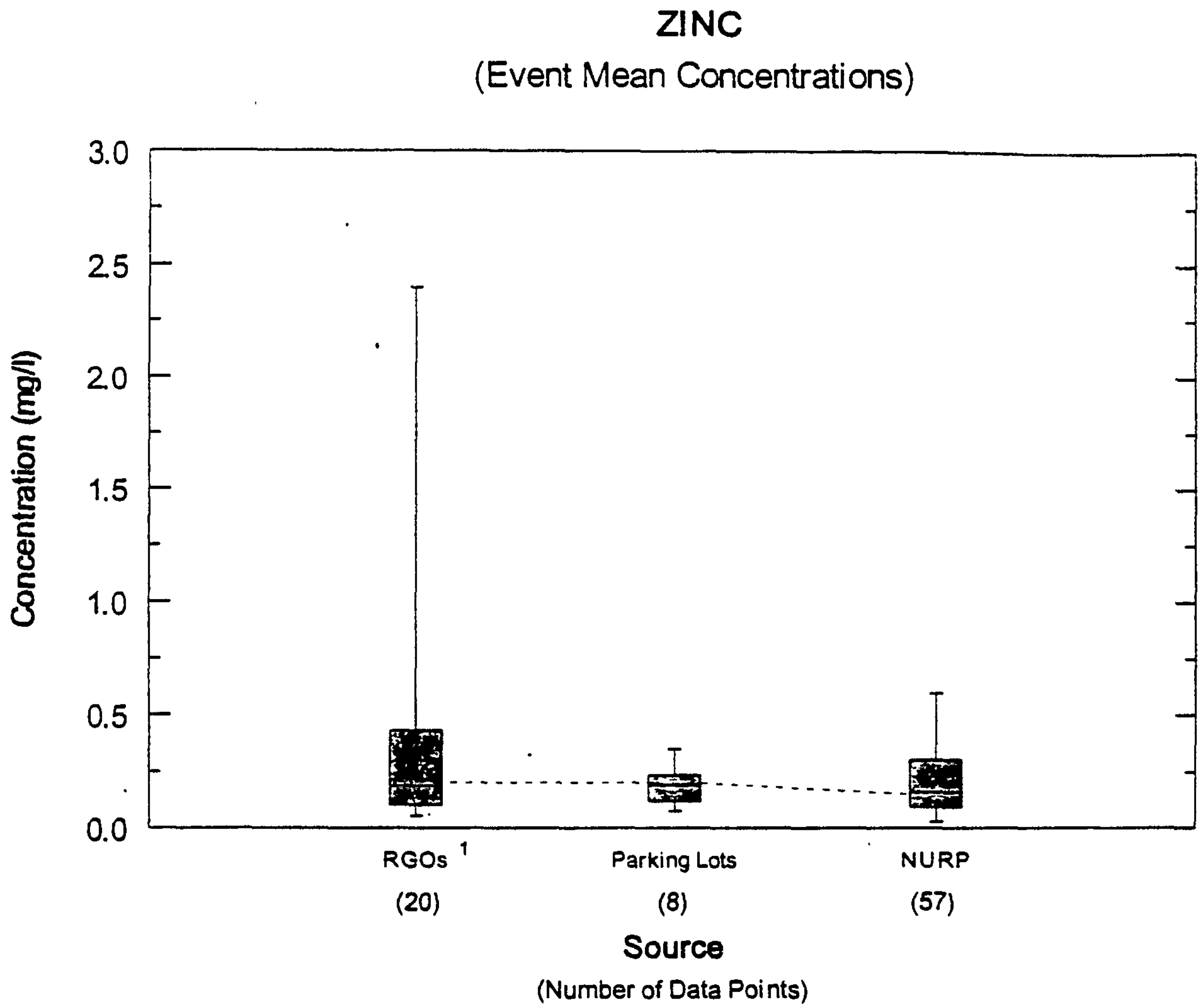
GEOMATRIX



[1]Results from Uribe (1993) only.

FIGURE 23

R0009134



[1]Includes WSPA and Uribe (1993) results.

FIGURE 24

SWQTF *California Stormwater Quality Task Force*

BACK

Work Products

Best Management Practice Guide

Retail Gasoline Outlets

California
Stormwater Quality Task Force

Prepared by
Retail Gasoline Outlet Work Group

March 1997

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Pavlova Vitale Regional Water Quality Control Board - Santa Ana

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Jean Young Unocal

Nancy Zavesky Chevron

Don Zedrick Environmental Resource Council

Disclaimer

The statements and conclusions of this guide are those of the California Stormwater Quality Task Force (Task Force) and not necessarily those of the State of California. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

The guide was produced and published by the California Stormwater Quality Task Force, an advisory body of municipal agencies regulated by the storm water program. This guide is not a publication of the State Water Resources Control Board or any Regional Water Quality Control Board, and none of these Boards has specifically endorsed the contents thereof. The purpose of this guide is to assist municipal agencies and retail gasoline outlets subject to storm water regulations, in attaining compliance with such regulations. This guide is not specifically intended for use in geographic areas not subject to federal or state storm water regulations, or at facilities that do not discharge storm water either directly to surface waters or indirectly, through municipal separate storm drain systems. Implementation of these best management practices can not be construed as compliance with all other applicable regulations, including local requirements.

Introduction

This guide represents the work of the California Stormwater Quality Task Force's (SWQTF) Retail Gasoline Outlet Work Group. The Work Group formed in May 1996 and met on a regular basis to review and discuss appropriate best management practices for fueling and other closely related activities likely to be found at retail fueling operations. Representatives from industry, municipalities, and regulatory agencies participated. Best management practices (BMPs) from throughout California, and elsewhere, were reviewed and considered for inclusion in this guide. The Work Group worked in the tradition of the SWQTF by raising and discussing issues in an open forum, and working to reach consensus on each issue. The Work Group worked in parallel and communicated with State and Regional Board staff responsible for storm water permit compliance.

These best management practices were developed with retail gasoline outlets primarily in mind, and may or may not have applicability to other facility types (e.g., cardlocks, bulk plants, fleet operations). The need for and application of these BMPs to other facility-types should be carefully reviewed on a case-by-case basis. During the development of this guide, storm water and wastewater issues were addressed together to avoid cross-media transfers of waste. In addition, the potential of these BMPs to affect other environmental media/regulations (e.g., hazardous waste) was considered before their inclusion in this guide.

Regulatory Context

The Federal Clean Water Act, as amended in 1987, and the State Porter-Cologne Act are the principle regulations for control of storm water pollutants. There are, however, other regulations that deal with the control of storm water pollutants. Examples include the Federal Coastal Zone Act Reauthorization Amendments of 1990, and the State Hazardous Waste Source Reduction and Management Review Act. The 1987 amendments to the Federal Clean Water Act added section 402(p) which establishes a framework for regulating municipal, industrial, and construction storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. On November 16, 1990, the USEPA published final regulations that establish application requirements for storm water permits from five classes of discharges (Phase 1) including storm water associated with industrial activity (industrial storm water) that discharges either directly to surface waters or indirectly through municipal separate storm drain systems. Municipalities with a population over 100,000 or those that have been determined to be a significant contributor of pollutants are also required to obtain a NPDES storm water permit.

As part of its storm water management program, a municipality is required to develop a program to monitor and control pollutants in storm water discharges from its municipal system. These programs must include structural and source control measures to reduce pollutants from runoff from commercial and industrial areas. Thus it is important for commercial and industrial facilities located within municipalities to realize that there may be municipal requirements on storm water discharges from their facilities.

In addition to the storm water requirements, both the Federal Clean Water Act and the State Porter-Cologne Act require the control of pollutants in wastewater discharges. The Porter-Cologne Act requires the development of Basin Plans for drainage basins in California. These basin plans are used in turn to identify more specific controls for discharges (e.g., wastewater treatment plant effluent). The basin plans are implemented through the NPDES program. Many municipalities, being subject to both storm water and wastewater regulations, will develop water quality protection programs that deal with both types of discharges in a coordinated and integrated way.

Purpose and Intent

The purpose of this guide is two-fold. First, to be a compilation of peer-reviewed best management practices for fueling and other closely related activities found at retail fueling operations. Second, to be a reference for municipalities, regulators, and facility owners and operators.

The intent of the SWQTF is that these best management practices serve as a "default" set of BMPs for use throughout California. Municipalities and retail gasoline outlets that have not yet adopted best management practices for these activities should give these practices strong consideration. Municipalities and retail gasoline outlets that do have and use BMPs should compare their current practices with those presented here. Substantive differences should be identified and re-evaluated. Successful implementation of these BMPs depends on a partnership between municipalities, regulators, and facility owners and operators. Each has a role to play:

- Municipalities should become familiar with these BMPs and incorporate them into their water quality protection programs, as appropriate.
- Regulators and inspectors should use these or similar BMPs to measure the pollution prevention efforts of facilities.
- Facility owners and operators should become familiar with these BMPs, teach their employees about them, and ensure that they are used on-site.

How to Use the Best Management Practices

Coverage - These best management practices cover three activities or areas:

- Fuel dispensing
- Air/water supply
- Outdoor waste receptacles

Retail gasoline outlets will have every combination of these activities/areas on-site, including other activities not covered by this guide. For example, a facility may have a fuel dispensing area, air/water supply area, indoor service bay, but no outdoor waste receptacles. These BMPs cover the first two areas but not the indoor service bay. Best management practices for the indoor service bay may be found elsewhere. The inclusion of best management practices for air/water supply areas is not intended to suggest that air and/or water must be supplied by retail gasoline outlets in geographic areas not otherwise required to do so.

Design - The design of this guide is purposely different from many BMP lists that are designed as a menu of BMPs from which the facility owner/operator, and the inspector, may choose some but not necessarily all BMPs. These BMP lists are designed so that if the activity/area is on-site, each numbered BMP listed below the activity should be implemented. For some BMPs, as described below, several implementation options are provided. The best management practices are meant to be implemented, monitored, and maintained on a year round basis. The guide also makes an important distinction between existing facilities and new or substantially remodeled facilities. A definition of new or substantially remodeled is also provided. The Work Group used these design elements to help clarify and unify expectations.

Options - Several of the best management practices provide facility owners and operators options for compliance. For example, one best management practice is:

- Minimize the possibility of storm water pollution from outside waste receptacles by doing at least one of the following:

a. use only watertight waste receptacle(s) and keep the lid(s) closed, or
b. grade and pave the waste receptacle area to prevent run-on of storm water, or
c. install a roof over the waste receptacle area, or
d. install a low containment berm around the waste receptacle area, or
e. use and maintain drip pans under waste receptacles.

It is the intent of these BMPs that a) through e) are options. Effective implementation of at least one of these options, chosen by the facility owner/operator, should be deemed implementation of this best management practice.

Other BMPs - The Work Group considered other BMPs not listed here including:

- Oil/water separators
- Catch basin inserts

The evidence reviewed by the Work Group indicated that the effectiveness and efficiency of these and other BMPs not listed was insufficient for them to pass peer review and therefore these BMPs can not be generally recommended for use statewide. There may be situations in which these BMPs would be effective and efficient (as evidenced by research), and therefore appropriate, but these situations should be the exception, not the rule. Members of the SWQTF are conducting studies on these and other BMPs. If that research shows that a particular BMP is effective and efficient, the SWQTF will consider adding it to this guide.

Best Management Practices

Existing Facilities

Fuel Dispensing Areas

1. Maintain fuel dispensing areas using dry cleanup methods such as sweeping for removal of litter and debris, or use of rags and absorbents for leaks and spills. Fueling areas should never be washed down unless the wash water is collected and disposed of properly.
1. Fit underground storage tanks with spill containment and overfill prevention systems meeting the requirements of Section 2635(b) of Title 23 of the California Code of Regulations.
1. Fit fuel dispensing nozzles with "hold-open latches" (automatic shutoffs) except where prohibited by local fire departments.
1. Post signs at the fuel dispenser or fuel island warning vehicle owners/operators against "topping off" of vehicle fuel tanks.

Facility - General

1. "Spot clean" leaks and drips routinely. Leaks are not cleaned up until the absorbent is picked up and disposed of properly.
1. Maintain and keep current, as required by other regulations, a spill response plan and ensure that employees are trained on the elements of the plan.
1. Manage materials and waste to reduce adverse impacts on storm water quality.
1. Train all employees upon hiring and annually thereafter on proper methods for handling and disposing of waste. Make sure that all employees understand storm water discharge prohibitions, wastewater discharge requirements, and these best management practices. Use a training log or similar method to document training.
1. Label drains within the facility boundary, by paint/stencil (or equivalent), to indicate whether they flow to an oil/water separator, directly to the sewer, or to a storm drain. Labels are not necessary for plumbing fixtures directly connected to the sanitary sewer.
1. Inspect and clean if necessary, storm drain inlets and catch basins within the facility boundary before October 1 each year.

Outdoor Waste Receptacle Area

1. Spot clean leaks and drips routinely to prevent runoff of spillage.
1. Minimize the possibility of storm water pollution from outside waste receptacles by doing at least one of the following:

a. use only watertight waste receptacle(s) and keep the lid(s) closed, or
b. grade and pave the waste receptacle area to prevent run-on of storm water, or
c. install a roof over the waste receptacle area, or
d. install a low containment berm around the waste receptacle area, or
e. use and maintain drip pans under waste receptacles.

Air/Water Supply Area

1. Minimize the possibility of storm water pollution from air/water supply areas by doing at least one of the following:

a. spot clean leaks and drips routinely to prevent runoff of spillage, or
b. grade and pave the air/water supply area to prevent run-on of storm water, or
c. install a roof over the air/water supply area, or
d. install a low containment berm around the air/water supply area.

New or Substantially Remodeled Facilities

The elements listed below should be included in the design and construction of new or substantially remodeled facilities.

Fuel Dispensing Areas

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1. Fuel dispensing areas must be paved with portland cement concrete (or, equivalent smooth impervious surface), with a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of storm water to the extent practicable. The fuel dispensing area is defined as extending 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus 1 foot, whichever is less. The paving around the fuel dispensing area may exceed the minimum dimensions of the "fuel dispensing area" stated above.
1. The fuel dispensing area must be covered, and the cover's minimum dimensions must be equal to or greater than the area within the grade break or the fuel dispensing area, as defined above. The cover must not drain onto the fuel dispensing area.

Outdoor Waste Receptacle Area

1. Grade and pave the outdoor waste receptacle area to prevent run-on of storm water to the extent practicable.

Air/Water Supply Area

1. Grade and pave the air/water supply area to prevent run-on of storm water to the extent practicable.

Substantially Remodeled Facilities

One of the following criteria must be met before a facility is deemed to be substantially remodeled and the design elements described above are required to be included in the new design and construction:

- the canopy cover over the fuel dispensing area is new or is being substantially replaced (not including cosmetic/facial appearance changes only) and the footing is structurally sufficient to support a cover of the minimum dimensions described above, or
- one or more fuel dispensers are relocated or added in such a way that the portland cement concrete (or, equivalent) paving and grade break or the canopy cover over the fuel dispensing area do not meet the minimum dimensions as defined above. Replacement of existing dispensers or underground storage tanks do not, by themselves, constitute a substantial remodel.

Special note on the paving BMP (#1 only) addressing Fuel Dispensing Areas under New or Substantially Remodeled Facilities

This best management practice is not specifically intended to apply to facilities that install a new canopy where no canopy existed.

Special note on the canopy BMP (#2 only) addressing Fuel Dispensing Areas under New or Substantially Remodeled Facilities

This best management practice is not specifically intended to apply to facilities that:

- are located in geographic areas not subject to federal or state storm water regulations
- do not discharge storm water either directly to surface waters or indirectly, through municipal separate storm drain systems
- do not add fuel dispensers
- replace, relocate, or add fuel dispensers within the parameters described in the BMP
- increase their throughput of fuel dispensed without modifying their equipment
- make only cosmetic or facial appearance changes to their existing canopy

For the purposes of the waste receptacle area and air/water supply area BMPs only, the facility is considered substantially remodeled if the area around the waste receptacle area or air/water supply area is being regraded or repaved.

Help

For assistance with implementation of these best management practices, municipal staff or facility owners and operators should contact their local storm water program representative, Regional Board or State Board storm water contact, or the Stormwater Quality Task Force.

PETROLEUM HYDROCARBONS IN STORMWATER RUNOFF FROM RETAIL GASOLINE STATIONS

Pat L. Ashley
Environmental Studies Program
California State University, Fullerton
August 17, 1998

R0009145

PETROLEUM HYDROCARBONS IN STORMWATER RUNOFF FROM A RETAIL GASOLINE STATION

A Project Report
Presented to the
Faculty of
California State University, Fullerton

in Partial Fulfillment
of the Requirements for the Degree
Master of Science
in
Environmental Studies

By
Pat L. Ashley

Approved By:

Prem K. Saint .... August 19, 1998 ....

Prem K. Saint Ph.D Advisor **Date**
Department of Geological Sciences

R0009146

ABSTRACT

This paper presents a detailed study of the presence of petroleum hydrocarbons, Benzene, Toluene, Ethylbenzene, Xylene, and MTBE in stormwater runoff that originates from Retail Gasoline Stations in Orange County, California. Background information presented here includes: the physical and environmental characteristics of petroleum hydrocarbons in surface and subsurface waters. Geologic and climatic characteristics of the Orange County, California region and other previous studies done in the region and a brief overview of regions stormwater regulatory requirements. This study also investigates the effectiveness of required and proposed structural Best Management Practices (BMPs) for all new and renovated retail gasoline stations in the county utilizing field observations during actual storm events for the 1997-1998 rainy period.This study concludes with 4 sampling events in which stormwater runoff was collected from the stations parking lot, the intake and outlet of the stations clarifier system (S11 Requirement) and tested for the presence of petroleum hydrocarbons. The samples tested were all found to be well below applicable Maximum Contamination Levels (MCLs). The samples all lacked measurable differences (all < 0.5 ppm) for BTEX and (all < 0.5 ppm) for MTBE indicating that there was no measurable difference in petroleum hydrocarbons for stormwater entering and exiting these stations clarifiers as well as the stations surrounding parking lots. These conclusions also reflect similar conclusions from a previous study in the region where stormwater samples were collected and analyzed from retail gasoline stations and compared with commercial parking lots.

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1.0) INTRODUCTION

In the first half of this century deterioration of water quality due to urbanization and urban sources was associated with point sources from industrial and commercial operations and with domestic sewage. As more significant sources of water pollution were brought under control, the impact of pollutants in storm water began to receive greater attention. However, not until the 1970s was it realized that a significant portion of pollution from urban and urbanizing areas originated from nonpoint diffuse sources such as construction and washoff from impervious surfaces such as streets and parking lots. Urban nonpoint sources have been identified as a major cause of pollution of surface-water bodies by the US EPA (Vladimer, Novotny, and Olem 1994, 439).
In the 1988 Report to Congress (U.S. EPA, 1990) it was stated that urban stormwater runoff is the fourth most extensive cause of the impairment of the water quality of the nation's rivers and the third most extensive source of water quality impairment of lakes.

Urbanization usually increases the impervious area of a watershed, which increases storm-runoff rates and, subsequently, total volume of storm runoff. Associated with storm runoff are properties and constituents that can cause the degradation of water quality locally and in receiving waters downstream. Because of concerns about the effects of urban runoff on water quality, the Water Quality Act of 1987 contains provisions that specifically address stormwater run off discharges. The U.S. Environmental Protection Agency, under section 319 of the Water Quality Act of 1987, requires that states " assess the nature and extent of nonpoint sources of pollution." In addition to potential regulation under state and federal programs, local municipalities, as part of their mandated storm water management programs, are required to monitor and control pollutants in storm water discharges from their municipal storm drainage systems. Methods of control may include storm water discharges from facilities, that the municipality determines are contributing pollutants to the municipal storm drain system.

As urbanization increases so do new sources of urban stormwater runoff. One of the areas of concern are retail gasoline outlets (RGOs) or gas stations. It has long been suspected that RGOs are a contributor of inorganic and organic pollutants to both surface and subsurface waters nationwide. The extent of the contribution of these pollutants to the nations receiving waters is still not fully understood and is an ongoing topic of debate. This report is intended to help provide a basis for evaluating and recommending appropriate Best Management Practices (BMPS) for modern RGOs through site observations and sample data analysis.

1.1) Geochemistry of Petroleum Hydrocarbons

The term petroleum is derived from the Latin derivative petra for rock and oleum for oil. Current usage defines petroleum as any hydrocarbon mixture of natural gas, condense, and crude oil. The composition may vary with the location and age of an oil field, and may be depth dependent within an individual well. Crude oils are commonly classified according to their respective distillation residues, which reflect the relative contents of three basic hydrocarbon structural types: paraffins, naphthenes, and aromatics. Aromatic hydrocarbons usually comprise less then 15% of a total crude oil, although they often exceed 50% in heavier fractions of petroleum (Testa and Stephen 1991, 28). The aromatic fraction of petroleum is the most important environmental group of hydrocarbon chemicals and contains at least one benzene ring comprised of six carbon atoms in which the fourth bond of each carbon atom is shared throughout the ring. The aromatics are unsaturated, allowing them to react with hydrogen and other elements in the ring. Benzene is known as the parent compound of the aromatic series and, along with toluene, ethylbenzene, and the three isomers of xylene (ortho, meta, and para) are major constituents of gasoline (Table 1.1). These constituents will be referred to as the BTEX hydrocarbons.

CONSTITUENT	**PERCENTAGE**
Benzene	0 - 4.9%
Cumene	0 - 4%
Cyclohexane	0 - 3%
Di-isopropyl Ether	0 - 16%
Ethanol	0 - 10%
Ethylbenzene	0 - 4%
Ethyl tert-Butyl Ether	0 - 16%
Hexane	0 - 8%
Tert-Amly Ethyl Ether	0 - 16%
Tert-Amly Methyl Ether	0 - 16%
Methyl tert-Butyl Ether	0 - 16%
Toluene	0 - 20%
Trimethylbenzenes	0 - 5%
Xylenes	0 - 18%

Table 1.1 Constituents of a typical unleaded gasoline on the market today varies from manufacturer and brand (Citgo Petroleum Corporation 1997).

1.2) BTEX Hydrocarbons in Gasoline

The principal method for separating crude oil into useful products is through distillation. Boiling points of hydrocarbons generally increase with an increase in the number of carbon atoms that comprise the compound. As a crude sample or any hydrocarbon blend, is heated in increasing increments, the hydrogen compounds having a boiling point at or below the current temperature volatilizes. The remaining hydrocarbon compounds in the sample will not volatilize until the temperature is raised to their respective boiling points The range of boiling temperatures are from high to low, divided into the following product types: residue, heavy gas-oil, light gas-oil, kerosene, naphtha, gasoline, and butanes. The crude source has a definite effect on the composition of all refined products (Testa and Stephen 1991, 29). The BTEX constituents contained in gasoline and their respective physical properties are presented in Tables 1.2.

BENZENE	
Boiling Point	175-177.8 F @ 760 mmHg
Specific Gravity	0.882 - 0 .886 @ 60 F
Liquid Density	7.730 lbs/gal @ 60 F
Molecular Weight	78
Percent Volatile	100 %
Physical State	Colorless Liquid
Vapor Pressure	74.3 mmHg @ 68 F

TOLUENE	
Boiling Point	232 F @ 760 mmHg
Specific Gravity	0.870 @ 60 F
Liquid Density	7.250 lbs/gal @ 60 F
Molecular Weight	92
Percent Volatile	100 %
Physical State	Colorless Liquid
Vapor Pressure	22 mmHg @ 68 F

ETHYLBENZENE	
Boiling Point	277 F @ 760 mmHg
Specific Gravity	0.870 - 0.873 @ 60 F
Liquid Density	7.26 lbs/gal @ 60 F
Molecular Weight	106
Percent Volatile	100 %
Physical State	Coloress Liquid
Vapor Pressure	7.1 mmHg @ 68 F

XYLENE	
Boiling Point	297 F @ 760 mmHg
Specific Gravity	0.870 @ 60 F
Liquid Density	7.250 lbs/gal @ 60 F
Molecular Weight	NA
Percent Volatile	100 %
Physical State	Colorless Liquid
Vapor Pressure	2.400 mmHg @ 68 F

MTBE	
Boiling Point	55.2 @ 760 mmHg
Specific Gravity	NA
Liquid Density	NA
Molecular Weight	NA
Percent Volatile	100 %
Physical State	Colorless Liquid
Vapor Pressure	245 mmHg @ 25 C

Tables 1.2. Selected physical properties for BTEX and MTBE hydrocarbons (Ashland Chemical Company 1996).

1.3) Hydrocarbon Degradation Processes

Degradation processes include biodegradation as well as chemical and physical degradation via mechanisms such as oxidation, waterwashing, and inspissation (the evaporation of the lighter constituents of petroleum), leaving the heavier residual behind . Degradation processes tend to destroy paraffins, to remove the light ends, and to oxidize the remaining fractions of the product (Testa and Stephen 1991, 33). During biodegradation, aromatics are susceptible to microbial decomposition, including the BTEX hydrocarbons and the gasoline additive MTBE. Over 30 genera and 100 species of various bacteria, fungi, and yeast exist that metabolically utilize one or more kinds of hydrocarbons (Testa and Stephen 1991, 33). The order in which hydrocarbons are oxidized depends on numerous factors. However, in general smaller carbon molecules up to C20 are consumed before larger ones. Degradation processes exist in both surface and subsurface waters and their influence on the presence and fate of BTEX and MTBE found there cannot be ignored.

1.4) BTEXs Toxicity and Health Concerns

We have been releasing harmful materials since humans first gathered to form societies. In the last 100 years we have begun to generate an astonishing variety of chemicals with various potentials for harm to ecosystems and human health. Particularly since the end of world war 2 , the production and release of such materials has risen tremendously (Devinny and others 1990). Modern cities are built on the assumption that separate systems for wastewater collection are best. Sewage from homes and industries is collected in an enclosed system and treated, while the much larger amount of clean rain water is collected in an open system such as street gutters, storm sewers, and man made channels. These smaller urban systems are channeled to rivers, lakes, retention basins, reservoirs, or the ocean. Runoff from urbanized regions contain significant quantities of contaminants that provide pathways for potential human exposure. For example, rivers carrying stormwater runoff from urban areas are often sites for recreational uses such as swimming, fishing, and boating. Lakes and reservoirs serve similar purposes and are often used as a source for drinking water and groundwater recharge, another valuable drinking water supply. Ultimately, urban stormwater runoff reaches the ocean where its effect can degrade resources such as fisheries, estuaries, and public beaches.

An obvious first question about the composition of gasoline is "what dangers does it pose to public health ?" The question is important in the legal and regulatory sense, because chemicals which are not legally classified as hazardous are subject to very little regulation. Federal law considers chemicals hazardous if they are ignitable, corrosive, reactive, toxic, or radioactive. A summary of some of the hazardous characteristics for the BTEX constituents and some other common chemicals are listed in Table 1.3

CHEMICAL	TOXICITY	PERSISTENCE	IGNITABILITY	REACTIVITY	VOLATILITY
ACETONE	2	1	3	0	3
BENZENE	3	1	3	0	3
CHLOROFORM	3	3	0	0	3
ETHYLBENZENE	2	1	3	0	1
METHANE	1	1	3	0	3
NITRIC ACID	3	0	0	0	3
PARATHION	3	3	1	2	0
TOLUENE	2	1	3	0	2
XYLENE	2	1	3	0	1

Table 1.3. Characteristic values of BTEX and some other common hazardous industrial chemicals, 0= none, 1=low, 2=med, 3=high (Devinny and others 1990).

A study was done that ranked the threats presented by a chemicals toxicity according to a more complex criteria. The threat associated with a given chemical is rated by its frequency of occurrence. Data on the frequency of occurrence was gathered from reports of sampling programs at 32 sites. Benzene and Toluene topped the list (Table 1.4).

TOXIC COMPOUND	FREQUENCY OF OCCURRENCE
1. Benzene	.688
2. Toluene	.656
3. Methylene Chloride	.594
7. Ethylbenzene	.500
7. Xylenes (total)	.500
16. Vinyl Chloride	.375
17. PCBs (total)	.344
18. Acetone	.313
20. Dialkylphthalates (total)	.281

Table 1.4 Toxic compounds listed in order of frequency of occurrence (Devinny and others 1990).

Each chemical is also assigned a rating for toxicity and another for persistence. This combined Hazard Rating ranged from 3 for slightly toxic and nonpersistent chemical to an 18 for a highly toxic and nondegradable chemical. For example, PCBs which are highly toxic and difficult to degrade received an 18. Acetone, which is much less toxic and readily degraded, received a 6. Multiplying the frequency of occurrence by the hazard rating produced an overall ranking of threat to public health. When this is done, BTEX constituents in gasoline are ranked with some other commonly found hazardous chemicals in table 1.5 (Hallstedt et al 1986).

TOXIC COMPOUND	FREQUENCY X HAZARD RATING
1.Chloroform	9.00
1. Trichloroethane	9.00
3. Methylene Chloride	8.91
4. Benzene	8.25
5. Tetrachloroethylene	7.97
6. Toluene	7.99
8. Trichloroethene	7.50
9. PCBs (total)	6.19
11. Xylenes (total)	6.00
14. Naphthalene	5.25
18. Carbon Tetrachloride	4.50
18. Ethylbenzene	4.50
18. Vinyl Chloride	4.50

Table 1.5. Toxic compounds listed in order of frequency and hazard rating (Devinny and others 1990).

The State of California enacted Proposition 65, formally known as the Safe Drinking Water and Toxic Enforcement Act as of 1986 (Health and Safety Code, Chapter

6.6, Sections 25249.5 through 25249.13), was enacted as a ballot initiative in November, 1986. Among other things, it was intended by its authors to protect California citizens and the States drinking water sources from chemicals known to cause cancer, or birth defects or other reproductive harm, and to inform the citizens about exposures to such chemicals. Proposition 65 requires the Governor to publish by March 1, 1987 and to update at least annually, a list of chemicals known to the State to cause cancer or reproductive toxicity. As of September 1, 1996, 580 chemicals have been listed: 420 carcinogens and 160 reproductive toxicants. The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) is designated by the Governor as the lead agency for proposition 65 implementation.

The State of California relies upon information that already exists in the scientific literature when determining the threat of a chemical. A chemical is listed if the "state's qualified experts" consisting of an independent panel of scientists and health professionals, appointed by the Governor, find that the chemical has been clearly shown to cause cancer or birth defects or other reproductive harm. In addition, a chemical can be listed if it has been classified as a carcinogen or as a reproductive toxicant by an organization that has been designated as "authoritative". Examples include the World Health Organization and the International Agency for Research on Cancer. For purposes of Proposition 65, a substance is required to be labeled or identified as a carcinogen or as a reproductive toxicant by an agency of the state or federal government. A summary for BTEX and MTBE with regards to Proposition 65 and State drinking water standards are presented in table 1.6 (Cal EPA 1997).

CHEMICAL	LISTED AS CARCINOGEN	LISTED AS REPRODUCTIVE TOXIN	STATE MCL FOR DRINKING WATER
BENZENE	YES	YES	0.001 MG/L
TOLUENE	YES	YES	0.15 MG/L
ETHYLBENZENE	YES	YES	0.75 MG/L
XYLENE	YES	YES	1.75 MG/L
MTBE	NA	NA	NA

Table 1.6. Chemicals known to the State of California to cause cancer and/or reproductive toxicity (Cal EPA 1997).

1.5) VOCs in Surface and Subsurface Waters

When VOCs enter a moving body of water such as a gutter, channel or river, chemical and physical changes begin to take place. It is known that BTEX and MTBE can volatalize from water. Their half-lives in rivers, streams and aqueducts can be greater than one day. They travel distances range from about 1 km for shallow streams to more then 900 km for deeper rivers (Pankow and others 1996, 936). No one single factor can describe a VOC's half-life; factors that affect these volatilization rates include: water velocity, water depth, water temperature, wind speed, and air temperature. No single volatilization rate characterizes the loss process from rivers and streams. Studies have shown that in deep and slow moving channels, MTBE volatilizes at rates similar to those for the BTEX compounds. But, in shallow and faster moving channels, MTBE volatilizes at rates that are significantly slower then those for BTEX compounds (Pankow and others, 1996, 921).

In a 4 year study by the United States Geological survey, stormwater samples were collected in 16 cities and metropolitan areas with a population greater then 100,000 were analyzed for BTEX, MTBE, and other constituents (Figure 1.1). The cities are required by the Clean Water Act to obtain permits for stormwater discharged from municipal separate storm-sewer systems into surface waters. Concentrations of 62 VOCs were measured in 592 stormwater samples taken between 1991 through 1995. MTBE was the seventh most frequently detected VOC in urban stormwater. (Table 1.7) (Detzer and others 1996).

VOC	Minimum detected concen-tration (µg/L)	Maximum detected concen-tration (µg/L)	Median detected concen-tration (µg/L)	Fre-quency of detection (percent)
Toluene	0.2	6.6	0.3	23.2
Total xylene	0.2	15	0.4	17.5
Chloroform	0.2	7.0	0.7	13.4
Total trimethyl-benzene	0.2	15	0.3	12.4
Tetrachloro-ethene	0.2	42	0.6	8.0
Naphthalene	0.2	5.1	0.3	7.4
MTBE	0.2	8.7	1.5	6.9
Dichloro-methane	0.2	13	0.3	5.9
Bromo-dichloro-methane	0.2	2.8	0.6	5.8
Ethylbenzene	0.2	2.0	0.3	5.0

Table 1.7. VOCs in stormwater study (Detzer and others 1996).

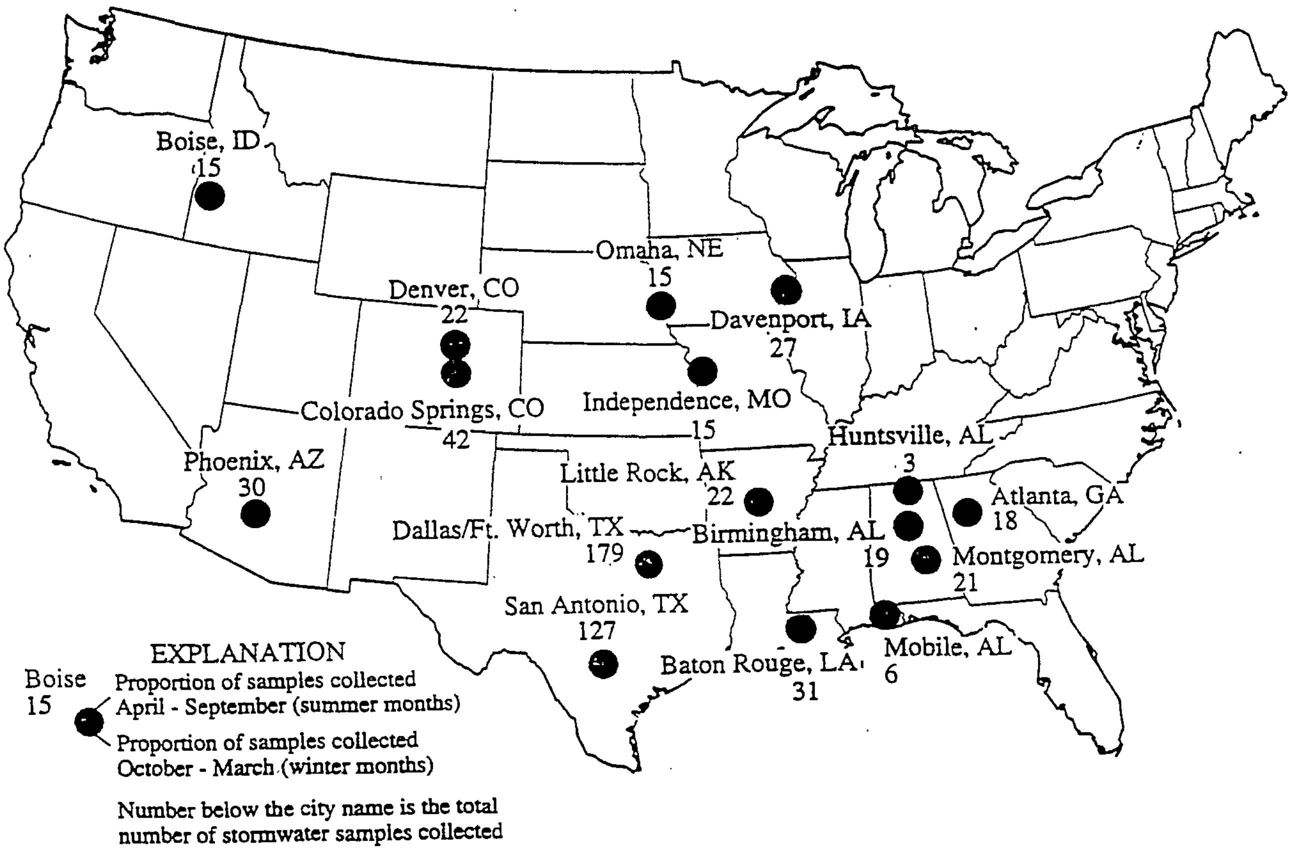

Figure 1.1. Stormwater sampling sites in the U.S. Number of stormwater samples taken from metropolitan areas with a population greater then 100.000 (Detzer and others 1996).

Petroleum derived hydrocarbons are regularly released into surface waters in proportion to surrounding urbanization and technological development. Sources of hydrocarbons to urban surface waters include: accidental spills, deliberate dumping of waste oil and fuels, emissions from engines during normal operations (primarily uncombusted exhaust hydrocarbons and crankcase drippings), fallout from atmospheric particles, spillage of refined products during refining and transportation, natural seepage and erosion of sedimentary rocks, and natural biogenic sources (Stenstrom, Silverman, and Bursztynsky 1983, 59). During a study of the Richmond California Watershed the most significant single identified factor that effects oil and grease pollution in urban runoff is land use. Runoff from commercial properties and parking areas contained an oil and grease concentration nearly three times higher than runoff from residential property. For the Richmond Watershed, controlling approximately ten percent of the land use could result in a 50% decrease in hydrocarbon emission (Stenstron, Silverman, and Bursztynsky 1983, 70).

Oil and grease pollution were found to be independent of all storm characteristics, with the exception of total rainfall. Rate of rainfall, days between storm events, and length of storms had no significant effect on oil and grease concentration, although there was an indication of a modest "first flush" effect (Stenstron, Silverman, and Bursztynsky 1983, 63). Monoaromatic hydrocarbons have been found regularly in bay water and in fish and shellfish tissue. Studies have also reported that monoaromatics may be contributing to the decline of the striped bass (Monroe Saxatites) and other fisheries in the bay. Thus the relatively high levels of oil and grease found in urban runoff in this study, and the potential for introduction of aromatics, may indicate that stormwater is a significant pollution contributor to San Francisco Bay (Stenstron, Silverman, and Bursztynsky 1983, 70).

Another important water resource at risk to possible storm water runoff contamination is groundwater. Here biological activity plays a very important role to one of the United States most valuable natural resources. Biological transformations often provide the predominant decay pathways in water and soil, and the complete mineralization of an organic molecule in water and soil is almost always a consequence of microbial activity
(Squillace and others 1996, 4). Water solubility is probably the most important chemical property affecting the partitioning of BTEX VOCs between water and subsurface solids or soils. In general, BTEXs low solubility's in water indicate a strong partitioning to the organic carbon associated with the subsurface solids. However, the VOC MTBE, a gasoline additive to gasoline to fight air pollution is highly soluble in water compared to the BTEX compounds. In fact, the solubility of pure liquid MTBE in water is about 50,000 Mg/L where as the next most soluble component of the BTEX constituents is benzene, which has a solubility of 1780 Mg/L (Mackay and others 1992, 3722).

In waters, BTEX compounds readily undergo biological transformations, however most studies have indicated that MTBE does not biodegrade easily under various environmental conditions. Because MTBE tends to stay in the water and not sorb to subsurface solids, it can move to the ground water at almost the same velocity as the recharge water. Once MTBE is in the groundwater it can move at virtually the same velocity as the water (Squillace and others 1996, 5). In a USGS National Water Quality Assessment Program, MTBE was the second most frequent detected VOC in groundwater sampled from 210 shallow wells and springs in 8 urban areas (Squillace and others 1996, 1). Data from the previous study also showed that in shallow urban groundwater, MTBE generally was not found with BTEX compounds, which are commonly associated with gasoline spills. This disassociation causes uncertainty as to the source of MTBE (Squillace and others 1996, 1721). The infrequent concurrent detection of MTBE with BTEX compounds suggest that point source leaks are not the principal source of MTBE detected in urban groundwater, although the lack of association does not completely rule out point source spills as a potential source. MTBE plumes originating from point source gasoline spills would generally occupy a larger proportion of the subsurface compared to BTEX compounds and concentrations of MTBE at the leading edge of the plume would be small but would be expected to increase with time. Therefore, if the small concentrations of MTBE detected in shallow urban groundwater originated from gasoline spills, then generally one would expect the concentrations of MTBE and detection's of BTEX compounds to increase with time at these same wells. MTBE plumes will generally occupy a larger portion of the subsurface compared to BTEX compounds for three reasons: (1) MTBE is persistent in aerobic and anaerobic groundwater, (2) MTBE can occur in large concentrations in gasoline as compared to BTEX, (3) MTBE dose not sorb to aquifer material and is more mobile in groundwater then other BTEX compounds based on field data and physical and chemical properties, solubility, and vapor pressure (Squillace and others 1996, 1727).

2.0) PHYSICAL SETTING OF THE STUDY AREA IN ORANGE COUNTY, CA

The study area covers the area of Orange County in Southern California. It is a classic Mediterranean type climate with dry summers and moderately wet winters. The area receives less than 14 inches of rainfall in a typical year, ranging from an average of 12 annually in the Costa Mesa area to more then 25-30 inches on the upper slopes of the Santa Ana Mountains. During the winter months, rains in the latter area are often accompanied by light snow fall above the 4000 feet. Rain falls in the County on the average of 35 days a year. Nearly four-fifths of the County's precipitation occurs between December and March. Orange County's 782 square mile area has a somewhat rectangular shape (Figure 2.1). The long northwest-southeast axis stretching from La Habra in the northwest of the County to San Clemente is about 40 miles in length, while the width is about 20 miles. Most of the County's urbanization is centered on the relatively smooth lowland plain stretching northwesterly from the vicinity of Irvine past Santa Ana, Garden Grove and Buena Park into neighboring Los Angeles County. The central lowland of the County is comprised of the Downey and Tustin Plains. Alluvial deposits of sand, mud and other sediments deposited over thousands of years by the Santa Ana, Los Angeles and San Gabriel Rivers have resulted in the Downey Plain. The Tustin Plain on the other hand, was formed by alluvial deposits from Santiago Creek and other smaller rivers flowing from the southern part of the Santa Ana Mountains. Plano Trabuco, although smaller then the above described Plains, is abruptly located a thousand feet above sea level south of O'neill Park between Trabuco Arroyo and Tijeros Canyon.

Orange County has three main mesas. which are along the northern portion of the coastline.Thousands of years ago the mesas were uplifted into one continuos ridge along the Newport Inglewood Fault. In time, streams cut through the ridge and formed three separate mesas, Bolsa Chica mesa, Huntington Beach Mesa, upon which most of the city of Costa Mesa is located. The foothills of the County are believed to have been elevated and formed by continuing earth movements. Rising to an elevation of 1400 feet are the Punte Hills in the northern part of the County. Southeast extensions of these hills are called the Chino Hills

LAND FORMS

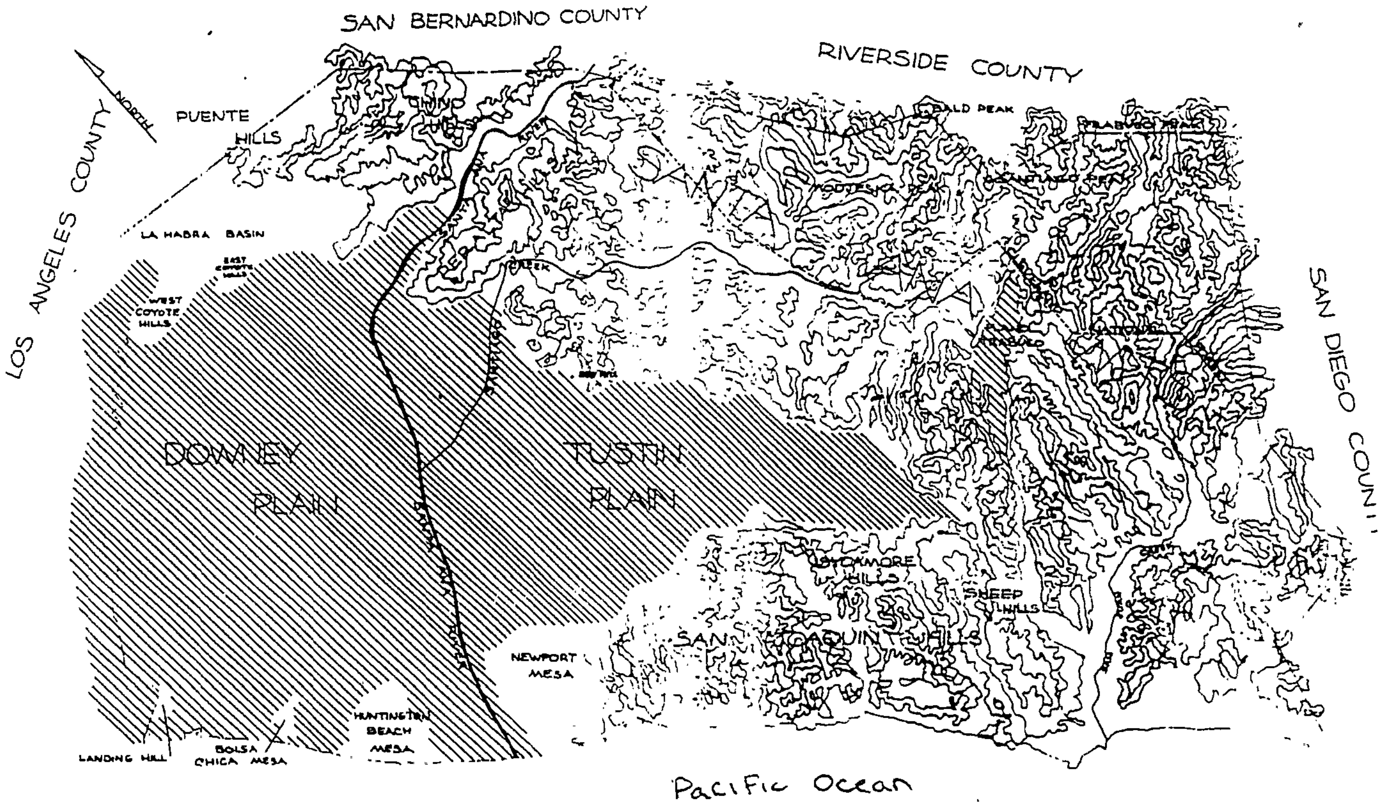

Figure 2.1. Orange Countys physiographical area (Orange County Planning Department 1971).

and reach 1780 feet. Separated from the Punte Hills by the La Habra Basin, the Coyote Hills rise 600 feet before descending into the Santa Ana Basin. Another belt of hills, reaching 1100 feet and running parallel to the coast in the south, are known as the San Joaquin Hills. These hills are composed of marine sediments and deposits of rock, boulders and gravel millions of years old. Several streams cut through the San Joaquin Hills creating small canyons perpendicular to the Coast. Over the years, the streams in these canyons have left sand and gravel deposits on their floors and have formed the beaches that meet the Pacific. The Santa Ana Mountains, rising to a height of over one mile, frame the northeast border of the County. Uplifted many millions of years ago along

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the Elsinore Fault and tilted toward the Coast, these mountains, such as Old Sattleback, 5496 feet and Santiago Peak, 5687 feet are visible throughout the County (Orange County Planning Department 1971).

Today around seventy-five percent of California's population (about 21 million people) live in the southern half of the state. Therefore, the heavily populated and semi-arid Southern California region must import the majority of its water supply. Imported water accounts for sixty-five percent of the Southern California supplemental water supply with the balance coming from local ground water sources. The water demand is met by surface water supplied by two primary aqueducts that bring water to the sprawling Southern California area from snowpack and rivers in the Northern region of the state and the seven state Colorado River Basin area (Figure 2.2).

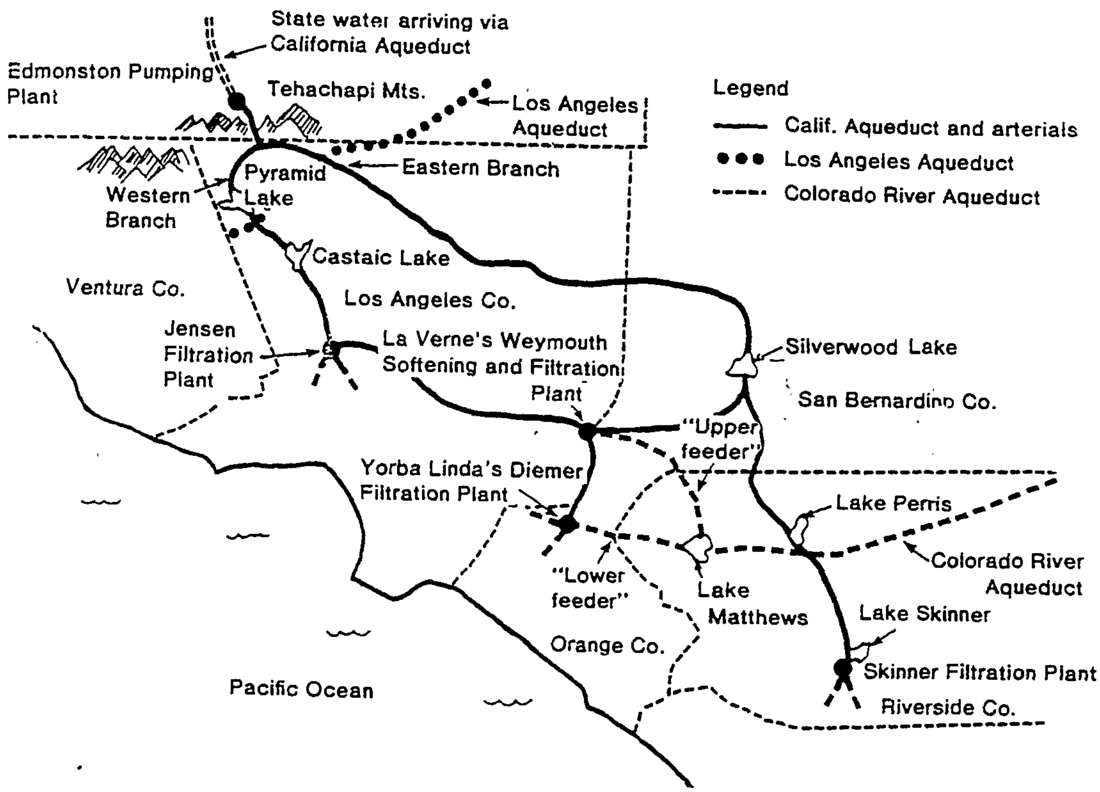

Figure 2.2. The major aqueducts of Southern California (Parratt 1985).

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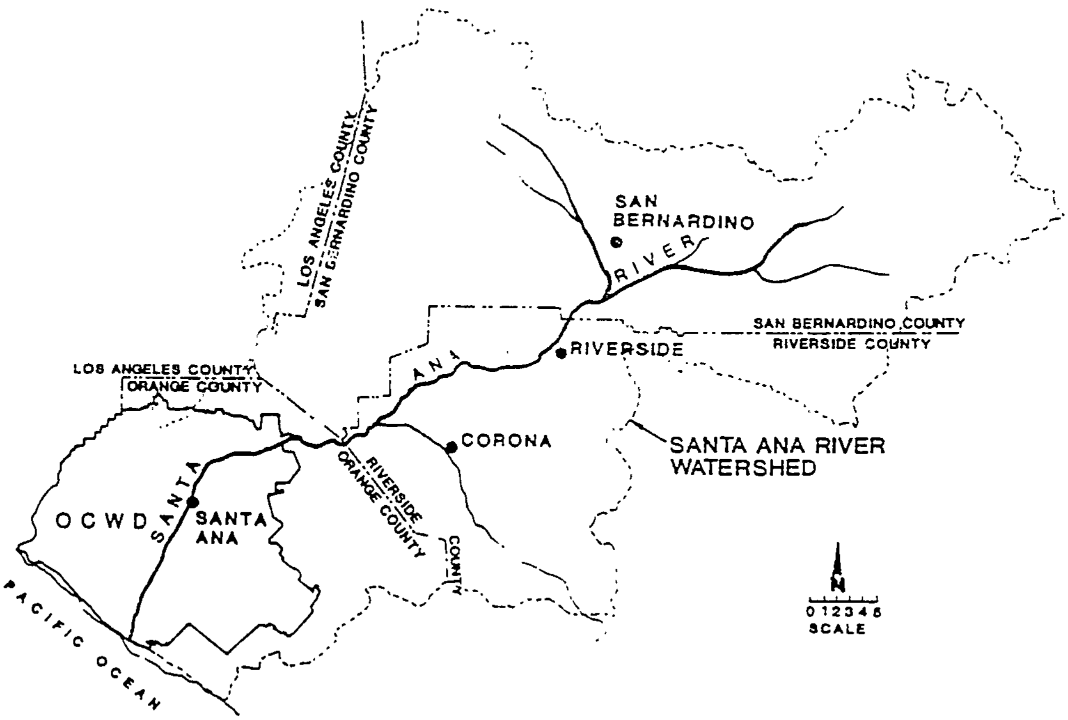
Today, Orange County is one of the fastest developing urban regions in the United States. Within its boundaries lies a huge natural underground reservoir of water. In fact, this underground reservoir, or aquifer system is so important to the region that the Orange County Water District was formed by the State of California in 1933 to protect and manage this valuable subterranean water supply. The needs of this area must be met while ensuring that the groundwater supply does not become depleted or contaminated. A legal right to all the water that flows into Orange County in the Santa Ana River has been granted to the Orange County Water District, which owns about 1,200 acres of land in and near the river channel. With a drainage area of nearly 2500 square miles, the Santa Ana River is the largest coastal stream in Southern California (Figure 2.3), transversing through San Bernardino and Riverside counties before entering the south coastal plain. In the channel area is a region called the Forebay Region (Figure 2.4). The soil in this area is very permeable and water can seep into the aquifers. These are primarily used to percolate or recharge the aquifer. Bulldozers and earthmovers have transformed this part of the Santa Ana River into a series of ponds with sand berms for sides, these help to hold water and allow it to percolate through the ground here and "recharge" the groundwater basin.To satisfy the huge water demand of the region both stormwater runoff and imported water are diverted to this region to help recharge the aquifer below.

The effects of VOCs entering the the underground aquifer by stormwater runoff would probably be most profound in the forebay region. But VOC data from monitoring wells throughout the region do not show this to be the case. During my personal interview with Orange County Water District hydrologist Roy Herndon, he noted, we have been monitoring for BTEX VOCs for many years and have observed some detectable levels in the shallow aquifers here, but no detectable levels in the deeper primary aquifers (Herndon 1998).



SANTA ANA RIVER WATERSHED

Figure 2.3. The Santa Ana River Watershed in Orange and other neighboring Counties.

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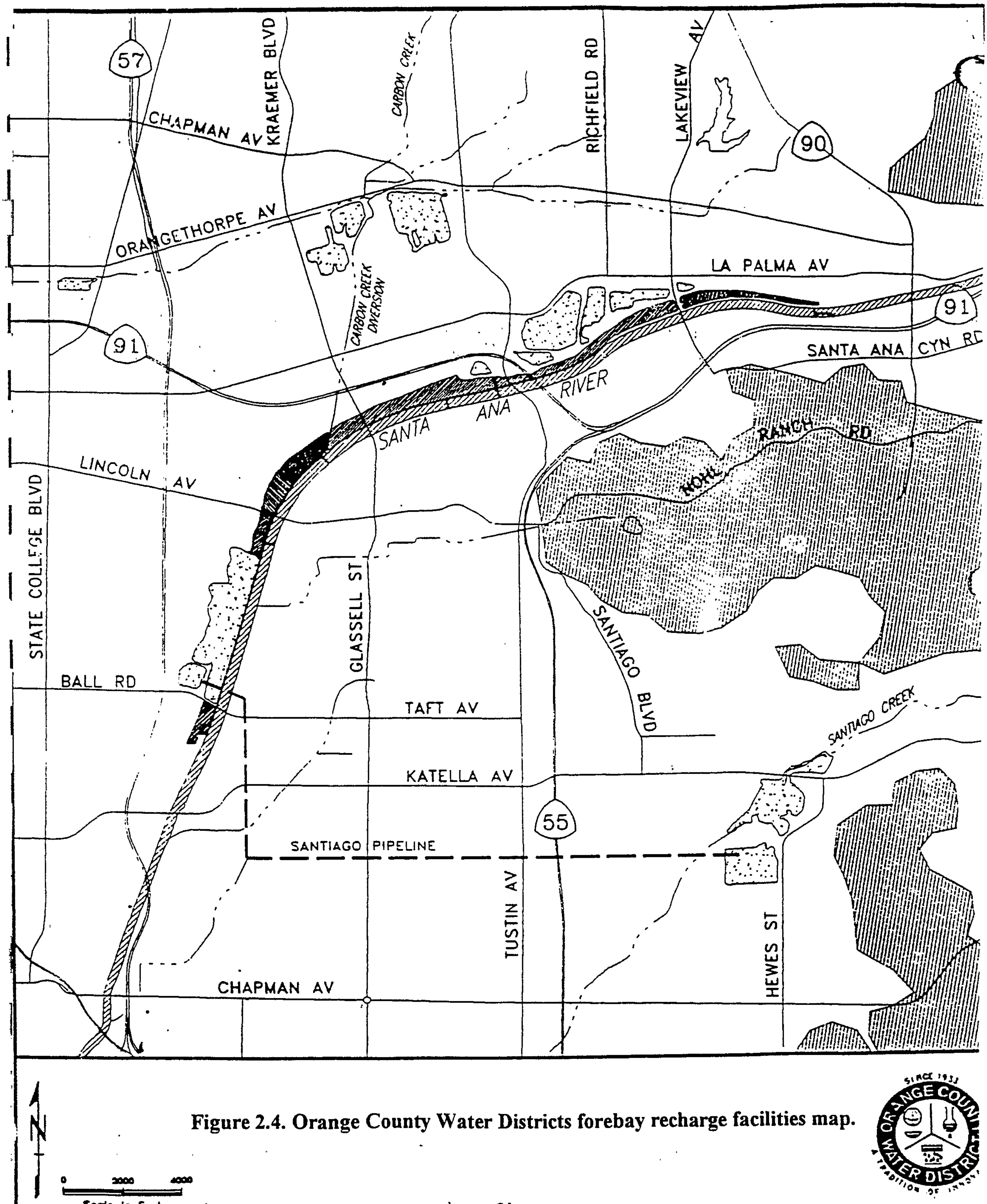


Figure 2.4. Orange County Water Districts forebay recharge facilities map.

3.0) OVERVIEW OF REGULATORY REQUIREMENTS

The Federal Clean Water Act, as amended in 1987, and the State Porter-Cologne Act are the principal regulations for control of storm water pollutants. Other regulations that deal with the control of storm water pollutants include: the Federal Coastal Zone Act Reauthorization Amendments of 1990, and the State Hazardous Waste Source Reduction and Management Review act. Under the Federal Clean Water Act stormwater discharges are regulated under the National Pollutant Discharge Elimination System (NPDES) program. The United States Environmental Protection Agency requires permits for the discharge either directly to surface waters or indirectly through municipal separate storm drain systems. Municipalities with a population exceeding one hundred thousand or those that have been determined to be a significant contributor of pollutants are required to obtain a NPDES storm water permit. These municipalities are required to develop a management plan to monitor and control pollutants in storm water discharges from its municipal system. Commercial and industrial facilities located in these municipalities that have storm water discharges from their facilities may be required to monitor and control pollutants that may be present in their storm water discharges (Stormwater Quality Task Force 1997, 2-3).

Pursuant to Article 11, Sec.7 of the State Constitution, which authorizes Orange County to exercise the police power of the state by adopting regulations promoting the public health, public safety and general prosperity, and in compliance with the conditions of the National Pollution Discharge Elimination System Permit (NPDES Permit), a Water Quality Ordinance was adopted. The purpose of this Water Quality Ordinance is to prescribe regulations as mandated by the Clean Water Act [33 usc sec.1251 et seg., as amended] "to effectively prohibit non-storm water discharges into the storm sewers and to reduce the discharge of pollutants from human activities that may result in undesirable discharges of pollutants, which eventually may be deposited in the waters of the United States". This ordinance is dedigned to improve water quality by controlling the pollutants which enter the storm water discharge system throughout Orange County (Office of County Counsel, Orange County 1997, Article 1).

3.1) BMP Selection

As written in the Drainage Area Management Plan (DAMP) candidate non-point sources (NPS) control measures have been selected from review of technical literature, review of existing NPS programs, and input from consulting firms and municipalities already involved in NPS control program implementation. As required by terms of Orange County's municipal NPDES Permits, consideration was given to:

"Structural Controls include: first flush diversion, detention and retention basins, infiltration trenches and basins, porous pavement, oil and grease separators, grass swales, swirl concentrators, and engineering and design modification of existing structures".

"Non-Structural Controls include: programs to educate the public on proper disposal of hazardous and toxic wastes, regulatory approaches, street sweeping, facility maintenance, and detection and elimination of illicit connections and illegal dumping".

Each new development will be required to implement appropriate "routine" structural BMPs and appropriate non-structural BMPs in keeping with the size and type of development, to minimize the introduction of pollutants into the stormwater discharge system. 'Routine" structural BMPs are economical, practicable, small scale measures which can be feasibly applied at the smallest unit of development. A wide variety of documents from other jurisdictions, including the state BMP manuals, as well as a number of new development BMP plans approved in the unincorporated area (plus a number of cities) were identified as having been reviewed. Later "special" structural BMPs may be installed to address specific water quality problems identified in the watershed planning process. "Special" structural BMPs are "engineered facilities designed to address specific pollutant problems identified in the watershed planning process, runoff management plan, CEQA process, or similar watershed planning". Thus, there will be the future need to revisit these requirements at an as-yet unspecified date or frequency. (Drainage Area management Plan 1993).

3.2) Orange County Discharge Permit Procedures

On application, the owner of property or the operator of any facility, which property or facility is not otherwise subject to the requirements of a State General Permit or a National Pollution Discharge Elimination System Permit. The permits regulate stormwater discharges. The Director, Public Facilities and Resources Department or his/her designee, may issue a permit authorizing the release of non stormwater discharges to the stormwater drainage system if: "the discharge of material or constituents is reasonably necessary for the conduct of otherwise legal activities on the property, and the discharge will not cause a nuisance, impair the beneficial uses of receiving waters, or cause any reduction in established water quality standards".

The applicant shall provide all information requested by the director, Public Facilities and Resources Department or his/her designee, for review and consideration of the application, including but not limited to specific detail as to the activities to be conducted on the property, plans and specifications for facilities located on the property, identification of equipment or processes to be used on site and other information as may be requested in order to determine the constituents, and quantities thereof, which may be discharged if permission is granted. The permit may include terms, conditions and requirements to ensure compliance with the objectives of this ordinance and as necessary to protect the receiving waters, including but not limited to:

a) Identification of the discharge location on the property and the location at which the discharge will enter the storm water discharge system;

b) Identification of the constituents and quantities thereof to be discharged into the stormwater drainage system;

c) Specification of pollution prevention techniques and structural or non structural control requirements as reasonably necessary to prevent the occurrence of potential discharges in violation of this Ordinance;

d) Requirements for self monitoring of any discharge.

e) Requirements for submission of documents or data, such as technical reports, production data, discharge reports, self monitoring reports and waste manifests.

f) Other terms and conditions appropriate to ensure compliance with the provisions of this Ordinance and the protection of receiving waters.

The permit shall be granted or denied by the director, Public Facilities and Resources Department or his/her designee, no later then 60 days following the completion and acceptance of the application as determined by the Director, Public Facilities and Resources Department or his/her designee. The applicant shall be notified in person or by first class mail, postage prepaid, of the action taken.

4.0) GAS STATION SITE SELECTION AND OBSERVATIONS

I compiled a list of stations built in Orange County that I could feasibly sample during storm events. These stations had to be subject to the latest BMPs required by the County of Orange and most importantly the S11 requirement. There was no one list of these stations compiled by the county, therefore it required visiting various cities and meeting with their planners. After compiling a list of about 20 candidate sites, I personally visited each and found only 9 employing the S11 requirement. From this list of 9, I chose 5 that I felt I could regularly visit during storm events from December, 1997 through May, 1998.

4.1) Site Observations

My main goal now was to visit each of these 5 stations during as many stormevents as possible and study the movement of stormwater runoff from each. I was interested in how certain BMPs actually work in the field, the BMPs included:

1) Canopies size and design.

2) The grading of the surrounding parking lot and fuel dispension area.

3) The type of clarifier used and its drain location, (S11 Requirement).

My next objective was to develop and test a possible sampling plan that would work at each of the 5 candidate sites. I decided to develop a sampling plan utilizing the clarifier and to test its effectiveness. Since the clarifier is built and located in a way as to intercept spilled gasoline before it reaches the storm water drainage system, it seemed like a logical place to sample for the possible presence of VOCs leaving these sites. This involved taking a sample from the stormwater inlet of the clarifier and another sample from the outlet and having those samples analyzed for possible difference in the presence of VOCs.

Each site consists of the following areas:

- Fuel Dispension Area: the area where the pumps are located. This is usually a concreted region sometimes referred to as the island. It is usually that region that is covered by the rain canopy (see Figure 4.9, page 43).
- Parking lot: the area that is around the fuel dispension area. This is usually the asphalted region and includes the driveways into the site and that lead to the fuel dispension area (see Figure 4.12, page 48).
- Drain: this is usually a barred grate in the ground located in the fuel dispension area or parking lot where stormwater runoff is channeled to. Under this barred grate exists a box like area usually a couple of feet wide and a couple of feet deep where stormwater collects and is treated or leads to a treatment box, before it is released to the street or storm water collection system (see Figure 4.7, page 39).
- Exit Port: this is usually located on the street and is usually just a couple of holes in the curb where water that has been treated by the clarifier is released to the gutter. Some stations have underground pipes from the clarifier to a storm drain. (see Figure 4.8, page 40).

4.2) Site A

Location: Yorba Linda, Ca.

Legend:

Cd - Drain to clarifier

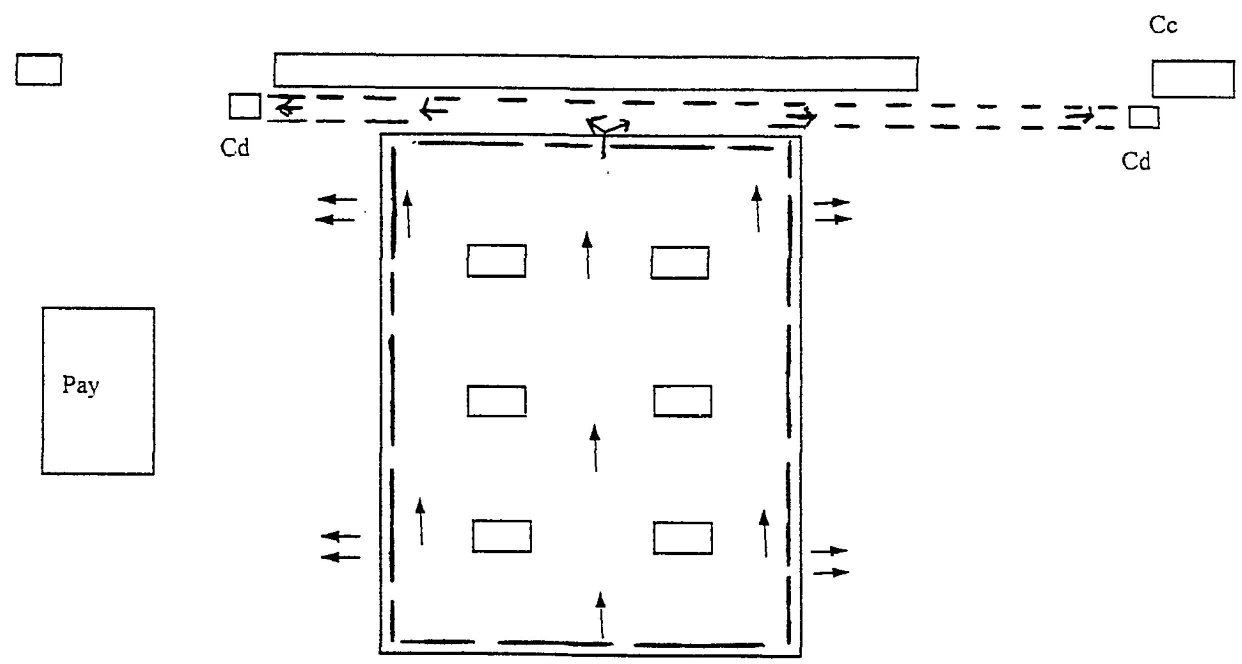
Cc - Exit port from clarifier, located on the street.

Single arrows - runoff that originates from fuel dispension area.

Double arrows - runoff that originates from surrounding parking lot area.

Small black dashed lines - graded gullies that channel stormwater runoff.

Large black dashed lines - canopy outline in relation to fuel dispension area



Grading: This stations parking lot is graded in asphalt and did a good job in keeping stormwater from flowing onto the fuel dispension area. This station is built on a large lot that is also occupied by a block of small stores and thus the station has an unusually large parking lot on its west side. During storm events this large parking lot area produces a lot of runoff that flows in to the clarifier, either by design or accident. The fuel dispension area is concrete and is graded to cause any possible flow to move down to a gully that leads to the clarifier drain. This gully and drain are located outside of the protective canopy and exposed to direct rain fall. In fact, the drains are located approximately 100 feet away in the parking lot area (Figure 4.1).

Canopy: The canopy here is a single rectangular design that ends just inside the outer edges of the fuel dispension area. During all storm events I have witnessed here the outer 2-5 feet of the fuel dispension area usually gets wet to the point of producing a flow The outer edge of the canopy produces drippings that land on the outer edge of the fuel dispension area (Figure 4.2).

Clarifier: This station uses two drains. The drains are located at the east and west sides of the fuel dispension area. The two drains are connected by a gully that intercepts any flow that comes from the fuel dispension area. The drains themselves are easily accessible by lifting up a steel grate that is approximately 2 feet by 2 feet. The drain depth is about 3 feet, but an upper metal screen makes sampling more difficult during low flow conditions. The outlet consists of two exit port holes in the curb at the gutter.

Comments: This station was built or renovated at an unknown time. It is a high volume outlet with a mini mart. I have visited this station 6 times during varying storm event intensities and have noted the following observations.

1) This station has by far the most visible sheens in the parking lot and flowing on top of water that was moving in the gullies (Figure 4.3).

2) The condition of the grading in the parking lot allowed for a lot of puddles to form.

3) The canopy allowed for rainfall to land on the outer 2-5 feet of the fuel dispension area.

4) The clarifier and the exit port at the curb (Figure 4.4) were easy to sample.

Figure 4.1. Parking lot stormwater gully in Yorba Linda. This drain carries fuel dispension area runoff to the clarifier is located in the parking lot and thus intercepts alot of parking lot runoff as well as direct rainfall. The puddles and gullies visible get splashed through by cars and thus drip more water on to the fuel bay dispension area (January 30, 1998).

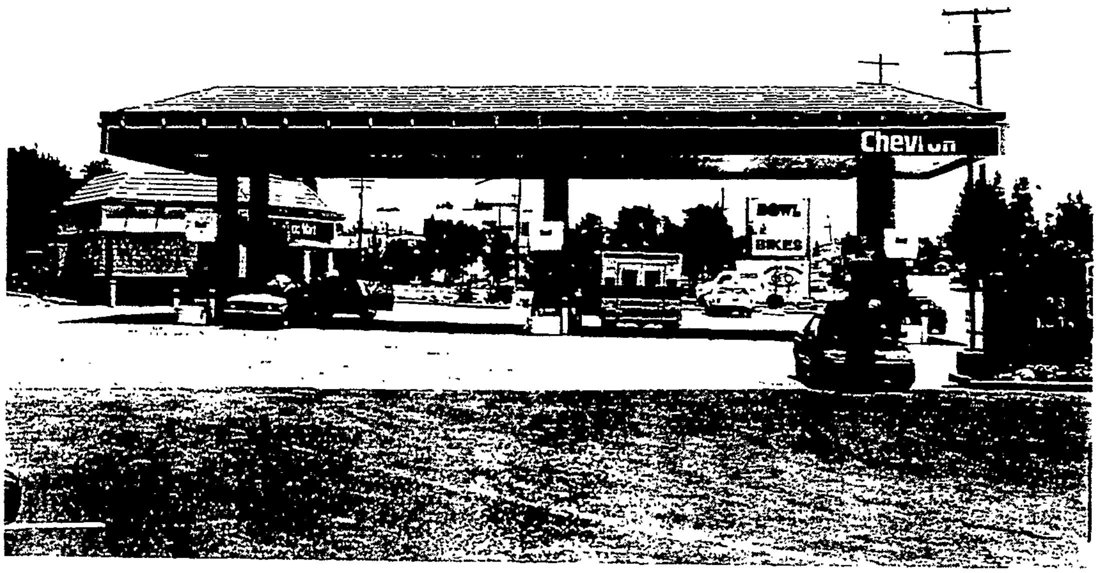


Figure 4.2. Rain canopy in Yorba Linda. Canopies with tall sides provide surface areas where rainwater builds up and can drip down onto the fuel dispension area (January 30, 1998).

Figure 4.3. Gasoline sheen in stormwater gully. A gasoline sheen is visible in a gully that transports stormwater from the fuel dispension area to the clarifier for treatment. During intense rain, clarifiers with drain locations such as these get quickly overwhelmed if parking lot runoff is not channeled away from drain (January 30, 1998).

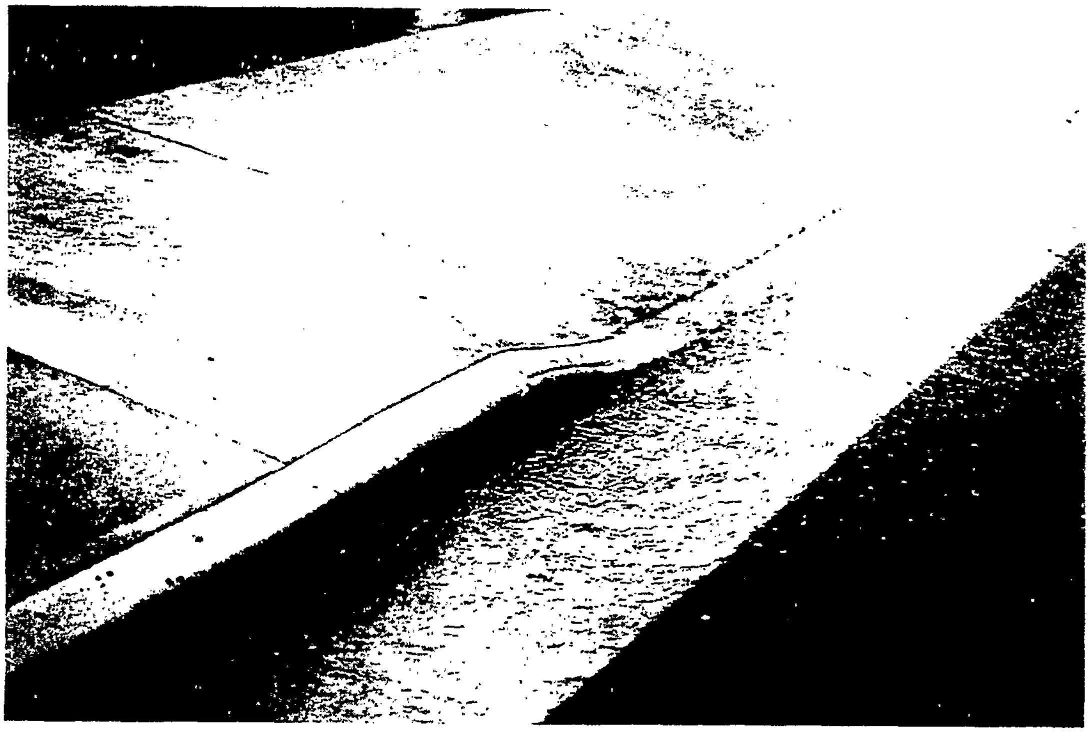


Figure 4.4. Stormwater release site at street. After stormwater is treated in the clarifier it is released to the street by 3 holes drilled in the curb. During more intense rainfalls it was sometimes necessary to block the gutter flow with sandbags to get a sample (January 30, 1998).

4.3) Site B:

Location: Anahiem, Ca.

Legend:

Cd - Drain to clarifier

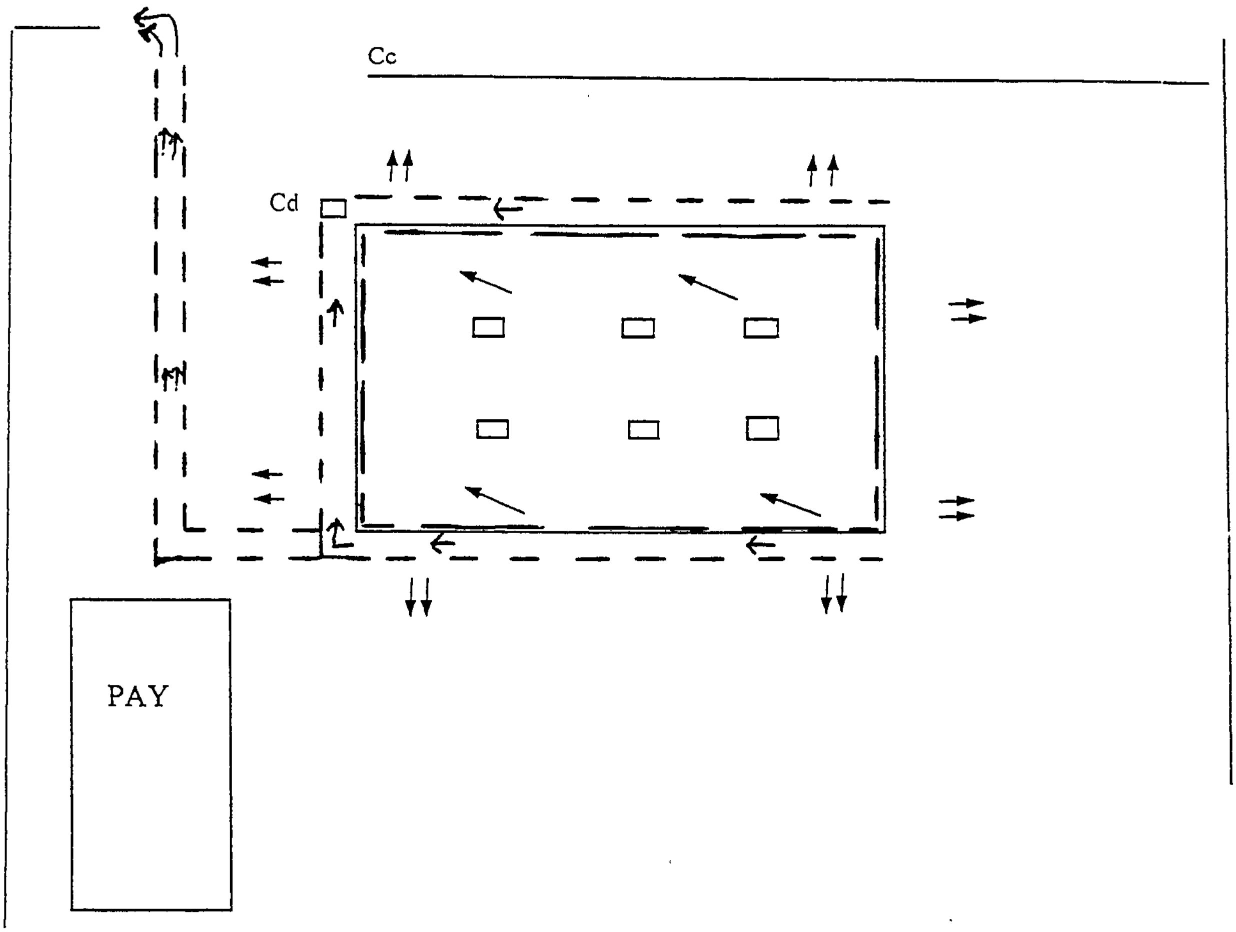
Cc - Exit port from clarifier, located on the street.

Single arrows - runoff that originates from fuel dispension area.

Double arrows - runoff that originates from surrounding parking lot area.

Small black dashed lines - graded gullies that channel stormwater runoff.

Large black dashed lines - canopy outline in relation to fuel dispension area



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Grading: This station employs gullies in the parking lot that intercept parking lot runoff and channels it to the curb. This system worked very well in keeping any flows from reaching the fuel dispension area. In fact, I have been here during some heavy downpours and did not observe any parking lot runoff flow on to the fuel dispension area (Figure 4.5).

The fuel dispension area is graded to cause any flow can originates there to move towards the gullies that run along the edges of fuel bay dispension area. The gullies and the drain are located just outside of the protective canopy and thus receive a lot of direct rainfall. (Figure 4.6).

Canopy: The canopy here is a single rectangular design that ends just above the outer edges. The outer 2-5 feet of the fuel dispension area received a lot of direct rainfall. This canopy had a lot of build up that dripped from the edges and lands on the edge of the fuel dispension area.

Clarifier: The drain to the clarifier is located at the northwest corner of the fuel dispension area edge and is connected by a gully that runs along two sides of the fuel dispension area. The drain itself is about 2 feet by 2 feet and the cover can be lifted up to get inside. The bottom is about 3 feet deep and a pipe is visible about midway up that appears to run underground to an exit port located on the curb in the gutter. A metal ring filter runs around the outside of the drain, but the middle is wide open and easy to sample by just submerging the sample bottle (Figure 4.7). The exit port is a single hole in the curb that produces a fast flow that is also easy to sample (Figture 4.8).

Comments: This station is the newest of my candidate sites and opened approximately February 15, 1998. It is a high volume outlet with a mini mart in a prime location. I have visited this station during 5 storm events and have noted the following observations.

1) The grading and use of gullies in the parking lot to keep stormwater from entering the fuel dispension area was among the best I have seen. There are no puddles that form in the parking lot area.

2) The use of gullies along the edge of the fuel dispension area to channel runoff to the clarifier would be very useful in the event of a major gasoline spill on the fuel

dispension area. Other wise it appeared the exposure of these gullies to direct rainfall just served to dilute the runoff from the fuel dispension area before reaching the clarifier. I also noticed that oncoming cars tended to splash through these gullies and bring water back on to the fuel dispension area. Departing cars also appear to splash through these gullies and carry fuel dispension area runoff into the parking lot and streets.

3) I have observed sheens moving on water in gullies during the entire times I have been at this station.

4) The majority of the water that reached the fuel dispension area appeared to be coming from direct rain and runoff that driped from the edge of canopy that fell on the edge of the fuel dispension area. The rest originated from customers cars.

5) As of this writing, I have not been able to get detailed information from the RGO on the type of clarifier being used at this site. When you look into the drain the water falls through a metal filter and fills the drain until the level reaches a pipe that goes underground and is released at the curb. I am assuming there must be a clarifier somewhere underground between the drain and the curb, otherwise this system would do little more then physically remove larger floating debris from the runoff before it is released to the stormwater drainage system. There is a large planter and I have been to other stations that have an access in the planter for maintenance of such an underground device, but the planter here does not appear to have anything like that.

Figure 4.5. Parking lot stormwater gully in Anahiem. This gully collects parking lot runoff and channels it to the street. Even during heavy downpours these channels keep runoff from the surrounding parking lot area from flowing on to the fuel dispension area (February 3, 1998).

Figure 4.6. Stormwater gullies leading to clarifier drain.This fuel dispension area is graded so as to allow any flow that originates there to move into these surrounding gullies. These gullies lead to the drain in the middle of the picture, where it is treated before it is released at the street (February 3, 1998).

Figure 4.7. Close up of drain to clarifier. With the barred cover swung open you can see the screen filter that surrounds the center of this clarifier. This style of clarifier is easy to take a sample from (February 3, 1998).

Figure 4.8. Exit port at street for releasing stormwater from clarifier. This is a typical exit port for treated water coming from the clarifier. The sand bag makes sampling easier and less of a chance for contamination from gutter flow. During heavy gutter flows, I have had to use as many as 5 bags to get a sample (February 3, 1998).

4.4) Site C:

Location: Anahiem, Ca.

Legend:

Cd - Drain to clarifier

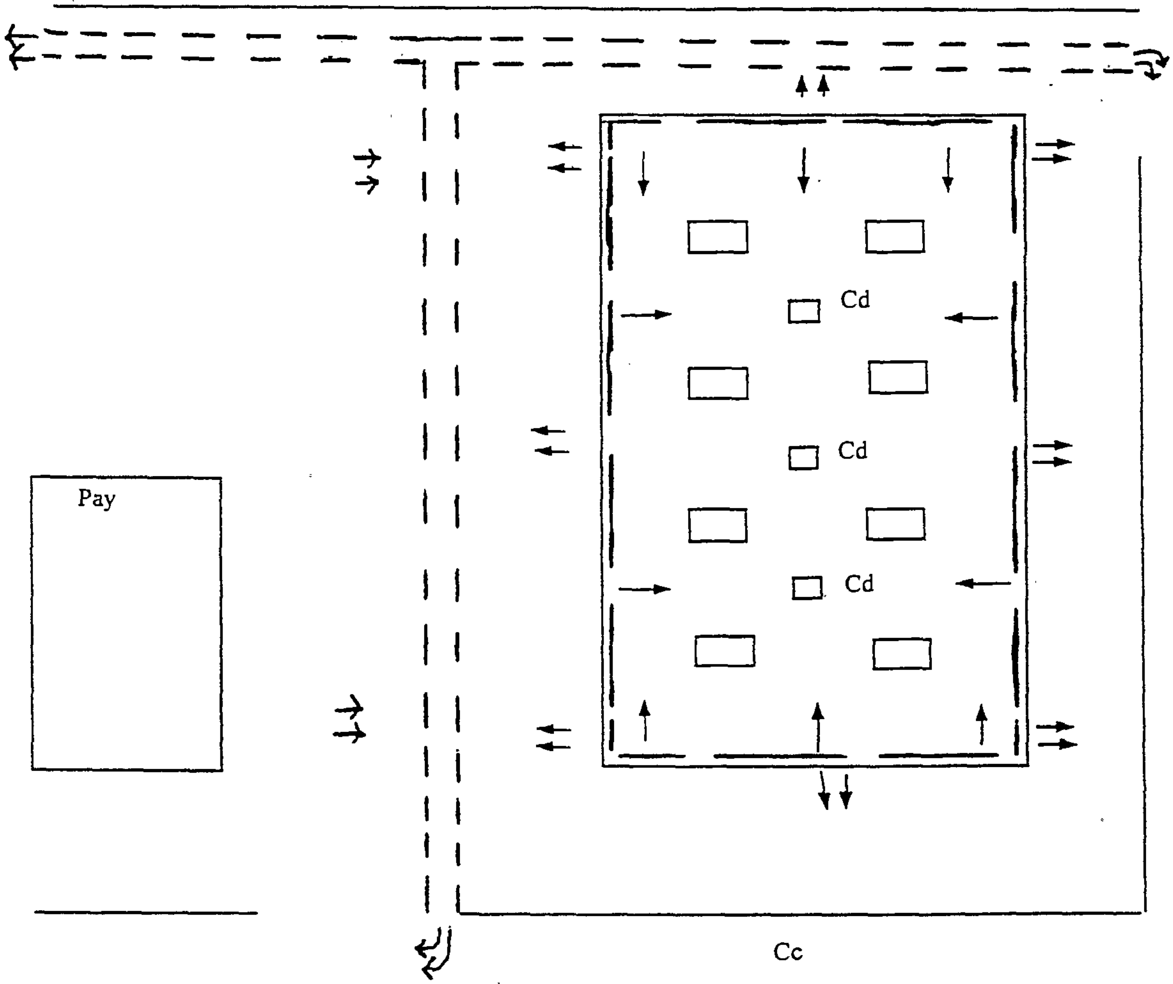
Cc - Exit port from clarifier, located on the street.

Single arrows - runoff that originates from fuel dispension area.

Double arrows - runoff that originates from surrounding parking lot area.

Small black dashed lines - graded gullies that channel stormwater runoff.

Large black dashed lines - canopy outline in relation to fuel dispension area



Grading: The parking lot is paved with asphalt and the grading does an excellent job of keeping stormwater from flowing on to the fuel dispension area. The parking lot uses gullies to channel away parking lot runoff to the street.The fuel dispension area is cement and graded to cause any flow that originates there to flow toward the center of the fuel dispension area. In the center of the fuel dispension area were three small drains that collected any spills or stormwater that occured on the fuel dispension area (Figure 4.9).

Canopy: The canopy here is a single rectangular "zigzag. design that ends just above the outer edges of the fuel dispension area. I have only observed light to medium strength storm events at this station and the outer 2-5 feet of the fuel dispension area received more rain fall than both sites A and B. Drippings from the outer edge of the canopy that landed on the edge of the fuel dispension area were also heavy. The reason for this is because of the way the design leaves gaps over the fuel dispension area. (Figure 4.10).

Clarifier: This station uses a system that employs 3 drains in the middle of the fuel dispension area. At the time of this writing I have not been able to get any information on the type of clarifier used and I have not been able to locate any possible exit ports in the curb along the adjacent streets. It is possible this location has a tank or an underground clarifier that holds or releases treated runoff from the fuel dispension area directly to the storm water drainage system underground.

Comments: This station opened approximately March 1, 1998 and is the second newest of my candidate sites. It is a high volume outlet with a mini mart in a busy location. I have visited this station three times during storm events and have noted the following observations:

1) The grading here is so effective I have never observed any runoff from the parking lot to flow on to the fuel dispension area. I have observed no standing puddles of water at this station.

2) The fuel dispension area grading and the positioning of the drains here worked excellent.

3) I have observed some moving sheens in the parking lot gullies, but I believe it was less then those at site B which has a very similar grading and gully design.

4) The storms I have observed here were not as strong as some of the others I have seen at other stations and the storms did not produce slanted rainfall that I have seen

during accomaning strong winds But the "zigzag" canopy design allows vertical rainfall to land on the fuel dispension area.

5) The overall design here (with regards to keeping stormwater off the fuel dispension area), worked excellent.Unfortunately the lack of access to the drain here makes it very difficult to get any kind of sample. If there is an underground exit port to the storm water drainage system, it might be to difficult to sample the water exiting the clarifier.

Figure 4.9. Fuel Dispension Area in Placentia. This station uses a 3 drain configuration in the center of the fuel dispension area. The fuel dispension area is graded to cause any kind of spill or stormwater flow to move to its center. This keeps the drains out of direct rainfall and far away from flows that originate in the surrounding parking areas (February 22, 1998).

Figure 4.10. Rain canopy in Anahiem. The "zigzag" design of this canopy may be stylish, but it allows way to much direct rainfall on to the fuel dispension area even during mild rainfall events (February 22, 1998).

4.5) Site D:

Location: Laguna Hills, Ca.

Legend:

Cd - Drain to clarifier

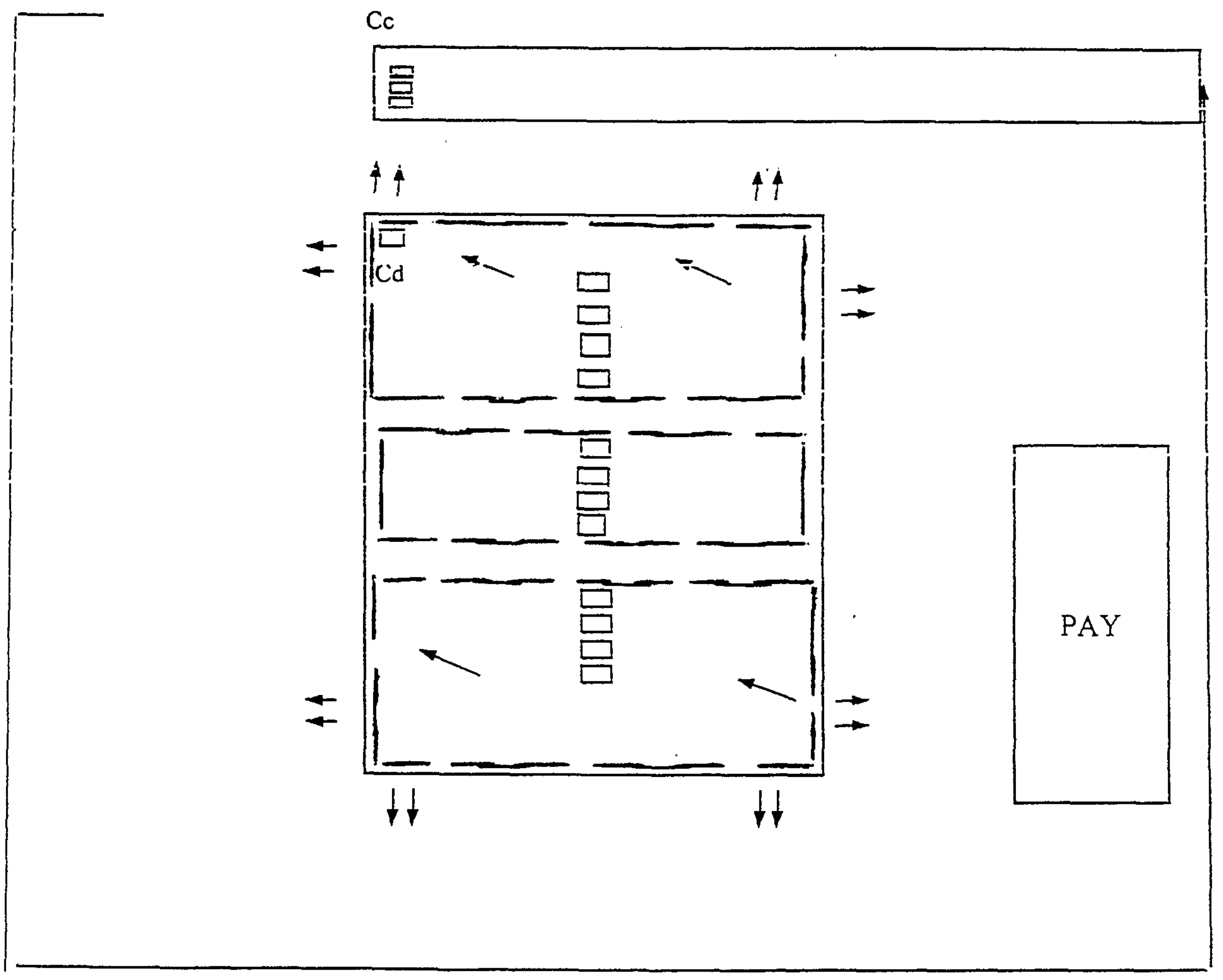
Cc - Exit port from clarifier, located on the street.

Single arrows - runoff that originates from fuel dispension area.

Double arrows - runoff that originates from surrounding parking lot area.

Small black dashed lines - graded gullies that channel stormwater runoff.

Large black dashed lines - canopy outline in relation to fuel dispension area



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Grading: The stations parking lot is graded in asphalt and does an excellent job of keeping stormwater from flowing on to the fuel dispension area. This parking lot also utilizes a single gully that channels stormwater runoff to the street (Figure 4.11).
The fuel dispension area is cement and graded so as to cause any flow that originates their to travel to the northeast corner to the drain location.

Canopy: this station uses a canopy that consists of three separate square canopies. This leaves open gaps between the canopies that allows direct rainfall on to the fuel dispension area. This also appeared to provide more edge surfaces to allow for more dripping from the sides of the canopies that land on the edges of the fuel dispension area. These canopies are also narrower then most I have observed and allow a lot of rainfall to directly land on the fuel dispension area (Figure 4.12).

Clarifier: This station has a 1300 gallon oil/water separator box, which is a three compartment sand and grease interceptor and sample box. There is a shut-off valve on the outlet pipe to restrict flow to the storm water drainage system. The first compartment captures all the stormwater runoff from the fuel dispension area. Sand will settle to the bottom of this compartment and liquid will flow freely into the second compartment. As enough liquid collects here, it will be forced into the sample box or third compartment. This system is located in the North planter (Figure 4.13)

Comments: This station was renovated in the mid 90s. It is a high volume outlet with a mini mart in a prime location. I visited this station three times during storm events and have noted the following observations:

1) This station makes use of 3 separate canopies that allows by far the most direct rainfall to land on the fuel dispension area. Its narrower design also allowed even the slightest of slanted rainfall to land as far in as to hit the pumps themselves. The 3 stage canopy also allowed for a lot of unnecessary drippings from all the extra edges present

2) This station uses a 3 stage clarifier that is installed in the planter. The drain in the fuel dispension area is small and utilizes small holes in a steel plate that is not easily removable (Figure 4.14). Since there is no access to the inside of this drain it would be necessary to some how cover it and allow a pooling to build up and take my sample when enough stormwater is present. But, because of the poor design of the canopy here (with

respect to keeping rainfall off the fuel dispension area) stormwater builds up fast on the fuel dispension area compared to other stations with a drain located under the canopy

3) This station seemed to employ the more sophisticated clarifier system I have seen, but as of this writing have not been able to gain access to the inside of the system. It appears that this system drained directly into a storm drain right on the street. Just above the storm drain and across the side walk is a steel cover with barred holes and a very noticeable stain coming from it and leading to the gutter (Figure 4.15).

Figure 4.11. Parking lot grading in Laguna Hills. The grading in this parking lot utilizes a gully to channel stormwater to the street. The steeper inclines around the fuel dispension area help keep parking lot runoff from flowing on to the fuel dispension area (March 4, 1998).

Figure 4.12. Rain canopy in Laguna Hills. This 3 stage canopy design contains more surface area on its sides then a single rectangular type, thus the fuel dispension area receives more stormwater in the form of drippings. Its narrow design also allows more rainfall even at the slightest slant to penetrate deep in to the fuel dispension area (March 4, 1998).

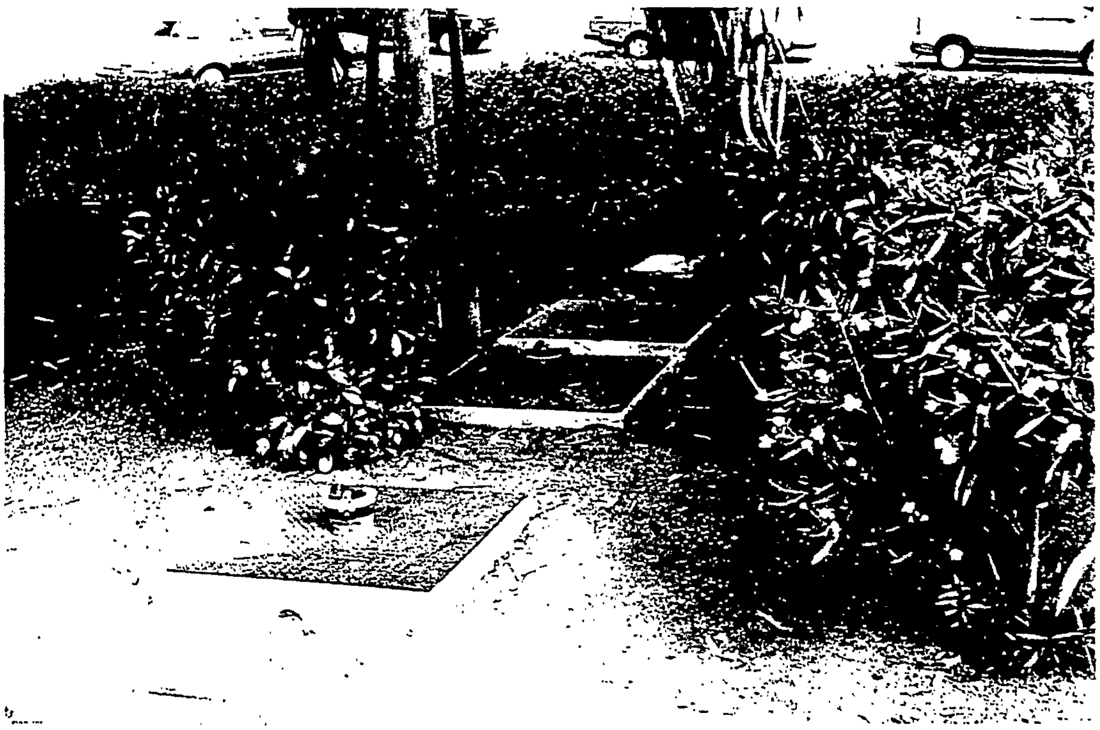


Figure 4.13. Stormwater treatment system in Laguna Hills. This stations 3 stage clarifier is located in the north planter. (March 4, 1998).

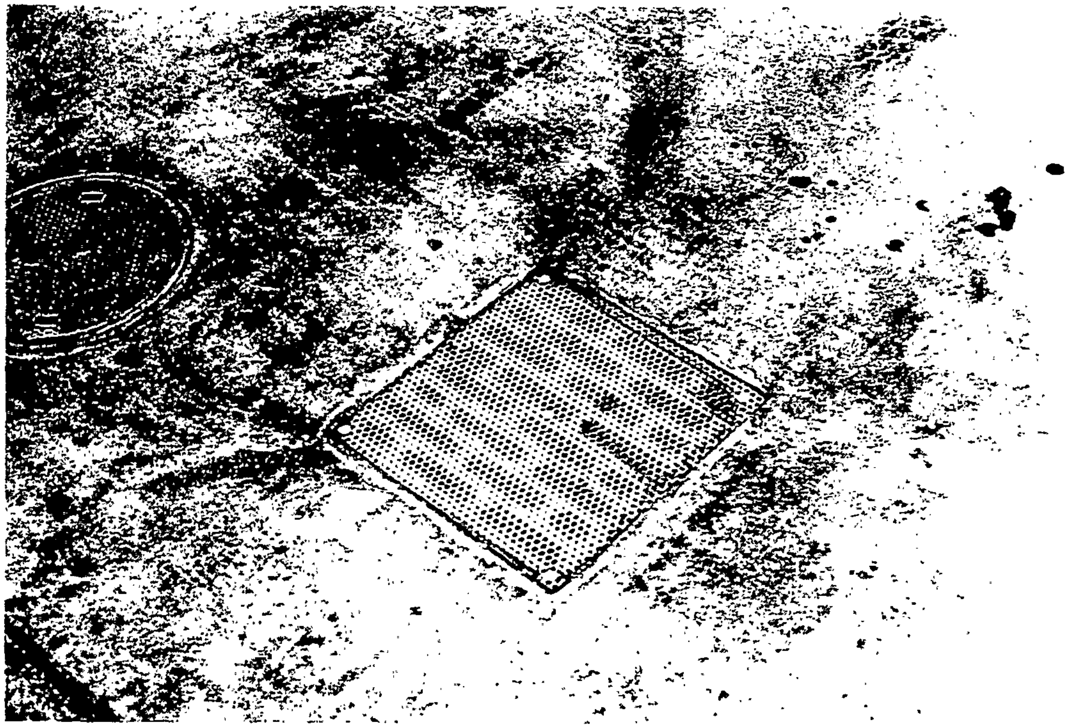


Figure 4.14. Drain to clarifier in Laguna Hills. This drain to the clarifier is located on the northwest corner of the fuel dispension area just under the corner of the protective canopy. Its small design could make sampling difficult if I cannot gain access to the inside. (March 4, 1998).

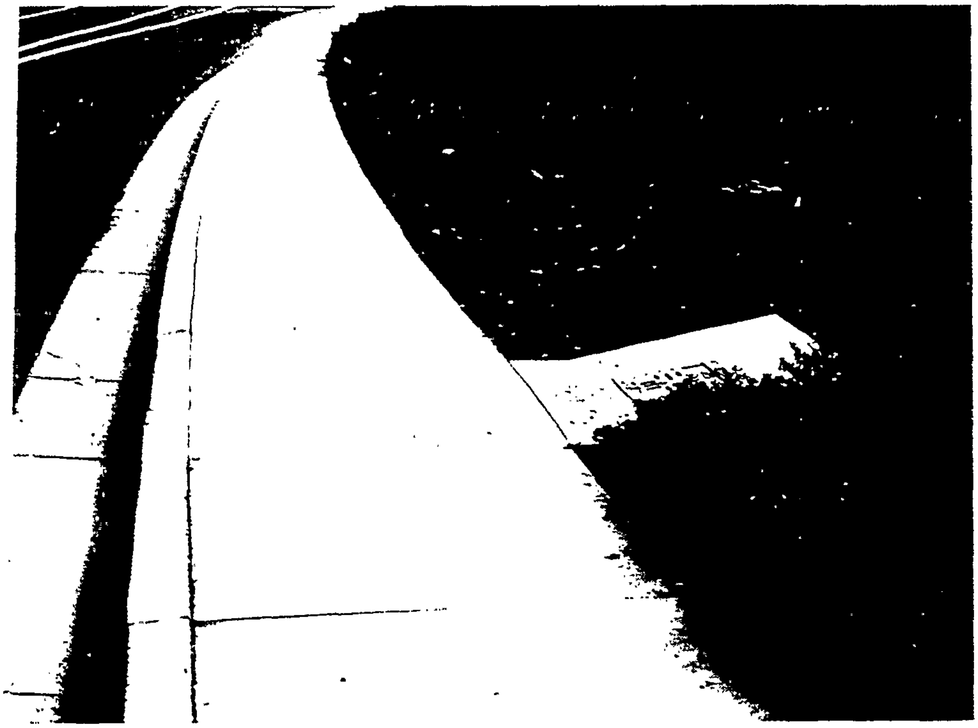


Figure 4.15. Exit port for treated stormwater. Water is released at the street after being treated in the clarifier, a stain on the sidewalk is obvious. (March 4, 1998).

4.6) Site E:

Location: El Toro, Ca.

Legend:

Cd - Drain to clarifier

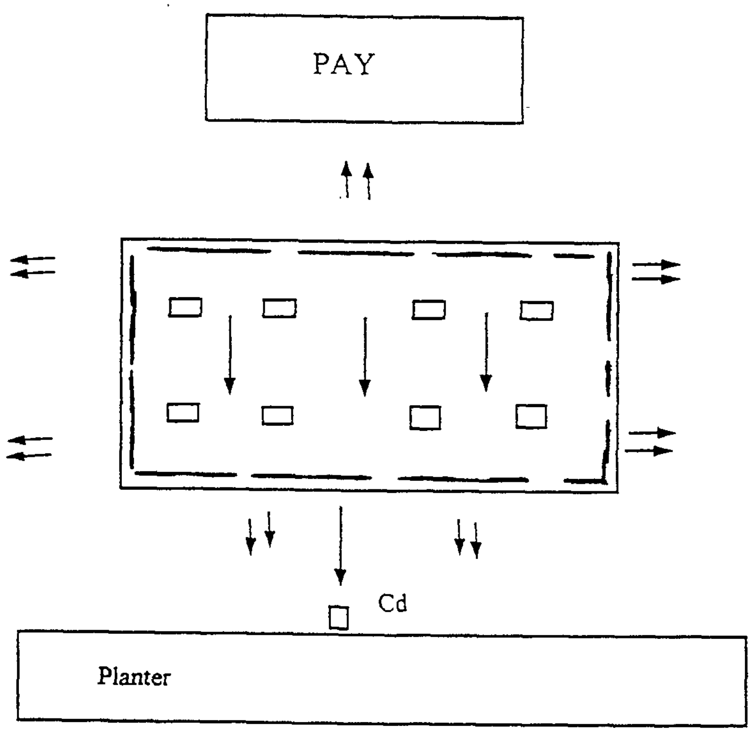
Cc - Exit port from clarifier, located on the street.

Single arrows - runoff that originates from fuel dispension area.

Double arrows - runoff that originates from surrounding parking lot area.

Small black dashed lines - graded gullies that channel stormwater runoff.

Large black dashed lines - canopy outline in relation to fuel dispension area



Grading: The parking lot is graded in asphalt and in a way that does an average job of keeping stormwater flow off the fuel dispension area. This station is located on a large corner and has a larger then usual parking lot. I have also observed some puddling in this parking lot.

The fuel dispension area is cement and is graded so as to cause any flow that originates their to move to the west end of the fuel dispension area to a drain that is located at a planter curb. Under this drain is a holding tank (Figure 4.16).

Canopy: The canopy here is of a single rectangular design that ends just above the outer edges of the fuel dispension area. I have observed some drippings from the outer edges of this canopy that land on the fuel dispension area. The outer 2-5 feet of the fuel dispension area collected a fair amount of stormwater from direct rainfall.

Clarifier: This station employs a 550 gallon underground tank that collects stormwater runoff from the fuel dispension area. The drain is located across the parking lot and consists of a metal barred grate that leads to the tank. The drain would not be that hard to sample but, I was not sure how I would get an exit sample or access to the inside of the tank.

Comments: This station opened or was renovated at an unknown date. It is a high volume outlet with a mini mart in a busy location. I have visited this site 2 times during storm events and have noted the following observations:

1) Any runoff from the fuel dispension area crossed an uncovered portion of the parking lot before it reaches the drain to the holding tank (Figure 4.17). This allowed direct rainfall and parking lot runoff to mix with fuel dispension area runoff, thus causing a dilution effect.

2) The holding tank design did not work well here. I have visited this location twice during stormevents and the tank is always full and overflowing to the stormwater drainage system (Figure 4.18). I have also visited this station 1 time during clear weather and the tank was still full with a noticeable sheen across the top (Figure 4.19).

Figure 4.16. View of Fuel Dispension Area in El Toro.This fuel dispension area uses a grading to the center that drains to the curb in front of the planter. Under the planter is a 550 gallon holding tank (March 24, 1998).

Figure 4.17. View of rain canopy in El Toro. From this angle, you can see how water from the fuel dispension area runs down to the curb where a drain is located. The last 30-40 feet of the grade is not under the protective canopy and gets a dilution effect, this also causes the tank to fill up very quickly and overflow to the street (March 24, 1998).

Figure 4.18. Drain leading to underground stormwater storage tank in El Toro. This drain to the 550 gallon tank was always full and overflowing during every stormevent I observed here. There is an access to the tank in the planter that can be used to pump out contaminated water. (March 24, 1998).

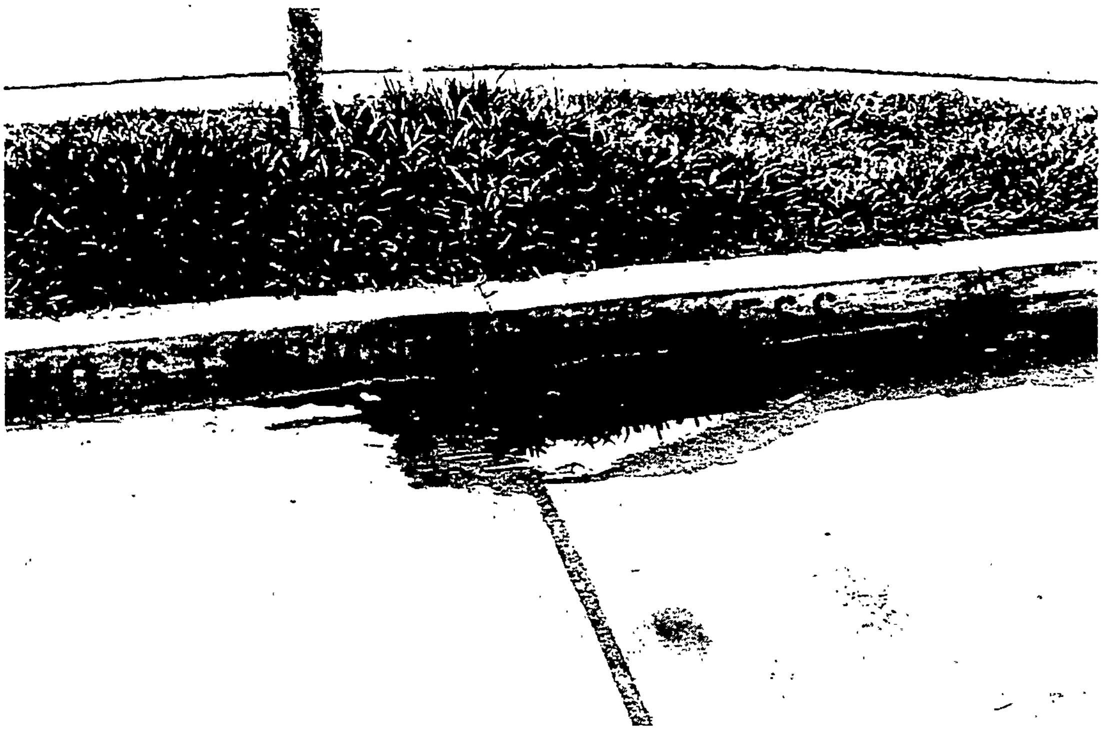


Figure 4.19. Drain to underground stormwater storage tank in El Toro. Close up of the drain to underground 550 gallon tank. When the tank is full of water from fuel dispension area it runs off to the street. (March 24, 1998).

4.7) Disscussion

Gasoline is regularly spilled during the refueling process or leaked from any vehicle on the fuel dispension area. I have come to the conclusion that the best way to reduce the amount of VOCs that originate from RGOs and enter the storm water drainage system is to minimize the accessibility of the fuel dispension area to stormwater from all possible sources. For modern high volume RGOs the major contributors of stormwater to the fuel dispension area include:

1) Rainfall that lands directly on the uncovered outer edge of the fuel dispension area during storm events.

2) Rainfall that lands on the canopy or sides of the canopy and drops on to the outer edge of the fuel dispension area.

3) Grading techniques that allow parking lot runoff to flow on to the fuel dispension area.

4) Grading techniques that allow for standing puddles of water in the parking lot area and/or the use of gullies adjacent to the entrance and exit ends of the fuel dispension area, that cars splash on to the fuel dispension area.

5) Stormwater that is brought on to the fuel dispension area by vehicles to be refueled.

I will now elaborate on each of the above 5 major contributors of stormwater to the fuel dispension area that I have been studying from December, 1997 through May, 1998.

1) None of the stations I have been observing during storm events had a canopy that totally protected the fuel dispension area even during light rain with a straight vertical fall. During heavy rains with strong winds, fuel dispension areas become so saturated, so fast, that some of the clarifier drains get totally overwhelmed and overflow. In fact, just a light wind can carry rainfall so far in to the fuel dispension area that the pumps are hit with direct rain fall at times. The best canopies I have seen are the single flat rectangular type. I would recremmend one that extends 5 feet "beyond" the outer most edge of the fuel

dispension area on all 4 sides. The use of "zigzag" and "multiple section" canopies might be stylish but allow acess direct rainfall to land on the fuel dispension area.

2) Canopies also drip stormwater from their edges on to the fuel dispension area, even during light vertical rainfall dripping edges sometimes land as far in as 2-5 feet from the outer edge. I have noticed that edges with tall vertical sides drop considerable more drippings then sides that are short with a sharp edge.

3) I have observed at some of my candidate sites the use of grading in the parking lot that does an excellent job of keeping stormwater from flowing on to the fuel dispension area. The most effective of my candidate sites make use of gullies located in the parking lot that channel stormwater runoff to the street.

4) I have observed that cars that drive through parking lot puddles before they pull up to be refueled tend to drip a lot more water on to the fuel dispension area. Gullies that are located at the edges of the fuel dispension area designed to carry fuel dispension area runoff to the clarifier drain, tend to get this water splashed back on to the fuel dispension area by on coming and departing cars.

5) Out of all the sources of stormwater to the fuel dispension area, the most difficult to control will probably be stormwater brought on by refueling vehicles. I have logged many hours at many different stations during many storm events of varying intensities peering out the window of my vintage 70s six pack camper and have found the best stations have no standing water or gullies that cars can splash through on the way up to the fuel dispension area. Furthermore it might be advantageous to have incoming cars approach the fuel dispension area from the direction that crosses the longest section of parking lot area to allow water slashed up under the car from the gutter at the street entrance to drip off some before they pull on to the fuel dispension area.

I have also noted one interesting common feature for all 5 of my stations. Storm events that occur during daylight hours are the best times to observe sheens that appear on standing and moving water. I have observed as many sheens in the parking lot area as I have that appear to originate from the fuel dispension area. This seems strange when you consider the many differences between these stations. For example, sites A and B have been open only 2-3 months, site A utilizes 2 clarifiers with drains located well out into the parking lot and 2 use drains located on the fuel dispension area. Another interesting observation I have made is that the duration or intensity of the storm event dose not seem to affect the amount of sheens visible, they seem to always be present in about the same quantity.

So where is all this fuel coming from and why does it seem to be so evenly spread across the entire station property ? I have been watching for sheens at all of the stations since I first began this project (sites A, D, E). I have been observing sites B and C since they opened, February and January respectively, I did not expect to see a lot of sheens as a result, but sheens were always present at these stations as well.

I have a suspicion that all of these sheens showing up are a result of incoming vehicles pulling up on a stormwater saturated fuel dispension area then departing and carrying water contaminated fuel on their tires and fenderwells to the surrounding parking lot area. There for, I think that minimizing the accessibility of the fuel dispension area to stormwater may be worth further study and offer the following suggestions:

1) The use of single rectangular type canopies and the extension of the edges over the fuel dispension area at least 5 feet on all 4 sides.

2) The use of grading that keeps stormwater from the surrounding parking lot area from flowing on to the fuel dispension area. If gullies are to be used to channel water off the property .they should be routed as far away from the fuel dispension area as possible.

3) If a clarifier is to be used, the fuel dispension area should be graded in a manner so as to cause any flow that originates there to move to the center and empty into a drain or drains located at the center of the fuel dispension area This eliminates the need for gullies along the outside of the fuel dispension area and still affords containment of large spills on the fuel dispension area.

The following map gives an approximation of the location of the previous 5 sites used in this study. As requested by the owners and associated groups the names and exact locations of my study sites are kept confidential.

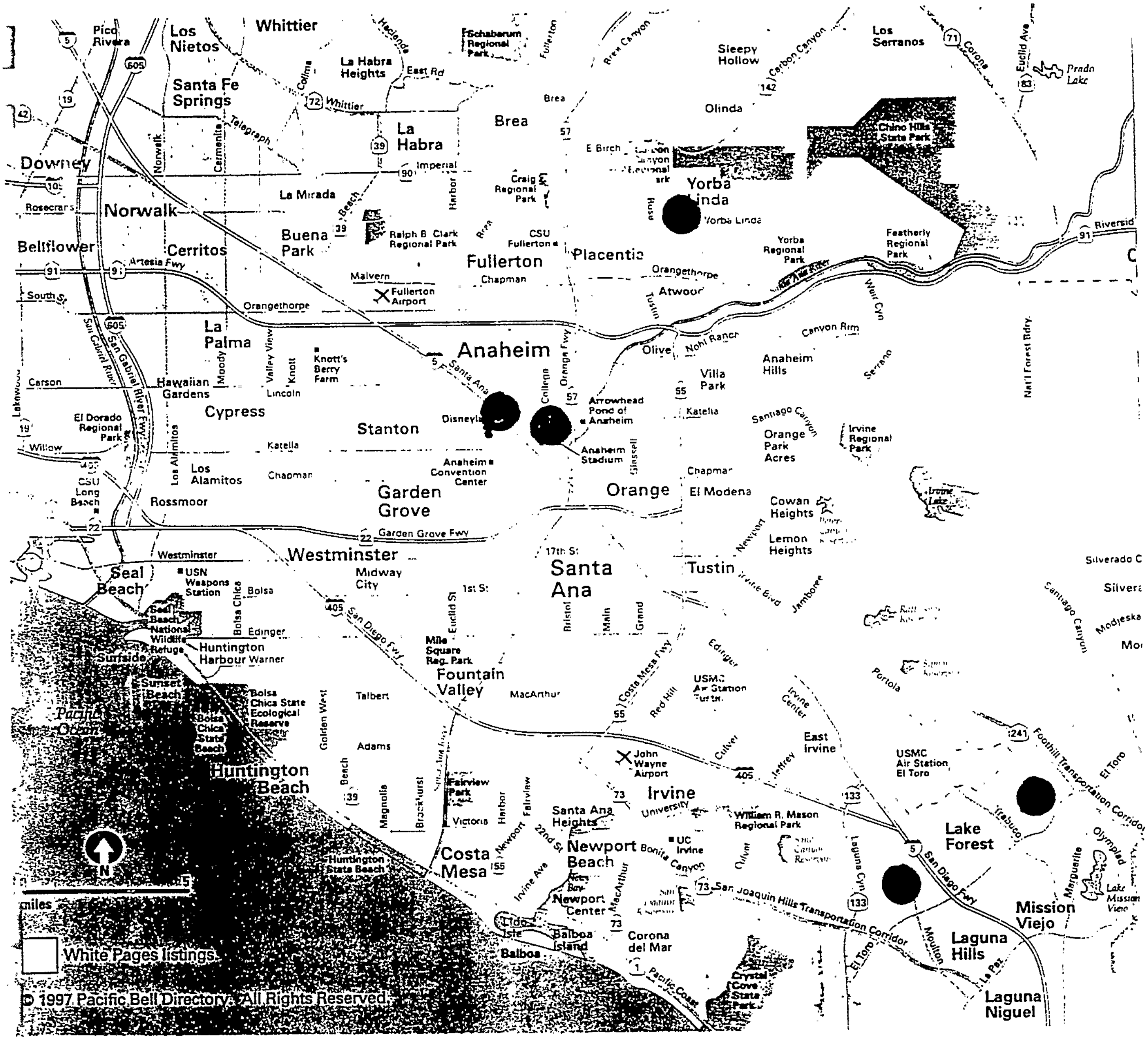


Figure 4.20. Red rings indicate approximate location of sites used in this study.

R0009213

5.0) SIMULATED STORMWATER STUDY AT A GASOLINE STATION

A literature search was conducted using the California State University Library and the University of California Library. I also conducted a search on the internet. I found no studies available for stormwater runoff that originates from RGOs. What information and studies I could find are summarized here.

A study conducted on Southern California RGOs entitled Results of a Retail Gasoline Outlet and Commercial Parking Lot Storm Water Runoff Study was prepared by Geomatrix Consultants (Geomatrix 1994). This report presents the results of a simulated storm water runoff from six RGOs and four commercial parking lots. This study was conducted for the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API). This study has two parts. Part 1, conducted by Hart Crower, characterized simulated storm water runoff from 5 RGOs. Part 2, conducted by Geomatrix, characterized simulated storm water runoff from four commercial parking lots and one RGO. Six RGOs, all located in southern California, were selected for this study. The six RGOs provide a representative cross section of typical RGOs in Southern California. Site characteristics for each RGO are summarized in Table 5.1.

Hart Crower and Geomatrix conducted a simulated rainfall application and sample collection at a pump island and driveway approach area within each RGO.
The water was applied at a rate of approximately 2 gallons per minute for the duration of a 45 minute test. This rate represents a rainfall rate of approximately 0.008 inch per minute or 0.12 inch every 15 minutes. The area used was approximately 400 square feet and the method of applying the water consisted of a network of perforated 1 inch pipe

Characteristic	RGO 1	RGO 2	RGO 3	RGO 4	RGO 5	RGO 6
Age of Facility	New	New	Older	Older	Older	Older
Location/Use	Urban, Little to No Commercial	Urban, Little to No Commercial	Inner City, Light Commercial	Urban, Light Commercial	Inner City, High Commercial	Urban, Little to No Commercial
Adjacent Property	Shopping Center	Fast Food	Residential /Retail	Shopping Center	Industrial /Retail	Residential /Retail
Throughput (gallons/month)	>250,000	>250,000	150,000 to 250,000	150,000 to 250,000	<150,000	>250,000
Carwash	Yes	Yes	No	No	No	No
Convenience Store	No	Yes	No	No	No	Yes
Mechanic's Bays	No	No	Yes	Yes	Yes	Yes
Structural BMPS						
Berms	Yes	Yes	No	No	No	No
Fuel Island Covered	Yes	Yes	Yes	Yes	Yes	Yes
Good Housekeeping BMPs						
Concrete Area Swept Daily	Yes	Yes	Yes	Yes	Yes	Yes
Inspect & Clean Spots Weekly	Yes	Yes	Yes	Yes	Yes	Yes
Monthly Washdown of Area	No	No	Yes	No	Yes	No

Table 5.1. Summary of retail gasoline outlet characteristics and best management practices for WSPA/API storm water runoff study (Geomatrix 1994).

schedule 80 polyvinyl chloride pipes, elevated 4 feet above the pavement surface. The areas were selected to provide results that are representative of discharge from the entire RGO. A summary of pavement types and conditions of each test site location is presented in Table 5.2.

Test Site	Location	Pavement Type	Pavement Condition	Surface Condition
RGO 1	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 1	Driveway Approach	Portland Cement Concrete	Good	No Staining
RGO 2	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 2	Driveway Approach	Portland Cement Concrete	Good	Moderate Staining
RGO 3	Pump Island	Portland Cement Concrete	Degraded	Heavy Staining
RGO 3	Driveway Approach	Asphaltic Concrete	Degraded	Heavy Staining
RGO 4	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 4	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining
RGO 5	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 5	Driveway Approach	Asphaltic Concrete	Degraded	Moderate Staining
RGO 6	Pump Island	Portland Cement Concrete	Good	Moderate Staining
RGO 6	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining

Table 5.2. Summary of retail gasoline outlet test locations and surface conditions for WSPA/API storm water runoff study. (Geomatrix 1994).

Commercial parking lots were selected for the second part of this study. Geomatrix and WSPA selected four commercial parking lots, all located in the Southern California. Simulated rainfall was applied and samples were collected at 2 locations at each of the 4 parking lots for a total of eight test sites. The test locations included one high-use and one moderate-use parking area. The high-use area was generally closer to the commercial facility entrance, and was occupied more frequently than the moderate-use area. Each of the parking lots used scheduled sweeping as a good housekeeping BMP. Parking lot test locations, conditions, and BMPs are summarized in Table 5.3.

Test Site	Site Use	Location and Traffic/Parking Condition	Traffic/Parking Frequency	Pavement Type and Condition	Best Management Practices
TS-1	Grocery Store Parking Lot	Near Store Entrance	High Volume of Traffic/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-2	Grocery Store Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Area Used For Overflow Parking, Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-3	Bank Parking Lot	Near Bank Entrance/Parking	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-4	Bank Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-5	Office Complex Parking Lot	Near Office Entrance	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-6	Office Complex Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume/Spaces Normally Filled During Business Hours	Asphaltic Concrete, Slightly Degraded Condition	Daily Sweeping
TS-7	Restaurant Parking Lot	Near Restaurant Entrance	High Traffic Volume/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown
TS-8	Restaurant Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown

Table 5.3 Summary of parking lot test locations, conditions, and best management practices for WSPA/ API storm water runoff study. (Geomatrix 1994)

Sampling procedures for both Part 1 and Part 2 follow the sampling protocol established by SW-846, "Test Methods for Evaluating Solid Wastes". The results from the simulated runoff from RGOs are presented in Tables 5.4.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	15 MINUTES	0.3 ppb	0.5 ppb	0.3 ppb	0.7 ppb
ISLAND	30 MINUTES	0.3 ppb	0.6 ppb	0.3 ppb	0.8 ppb
ISLAND	45 MINUTES	0.3 ppb	0.8 ppb	0.3 ppb	1.4 ppb
ISLAND	COMPOSITE	0.3 ppb	0.8 ppb	0.3 ppb	1.3 ppb
DRIVEWAY	15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb

RGO 1. 09-04-92.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	15 MINUTES	1.5 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	COMPOSITE	0.4 ppb	0.3 ppb	0.3 ppb	0.6 ppb

RGO 2. 09-10-92.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	15 MINUTES	0.3 ppb	7.9 ppb	3 ppb	20 ppb
ISLAND	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	45 MINUTES	0.3 ppb	0.4 ppb	0.3 ppb	1.1 ppb
ISLAND	COMPOSITE	0.3 ppb	0.3 ppb	0.2 ppb	1.1 ppb
DRIVEWAY	15 MINUTES	3 ppb	3 ppb	3 ppb	6 ppb
DRIVEWAY	30 MINUTES	2 ppb	3 ppb	3 ppb	6 ppb
DRIVEWAY	45 MINUTES	0.5 ppb	4.5 ppb	1.1 ppb	12 ppb
DRIVEWAY	COMPOSITE	0.3 ppb	0.8 ppb	0.3 ppb	3.4 ppb

RGO 3, 09-03-92.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	7.1 ppb
ISLAND	15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	45 MINUTES	0.3 ppb	3.4 ppb	0.3 ppb	1.5 ppb
ISLAND	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	6 ppb
DRIVEWAY	15 MINUTES	3 ppb	3 ppb	3 ppb	0.6 ppb
DRIVEWAY	30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DRIVEWAY	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb

RGO 4, 09-09-92.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
ISLAND	15 MINUTES	3 ppb	9.5 ppb	3 ppb	19 ppb
ISLAND	30 MINUTES	3 ppb	14 ppb	5 ppb	37 ppb
ISLAND	45 MINUTES	1 ppb	13 ppb	5.3 ppb	41 ppb
ISLAND	COMPOSITE	3 ppb	9.5 ppb	3.4 ppb	22 ppb
DRIVEWAY	15 MINUTES	7.5 ppb	7.5 ppb	7.5 ppb	15 ppb
DRIVEWAY	30 MINUTES	3 ppb	3 ppb	3 ppb	6 ppb
DRIVEWAY	45 MINUTES	7.5 ppb	7.5 ppb	7.5 ppb	15 ppb
DRIVEWAY	COMPOSITE	7.5 ppb	7.5 ppb	7.5 ppb	15 ppb

RGO 5, 09-19-92

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
DRIVEWAY	SOURCE	50 ppb	0.3 ppb	0.3 ppb	0.5 ppb
DRIVEWAY	15 MINUTES	NA	NA	NA	NA
DRIVEWAY	30 MINUTES	NA	NA	NA	NA
DRIVEWAY	45 MINUTES	NA	NA	NA	NA
DRIVEWAY	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
DRIVEWAY	DUPLICATE	NA	NA	NA	NA
DRIVEWAY	TRIP BLANK	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
ISLAND	15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
ISLAND	30 MINUTE	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
ISLAND	45 MINUTE	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
ISLAND	COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb
ISLAND	DUPLICATE	NA	NA	NA	NA
ISLAND	TRIP BLANK	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb

RGO 6, 05-04-94

Tables 5.4. BTEX data from RGO study (Geomatrix 1994).

Constituent	Test Method	Detection Limit (ppm unless otherwise noted) RGOs 1-5	RGO 6 and Parking Lots
Volatile Organic Compounds	EPA Method 8020		
Benzene		0.0003	0.0003
Toluene		0.0003	0.0003
Ethyl Benzene		0.0003	0.0003
Total Xylenes		0.0006	0.0006
Total Petroleum Hydrocarbons	EPA Method 8015 (gasoline)	0.1	0.05

Na: Not analyzed
Island: Fuel dispension area.

A simulated gasoline spill was performed at RGO 5 to provide data regarding the effectiveness of standardized spili response procedures. One quart of regular unleaded gasoline from a pump nozzle was discharged onto the pump island pavement. Absorbent material was applied to the spill after one minute. the absorbent material was then swep. up after it appeared to have absorbed the spilled liquid, and the simulated runoff test was conducted.To minimize test variability caused by differing rainfall intensities and duration, both parts of the study used a simulated rainfall method to induce from the study sites. The water dispensing system and sampling procedures were identical for both the RGO and commercial parking lot sites. The water dispensing system was designed to apply water uniformly over the test area and create sheet flow. The resuits from the simulated runoff from parking lots are presented in Tables 5.5.

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.3 ppb	0.5 ppb

TS-1 01-12-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
15 MINUTES	NA	NA	NA	NA
30 MINUTES	NA	NA	NA	NA
45 MINUTES	NA	NA	NA	NA
COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.5 ppb	0.5 ppb

TS-2 01-12-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
15 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.74 ppb
30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.5 ppb	0.5 ppb

TS-3 01-12-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
15 MINUTES	NA	NA	NA	NA
30 MINUTES	NA	NA	NA	NA
45 MINUTES	NA	NA	NA	NA
COMPOSITE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.5 ppb	0.5 ppb

TS-4 01-12-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
BACKGROUND	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
15 MINUTES	0.3 ppb	0.45 ppb	0.3 ppb	0.63 PPB
30 MINUTES	0.3 ppb	0.36 ppb	0.3 ppb	0.6 ppb
45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
COMPOSITE	0.3 ppb	0.4 ppb	0.3 ppb	0.6 ppb
DUPLICATE	0.3 ppb	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.5 ppb	0.5 ppb

TS-5 01-13-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
15 MINUTES	NA	NA	NA	NA
30 MINUTES	NA	NA	NA	NA
45 MINUTES	NA	NA	NA	NA
COMPOSITE	0.3 ppb	0.33 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA
TRIP BLANK	0.3 ppb	0.3 ppb	0.5 ppb	0.5 ppb

TS-6 01-13-9

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
SOURCE	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
15 MINUTES	NA	NA	NA	NA
30 MINUTES	NA	NA	NA	NA
45 MINUTES	NA	NA	NA	NA
COMPOSITE	0.3 ppb	0.46 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA

TS-7 01-17-94

SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES
15 MINUTES	0.3 ppb	0.31 ppb	0.3 ppb	0.6 ppb
30 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
45 MINUTES	0.3 ppb	0.3 ppb	0.3 ppb	0.6 ppb
COMPOSITE	0.3 ppb	0.31 ppb	0.3 ppb	0.6 ppb
DUPLICATE	NA	NA	NA	NA

TS-8 01-17-94

Tables 5.5, BTEX data from parking lot study (Geomatrix 1994).

The authors of this paper concluded that for the constituents analyzed in this report, median event mean concentrations (EMCs) in storm water runoff from normally operated and maintained RGOs are no higher then those in runoff from commercial parking lots. In all cases, the fuel related constituents from pump islands were either not detected or below applicable Maximum Contaminant Levels (MCLs). These results indicate that fueling activities at normally operated and maintained RGOs do not contribute additional significant concentrations of measured constituents to storm water runoff (Geomatrix 1994, 13).

6.0) SAMPLING AND ANALYSIS DURING WINTER 1997/1998

The main focus of this CSUF sampling study was to evaluate the effectiveness of the S11 Motor Fuel Concrete Area Interruptable Drainage requirement. In the sites chosen there existed an underground clarifier or filter system that had a drain entry that collected stormwater from the fuel dispension area and an exit usually to the gutter along the street. The collected samples were analyzed for the presence of BTEX hydrocarbons.

6.1) Site Criteria

The following is a summary of the criteria used for my sampling sites.

- RGO was a modern high volume station located in Orange County California, built or renovated after June 1 1996.
- RGO was equipped with all the currently required BMPs.
- RGO was equipped with a clarifer (S11 requirement) with an inlet (drain) and an outlet (exit port) that could be sampled. The use of an underground tank or car wash system can not be utilized.

6.2) Qualifying Storm Event

Stormwater samples were collected and analyzed during as many storm events as possible. I used forecast information from the National Weather Service and the various radio and television news networks to plan my sampling trips. I also utilized the meteorological services at the Orange County Public Facilities and Resources Department ALERT stations to help forecast potential qualifying storm events. For the proposed study plan a qualified storm event was defined as an event that:

- Produced a "significant stormwater discharge" (a continuous discharge of stormwater for approximately one hour or more).

Was preceded by at least two working days of dry weather.

6.3) SAMPLING METHOD

In order to evaluate the effectiveness of the clarifiers which continually circulate stormwater for the entire duration of the storm event, I used a time weighted composite method. This method consisted of at least 4 sets and as many as 8 sets of manual samples collected at 15 minute intervals. The first of the 4-8 sets were collected within the first 30 minutes of discharge from a qualifying storm event as defined in section 4.2. In certain cases that samples could not be taken within the first 30 minutes, then sampling began when a continuous discharge begins, provided that the reason(s) for the delay was documented.This study plan includes a detailed account of each storm event sampled.

6.4) Sampling Procedure and Quality Control

When a candidate storm was forecast for the Orange County area, I went to the site to be sampled and waited for the rain to start. When the rain began, I waited 30 minutes or until enough runoff was flowing into the clarifier and out its exit port to the street to sample. The sampling sites consisted of the following:

- Fuel Dispension Area: the area where the pumps are located. This is usually a concrete region sometimes referred to as the island. It is usually that region that is covered by the rain canopy.
- Parking lot: the area that is around the fuel dispension area. This is usually the asphalt region and includes the driveways into the site and that lead to the fuel dispension area.
- Drain: this is usually a barred grate in the ground where stormwater runoff is channeled to. An underground pipe connects this drain to the clarifier where the water undergoes treatment before it is released to the street. This drain is usually located on/or near the fuel dispension area.
- Exit Port: this is usually located on the street and is usually just a couple of holes

in the curb where water that has been treated by the clarifier is released to the gutter.

I normally set up 2-5 sandbags in the gutter up gradient of the exit port in the curb.This deflected the gutter flow away from the exit ports and allows a sample to be taken without the possible contamination from other waters. During heavier storm episodes, gutter flows became so large that sampling was impossible due to the high levels of gutter flow. Indeed, in many storm events the exit ports were completely under water.The sand and bags were discarded after each sampling episode to prevent the possibility of cross contamination. I also used medical latex gloves and changed them after each sample was taken to prevent the possibility of cross contamination. The drain that was sampled was deep enough to totally submerge the 40 ml vial. Exit ports required a slight tilt of the vial, but could usually be totally filled without having to add water manually in some manner. When topping off of the vial was required, I used the cap as a dip inside the port and filled the vial.

As samples were collected at the site, they were placed in an ice chest and cooled to 4 degrees C. The samples were collected in 40 ml amber vials with septum caps. The vial was filled just to overflowing to ensure that there were no bubbles entrapped within the collection vial. They were then transferred to the lab as soon as possible.The volatile organic compounds were analyzed on a Sentex Scentograph Plus 2 gas chromatogragh (GC). This GC is owned and operated by the Orange County Public Facilities and Resources Department. The GC is equipped with a purge and trap system, a micro argon ionization detector (MAID) and a 30m VOCOL capillary column. A calibration standard was run after every third sample to ensure that the instrument is operating properly. All samples were also sent out to a certified laboratory.

6.5) Data Analysis

The first sample taken was labeled Cd. This sample was taken from the drain that collects stormwater runoff and allows it to enter the clarifier. The second sample taken was labeled Cc. This sample was taken at the exit port and represented water that had been treated by the clarifier and released to the street that eventually leads to the stormwater collection system. Sample Cd was compared with sample Cc for a measurable difference in the presence of BTEX constituents. I also took a background sample from the clarifier drain before storm water began to flow in. This gave me an idea of what was present in the clarifier before the storm event begins. This sample was labeled Cb and is a background sample. I was also interested in what is present in the parking lot and took a sample here at the beginning of each storm event and I took another sample when I was finished sampling at each site. These samples were labeled Cp. The amount of rain the sample sites received was measured by the County's ALERT system. This system is made up of 90 stations across the County. Each of sites that was sampled is located near at least 2 of these stations. Table 6.1 gives the locations, types and names of all Orange Countys active ALERT stations.

6.6) Sampling Event 1 on March 25, 1998

I arrived at site A, (see pages 28 -33) at 3.30 am during a light rain. Around 4 am I set up 3 new sand bags in the gutter to deflect flow away from outlet ports in the curb. By 4.30 am enough stormwater runoff was present to begin sampling. During the first hour enough stormwater was flowing to take 4 sets of samples with no problems. The drain at this location was shallow and made it impossible to submerge my sample bottle. I tilted the sample bottle and filled it to about 80% full and let the water flowing in fill it the rest of the by putting the bottle under the falling water. The exit port required that I tilt the bottle in the hole and fill it about 80% full. I then use the cap as a bucket by filling it in the hole and pouring it slowly into the sample bottle.

ACTIVE ALERT STATIONS
OPERATED BY OCEMA

Sta. No.	Station Name	Equip Type	North Latitude	West Longitude	Elev Feet	Record Begins
201	Santiago Peak	S	33-42-39	117-31-59	5660	1982
203	Portola Park	P	33-46-00	117-50-33	182	1991
205	Santiago Peak	P	33-42-39	117-31-59	5660	1982
206	Aliso Creek @ Jeronimo	W	33-37-30	117-41-07	455	1983
207	El Toro	P	33-37-30	117-44-14	455	1983
209	San Juan Guard	P	33-35-19	117-30-54	660	1983
212	Oso Creek @ Crown Valley	W	33-33-28	177-40-32	260	1983
213	Oso Creek @ Crown Valley	P	33-33-28	177-40-32	260	1983
214	San Juan Creek	W	33-29-30	117-39-43	75	1984
215	San Juan Capistrano	P	33-29-30	117-39-43	75	1984
217	Lambert Reservoir	P	33-41-41	117-42-39	450	1989
219	Santa Ana Engineering	P	33-45-04	117-52-11	170	1989
220	Villa Park Dam	P	33-48-59	117-46-00	560	1983
221	Villa Park Dam	A	33-48-59	117-46-00	560	1983
223	Katella Yard	P	33-48-11	117-52-34	160	1988
225	Santiago Creek, Santa Ana	W	33-46-09	117-52-54	120	1989
226	Santiago Creek, Santa Ana	P	33-46-09	117-52-54	120	1989
231	Lower Oso Creek	W	33-32-34	117-40-33	220	1994
232	Lower Oso Creek	P	33-32-34	117-40-33	220	1994
233	Modjeska Canyon	P	33-42-32	117-38-05	1260	1984
238	Westminster Channel @ Beach	W	33-45-07	117-59-26	40	1989
239	Westminster Channel @ Beach	P	33-45-07	117-59-26	40	1989
240	Miller Basin	W	33-51-53	117-51-09	220	1983
241	Miller Basin	P	33-51-53	117-51-09	220	1983
244	Prado Dam Outflow	W	33-53-00	117-38-39	460	1983
245	Prado Dam	P	33-53-00	117-38-39	460	1983
248	Coto De Caza	P	33-37-44	117-35-00	730	1993
251	Oak Flat	P	33-49-46	117-38-19	2700	1983
252	El Modena - Irvine @ Michelle	W	33-43-12	117-47-54	70	1989
253	El Modena - Irvine @ Michelle	P	33-43-12	117-47-54	70	1989
254	Brookhurst Tide	W	33-38-12	117-57-12	0	1992
256	Lower Silverado Canyon	P	33-44-33	117-39-28	1100	1984
258	Magnolia Tide	W	33-38-30	117-58-10	7	1984
260	EGG-Wintersburg	W	33-43-02	117-59-57	20	1983
261	Huntington Beach	P	33-43-02	117-59-57	20	1983
263	Corona Del Mar	P	33-36-45	117-51-27	300	1984
265	Brea	P	33-55-19	117-54-04	340	1983
267	Placentia Basin	W	33-51-30	117-53-00	190	1984
270	Yorba Park	P	33-52-00	117-46-11	300	1988
274	Sand Canyon	P	33-40-38	117-45-33	200	1989
277	Fullerton Creek	P	33-51-47	117-55-55	95	1988
282	Peters Canyon Wash @ Barranca	W	33-41-40	117-49-16	25	1987
283	Peters Canyon Wash @ Barranca	P	33-41-40	117-49-16	40	1987
287	Oceanview	W	33-43-12	117-55-54	43	1993
288	Oceanview	P	33-43-12	117-55-54	43	1993
290	Raymond Basin	W	33-50-52	117-54-31	165	1988
292	Alameda Storm Ch.	W	33-48-21	117-48-06	339	1989
293	Alameda Storm Ch.	P	33-48-21	117-48-06	339	1989
294	Anaheim Agriculture	P	33-49-12	117-54-48	148	1989
297	Upper Oso Creek	P	33-39-13	117-39-21	420	1991
805	Riverside Flood Control	P	33-58-49	117-21-47	830	1983
810	Gavilan Hills	P	33-47-23	117-23-46	2040	1983
819	Chino Creek	W	34-00-43	117-43-47	715	1984

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Sta. No.	Station Name	Equip Type	North Latitude	West Longitude	Elev Feet	Record Begins
820	Chino Creek	P	34-00-43	117-43-47	715	1984
824	Cucamonga Creek	W	34-01-50	117-36-00	820	1984
825	Cucamonga Creek	P	34-01-50	117-36-00	820	1984
828	San Antonio Dam	P	34-09-23	117-40-54	2000	1985
832	Camp Angelus	P	34-09-00	116-58-40	5780	1984
835	Mentone	W	34-06-30	117-05-59	1950	1985
836	Mentone	P	34-06-30	117-05-59	1950	1985
1100	Lacouaque	P	33-30-33	117-37-55	141	1990
1105	Bolsa Chica Channel	W	33-45-33	118-02-30	7	1990
1110	Santa Ana - Delhi Channel	W	33-39-36	117-52-49	24	1989
1111	Santa Ana - Delhi Channel	P	33-39-36	117-52-49	24	1989
1116	Anaheim - Barber City	W	33-45-16	118-02-04	7	1990
1117	Anaheim - Barber City	P	33-45-16	118-02-04	20	1990
1119	Laguna Beach @ Woodland	W	33-33-11	117-46-26	67	1990
1120	Laguna Beach @ Woodland	P	33-33-21	117-46-45	600	1990
1124	San Diego Crk. @ Campus	W	33-39-20	117-50-42	10	1990
1125	San Diego Crk. @ Campus	P	33-39-20	117-50-42	20	1990
1130	Laguna Audubon	P	33-36-04	117-44-36	314	1990
1133	Laguna Audubon	W	33-36-04	117-44-36	314	1992
1135	Santiago Creek @ E08	W	33-42-47	117-38-42	1220	1993
1136	Santiago Creek @ E08	P	33-42-47	117-38-42	1220	1993
1140	Fullerton Airport	P	33-52-23	117-58-24	95	1990
1141	Upper Aliso Creek	P	33-38-20	117-40-12	560	1991
1145	Pico Retarding Basin-San Clemente	P	33-24-32	117-35-10	250	1993
1150	Costa Mesa	P	33-40-07	117-53-35	47	1990
1152	Laguna Niguel Park	P	33-32-49	117-42-25	200	1991
1155	Segunda Desheca	P	33-26-10	117-35-30	85	1993
1160	El Cariso Guard Station	P	33-37-30	117-24-42	2600	1990
1165	Yorba Reservoir	P	33-52-19	117-48-37	300	1990
1170	Upper Silverado Canyon	P	33-44-50	117-32-34	2880	1990
1175	Garden Grove	P	33-47-58	117-58-03	80	1990
1180	Gilbert Retention Basin	P	33-50-20	117-57-42	100	1990
1182	Irvine Lake Dam	W	33-47-00	117-43-34	820	1983
1187	Upper East Garden Grove Wintersburg	W	33-47-10	117-54-03	120	1993
1188	Upper East Garden Grove Wintersburg	P	33-47-10	117-54-03	120	1993
1190	Trabuco Creek at Camino Capo	W	33-31-34	117-40-07	200	1983
1194	San Diego Creek @ Culver	W	33-40-54	117-48-31	54	1990
1195	San Diego Creek @ Culver	P	33-40-54	117-48-31	70	1990
8014	Seal Beach Pump Station	P	33-44-30	118-07-00	5	1988
8018	Seal Beach Pump Station	W	33-44-30	118-07-00	5	1988
8036	Cypress Pump Station	P	33-49-07	118-03-32	30	1988
8041	Cypress Pump Station	W	33-49-07	118-03-32	30	1988
8085	Huntington Beach Pump Station	P	33-40-19	117-59-00	5	1988
8089	Huntington Beach Pump Station	W	33-40-19	117-59-00	5	1988
8110	Harbor at Edinger SAR Pump Station	P	33-43-05	117-55-12	50	1992
8114	Harbor at Edinger SAR Pump Station	W	33-43-05	117-55-12	50	1992
8132	Los Alamitos Pump Station	P	33-45-24	118-45-43	7	1992
8136	Los Alamitos Pump Station	W	33-45-24	118-45-43	7	1992

800 series stations are outside Orange County

P = Precipitation
W = Water Level
A = Anemometer - Wind Velocity
S = Snow

Table 6.1. Orange Counties active ALERT stations.

I observed many moving sheens of fuel at this station on many observations in the past and this time I observed just as many on this trip alone. During the second hour rain was starting to vary in its intensity. Enough water was still flowing to take 4 more sets of samples. Sheens of fuel were still present in the gullies and surrounding parking lot areas. Customer traffic has increased and I counted 37 vehicles this hour.This station had a grading design that works well at keeping parking lot stormwater runoff from moving on to the fuel dispension area. I observed none during this event. The canopy did not totally cover the fuel dispension area and even in this light consistent rain the west end of the fuel dispension area was wet about 4 feet in and a small flow was moving down to the gully that leads to the drain. The cars that were pulling up to refuel were bringing water on to the fuel dispension area but it was not enough to create a flow down to the drain. This station was designed in a way that water that reaches the fuel dispension area flows down gradient to a gully that travels about a 100 feet across the parking lot and empties into the drain. The drain therefore intercepts a lot of parking lot water and direct rainfall. The consistent presence of observed moving sheens was a bit surprising even after 2.5 hours of rain and I also noticed a strong turpentine and metallic smell from my hands and gloves. In fact, even after 48 hours in my garage the sand bags still had that strong smell. The results of this sampling are presented in Table 6.2.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENE	MTBE
Cb	BACKGROUND	NA	NA	NA	NA	NA
Cd	15 MINUTES	NA	NA	NA	NA	NA
Cc	15 MINUTES	NA	NA	NA	NA	NA
Cd	30 MINUTES	NA	NA	NA	NA	NA
Cc	30 MINUTES	NA	NA	NA	NA	NA
Cd	45 MINUTES	NA	NA	NA	NA	NA
Cc	45 MINUTES	NA	NA	NA	NA	NA
Cd	60 MINUTES	NA	NA	NA	NA	NA
Cc	60 MINUTES	NA	NA	NA	NA	NA
Cd	75 MINUTES	NA	NA	NA	NA	NA
Cc	75 MINUTES	NA	NA	NA	NA	NA
Cd	90 MINUTES	NA	NA	NA	NA	NA
Cc	90 MINUTES	NA	NA	NA	NA	NA
Cd	105 MINUTES	NA	NA	NA	NA	NA
Cc	105 MINUTES	NA	NA	NA	NA	NA
Cd	120 MINUTES	NA	NA	NA	NA	NA
Cc	120 MINUTES	NA	NA	NA	NA	NA

Table 6.2. VOC data results for sampling event 1 (3-25-98).

* *Sample Analysis was performed 2 weeks beyond holding period and results were hindered by numerous malfuntions on test equipment.*
NA: Not Analysed.

Table 6.3 presents the rain gauge data from the alert stations. This table shows the amount of precipitation in days preceding the storm event and then the amount of precipitation during the sampling session every 30 minutes.

STA. NO.	270	1165
DATATYPE	PRECIP	PRECIP
UNITS	IN	IN
03-22-98	0.00	0.00
03-23-98	0.00	0.00
03-24-98	0.00	0.00
03-25-98		
0430	0.00	0.00
0500	0.04	0.04
0530	0.00	0.00
0600	0.04	0.04
0630	0.00	0.00
TOTAL	0.08	0.08

Table 6.3. Rainfall data for sampling event 1.

Figure 6.4 shows the approximate locations of the two ALERT stations used in

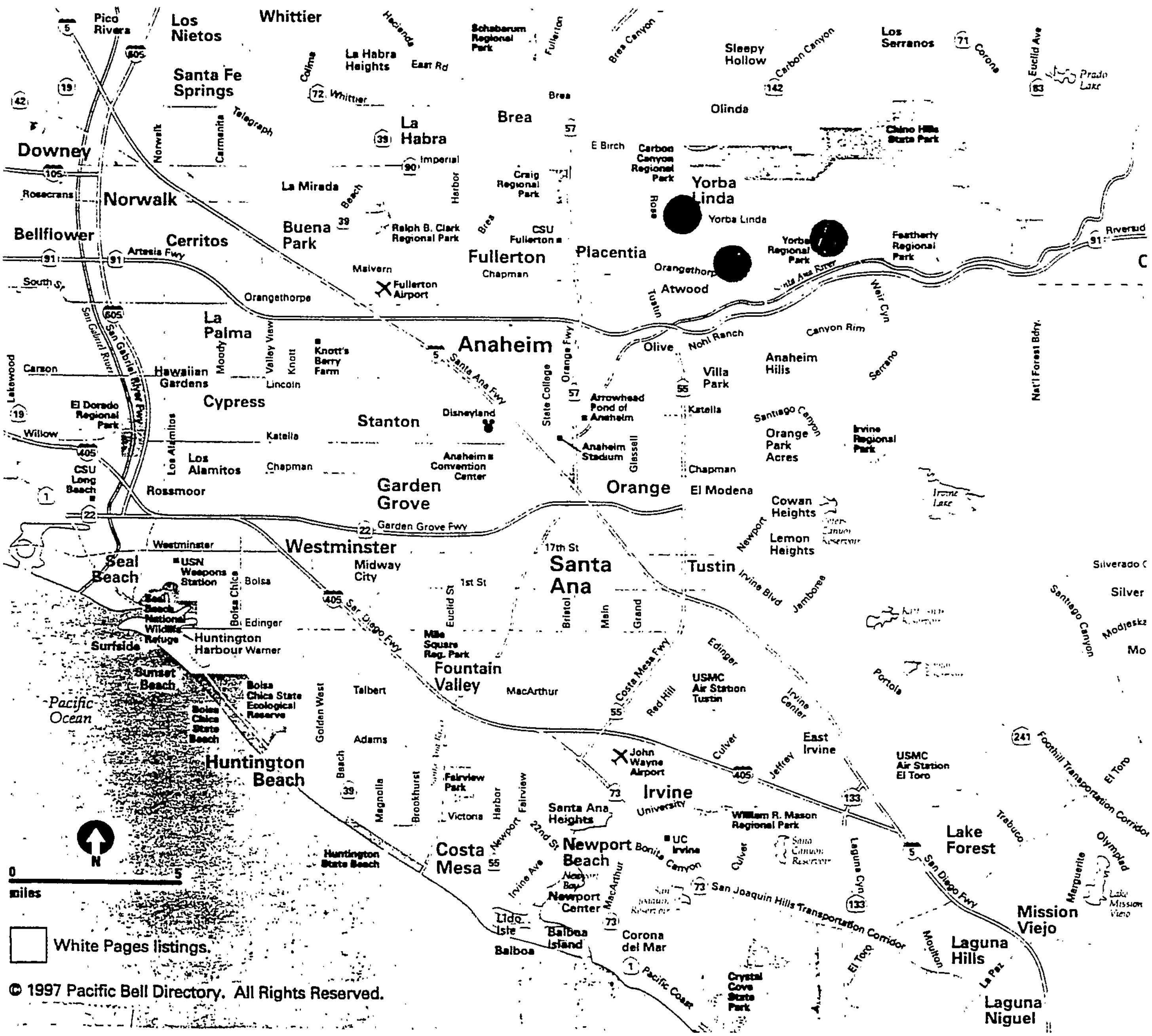

Figure 6.4. Map of active ALERT stations used to monitor rainfall for site A. Approximate location of site A is represented by a red circle and approximate locations of rain gauge stations are represented by blue circles. (Orange County Public Facilities & Resources Department

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6.7) Sampling Event 2 on March 31, 1998

Arrived at the site B, (see pages 34-40) at 4 pm during a light rain. At 6.45 pm I took a sample from the drain before runoff begins to trickle in. Parking lot runoff in gully was flowing enough to take a sample .The drain here was easy to sample, and it was deep enough to totally submerge sample bottle. At the curb at the exit port, I tilted the sample bottle in the exit port and filled it to about 80% and used the cap as a scoop inside the port to fill the rest of the way.

Light rain turns to medium intensity rain and the outer 4-5 feet of the fuel dispension area was wet enough on all 4 sides to start a trickle flow moving toward the gullies that lead to the drain. The edge of the canopy was dropping a lot of water on to the edge of the fuel dispension area. I did observe moving sheens in the gullies until it got dark. The lighting here made it very difficult to observe possible sheens at night. In fact, the logo colors of this franchise that was painted on the canopy reflected in a manner that they look like sheens on the wet surfaces. This station was by far the busiest one I have been to. But I did not see as many sheens here as I did at site A. The strong metallic turpentine smell was present here but, not near as strong as site A. The results of this sampling are presented in Table 6.4.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENE	MTBE
Cb	BACKGROUND	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	90 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	90 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	105 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	105 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	120 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	120 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	120 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb

Table 6.4. VOC data results for sampling event 2 (3-13-98).

Table 6.6 presents the rain gauge data from the alert stations. This table shows the amount of precipitation in days preceding the storm event and then the amount of precipitation during the sampling session every 30 minutes. Figure 6.5 shows the approximate locations of the three ALERT stations used in Table 6.5.

STA. NO.	1188	294	223
DATATYPE	PRECIP	PRECIP	PRECIP
UNITS	IN	IN	IN
03-29-98	0.00	0.00	0.00
03-30-98	0.00	0.00	0.00
03-31-98			
2100	0.12	0.08	0.08
2030	0.04	0.12	0.08
2000	0.12	0.04	0.08
1930	0.00	0.04	0.04
1900	0.12	0.20	0.20
1830	0.04	0.04	0.00
1800	0.00	0.04	0.00
TOTAL	0.44	0.56	0.48

Table 6.5. Rainfall data for sampling event 2.

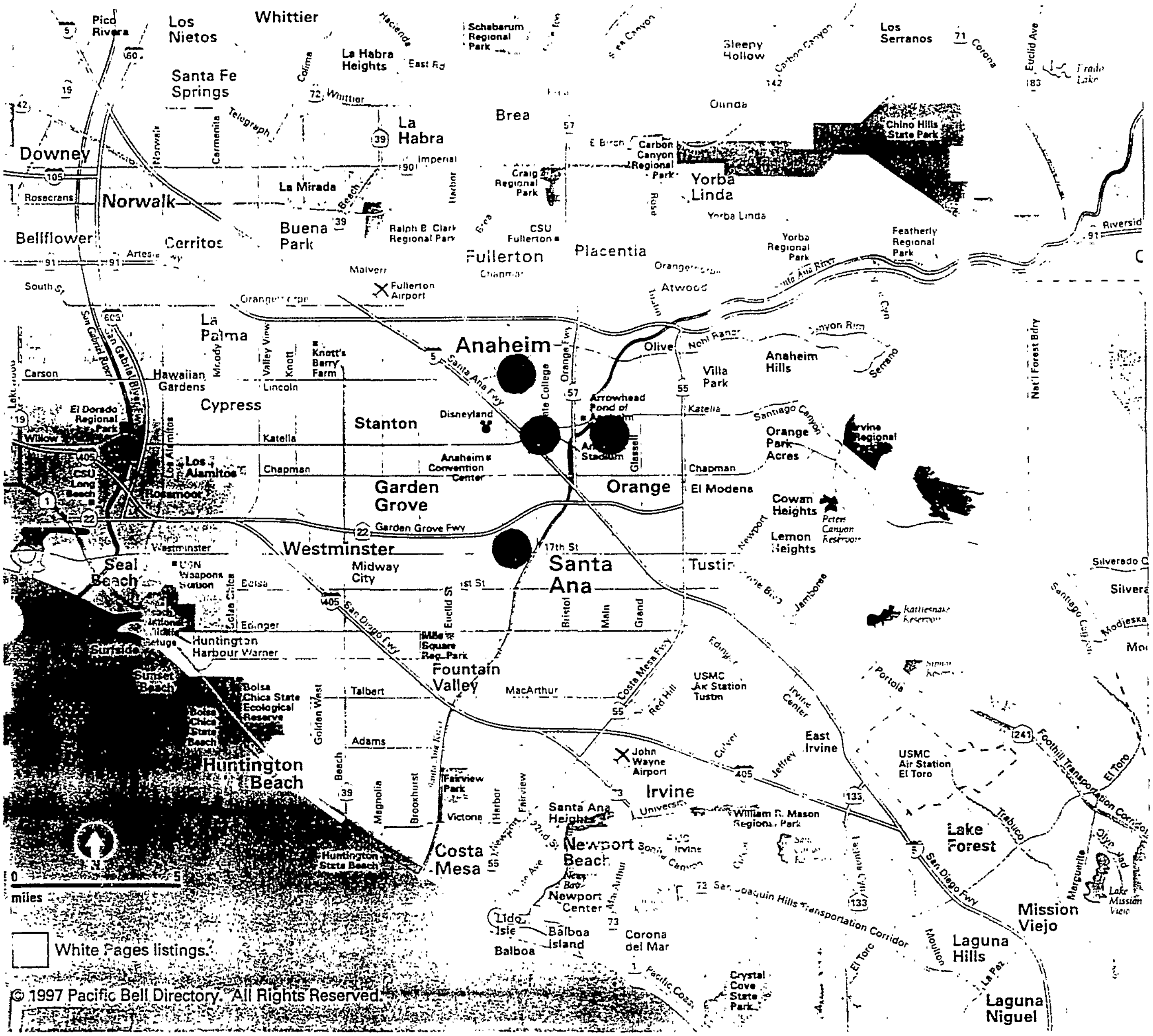

Figure 6.5.Map of active ALERT stations used to monitor rainfall for site B. Approximate location of Site B is represented by a red circle and the approximate locations of rain gauge stations are represented by blue circles (Orange County Public Facilities & Resources Department).

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6.8) Sampling Event 3 on April 11, 1998.

I arrived at site B (see pages 34-40) around 10.30 am. A light rain began to fall around 10.45 am. I set up two sand bags at the curb to deflect off any possible gutter flow from the exit port at the curb. At 11 am enough flow was moving from the parking lot area to the gully that carries it to the street to take a sample (Cp). I also took my background sample from the clarifier drain (Cb) before any flow began to trickle in at 11 am. By 11.15 am enough runoff was trickling into the clarifier drain (Cd) and out of the exit port at the street (Cc) to begin sampling. Rain is light but steady during the duration of the storm event. But by 12 pm, rain had lightened up considerably and the storm was starting to break up. Runoff flow started to decrease and by 12.30 pm was no longer trickling into the clarifier drain. I took my second parking lot sample and left. This was the first time I had been able to sample or observe this station in the daylight hours. I have observed more sheens of fuel moving throughout the property and most of which were seen in both the parking lot and fuel dispension area gullies. I also observed sheens flowing in the street gutter that did not appear to be originating from this stations property. I also did not smell that strong turpentine metallic odor that I had experienced at other sites in my study. The results of this sampling are presented in Table 6.8.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENE	MTBE
Cb	BACKGROUND	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb

Table 6.6. VOC data results for sampling event 3 (4-11-98).

Table 6.9 presents the rain gauge data from the alert stations. This table shows the amount of precipitation in days preceding the storm event and then the amount of precipitation during the sampling session every 30 minutes. Figure 6.5 shows the approximate locations of the three ALERT stations used in Table 6.7.

STA. NO.	1188	294	223
DATATYPE	PRECIP	PRECIP	PRECIP
UNITS	IN	IN	IN
04-07-98	0.00	0.00	0.00
04-08-98	0.00	0.00	0.00
04-09-98	0.00	0.00	0.00
04-10-98	0.00	0.00	0.00
04-11-98			
1400	0.04	0.00	0.00
1330	0.00	0.00	0.00
1300	0.00	0.04	0.00
1230	0.00	0.00	0.00
1200	0.00	0.04	0.04
1130	0.04	0.00	0.04
1100	0.00	0.00	0.00
TOTAL	0.08	0.08	0.08

Table 6.7. Rainfall data for sampling event 3.

6.9) Sampling Event 4 on May 12, 1998

I arrived at the site B (see pages 34-40) at 2 pm during a light rain. At 2.15 pm I took a sample from the drain (Cb) before runoff began to trickle in. Parking lot runoff in gully was flowing enough to take a sample (Cp).The drain here was easy to sample (Cd), and it was deep enough to totally submerge sample bottle. But, this time I allowed the bottle to fill by collecting water that was flowing downward into the drain. This storm was stronger than the previous two I had sampled here and water is cascading down into the drain for the entire sampling event. At the curb at the exit port (Cc). I tilted the sample bottle in the exit port and filled it to about 80% and used the cap as a scoop inside the port to fill to the top. This time it took 3 sand bags to deflect the gutter flow enough to avoid contamination.

Light rain turned to medium intensity rain and the outer 4-5 feet of the fuel dispension area was wet enough on all 4 sides to start a trickle flow moving toward the gullies that lead to the drain. This storm had strong winds associated with its rainfall and at times was blowing rainfall on to the pumps. I had also noticed that flow from the fuel dispension area was flowing into the gullies that channels stormwater to the street.The edge of the canopy is dropping a lot of water on to the edge of the fuel dispension area. I did observe moving sheens in the gullies during the entire event.This station was still by far the busiest one I have been to. But I did not see as many sheens here as I did at site A. The strong metallic turpentine smell was present here but, not as strong as site A. The results of this sampling are presented in Table 6.8.

LOCATION	SAMPLE	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENE	MTBE
Cb	BACKGROUND	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	30 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	45 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	60 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	75 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cd	90 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cc	90 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	15 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb
Cp	90 MINUTES	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 0.5 ppb	< 10 ppb

Table 6-8. VOC sampling results for sampling event 4.

Table 6.9 presents the rain gauge data from the alert stations. This table shows the amount of precipitation in days preceding the storm event and then the amount of precipitation during the sampling session every 30 minutes. Figure 6.5 shows the approximate locations of the three ALERT stations used in Table 6.9.

STA. NO.	1188	294	223
DATATYPE	PRECIP	PRECIP	PRECIP
UNITS	IN	IN	IN
05-07-98	0.00	0.00	0.00
05-08-98	0.00	0.00	0.00
05-09-98	0.00	0.00	0.00
05-10-98	0.00	0.00	0.00
05-11-98	0.00	0.00	0.00
05-12-98			
1600	0.00	0.00	0.00
1530	0.16	0.08	0.24
1500	0.20	0.12	0.08
1430	0.00	0.04	0.04
1400	0.00	0.00	0.00
TOTAL	0.36	0.24	0.36

Table 6-9. Rainfall data for sampling event 4.

6.10) Discussion

All my samples taken from the drain to the clarifiers were less then 0.5 ppb and all the samples from the exit port were less then 0.5 ppb, well below applicable Maximum Contaminant Levels (MCLs). This would indicate either the clarifier was not working properly or the BTEX levels were below the clarifiers capacity to separate them out.The samples were taken from a modern Retail Gasoline Outlet built in the current year (1998) and subject to all the current Best Management Practices. Furthermore I took samples from a separate location in the stations parking lot before and after each sampling event and those samples were also less then 0.5 ppb, well below applicable MCLs. The constant presence of visible gasoline sheens from the fuel dispension area and parking lot area were suspect, but the data indicates that there was no measurable difference between the two and more importantly, both were well below applicable MCLs.

7) CONCLUSIONS

I have spent the last 8 months studying articles, books, internet sites, and other studies done on stormwater runoff and petroleum hydrocarbons. I have also visited numerous Retail Gasoline Outlets during storm events ranging from mild to extreme.I have carefully observed stormwater movement and how the structural Best Management Practices perform in the field under real world conditions. I have conducted my own sampling on three separate occasions and had those samples tested at a certified lab for the presence of BTEX hydrocarbons. My literature review focused on studies done on the presence of petroleum hydrocarbons taken from various locations such as channels, rivers, streams from many cities across the U.S and the common consensus is that BTEX hydrocarbons are almost always present in samples, but they are usually in low concentration levels. Here in Orange County, California the Orange County Water District operates one of the most modern and admired systems in the world. This region is also one of the most heavily developed urban, industrial, commercial, and automobile dependent regions in the country. A system of monitoring wells provides data on the regions water quality year round and other water agencies perform similar monitoring. BTEX hydrocarbons have been found in high concentration levels in shallow aquifers here but, the deeper primary drinking water aquifers are well below applicable MCLs.The main reason for this is BTEXs affinity to biodegradion. My studies have indicated that most of the data still points toward leaking underground fuel tanks as the primary source of this contamination. The one possible exception could be the gasoline additive MTBE. It has begun to rise in concentration levels in various locations throughout California, but because MTBEs use is somewhat new to the region, there is not much data on its presence and has stirred new debate about its routes of entry to the regions surface and subsurface waters.

My study of the structural BMPs required for all new and renovated gas stations, brings me to the conclusion that the best way to keep spilled gasoline out of the stormwater system is to keep the spilled fuel from being carried from the fuel dispension area to the surrounding parking area where it can then enter the stormwater system. This means either intercepting and treating stormwater runoff as it leaves the fuel dispension area with a clarifier (S11 Requirement) or minimizing the amount of stormwater that gets onto the fuel dispension area or both. All the stations used in this study employed the "both" scenario. My observations of the use of a clarifier at my five stations yielded the following:

1) The stations I studied all used a different type of system. I never got any designs, prints, or specifics about the clarifier systems used but I carefully inspected all five sites and found only one clarifier system that seemed to mechanically treat for BTEX hydrocarbons (see page 49). Two stations used a system that appears as a collection pit with a two inch plastic pipe leading from the side of the pit and then underground across to the curb where it releases water at the street (see pages 39 & 40). Another station used an underground 550 gallon holding tank (see page 46).

2) The locations of the drains were an important part of the system. When the drain is located outside the protective cover of the canopy such as sites A and E, they overflow. When the drain is located on the edge of the fuel dispension area or connected with gullies, excess water accumulated in them as well, sites B and D.

3) When excess stormwater from unnecessary sources such as gullies, direct rainfall, and parking lot runoff reached the drain a dilution effect occurs. The only drain location that I felt minimized all sources of possible unnecessary stormwater entry was site C (see page 43).

4) Another problem I observed was a lack of clarifier maintenance. I visited site E in early November of 1997 and the tank was full and overflowing to the street. I visited it again three more times in the next three months and it was still full. I also observed site B from the first day it opened. During the first storm event I observed in January, I placed a penny in the debris trap. I sampled the station for the last time in May and the penny was still there.

I believe it would be better to improve upon the use of structural BMPS such as an enlarged canopy with sharp edges that extends at least five feet over the fuel dispension area on all four sides. Grading that effectively keeps any parking lot runoff from flowing on to the fuel dispension area. The need for a clarifier could then be more affectivly studied.

In the Sampling portion of my study (chapter 6) the drain and the exit port of the clarifier were sampled for the presence of BTEX hydrocarbons. I also took a sample from the surrounding parking lot area. When the samples were tested the data showed that there was no measurable differences between all three sampled areas. All were less then 0.5 ppb for BTEX and 10 ppb for MTBE. Furthermore, all these samples were well below applicable MCLs. These conclusions also reflex similar conclusions from a previous study in the region where stormwater samples were collected and analyzed from retail gasoline stations and compared with commercial parking lots (chapter 5).

I believe there is one other important comment in regards to the lack of a measurable difference in BTEX hydrocarbons from the drain and the exit port of the clarifier. For sampling events 2, 3, and 4 of this study. The stormwater entering the drain to the clarifier received direct rainfall and drippings from the edges of the canopy. This could have had a dilution effect on the fuel dispension area runoff entering the drain and been partially responsible for the less then 0.5 ppb readings from the analysis. The same 0.5 ppb readings at the exit port were probably well below what the clarifier was capable of treating. The parking lot sample was taken well away from the fuel dispension area, but may have been affected by direct rainfall as well.

Related subjects for further study:

The effectiveness of non structural Best Management Practices: this study focused on evaluating the effectiveness of structural Best Management Practices and sampling for the presence of petroleum hydrocarbons by utilizing the stations clarifier system (S11 requirement). See appendix C for a list of currently required structural Best Management Practices and appendix B for a list of currently required non structural Best Management Practices.

The first flush effect: the wet season for the Orange County California region was accompanied by one of the strongest El Nino events in recent history. Areas of Orange County received an average rainfall of approximately 30 inches. My sampling did not begin until March of 1998 This was well into the rainy season for this region. The extended forecast for the next season in Orange County is for a possible La Nina effect (the opposite of an El Nino effect). A sampling of the first storm event of the next rainy season and a few of the following stormevents may yield different results than the results I got by sampling the late season storm events.

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APPENDIX A

Definitions (pursuant to RGOs)

1) "County" shall mean the County of Orange, California.

2) "Co-Permittee" shall mean the County, the Orange County Flood Control District, and all the municipalities within Orange County which are responsible for compliance with the terms of the NPDES permit.

3) "DAMP" shall mean the Orange County Drainage Area Management Plan, as the same may be amended from time to time.

4) "Development Project Guidance" shall mean Damp Chapter 7 and the Appendix there to, entitled Best Management Practices (BMPs) for new development including non-residential construction projects and all subsequent amendments thereto. This includes all Retail Gasoline Outlets.

5) "Discharge" shall mean any release, spill, leak, pump, flow, escape, leaching (including subsurface migration or deposition to groundwater), dumping or disposal of any liquid, semi-solid or solid substance.

6) "pollutant" shall mean any liquid, solid, or semi solid substance or combination thereof, included and not limited to:

a) Artificial materials (such as floatable plastics, wood products or metal shavings, trash and paper wastes.

b) Petroleum and related hydrocarbons (such as fuels, lubricants, surfactants, waste oils, solvents, coolants and grease.

c) Metals and non-metal compounds (such as lead, cadmium, zinc, copper, chromium and nickel) with characteristics which cause an adverse effect on living organisms.

d) Substances having a ph less then 6.5 or greater then 8.6, or unusual coloration, turbidity or odor.

7) "Renovation" shall mean the rehabilitation or reconstruction of a retail structure, for which either a discretionary land use approval, grading permit, building permit or non-residential plumbing permit is required.

8) "Storm Water Drainage System" shall mean street gutter, channel, storm drain, constructed drain, lined diversion structure, wash area, inlet, outlet to other facility, which is a part of a tributary to the county-wide stormwater runoff system and owned, operated, maintained or controlled by the County of Orange, the Orange County Flood Control District or any Co-Permittee City, and used for the purpose of collecting, storing, transporting, or disposing of stormwater (Office of County Council Orange County, Article 1).

APPENDIX B

Required Non-Structural BMPs for RGOs

N2. Activity Restrictions: If a Property Owners Association (POA) is formed, conditions, covenants, and restrictions shall be prepared by the developer for the purpose of surface water quality protection. Alternatively, use restrictions may be developed by a building operator through lease terms, ect.

N4. BMP Maintenance: Identification of responsibility for implementation of each non structural BMP and scheduled cleaning of all BMP structural facilities.

N5. Title 22 CCR Compliance: Compliance with Title 22 of the California Code of Regulations and relevant sections of the California Health and Safety Code regarding hazardous waste management, to be enforced by County Environmental Health on behalf of the State.

N6. Local Industrial Permit Compliance: Provides for clean storm water discharge from fuel dispensing areas, and requires permission to discharge industrial waste to public properties.

N7. Spill Contingency Plan: Prepared by building operator for use by specific types of building or suite occupancies (County Environmental Health has provided a list to the County Plan Check, as an example), and which mandates stockpiling of cleanup materials, notification of responsible agencies, disposal of cleanup materials, documentation, ect. An Accident Spill Plan is needed for restaurants, warehouses or grocery stores.

N8. Underground Storage Tank Compliance: Compliance with State regulations dealing with underground storage tanks, enforced by County Environmental Health on behalf of the State.

N9. Hazardous Materials Disclosure Compliance: Compliance with County and comparable City ordinances typically enforced by respective fire protection agency.

N10. Uniform Fire Code Implementation: Compliance with Article 80 of the Uniform Fire Code enforced by fire protection agency.

N11. Common Area Litter Control: For development with POAs, the POA will be required to implement trash management and litter control procedures in the common areas aimed at reducing pollution of drainage water. The Associations may contract with their landscape maintenance firms to provide this service during regularly scheduled maintenance, which should consist of litter patrol, emptying of trash receptacles in common areas, and noting trash disposal violations by homeowners or businesses and reporting the violations to the association for investigation.

N12. Employee Training: Education program (see N1) as it would apply to future employees of individual businesses. Developer either prepares manuals for initial purchasers of business site or for development that is constructed for an unspecified use makes commitment on half of POA to prepare.

N14. Common Area Catch Basin Inspection: For developments with POAs and privately maintained drainage systems, require the association to have privately owned catch basins inspected and, if necessary, cleaned prior to the storm system, no later then October 15th each year.

N15. Street Sweeping Private Streets and Parking Lots: For developments with POAs and privately streets and parking lots, require the streets and parking lots be swept prior to the storm season, no later than October 15th each year. Also applicable to developments with no POAs.

APPENDIX C

Required Routine Structural BMPs for RGOs.

S6. Trash Container (Dumpster) Areas: Trash container (dumpster) areas to have drainage from adjoining roofs and pavements diverted around the areas, and:

A. For trash container associated with fuel dispensing, vehicle repair/maintenance, and industry, such areas are to be roofed over or drained to a water quality inlet (see S16), engineered infiltration/filtration system, or equally effective alternative.

B. For trash container areas associated with restaurants and warehouse/grocery operations such areas are to be screened or walled to prevent off site transport of trash.

S9. Motor Fuel Dispensing Area Canopy: Areas used for fuel dispensing shall be paved with concrete (no use of asphalt). Concrete surfacing to extend 6.5 feet from the corner of each fuel dispenser in any direction. This distance may be reduced to or the maximum length that the fuel dispensing hose and nozzle assembly may be operated in any direction plus one foot. In addition, the fuel dispensing area shall be graded and constructed so as to prevent drainage flow either through or from the fuel dispensing area (also see S11).

S10. Motor Fuel Dispensing Area Canopy: All motor fuel concrete dispensing areas are to have a canopy structure for weather protection, extending over the motor fuel concrete fuel dispensing area as defined in No. 9.

S11. Motor Fuel Concrete Dispensing Area Interruptable: Drainage: The concrete motor fuel dispensing area will be graded and constructed so as to drain to an underground clarifier/sump/tank equipped with a shut off valve that can stop the further draining or stormwater or spilled material there from into the street or storm drain system. Spills will be immediately cleaned up according to spill contingency plan.

S13. Catch Basin Stenciling: Phrase "No Dumping Drains To Ocean", to be stenciled on catch basins to avert the public to the destination of pollutants discharged into stormwater.

S16. Water Quality Inlets: Water Quality inlets designed to remove free phase liquid petroleum compounds, grease, floatable debris, and settleable solids can be used in the following applications: S6, S8, S14.

(Orange County NPDES Clean Stormwater Program)

CONCENTRATIONS OF SELECTED CONSTITUENTS IN RUNOFF FROM IMPERVIOUS SURFACES IN FOUR URBAN CATCHMENTS OF DIFFERENT LAND USE

by

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ABSTRACT

Urban stormwater has been identified as a major contributor of various pollutants to the surface waters of the nation. Recent efforts to determine the sources of these pollutants have included investigations into the effects of land use on stormwater quality, particularly in runoff from impervious surfaces. A fifteen month field study of urban stormwater runoff was begun in September, 1992 in the Washington, D.C. metropolitan area, with the primary objective of investigating the nature of urban runoff from impervious surfaces in different urban land uses. Four small catchments, including an office parking area, a commercial fueling station, a fast food restaurant parking lot, and a single family residential street were included in the study. Passive runoff sampling equipment was used to collect flow-composited stormwater samples for a total of 123 events. Stormwater runoff samples were analyzed for 17 constituents, including nutrients, aggregate organic materials, and trace metals. Samples were characterized in terms of event mean concentrations (EMCs) Where possible, EMCS were compared to data from the Nationwide Urban Runoff Program.

INTRODUCTION

In the United States, studies of the significance of urban stormwater runoff have been included in efforts to improve water quality for over two decades. The most widely cited of these was undertaken nearly twenty years ago when the Environmental Protection Agency (EPA) established the Nationwide Urban Runoff Program NXJRP (EPA, 1983). During the 5 year study, runoff data from 29 different cities and 2300 storm runoff events was compiled and analyzed. A comprehensive national study of similar magnitude has not been performed since NURP. However, stormwater runoff, associated water quality impacts, and monitoring needs continue to be studied and identified.

This paper describes an 18 month study which began in September, 1992 in the Washington Metropolitan area. Four field monitoring stations were constructed and installed to collect flow-weighted stormwater runoff samples from urban catchments of different land uses. A total of 123 events were sampled and analyzed for selected constituents.

STUDY METHODS

All four monitoring stations were constructed in catchments located within a 16 km radius of the Capitol Building in Washington, D.C., and were located either in the District of Columbia or the nearby Maryland suburbs. The catchments were selected so that all of the drainage area consisted of impervious surfaces. In addition, the catchments were chosen to represent different land use types, including a daily parking lot, a gasoline station fueling pad, a residential street, and a fast-food chain restaurant parking lot.

Station HL10 The field site for HL10 was located on the grounds of the United States (U.S.) National Arboretum in the northeast quadrant of the District of Columbia The monitored portion of the staff parking lot drained 1300 square meters (m'), and was constructed primarily of bituminous concrete with a portland cement concrete curb and gutter. The surrounding area was lightly wooded with a variety of ornamental shrubs.

Station HL20 Station HL20 was located at a gasoline station near U.S. Route 1 in Laurel, Maryland. The 883 m2 catchment consisted of a fueling area canopy, convenience store roof, portland cement concrete fueling pads, and bituminous concrete driveways.

Station HL30 The field site for station HL30 consisted of a block of residential street located in northeast Washington, D.C.. A stable residential neighborhood and elementary school surrounded the 650 m2 drainage area. The slope was approximately 15%, with bitutninous concrete paving and portland cement concrete curb and gutter.

Station HL40. Station HL40 received stormwater runoff from a fast food chain restaurant parking lot located in Takoma Park, Maryland. The site drainage area was 502 m2, consisted of a bituminous concrete surface, and included a solid waste storage and pickup area. The slope of the parking area was found to be approximately 10 percent.

Monitoring Station Design and Installation. Each station was designed to accommodate a 0.15 m type-H flume mated to a Model N-l Coshocton Wheel (USDA, 1979) fitted with a multi-slot splitting device, which provided a runoff collection volume of 1/1000th of the generated flow. The sample thus collected during a runoff event was continuously composited and flow-weighted, thereby taking on the constituent concentration characteristics of the entire storm flow. The analytical results of such a sample may then be expressed as Event Mean Concentrations (EMCs) for the constituents of interest. The EMC, or some other statistic from a distribution of observed EMCS, **are**

taken as basic descriptors of urban stormwater runoff, and are commonly employed in comparisons of stormwater characteristics between sites. Roth tipping bucket and wedge rain gages were used for measurements of total catchment precipitation for each event.

Sample Collection. Staff monitored National Weather Service (NWS) radio reports to determine the probability of a suitable storm event. If a storm was likely to occur, the sites were prepared for sampling. After a storm event, runoff samples were collected and transported to the laboratory for further analysis.

Analytical Program and Methods. Collected samples were analyzed for 17 constituents, using commonly accepted methods (APHA, 1992; EPA, 1983 & 1986). All analyses were conducted in accordance with a formal quality assurance program, including where appropriate, the following activities:

- Instrument calibration curve
- Duplicate analysis to assess precision
- Matrix spike to measure recovery
- Field and trip blank analysis

Statistical Analysis. In order to determine the similarities and/or differences in characteristics of runoff from the impervious surfaces in the monitored catchments, a non-parametric statistical method was employed. Nonparametric, or distribution free, methods are commonly used in the analysis of data from populations which are not normally distributed, or whose underlying distributions are simply unkown. It is commonly found that rainfall-runoff datasets are not normally distributed, and further, that nonpoint pollution export characteristics that arise from catchment response to rainfall inputs are similarly non-normal. For this reason, the Kruskal-Wallis test for differences between sample statistics drawn from multiple was performed on each constituent data sets (Sokal and Rohlf, 1969). The null hypothesis, Ho, for this current study was that no significant difference existed between constituent EMCS in stormwater runoff from the impervious surfaces sampled.

RESULTS AND DISCUSSION

EMCS were determined for each constituent and used in the determination of summary statistics, including minimum (MIN), maximum (MAX), and median (MED), which are shown in Table 1. The results from the Kruskal-Wallis test have also been presented in Table 1. Where the null hypothesis was rejected, the table block corresponding to the appropriate constituent abbreviations has been highlighted, indicating that at the 0.05 significance level, at least one of the runoff EMC populations was different from the others. Comparisons of observed EMC statistics to those reported in the NURP dataset (EPA, 1983) for residential, commercial, and mixed urban land uses have been presented in the discussion where appropriate.

In general, the analytical and statistical results for all stations were thought to have been greatly influenced by site physical characteristics. Each station appeared to have distinct physical features that influenced the incident rainfall volume and intensity, thereby affecting the ultimate constituent concentrations. For example, tree foliage surrounding HL10 while not affecting total rainfall, reduced its impact energy by interception. Similarly, the fueling canopy at HL20 was found to reduce rainfall impact energy, and also to direct flow to a limited portion of the overall catchment surface.

The physical site characteristics thought to influence runoff flow rates at HL30 and HL40 were somewhat different than the previous station pair HL10 and hl20) The catchment drainage areas for hl30 and HL40 displayed relatively steep slopes, of 9% and 10% respectively. It is likely that this caused higher runoff veloticities, and the resulting increase in kinetic energy was sufficient to detach and suspend more particulate matter.

Sediment and Turbidity. As may be seen by the distribution of summary values in Table 1, turbidity and TSS EMCs were generally low. The median turbidity EMCs ranged from 4.0 NTU at HIJO to 13.0 NTU at HL30 The TSS median EMCS displayed a similar trend, with the lowest observed at HL10 (1.0 mg/L) and the highest at HL30 (43 mg/L).

Comparisons of TSS EMCSto thosfrom NURP EPA 1983)are shown inFigure l,and it may be seen that the current study values were much lower. In interpreting this, it must be remembered that NURP catchments generally contained both pervious and impervious surfaces, whereas the current study surfaces were completely impervious.

Nutrients. As shown in Table 1, median EMC values for OP were generally low at all four stations, ranging from 0.03 to 0.06 mg/L. The site with the lowest vehicular activity and lowest slope exhibited the lowest TP EMC (0.05 mg/l)while the remaining three stations had EMC values ranging from 0.15 to 0.37 mg/L.

Median NH,+-N EMCS ranged from 0.03 mg/L at HL20 to 0.28 mg/L at HL10 The corresponding values for TKN were substantially higher, with the lowest at HL10 (0.72 mg/L), and the greatest at HL30 (2.24 mg/L). Stations HL10 and HL20 had lower values of median TKN EMC, but conversely, also displayed higher values of median OX-N EMCS.

Comparisons of the TP median EMCS to NURP values showed mixed results, with stations HL30 and HL40 comparing well with the residential and mixed land use NURP (EPA, 1983) characterizations, respectively, as illustrated in Figure 2. The median EMC TP values for HL10 and HL20 were lower than those reported from NURP. The higher concentrations observed at HL30 and HL40 were thought to be due to a combination of steep slopes and also were affected by detergent washing practices on the lot at HL40

It should be noted that TP median EMCS from the current study, with the exception of HL10 all exceeded the EPA water quality criterion of 0.05 mg/L (1986) for the prevention of nuisance plant growth in streams and flowing waters.

comparisons of nitrogen median EMC values to those from NURP (EPA, 1983) were limited to TKN and OX-N, as shown in Figures 3 and 4. As shown in Figure 3, median TKN EMC values for the current study were slightly higher than those reported from NURP for the residential catchment (HL30), and for the fast food parking lot (HL40) when compared to the NURP commercial site data. Roth the HL10 and HL20 TKN EMCS were lower than any of the reported NURP values. The median JZMCS at HL30 and HL40 were at sufficiently high concentrations to possibly contribute some significant nitrogenous oxygen demand (NOD) in ultimate receiving waters.

Aggregate Organic Matter. Results from measurements of organic matter are presented in Table 1, and may be seen to display differing trends with respect to the median EMCs The highest median EMCs for COD were observed at HL20 (55.3 mg/L) and HL30 (53.2 mg/L). The highest median EMCS for TOC and DOC were observed at HL30 and HL40. Finally, the highest median EMCS for oil and grease were observed at HL20 and HL40.

The observed differences in occurrence of the highest median EMC values for aggregate organic measurements were thought to be largely due to analytical methods and site physical characteristics. Generally, the EMC values for all aggregate organic measurements from HL10 were lower than those from the other stations, and this may be largely explained by the low slope and the relatively low vehicular density. COD and organic carbon EMC values were quite similar at the remaining three stations. When the oil and grease measurement was used to estimate organic strength, however, a somewhat different comparison emerged. Stations HL20 and HL40 were observed to have EMC values substantially above those for HL10 and HL30. This was very likely due to the presence of higher concentrations of petroleum hydrocarbons in the runoff from the gasoline station, and of oils and greases from food preparation in the runoff from the solid waste handling area of the fast food parking lot. In addition, at the latter site, the parking lot was periodically cleaned with a high pressure water flow, which probably moved organic matter downslope and into closer proximity to the stormwater drain.

Limited organic measurements in the NURP (EPA, 1983) database made it possible to only conduct a comparison of EMC values for COD, as shown in Figure 5. In general, the median COD EMCS for the current study were less than those reported for NURP for all land use types. This may be due to the previously mentioned differences in catchment types. In the current study, the catchments were completely impervious, while the NURP catchments contained both pervious and impervious areas. It may, therefore, be speculatedthatsomeoftheobserved COD concentrations in the NURP database were due to organic matter originating from the pervious portion of the catchment.

A general depiction of the organic strength of the stormwater was provided by the current study results. In order to obtain a better assessment of the potential impact on the oxygen resources of a receiving water body, it would be necessary to have some degradation rate measurements. It should be noted, however, that all the COD EMCB were in a range that would be of some legitimate concern with respect to anticipated oxygen depletion.

Trace Metals. The extractable cadmium (Cd) dataset was highly censored, with more than half of the values at all sites were found to lie below the method quantitation limit (QL) of 1.0 µg/L. Because of this, the median station EMCS for the cadmium analyses presented in Table 1 may be seen to not only be identical, but also equal to the QL. The presence of cadmium in stormwater runoff is generally thought to be related to industrial activities, and the low level of such activity in the subject catchments may partially explain the low observed EMCS for cadmium.

The highest median EMC value for chromium was computed at HL20 (9.65 ug/L), and the lowest at HL10 (2.3 µg/L). The greater vehicular traffic density and associated brake wear probably contributed to the higher values observed at HL20. None of the median EMC values exceeded either the chronic or acute freshwater criteria (EPA, . 1986).

The highest median EMC for copper was found at HL30 (18.1 µg/L), and the lowest at HL10 (4 µg/L). The computed median EMCs at all stations either closely approached or exceeded the freshwater chronic exposure criterion. The median EMCs at HL20, HL30, and HL40 also exceeded the acute exposure criterion for copper (EPA, 1986). Because the area has little industrial activity, it may be speculated that the principal sources of copper in runoff from the stations monitored were related to vehicle operation.

Lead concentrations in urban stormwater have been historically associated with fossil fuel combustion (space heating and internal combustion engines), tire wear, and lubricating oils and greases. As would have been expected from knowledge of the vehicular associations of the potential sources, the highest median EMCS for lead were observed at stations HL20 (14.0 µg/L) and HL30 (14.8 µg/L). At HL20, the sources may be logically attributed to high traffic densities, and concentrated sources. At HL30, however, the higher EMCS may have been related to more effective removal of particulates in runoff from the higher slopes. The lowest value, which was observed at HL10 (5.4 µg/L), was consistent with the low site slope and vehicular traffic When compared with the freshwater chronic and acute water quality criteria, the median lead EMC values exceeded the former at all stations, and approached the latter at HL20 and HL30 (EPA, 1983).

The high median EMC values of zinc (Zn) shown in Table 1 illustrate the ubiquity of the metal in the environment. The greatest value was observed at HL30 (212 µg/L), and the lowest at HL10 (79 mg/L). Given that zinc concentrations in stormwater have also been related to vehicular activities, it was surprising that the highest value was not observed at HL20 (159 µg/L), where traffic flow and activity was greatest. It was probable that the slightly larger value observed at HL30 was again an artifact of high catchment slope, and not land use. The median EMC values for zinc were less than the chronic water quality criterion at HL10, and exceeded both the chronic and acute water quality criteria at HL20, HL30, and HL40 (EPA, 1986).

Comparisons of the current study median EMCS to those from NURP have been presented in Figures 6,7, and 8 for the trace metals copper, lead, and zinc, respectively. In general, the median EMC values reported for copper and lead in the current study were significantly less than those reported by NURP. In the case of lead, this is explained by the almost complete transition to unleaded fuels in the years since NURP. The reasons for the lower observed copper concentrations are less clear. In the case of zinc, the median EMC values for the current study were observed to be comparable to those reported in NURP, with the possible exception of HL10, which displayed zinc EMC values that were substantially lower than those in the NuRp data (EPA, 1983).

SUMMARY

Physical site characteristics played a key role in determining the runoff quantity and EMCs of the constituents monitored. Because of the dramatic slope differences between catchments, it was often difficult to isolate the effects of land use on constituent EMCs

Stormwater runoff EMCs from the impervious urban surfaces monitored were compared to those reported from NURP (EPA, 1983) and the following general observations made:

Suspended sediment EMCS were generally lower than those previously reported in the NURP database. This was speculated to be related to influences of detached material from pervious surfaces in the NURP catchments.

With the eXCeptiOn Of the lOW aCtiVityflOW slope she at HL10, TP EMUS from this study had similar ranges to those reported from similar land uses in NURP. All TP EMCS were at concentrations above those desired in free flowing receiving waters.

EMCS for nitrogen forms in the current study were similar to those reported in the NURP data. Reduced nitrogen (TKN) form EMCS were sufficiently high to raise some question with respect to exertion of NOD in receiving waters.

Aggregate organics EMCS from the current study were generally found to be lower than those reported in NuRp. However, concentrations of COD were still sufficiently high raise some question about exertion of oxygen demand in receiving waters.

Trace metals EMCS were found to exceed either chronic or acute water quality criteria in the cases of copper, lead, and zinc. In the case of copper, EMCS from the current study were generally found to be lower than those reported in NURP. For lead, the same observation was made, and was concluded to be a result of the almost complete elimination of leaded motor fuel use in the U.S. For zinc, EMCS from the current study were found to be comparable to those reported in NURP.

Table 1. Summary statisticsfrom analysis of collected runoff samples.

	stations											
	HL10			HL20			HI30			HL40		
	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX	MIN	MED	MAX
TURB	2.1	3.95	600	4.4	8.0	31	3.9	13.0	170	3.7	10.0	40
TSS	1.0	10.6	271	12.8	38	88	15.3	43	250	8.7	20.8	109
OP	0.01	0.04	0.2	0.01	0.03	0.14	0.01	0.06	0.21	0.01	0.06	0.4
TP	0.02	0.05	1.49)	0.06	0.15	0.420	0.11	0.37	0.73)	0.11	0.27	1.67
NH_3-N^+	0.01	0.28	3.4	0.01	0.03	D.44	0.01	0.11	0.87	0'01	0.02	0.95
TKN	0.19	0.72	21.8	0.40	0.91	6.21	0.89	2.24	8.20	0.74	1.94	6.80
OX-N	0.26	0.82	2.65	0.42	0.79	1.68	0.20	0.46	2.26	0.03	0.28	1.47
COD	11.3	22.5	48.0	17.3	55.3	86.4	35.9	53.2	101	30.4	35.9	98.9
DOC	2.2	5.1	24.7	5.8	8.5	11.0	8.4	8.5	15.5	5.3	12.2	17.0
TOC	2.9	6.0	111	4.8	11.4	20.4	9.1	14.7	36.2	5.3	18.6	184
OIL_GR	0.3	0.7	2.4	1.2	4.2	5.5	0.8	1.9	4.7	2.7	7.0	5.6
ECD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ECR	1.0	2.3	119	0.70	9.65	23.6	1.0	4.7	20.2	1.0	2.0	2123
ECU	2.0	4.0	76.6	2.6	7.15	25.7	6.6	18.1	36.3	3.0	10.2	82.1
[illegible]	4.0	5.4	29.6	4.0	14.0	48.5	11.3	14.8	213	4.0	6.9	49.4
EZN	23.0	79	467	60.0	159	650	99.0	212	306	29.0	144	852
pllm	4.0	15.5	43.0	22.0	36.0	114	16.0	33.0	47.0	13.0	34.0	114

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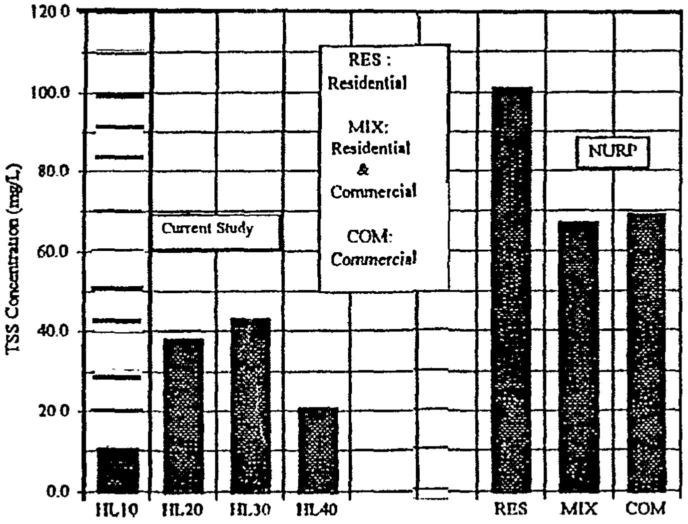


Figure 1. Current study and NURP (EPA, 1983) median TSS values.

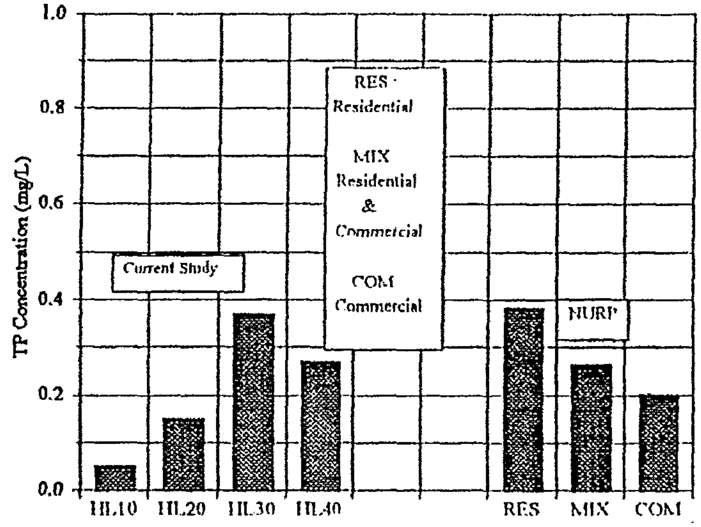


Figure 2. Current study and NURP (EPA, 1983) median TP values.

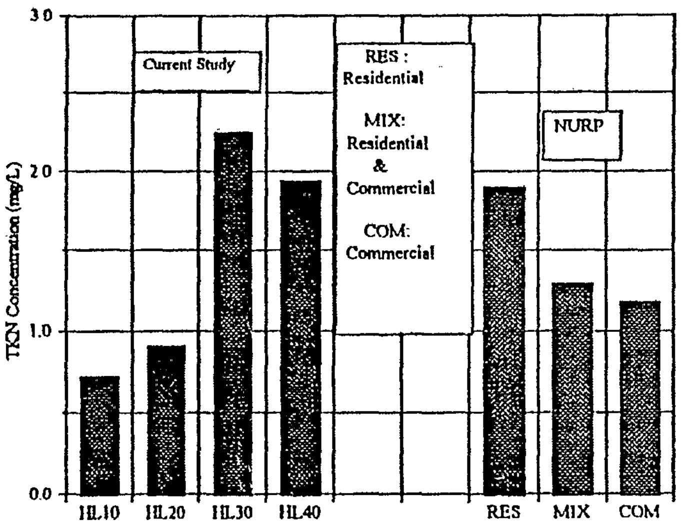


Figure 3. Current study and NURP (EPA, 1983) median TKN values

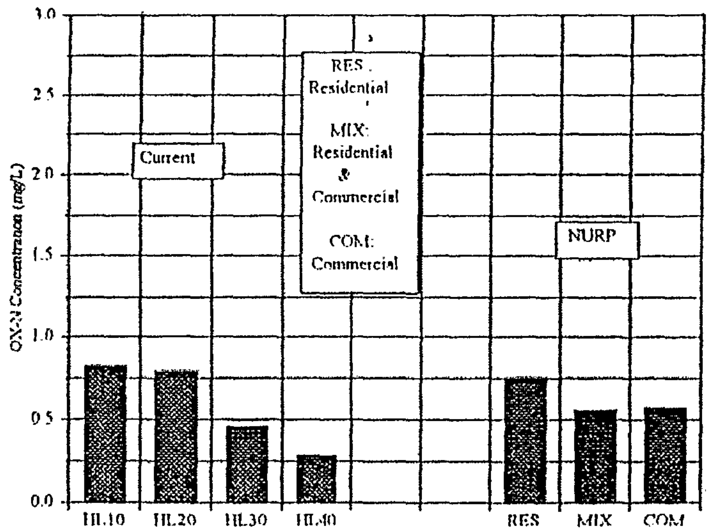
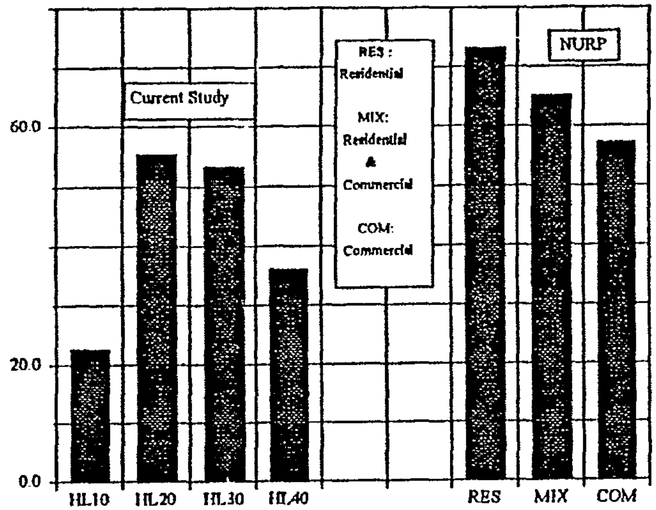


Figure 4. Current study and NURP (EPA, 1983) median OX-N values.



Current study and NURP (EPA, 1983) median COD values

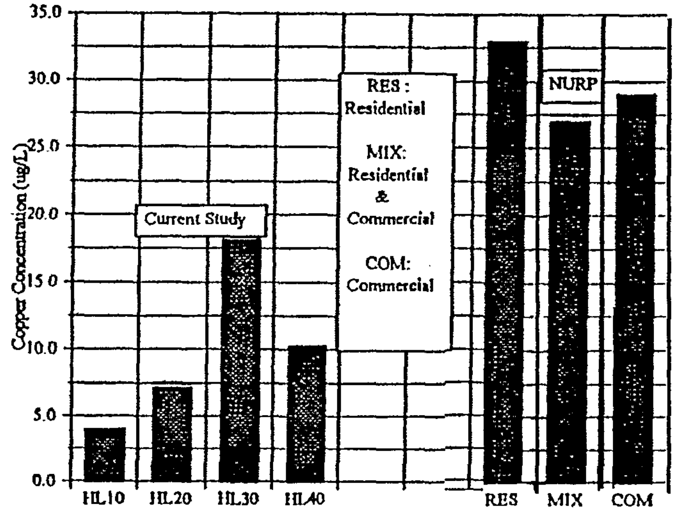


Figure 6 . Current study and NURP (EPA, 1983) median copper values.

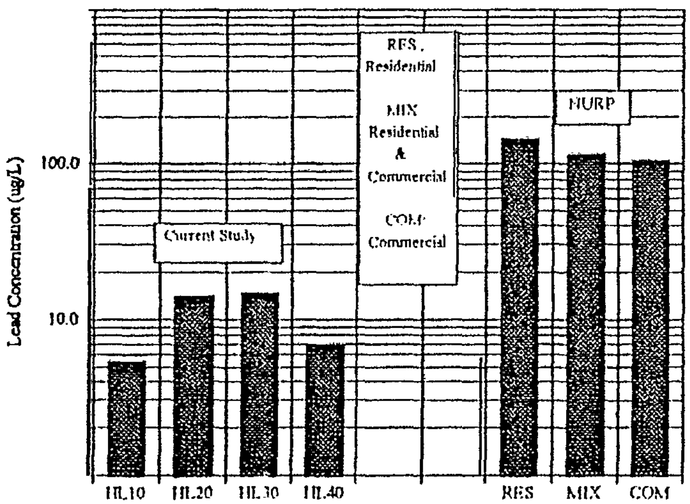
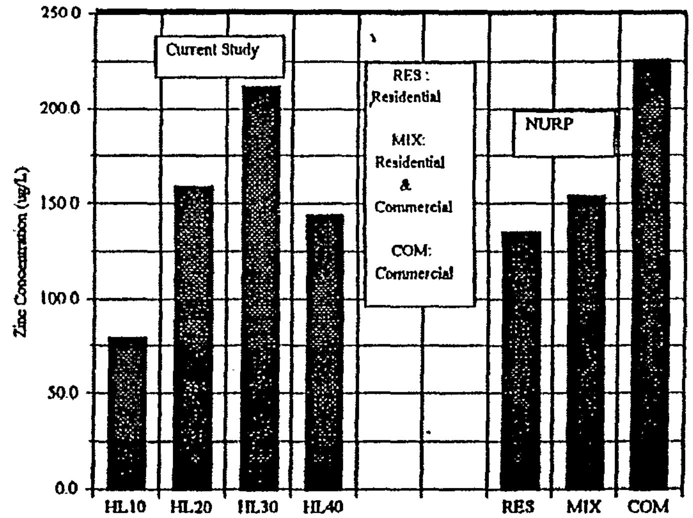


Figure 7. Current : ' ' ' ' IURP (EPA, 1983) median l_ _l values.



) median Zinc Values.

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U.S. Department of the Interior
U.S. Geological Survey

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Open-File Report 98-409

A Contribution to the
National Highway Runoff Data and Methodology Synthesis

U.S. Department
of Transportation

USGS
science for a changing world

U.S. Department of the Interior
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A Review of Semivolatile and Volatile Organic Compounds in Highway Runoff and Urban Stormwater

By THOMAS J. LOPES and SHANNON G. DIONNE

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PREFACE

Knowledge of the characteristics of highway runoff (concentrations and loads of constituents and the physical and chemical processes which produce this runoff) is important for decision makers, planners, and highway engineers to assess and mitigate possible adverse-impacts of highway runoff on the Nation's receiving waters. In October, 1996, the Federal Highway Administration and the U.S. Geological Survey began the National Highway Runoff Data and Methodology Synthesis to provide a catalog of the pertinent information available; to define the necessary documentation to determine if data are valid (useful for intended purposes), current, and technically supportable; and to evaluate available sources in terms of current and foreseeable information needs. This paper is one contribution to the National Highway Runoff Data and Methodology Synthesis and is being made available as a U.S. Geological Survey Open-File Report pending its inclusion in a volume or series to be published by the Federal Highway Administration. More information about this project is available on the World Wide Web at http://mass1.er.usgs.gov/fhwa/runwater.htm

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

NOTE: Volumes greater than 1000 l shall be shown in m^3.

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

A Review of Semivolatile and Volatile Organic Compounds in Highway Runoff and Urban Stormwater

By Thomas J. Lopes *and* Shannon G. Dionne

Abstract

Many studies have been conducted since 1970 to characterize concentrations of semivolatile organic compounds (SVOCs) in highway runoff and urban stormwater. To a lesser extent, studies also have characterized concentrations of volatile organic compounds (VOCs), estimated loads of SVOCs, and assessed potential impacts of these contaminants on receiving streams. This review evaluates the quality of existing data on SVOCs and VOCs in highway runoff and urban storm–water and summarizes significant findings. Studies related to highways are emphasized when possible. The review included 44 articles and reports that focused primarily on SVOCs and VOCs. Only 17 of these publications are related to highways, and 5 of these 17 are themselves review papers. SVOCs in urban stormwater and sediments during the late 1970's to mid-1980's were the subject of most studies.

Criteria used to evaluate data quality included documentation of sampling protocols, analytical methods, minimum reporting limit (MRL) or method detection limit (MDL), quality-assurance protocols, and quality-control samples. The largest deficiency in documenting data quality was that only 10 percent of the studies described where water samples were collected in the stream cross section. About 80 percent of SVOCs in runoff are in the suspended solids. Because suspended solids can vary significantly even in narrow channels, concentrations from discrete point samples and contaminant loads estimated from those samples are questionable without information on sample location or how well streamflow was mixed. Thirty percent or fewer of the studies documented the MRL, MDL, cleaning of samplers, or use of field quality-control samples. Comparing results of different studies and evaluating the quality of environmental data, especially for samples with low concentrations, is difficult without this information.

The most significant factor affecting SVOC concentrations in water is suspended solids concentration. In sediment, the most significant factors affecting SVOC concentrations are organic carbon content and distance from sources such as highways and power plants. Petroleum hydrocarbons, oil and grease, and polycyclic aromatic hydrocarbons (PAHs) in crankcase oil and vehicle emissions are the major SVOCs detected in highway runoff and urban stormwater.

The few loading factors and regression equations that were developed in the 1970's and 1980's have limited use in estimating current (1998) loads of SVOCs on a national scale. These factors and equations are based on few data and use inconsistent units, and some are independent of rainfall. Also, more cars on the road today have catalytic converters, and fuels that were used in 1998 are cleaner than when loading factors and regression equations were developed.

Comparisons to water-quality and sediment-quality criteria and guidelines indicate that PAHs, phenolic compounds, and phthalates in runoff and sediment exceeded U.S. Environmental Protection Agency drinking-water and aquatic-life standards and guidelines. PAHs in stream sediments adjacent to highways have the highest potential for adverse effects on receiving streams.

Few data exist on VOCs in highway runoff. VOCs were detected in precipitation adjacent to a highway in England, and chloromethane, toluene, xylenes, 1,2,4-trimethylbenzene, and 1,2,3-trichloropropane were detected in runoff from a highway in Texas. In urban stormwater, gasoline-related compounds were detected in as many as 23 percent of the samples. Land use could be the most significant factor affecting the occurrence of VOCs, with highest concentrations of VOCs found in industrial areas. Temperature is another factor affecting the occurrence and concentrations of VOCs. Urban land surfaces are the primary nonpoint source of VOCs in stormwater. However, the atmosphere is a potential source of hydrophilic VOCs in stormwater, especially during cold seasons when partitioning of VOCs from air into water is greatest. Tetrachloroethene, dichloromethane, and benzene were the only VOCs detected in stormwater that exceeded U.S. Environmental Protection Agency drinking-water standards.

INTRODUCTION

Runoff from highways and urban areas has long been recognized as a source of contaminants that could affect the Nation's water resources. Federal, State, and local agencies and universities have conducted or sponsored research since about 1970 to characterize runoff quality, estimate contaminant loads, and assess impacts on receiving streams. Sampling protocols, analytical methods and detection limits, and quality-assurance/quality-control (QA/QC) protocols have improved during this time. In addition, new contaminants are being released into the environment, more is known about their toxic effects, and water-quality criteria for contaminants have been established or changed. In light of these changes, highway-runoff and urban-stormwater studies need to be periodically reviewed for quality of data and whether the results address current water-quality issues.

Semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs) are two groups of contaminants that have been measured in runoff from highways and urban areas. SVOCs are operationally defined as solvent-extractable organic compounds that can be determined by gas chromatography/mass spectrometry (GC/MS) (Furlong and others, 1996). Examples of SVOCs include phthalates, phenols, and polycyclic aromatic hydrocarbons (PAHs). Smith and others (1988) reviewed the sources of several types of SVOCs and processes affecting their fate and distribution in surface water. SVOCs are present in many products, including plastics, dyes, and disinfectants, and PAHs are produced by burning gasoline, oil, wood, and other fuels. SVOCs typically are hydrophobic and by definition have a moderate tendency to volatilize (Karickhoff and others, 1979; Lucius and others, 1989). These properties control how SVOCs are distributed among air, water, and soil when released into the environment. Because they are hydrophobic and moderately volatile, SVOCs preferentially distribute into organic phases, such as tissue and sediments containing organic carbon (Witkowski and others, 1987; Smith and others, 1988).

SVOCs are an environmentally significant group of contaminants because they may accumulate to concentrations that will adversely affect aquatic organisms. Benthic organisms that live in contaminated sediment are most affected because sediments have the largest fraction of SVOCs; however, organisms that feed on benthic species also may be affected. Adverse effects could include mortality, reduced fecundity, and inhibited or abnormal growth. Recently, scientists have become aware of compounds that disrupt the endocrine system and reproduction of fish, reptiles, and mammals (Colborn and others, 1993). Endocrine disruption occurs when a compound either mimics natural hormones or blocks their function. Certain phthalates and PAHs are among the organic compounds that cause endocrine disruption, although their effect is weaker than the effect of some pesticides. In a national survey, concentrations of phenols in bottom sediment were found to correlate with concentrations of 11-ketotestosterone in male carp at an alpha-level of 0.05, suggesting these SVOCs also could cause endocrine disruption (Goodbred and others, 1997).

VOCs are operationally defined as organic compounds that can be extracted from water by purging with an inert gas, then trapped and determined by GC/MS (Connor and others, 1998). VOCs are present in many products including fuels, solvents, refrigerants, paints, adhesives, and deodorants. VOCs also are present in vehicle exhaust and chlorinated water. In contrast to SVOCs, VOCs can be either hydrophobic or hydrophilic, have a high tendency to volatilize, and distribute preferentially into air because of their volatility.

VOCs have low aquatic toxicity (Rowe and others, 1997). Except for spills, concentrations found in highway runoff and urban stormwater are too low to cause a toxic response in aquatic species. However, VOCs in highway runoff and urban stormwater could enter drinking-water supplies and have chronic effects on the consumers. For example, ground water in Tucson, Arizona, was contaminated with low concentrations of VOCs in urban stormwater (Pritt and others, 1996).

Objectives and Scope

The objectives of this review are to evaluate the quality of existing data on SVOCs and VOCs and to summarize significant findings. This is not an exhaustive review of all studies that contain information on SVOCs and VOCs, but a review of studies that focused primarily on SVOCs and VOCs in highway runoff, urban stormwater, precipitation, and sediments. Studies related to highway runoff are emphasized when possible. Measures of extractable organic compounds, such as petroleum hydrocarbons and oil and grease, are included in the discussion of SVOCs, but pesticides and polychlorinated biphenyls are not within the scope of this report.

A total of 44 articles and reports published between 1976 to 1998 were reviewed. Only 17 of these publications were related to highways, and 5 of these 17 are themselves review papers. SVOCs in urban stormwater and sediments were the subjects of most studies.

Criteria for Data Quality

Studies done since 1970 are useful if they were documented such that the quality, interpretations, and limits of the data can be qualified. Documentation should be able to answer several important questions, such as: Where, when, and how were samples collected? What analytical methods were used to identify and quantify contaminants, and what was the minimum reporting limit (MRL) or method detection limit (MDL)? What QA/QC steps were taken to assure data are representative, accurate, and precise? These questions comprise the criteria for evaluating the quality of existing data.

MONITORING TRACE ORGANIC CHEMICALS

Because of their physical and chemical properties, different samplers and sampling procedures are needed for SVOCs and VOCs. SVOCs can be sampled using a variety of samplers because analyte loss during sampling is not a significant issue. The choice and use of a sampler depends on sampling objectives and logistical considerations. For example, discrete point samplers are adequate for obtaining occurrence data, but do not obtain accurate concentrations of SVOCs unless the stream is well mixed and suspended solids are evenly distributed in the stream cross section. The best techniques to obtain accurate data are equal-width-increment (EWI) and equal-discharge-increment (EDI) sampling using samplers that collect depth-integrated samples (Wells and others, 1990). However, these sampling techniques are difficult in flashy runoff from urban areas and highways, which is why automatic samplers commonly are used in stormwater studies. Regardless of the sampler type, the sampler should be made of noncontaminating materials. Generally, metal and glass are the best materials for sampling trace concentrations of organic compounds. Teflon is the preferred material when metal and glass cannot be used, such as for sampling lines for automatic samplers.

In contrast, analyte loss during sampling is a significant issue for VOCs because of their volatility. Three types of samplers and sampling techniques are used to collect VOC samples, all three of which collect discrete point samples. If point sources are not nearby, point sampling for VOCs is not as significant an issue as for SVOCs because VOCs are mostly in the dissolved phase and not sorbed to sediments (Rathbun, 1998). The two most common sampling techniques are to manually dip a 40-mL (milliliter) glass vial directly into the stream or to obtain a sample with another container and then transfer the water to a vial. Vials are then quickly sealed with a Teflon-lined septum cap.

Dipping a vial directly into the stream eliminates potential contamination from sampling equipment. However, this technique is limited to the length of the sampler's arm and can be hazardous during high-flow conditions. A stainless steel and copper sampler (Shelton, 1997) is more versatile and safer than dip sampling because it collects samples at greater depths and can be suspended from bridges. Sample water is collected directly into sample vials, which are sealed when the sampler is retrieved from the stream. Laboratory and field testing has shown that this sampler collects accurate data (Gregory Delzer, U.S. Geological Survey, written commun., 1997). VOCs should not be collected using automatic samplers with peristaltic pumps that do not quickly seal vials because the negative pressure created by the pumps and volatilization from open vials can bias sample results. Recently, ISCO Inc. developed the model 6100 automatic sampler for sampling VOCs in streams. This sampler uses a positive-displacement pump and quickly seals vials. Laboratory testing of this sampler indicates it produces accurate data with less than 2 µg/L (micrograms per liter) of carryover between samples (Gregory Delzer, written commun., 1997).

Preservation of water samples for analysis of SVOCs and VOCs depends on laboratory requirements. SVOC samples usually are chilled at 4°C. VOC samples usually are chilled and may be acidified to a pH of less than 2 using hydrochloric acid. Some laboratories require addition of ascorbic acid to VOC samples if free chlorine is present.

GC/MS is the most accurate method of identifying and quantifying most SVOCs and VOCs. Even if laboratories use the same analytical method, they may report varying MRLs and MDLs that can create difficulties in data interpretation (Cole and others, 1984). MRLs and MDLs can vary because of the sample matrix, study objectives require different values, and analytical methods improve with time. For example, MRLs and MDLs that meet current regulatory requirements may be satisfactory for compliance monitoring. However, organic compounds in stormwater commonly occur at concentrations below water-quality criteria (Makepeace and others, 1995), so regulatory requirements may be inadequate to determine if compounds are present, to estimate loads, to identify causal factors and emerging problems, and to use data in the future if water-quality criteria are lowered. The National Water-Quality Laboratory of the U.S. Geological Survey (USGS) reports SVOCs in water as low as 5 µg/L (Fishman, 1993), SVOCs in sediment as low as 50 µg/Kg (micrograms per kilogram) (Furlong and others, 1996), and VOCs in water as low as 0.05 µg/L (Connor and others, 1998). Extraction and recovery efficiencies are lower for SVOCs than for VOCs, which is why SVOCs have higher MRLs and MDLs. Extraction and recovery efficiencies less than 90 percent are common for compounds that sorb to sediments (Furlong and others, 1996), whereas extraction and recoveries for most VOCs are 95 percent or greater (Connor and others, 1998).

Results of water-quality studies can form the basis of or alter agency policies and have significant economic and social implications. Studies should be supported by a QA/QC plan to ensure that these results are based on quality data. QA is the precautionary actions used to prevent systematic bias. Examples of QA are using noncontaminating materials and sample containers, cleaning equipment, preserving samples soon after collection, and shipping samples overnight. QC includes the steps used to check that QA is effective and to evaluate variability due to random error. Examples of QC are equipment blank samples to ensure that equipment is clean, replicates to assess sample variance and analytical precision, and samples spiked with analytes to evaluate analyte degradation and recovery. QC samples generally comprise 10 to 15 percent of all samples. The QA/QC plan usually is an unpublished document, but should be briefly described with study results. For large studies, the QA/QC plan often is a published document, such as that by Mueller and others (1997).

Sample Collection

Documentation of sample collection should include where, when, and how highway runoff and urban stormwater samples were collected. Documenting sample location is important so sampling can be repeated to evaluate apparent anomalies and to define changes with time. All studies answered the question of where samples were collected (table 1, at back of report), although the level of detail varied. Some studies provided maps showing precise sample locations; however, most studies included generalized maps or described sample locations. An extreme case of generalizing was Line and others (1997), who only stated that samples were collected in North Carolina.

Studies included in this review were conducted in the United States (fig. 1) and in Canada, Germany, Japan, Norway, Spain, Switzerland, and the United Kingdom. Most studies in the United States were conducted along the northeast coast and in southern states where population densities are greatest. Few studies have been conducted in the Great Lakes region and the central and western states.

Seventeen studies were related to SVOCs and VOCs in highway runoff or in rain, snow, and sediment near highways. Ten of the 17 studies related to highways were in the United States (Wiland and Malina, 1976; Zawlocki and others, 1980; Gupta, 1981; Hoffman and others, 1983, 1984, 1985; Hoffman and Quinn, 1987; Latimer and others, 1990; Barrett and others, 1993; Baldys and others, 1997); four were in England (Butler and others, 1984; Johnston and Harrison, 1984; Harrison and Johnston, 1985; Hewitt and Rashed, 1990); and one was in each of Canada (Boom and Marsalek, 1988), Norway (Gjessing and others, 1984), and Germany (Stotz, 1987). PAHs were the topic of most highway-related studies.

The priority pollutant monitoring project of the Nationwide Urban Runoff Program (NURP) had the widest geographic distribution and is the most frequently cited study of organic contaminants in urban stormwater. The U.S. Environmental Protection Agency's (USEPA) priority pollutants, including SVOCs and VOCs, were monitored in 15 cities in 14 states (Cole and others, 1984). Concentrations of the priority pollutants were measured in 86 stormwater samples collected from drainage basins with residential, commercial, or industrial land use.

Marsalek and Schroeter (1988) conducted a study similar to NURP in 12 Canadian cities in the Great Lakes region. Up to 125 stormwater and sediment samples from 81 sites with residential, commercial, industrial, or transportation land use were analyzed for 50 priority pollutants, including PAHs and chlorinated benzenes.

A set of independent urban stormwater studies conducted by the USGS comprise another type of study with a wide geographic distribution. In 1991, USEPA required cities with a population of 100,000 or more to monitor stormwater quality and obtain municipal National Pollutant Discharge Elimination System (NPDES) permits. The USGS monitored stormwater from drainage basins with residential, commercial, or industrial land use in 16 of these cities in 11 states (Delzer and others, 1996). Most of these

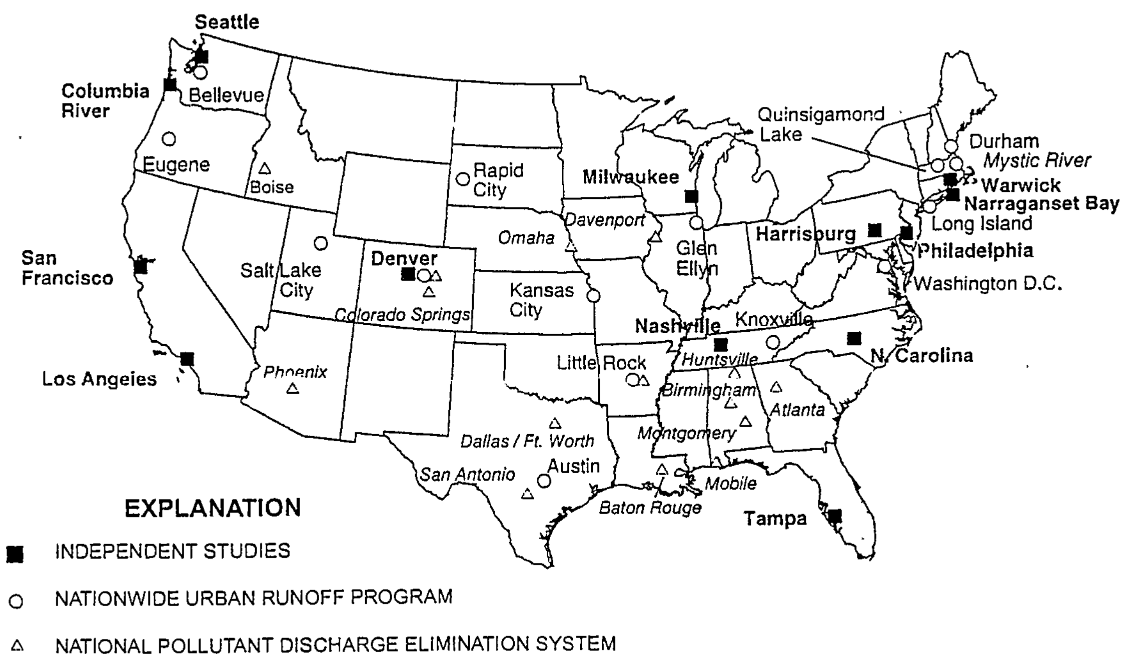

Figure 1. Cities in the United States where semivolatile and volatile organic compounds have been studied in highway runoff and urban stormwater.

cities are in southern and central states (fig. 1). A total of 642 stormwater samples were analyzed for up to 210 properties and constituents, including the priority pollutants. VOC data were compiled to characterize the occurrence of VOCs in stormwater (Delzer and others, 1996) and identify nonpoint sources (Lopes and Bender, 1998). Data on SVOCs and other contaminants that were measured in stormwater samples were not compiled.

Documenting when samples were collected is necessary to know if unusual weather occurred during the respective studies and to determine if state-of-the-art sampling and analytical methods were used. The question of when samples were collected was answered in about 84 percent of the studies. The majority of data were collected during the late 1970's to mid-1980's, including data related to highway runoff. Only 20 percent of studies, most of which were NPDES studies, collected data after 1990. Typically, the time between data collection and publication was about 2 to 4 years, although Latimer and others (1990) was published 10 years after data were collected. Studies that did not report when data were collected were published between 1982–91; therefore, data probably were collected prior to the mid-1980's.

The validity and comparability of data depend on several criteria, including documented sampling protocols. Description of the sampling protocol should include information on the type and material of the sampler; where in the stream cross section samples were collected; if discrete or composite samples were analyzed; and if whole water, suspended solids, or filtrates were analyzed. Most studies provided some, but none provided all information on the sampling protocol.

About 80 percent of studies reported the type of sampler. Water samples were collected with buckets, bottles, trays, cans, storage tanks, drums, and automatic samplers. Snow and sediment were sampled with corers, trowels, ponar samplers, jars, and lysimeters. Atmospheric deposition and rain were sampled with funnels. Line and others (1997) collected samples for VOCs with automatic samplers that were not designed for these contaminants; therefore, volatilization from sample water probably biased results.

About 60 percent of studies reported the sampler material. Most samplers were made of metal or glass, which are good materials to use for sampling organic contaminants. Studies that used flow splitters and samplers made of fiberglass and plastics included Zawlocki and others (1980), Gjessing and others (1984), Johnston and Harrison (1984), and Harrison and Johnston (1985). Sorption to these materials may have biased the SVOC and VOC data of these studies. Hewitt and Rashed (1990) conducted a study in the same area as Johnston and Harrison (1984) and Harrison and Johnston (1985) and may have used the same equipment, but there is insufficient information to determine this from the article. Seven studies used automatic-pumping samplers. Three NPDES studies (Lopes and others, 1995; von Guerard and Weiss, 1995; and Baldys and others, 1998) noted that sampling lines were made of Teflon. The other studies did not document the sampler-line material.

The largest deficiency in documenting data quality was that only 10 percent of studies described where water samples were collected in the stream cross section, if streamflow was well mixed, or if equal-width increment or depth-integrated techniques were used. The representativeness of discrete point samples and interpretations based on those data, especially load estimates, are questionable without this information. Sample location could have affected results because SVOC concentrations depend on suspended solids concentrations (Hunter and others, 1979; Hoffman and Quinn, 1987; and Barrett and others, 1993). Suspended solids concentrations can have significant horizontal and vertical variations (Horowitz and others, 1989) even in channels less than 5 ft wide (Edwards and Glysson, 1986). Samplers do not need to be sophisticated devices like electronically activated point samplers to obtain representative samples. However, the water samplers used in these studies and lack of information on flow conditions suggest most studies sampled surficial streamflow along the streambank. Stream velocity and suspended sediment concentrations typically are lowest along the banks, so point samples collected along the streambanks may result in biased (low) contaminant concentrations and load estimates. This may not be a significant issue in stormwater drainages where streamflow usually is fast and shallow.

About 90 percent of studies described whether samples were discrete or composite samples. About 70 percent of studies that described sampling methods manually collected discrete water samples. Eight studies composited stormwater samples, but two of these studies did not document whether these were time-weighted or flow-weighted composites. Composite samples were obtained using cone or churn splitters (Lopes and others, 1995; von Guerard and Weiss, 1995) and a flow splitter (Zawlocki and others, 1980). Other studies did not describe how samples were composited. About 90 percent of studies described whether bottom-sediment samples were point samples or composites and the depth interval of bottom sediment that was sampled. Most samples were point samples collected from the upper 10 centimeters of bottom sediment. Ellis and others (1985) and Brown and others (1985) composited surficial bottom-sediment samples from several sites. Gavens and others (1982) and Butler and others (1984) sieved bottom sediment and Hoffman and others (1984) sieved suspended solids for a consistent grain size among samples. Comparing bottom-sediment concentrations is difficult because most studies did not analyze for organic carbon, which is the most common way of normalizing organic contaminant concentrations in sediments.

About 90 percent of studies described whether whole-water samples were analyzed or if suspended solids and filtrates were analyzed separately. Unless stated otherwise, it was assumed that whole-water samples were analyzed. About 30 percent of studies separated suspended solids and analyzed the filtrate, solids, or both. Separation was done by filtration with glass fiber filters or by centrifugation.

Analytical Methods and Minimum Reporting and Detection Limits

Documenting the analytical methods, MRLs, and MDLs is important to use data from different studies for a common objective. About 90 percent of studies described the analytical method for contaminant identification and quantitation. Gas chromatograph/flame-ionization detection (GC/FID) was the most commonly used analytical method. GC/MS was used to identify analytes or confirm GC/FID results in about 30 percent of the studies. About 30 percent of studies documented analytical precisions and recoveries. Generally, precision was less than 25 percent and recoveries were greater than 80 percent.

About 30 percent of studies, most of which were conducted in the 1990's, documented the MRL or MDL. The MRL is the lowest concentration that can accurately be quantified. The MDL is the lowest concentration that the method can detect. For studies done in the 1980's, Brown and others (1985) reported an MRL of 1 µg/L for petroleum hydrocarbons, Schondorf and Herrmann (1987) reported MDLs ranging from 0.03 to 0.15 ng/L (nanograms per liter) for PAHs, Zawlocki and others (1980) reported an MRL of 100 µg/L for a variety of SVOCs, and Boom and Marsalek (1988) and Marsalek and Schroeter (1988) reported an MRL of 0.05 µg/L for PAHs. Except for Zawlocki and others (1980), these limits compare well with current (1998) limits of the U.S. Geological Survey. The high MRLs ranging from 5 to 100 µg/L used by Line and others (1997) could explain why few SVOCs and VOCs were detected in stormwater from industrial sites.

Quality Assurance and Quality Control

The validity and use of data depend on documenting the procedures used to ensure that high-quality data were collected. Most studies described some precautionary action to ensure sample integrity, but few studies described thorough QA/QC procedures. Only Cole and others (1984) described a QA/QC plan, although they were unable to evaluate the effectiveness of the plan for NURP.

As previously noted, about 60 percent of studies used noncontaminating materials such as glass and metal. However, only 30 percent of studies documented that equipment was cleaned before sampling or that samples were preserved. Chilling samples at 4°C was the most commonly used method for preserving samples. Infrequently described precautionary steps included use of Teflon-lined or metal lids, covering jars with aluminum foil, homogenizing samples before splitting into equal portions, slowly melting snow samples to minimize volatilization, sampling in well-mixed parts of a storm drain, shipping samples overnight, and using nitrogen to filter samples for SVOCs. Studies that retrieved samples up to 2 weeks after collection without chilling were Johnston and Harrison (1984) and Harrison and Johnston (1985). Latimer and others (1990) left samples at room temperature for up to 2 days before analysis. Line and others (1997) used automatic samplers for VOCs and retrieved and chilled samples sometimes hours after they were collected.

Both laboratory and field QC samples are needed to evaluate sample and analytical quality. About 30 percent of studies reported analyzing laboratory QC samples and 15 percent analyzed field QC samples.

Laboratory QC samples included blanks, lab-split duplicates, surrogate recoveries, and performance-evaluation samples. Four studies reported using laboratory blanks and surrogate recoveries to correct environmental concentrations. The use of field QC samples became prevalent after most of the studies in this review were conducted. Except for NURP, the only studies that reported analyzing field QC samples were conducted in the 1990's. Field QC samples included equipment blanks, trip blanks, replicates, and spikes. Evaluating the quality of environmental data, especially low concentrations, is difficult because few studies collected QC data and documented that samplers were cleaned.

SUMMARY OF STUDY RESULTS

Most highway-runoff and urban-stormwater studies were conducted to address regional or local issues. However, results from all studies could provide useful qualitative information to answer some general questions of national importance. For example, do certain SVOCs and VOCs occur more frequently and at higher concentrations in particular regions of the country? If so, do factors such as climate affect occurrence and concentrations of these compounds? What are the sources of SVOCs and VOCs? Can loads of SVOCs be estimated on a national scale? Could SVOCs and VOCs have an adverse effect on water resources? These questions are the focus of this summary.

Semivolatile Organic Compounds

SVOCs were the subjects of most highway runoff and urban stormwater studies. Much has been learned about these compounds, especially the extractable organic compounds and polycyclic aromatic hydrocarbons (PAHs).

Occurrence

Characterizing the occurrence of SVOCs in highway runoff and urban stormwater for the entire United States is not possible because few studies reported detection frequencies or were conducted in the Great Lakes region and the central and western states. Studies that reported detection frequencies are Cole and others (1984), Boom and Marsalek (1988), Marsalek and Schroeter (1988), Lopes and others (1995), von Guerard and Weiss (1995), and Baldys and others (1998). SVOC concentrations vary by several orders of magnitude, which is typical of stormwater quality (table 7 at back of report). Table 7 was compiled assuming that unknown sample types and samples described as sediment samples, but reported in milligrams per liter or nanograms per liter, were whole-water samples. Thirty SVOCs were measured but not detected in stormwater (table 2, at back of report).

Total oil and grease and hydrocarbon concentrations in runoff ranged from less than 1 to 480 milligrams per liter (mg/L) (table 7). In suspended sediment, bottom sediment, and soils, oil and grease and hydrocarbon concentrations ranged from 8 to 507,000 micrograms per gram (μg/g). The highest concentrations in water and solid phases were associated with highways and industrial land use.

Studies that analyzed petroleum hydrocarbons and oil and grease for the classes of organic compounds that comprise these measurements were Zawlocki and others (1980), Eganhouse and Kaplan (1981b), Brown and others (1985), Fam and others (1987), Hoffman and Quinn (1987), Marsalek and Schroeter (1988), and Barrett and others (1993). Comparing results is difficult because fractions were separated using non-standard procedures (Hoffman and Quinn, 1987). Most extractable organic compounds in stormwater are aliphatic compounds and, except for polar compounds, about 80 percent or more are in the solid phase. The high solubilities of polar compounds, such as phenols, ketones, and alcohols, explain the large percentages measured in filtrates. Generally, aromatic compounds, phenolic compounds, PAHs, alcohols, and ketones comprise less than 1 percent to about 15 percent of the extractable organic compounds.

Concentrations of individual PAHs in runoff ranged from less than 1 to 120 μg/L. Highest concentrations were associated with industrial land use; few data exist for individual PAHs in highway runoff. In solid phases, concentrations of individual PAHs ranged from less than 1 to 200 μg/g. Of the few studies that reported total PAH concentrations, the maximum concentrations were 18,210 μg/L in whole water and 1,100 μg/g in solid phases. The maximum detection frequency of PAHs in both urban stormwater and snow was 90 percent. Most PAHs were detected in less than 25 percent of samples (Cole and others, 1984;

Boom and Marselak, 1988; Marsalek and Schroeter, 1988; Lopes and others, 1995; von Guerard and Weiss, 1995; and Baldys and others, 1998).

Johnston and Harrison (1984) tentatively identified 2-chlorophenol and 2,4-dichlorophenol in bulk deposition adjacent to a highway. Baldys and others (1997) detected phenolic compounds at concentrations between 1 and 16 µg/L in 90 percent of highway runoff samples. Phenolic compounds were detected in 15 percent or less of urban stormwater samples from NURP (Cole and others, 1984), 55 percent for urban stormwater samples from Phoenix (Lopes and others, 1995), and were not detected in urban stormwater samples from Colorado Springs (von Guerard and Weiss, 1995) and Dallas-Fort Worth (Baldys and others, 1998). When detected, concentrations of phenolic compounds in urban stormwater generally were less than 20 µg/L.

Related Factors

Of the factors that affect SVOC concentrations in water, the most significant is suspended solids concentration. About 80 percent or more of SVOCs in stormwater are associated with the solid phase due to the hydrophobic character of these contaminants (Hunter and others, 1979; Zawlocki and others, 1980; Eganhouse and Kaplan, 1981a; Brown and others, 1985; Hoffman and Quinn, 1987; and Barrett and others, 1993).

Organic carbon content is the most significant factor affecting SVOCs in the solid phase (Butler and others, 1984; Ellis and others, 1985; and Witkowski and others, 1987). Mineral particles are less effective at sorbing nonionic SVOCs (Witkowski and others, 1987), thus grain size does not appear to be a significant factor affecting SVOC concentrations in sediments unless small grains have an organic coating (Witkowski and others, 1987; Gavens and others, 1982). In contrast, trace-element concentrations in sediments are strongly correlated with grain size because ionic elements adsorb to small particles that have charged surfaces (Horowitz and Elrick, 1987).

Sorption of SVOCs to solids is reflected in the high concentration of SVOCs in the initial runoff from a storm and correlation between concentrations of solids and SVOCs throughout a storm (Hunter and others, 1979; Stenstrom and others, 1984; Brown and others, 1985; Hoffman and others, 1984, 1985; and Hoffman and Quinn, 1987). The initial runoff, commonly called first flush, can have concentrations of suspended solids and sorbed SVOCs that are several factors higher than concentrations in composite samples. Suspended solids concentrations typically decrease during a storm due to flushing of particles that accumulated on the land surface (Novotny, 1995).

Land use also affects SVOC concentrations. Most studies found higher SVOC concentrations in runoff, snow, and bottom sediment from highways or industrial areas compared to residential and commercial areas (Hoffman and others, 1983, 1984; Hoffman and Quinn, 1987; Evans and others, 1990; Latimer and others, 1990; Bomboi and Hernandez, 1991; and Baldys and others, 1998). For example, PAH concentrations in snow near highways and a steel plant were similar, and PAHs were more frequently detected and concentrations were higher than NURP stormwater data (Boom and Marsalek, 1988). Gjessing and others (1984) found PAHs in snow up to 50 meters from a highway, the furthest of all contaminants they measured, and that PAHs were fractionated during atmospheric transport. Johnston and Harrison (1984) found PAHs in rain up to 70 meters from a highway and that concentrations decreased with distance. Butler and others (1984) found that PAH concentrations in bottom sediment decreased with distance from highways.

Storm characteristics, such as rainfall intensity and volume of runoff, are important factors affecting SVOC concentrations and loads in stormwater and sediments. As rainfall intensity increases, stream velocity and sediment-carrying capacity increase, resulting in increased SVOC concentrations in stormwater (Hoffman and Quinn, 1987; Barrett and others, 1993). In bottom sediment, Evans and others (1990) found that PAH concentrations weakly correlated with monthly rainfall and that concentrations increased about 4 to 30 days after a storm. Gupta (1981) observed higher concentrations of oil and grease in highway runoff and Prahl and others (1984) observed higher PAH concentrations in atmospheric particulates during winter compared to summer months. Schondorf and Herrmann (1987) found that freezing can concentrate organic compounds in water. During thaws, soluble organic compounds elute in the first and last parts of the melt and that about 90 percent of PAHs elute with the particulates during the last 20 percent of the melt. These observations indicate that concentrations and loads of SVOCs could vary seasonally.

Not all studies found a relation between storm characteristics and SVOC concentrations and loads. Stenstrom and others (1984) found no correlation between oil and grease concentrations and streamflow rates, total rainfall, time since beginning of storm, rainfall intensity, or antecedent dry days. Hunter and others (1979), Herrmann (1981), and Hoffman and others (1984) found that SVOC concentrations did not correlate with antecedent conditions. Zawlocki and others (1980) found no correlation between SVOC loads and rainfall, traffic volume, or runoff volume, although they noted that traffic volume during the storm had a greater effect than rainfall.

Conclusions have been mixed whether highway surface type significantly affects SVOC concentrations (Barrett and others, 1993). Gupta (1981) measured oil and grease concentrations from paved surfaces that were 20 times greater than from grass-covered surfaces, but concluded that land use was the most important factor. Strenstrom and others (1984) measured oil and grease concentrations 25 times greater from parking lots compared to residential areas. Wakeham and others (1980) concluded that PAHs in street dust were from asphalt. Zawlocki and others (1980) noted that higher suspended solids concentrations occurred in highway runoff at a site with a median barrier and side railings compared to another site without these features. Other variables, such as traffic volume and drainage, may be more important factors affecting SVOC concentrations than surface type (Stotz, 1987; Barrett and others, 1993).

Sources

Crankcase oil and vehicle emissions were consistently identified as the primary source of SVOCs in stormwater (Hunter and others, 1979; Zawlocki and others, 1980; Stenstrom and others, 1984; Brown and others, 1985; Hoffman and Quinn, 1987; Fam and others, 1987; Yamane and others, 1990; Latimer and others, 1990; and Bomboi and Hernandez, 1991). The significance of PAHs in automobile emissions is indicated by concentrations in sediment, snow, and rain that decrease with distance from highways (Butler and others, 1984; Johnston and Harrison, 1984; Gjessing and others, 1984; Harrison and Johnston, 1985; and Hewitt and Rashed, 1990).

Emission of most PAHs from automobiles is directly related to their concentration in gasoline (Westerhold and others, 1988). Naphthalene and its alkylated homologues comprise about 0.5 percent by weight of gasoline (Canadian Petroleum Institute, 1994); 13 other PAHs occur in gasoline at less than 0.01 to 54 mg/L (Westerhold and others, 1988). About 95 percent of PAHs in gasoline are decomposed during gasoline combustion. However, in gasoline with low PAH content, a large percentage of the PAHs emitted are formed during combustion, including 70 to 80 percent of cyclopenta[*cd*]pyrene and benzo[*b*&*k*]fluoranthene. Gasoline exhaust contains about 1 to 2 parts per million of phenol and o-cresol (Lucius and others, 1989) and is a possible source of phenolic compounds in stormwater.

Load Estimates

Estimates of SVOC loads and mass balances have been made on different scales to evaluate the relative importance of different sources and transport mechanisms. For example, Edwards (1983) estimated that forest and agricultural fires comprise 75 percent of the annual global release of PAHs. Hoffman and Quinn (1987) estimated 470,000 tons per year of petroleum hydrocarbons are released to waters of the United States and that up to 50 percent of this amount could be discharged in urban stormwater. Bjorseth and Ramdahl (1985) estimated that automobile emissions comprise one-third of the 6,000 tons of PAHs emitted each year in the United States. In contrast, Edwards (1983) estimated that automobiles, buses, and trucks comprise only 1.6 percent of benzo(a)pyrene emissions in the United States. The difference could be because Bjorseth and Ramdahl (1985) did not correct for catalytic converters, which were in about 50 percent of cars.

At a regional scale, Hoffman and others (1983, 1984) estimated hydrocarbon and PAH loads to Narraganset Bay, and Marsalek and Schroeter (1988) estimated SVOC loads to the Great Lakes. Estimates by Hewitt and Rashed (1990) and Stotz (1987) indicated that 30 percent or less of the PAHs emitted along highways is transported in runoff and the remainder is dispersed. Other estimates have been made at a local scale (Butler and others, 1984; Gjessing and others, 1984; Johnston and Harrison, 1984; Harrison and Johnston, 1985; Boom and Marsalek, 1988; and Hewitt and Rashed, 1990).

Few regression equations or loading factors have been developed for SVOCs compared to other constituents such as suspended solids and nutrients.

Most equations and factors were based on few data and have little statistical power and large uncertainties, especially for regional and national application. Also, studies reported loading factors with inconsistent units so comparisons are difficult or with units that limit their application (table 3, at back of report). For example, Hoffman and Quinn (1987), Stotz (1987), and Barrett and others (1993) report loading factors that are independent of rainfall and, therefore, apply only to areas with climates similar to their study areas. Gupta (1981) estimated loads from highways using regression equations for runoff, pollutant build-up and wash-off, and loads of suspended solids. Correlations between other contaminants and suspended solids were used to convert loads of suspended solids into loads of the other contaminants. However, conversion equations were developed for individual sites and have only site-specific application. Marsalek and Schroeter (1988) used a procedure similar to Gupta (1981) to estimate loads to the Great Lakes.

Using study results to develop equations and factors of SVOC loads and concentrations at a national level, particularly from highways, is not possible because ancillary information was not documented, raw data were rarely reported, laboratory reporting levels varied, and few studies were related to SVOCs from highways. In addition, vehicles emit fewer SVOCs and VOCs today than when most studies were conducted (U.S. Environment Protection Agency, 1996a). The lower emissions are probably due to catalytic converters and to the use of cleaner-burning fuels. Gasoline-powered cars without catalytic converters emit 25 times more total aerosol PAHs in comparison to cars with catalytic converters, and diesel trucks emit 7 times more PAHs than cars with catalytic converters (Rogge and others, 1993). Therefore, the few loading factors that are available in the literature probably have limited application for estimating current loads of SVOCs and VOCs.

Comparison to Water-Quality and Sediment-Quality Standards and Guidelines

The potential for SVOCs to adversely affect water resources can be made by comparing SVOC concentrations in urban stormwater, snowmelt, and sediment to water-quality and sediment-quality standards and guidelines. Makepeace and others (1995) and Boom and Marsalek (1988) concluded that certain PAHs, phenol, *m*- and *p*-cresols, pentachlorophenol, and phthalates in stormwater were a concern for drinking water and aquatic life. Of the PAHs, total PAH, acenaphthene, fluoranthene, and benzo(a)pyrene in urban stormwater exceeded drinking-water standards of the United States, Canada, and World Health Organization (WHO). Concentrations of fluoranthene in stormwater exceeded acute and chronic aquatic regulation values of the United States.

For this report, SVOC concentrations in sediments were compared to recently developed sediment-quality guidelines (U.S. Environmental Protection Agency, 1996b) as another assessment of their potential adverse effects. No single set of sediment-quality guidelines is universally accepted in the United States. Therefore, the method of USEPA (1996b) was used to determine an upper threshold concentration for selected SVOCs above which there is a high probability of adverse effects on aquatic life. However, guidelines do not exist for all SVOCs detected in urban stormwater and upper threshold concentrations may be over- or under-protective depending on site-specific conditions.

Briefly, USEPA (1996b) used several sets of sediment-quality guidelines that were developed using different methods and have considerable inconsistencies among them. Rather than select one set of guidelines over another, USEPA (1996b) used all available sediment guidelines for a contaminant to classify sites into one of three tiers based on the probability of adverse effects on aquatic life. Tier 1 sites have a high probability of adverse effects on aquatic life, Tier 2 sites have an intermediate probability of adverse effects on aquatic life, and Tier 3 sites have no indication of adverse effects on aquatic life. USEPA (1996b) used lower threshold guidelines, above which adverse effects occasionally occur, to define the Tier 2/Tier 3 boundary, and upper threshold guidelines, above which effects may be frequent or severe, to define the Tier 1/Tier 2 boundary. For a site to be designated as Tier 1, the measured contaminant concentration at that site must exceed at least two of the upper threshold guidelines for that contaminant.

The guideline used in this comparison was the Tier 1/Tier 2 boundary concentration (table 4, at back of report). The upper threshold values used were (1) the effects range-median (Long and Morgan, 1991; Long and others, 1995); (2) the apparent effects threshold-high (Barrick and others, 1988); (3) the probable effect level used by the Florida Department of

Environmental Protection (1994); (4) the probable effect level used by the Canadian Council of Ministers of the Environment (1995); (5) the USEPA sediment-quality criterion (U.S. Environmental Protection Agency, 1996b); and (6) the USEPA sediment-quality advisory level (U.S. Environmental Protection Agency, 1996b).

In the future, guidelines for PAHs are likely to change to PAH mixtures because PAHs typically co-occur in the environment. Testing and modeling is being conducted to determine the toxicity of PAH mixtures in sediment, which will form the basis for sediment-quality criteria for PAH mixtures (U.S. Environmental Protection Agency, 1998).

About 70 percent of surface-soil samples near a highway exceeded upper threshold concentrations of benz(a)anthracene, benzo(a)pyrene, chrysene, or pyrene, or of more than one of these PAHs, indicating adverse effects are probable (Butler and others, 1984). About 60 percent of bottom sediments from an urban stream exceeded upper threshold concentrations of fluoranthene, anthracene, pyrene, or benzo(a)pyrene, or of more than one of these PAHs (Ellis and others, 1985). Other studies had samples that exceeded upper threshold values, but the percentage of exceedence is unknown. For example, particulates in vehicle emissions and in the atmosphere exceeded upper threshold concentrations of benzo(a)pyrene (Prahl and others, 1984; Bjorseth and Ramdahl, 1985). Suspended sediments and street dust from highways and commercial areas exceeded upper threshold concentrations of fluoranthene, phenanthrene, pyrene, acenapthlyene, and benzo(a)pyrene (Hoffman and others, 1984 and 1985; Marsalek and Schroeter, 1988).

Volatile Organic Compounds

Few studies have been done on VOCs in highway runoff and urban stormwater. This summary of VOCs is mostly from the National Urban Runoff Program (NURP) and National Pollutant Discharge Elimination System (NPDES) studies.

Occurrence

Harrison and Johnston (1985) and Baldys and others (1997) were the only studies of VOCs in highway runoff. Harrison and Johnston (1985) sampled 2-week composites of atmospheric deposition at three sites near a highway in England. A total of 48 compounds were identified and quantified on a relative basis. Toluene and C_2-alkylbenzene were the major components in atmospheric deposition. No variation with distance from the highway was observed. Twenty-one highway runoff samples were collected at four sites between 1992-94 and analyzed for VOCs and other contaminants in the Dallas–Fort Worth area (Baldys and others, 1997). Chloromethane, toluene, xylenes, 1,2,4-trimethylbenzene, and 1,2,3-trichloropropane were detected in about 5 to 28 percent of samples at concentrations between 0.2 and 4.0 μg/L.

Most of the data on VOCs were collected during the NURP and NPDES studies. Together, these studies provide information on the occurrence of VOCs in most regions of the United States. For the NURP, the most frequently detected VOCs were dichloromethane, naphthalene, and chloroform, detected in 10 to 12 percent of all samples (Cole and others, 1984). In contrast, the most frequently detected VOCs for NPDES studies were toluene, xylenes, chloroform, and trimethylbenzene, detected in 12 to 23 percent of all samples (table 5, at back of report) (Delzer and others, 1996). A lower MRL for the NPDES studies could account from the greater frequencies of detection. Comparing VOC detections among regions of the United States may be possible using the NURP and NPDES data, but would be difficult because of the different reporting limits. Most detected concentrations of VOCs in urban stormwater for the NURP and NPDES studies were less than 10 μg/L and ranged from 0.2 to 43 μg/L.

The prevalence of gasoline-related compounds in NPDES data compared to NURP data probably is because stormwater was sampled closer to its source at NPDES monitoring sites and because the NURP did not measure xylenes, trimethylbenzenes, methyl *tert*-butyl ether (MTBE). MTBE and other ether oxygenates are added to gasoline to reduce vehicle emissions and enhance octane ratings. MTBE usage as an octane enhancer started about 1979. The use of MTBE to produce cleaner burning gasoline increased considerably during the late 1980's. In 1996, 17.6 billion pounds of MTBE were produced, making it the VOC with the third highest production (Chemical and Engineering News, April 8, 1996). MTBE's widespread use, high solubility, and resistance to degradation (Squillace and others, 1997) could account for its frequent occurrence in urban stormwater (Delzer and others, 1996) and in shallow urban ground water (Squillace and others, 1996).

Related Factors

Land use could be the most significant factor affecting the occurrence of VOCs. Lopes and Bender (1998) found that concentrations of gasoline-related and chlorinated VOCs were significantly higher in industrial areas as compared to commercial and residential areas and that MTBE was detected more frequently in commercial areas. Most VOCs have industrial applications (Pankow and Cherry, 1996), which probably is why concentrations were higher in industrial areas. The frequent detection of MTBE in commercial areas could be from spills at gas stations, which typically are located in commercial areas. Line and others (1997) infrequently detected VOCs in first-flush samples from industrial sites in North Carolina; sampling methods and high MRLs could account for the few detections.

Temperature is a significant factor affecting the occurrence of VOCs. A study by von Guerard and Weiss (1995) observed that more detections of VOCs occurred during snowmelt than during storm runoff. For all NPDES data, MTBE, benzene, xylenes, and 1,2,4-trimethylbenzene were detected more frequently during winter than summer (Delzer and others, 1996; Lopes and Bender, 1998). This higher detection of VOCs could be caused by the increased partitioning of VOCs from air into precipitation or slower volatilization from stormwater during cold months.

Sources

Lopes and Bender (1998) concluded that urban land surfaces are the primary nonpoint source of VOCs in stormwater. Most VOC concentrations in NPDES samples were higher than those in equilibrium with concentrations measured in urban air, indicating the atmosphere was not the source. VOCs associated with certain products, such as gasoline, frequently occurred together, and concentrations were significantly correlated and different among urban land uses. Model results indicated that VOC concentrations near the reporting limits evolved by volatilization. The primary source of VOCs probably was spills and VOCs sorbed to organic particulates and impervious surfaces, although partitioning between precipitation and VOCs in the atmosphere could be a source for MTBE.

The seasonal detection of some VOCs suggests that the atmosphere could be a nonpoint source. Measurements by Kawamura and Kaplan (1983), Pankow and others (1984), Harrison and Johnston (1985), Ligocki and others (1985), and Adachi and Kobayashi (1994) support the hypothesis that the atmosphere near highways and urban areas is a source of VOCs, although concentrations in precipitation were less than or equal to 0.2 μg/L. Concentrations of MTBE in precipitation estimated from concentrations in air range from less than 1 to about 4 μg/L (Squillace and others, 1996). These estimated concentrations of MTBE are why Squillace and others (1996) hypothesized precipitation could be a major source of MTBE detected in shallow urban ground water. Pankow and others (1997) demonstrated that MTBE and other VOCs in the atmosphere can be transported in recharge into sandy aquifers.

Comparison to Water-Quality Standards

From the NURP data, Makepeace and others (1995) concluded that tetrachloroethene, dichloromethane, and benzene could be a concern if stormwater entered drinking-water supplies. For the NPDES data, Delzer and others (1996) found that concentrations of MTBE in urban stormwater were less than the lower limit of the USEPA draft lifetime health advisory of 20 μg/L. Other VOCs detected in NPDES samples were compared to drinking-water standards (U.S. Environmental Protection Agency, 1996c) in table 6 (at back of report) because VOCs have low aquatic toxicities (Rowe and others, 1997) and primarily are a threat to drinking-water supplies. Less than 0.5 percent of NPDES samples exceeded drinking-water standards of dichloromethane and tetrachloroethene, similar to the NURP study (Makepeace and others, 1995).

INFORMATION NEEDS

This review has shown that highways can be major sources of SVOCs detected in water and sediment. However, there is insufficient information to determine if highways are sources of VOCs or to estimate loads and concentrations of SVOCs and VOCs from highways. Nationally consistent data are needed to (1) characterize the regional occurrence and concentrations of SVOCs and VOCs in highway runoff, (2) determine which are the most important factors affecting runoff quality, (3) estimate contaminant loads and concentrations on regional and national scales, and (4) identify water resources that potentially are affected.

A strategy is needed so that the distribution of information adequately represents factors affecting highway runoff in the United States. This strategy should define regions that have different values of factors that are expected to significantly correlate with water and sediment quality. For example, streams in drainage basins with residential and commercial land use are being monitored in regions with significantly different climate (Lopes and Price, 1997) because urban stormwater quality is significantly correlated with mean annual precipitation (Driver and Tasker, 1990). Other factors, such as highway-surface type, drainage, and traffic load, could be incorporated into this plan to develop a similar strategy for highways.

Information that is needed includes chemical data on SVOCs and VOCs in runoff, precipitation, and sediment to characterize their occurrence and ranges in concentrations. PAHs, oil and grease, and petroleum hydrocarbons are the primary classes of SVOCs associated with highway runoff. However, phenolic compounds and VOCs are in vehicle exhaust and could also be in highway runoff, precipitation, and sediment along highways. Parameters that could be related to chemical concentration, such as pH, dissolved oxygen, and total organic carbon, should also be measured. These data should be collected using appropriate procedures and materials and documented in a QA/QC plan.

Factors that are significantly related to water quality need to be characterized to estimate contaminant loads and concentrations from unmonitored sites and to identify potentially affected water resources. Factors that clearly affect concentrations and loads of SVOCs in highway runoff include suspended solids and organic carbon concentrations, total rainfall, rainfall intensity, traffic loads, and how runoff is drained. It is unclear if the type of surface has a significant effect, how much temperature affects concentrations and loads of SVOCs, and if surrounding land use has an effect. These and other factors may affect VOCs in highway runoff and precipitation. Relations between water quality and significant factors can be characterized by statistical analysis of ancillary data associated with monitoring sites and storms. From these relations, techniques similar to those of Driver and Tasker (1990) can be developed to estimate constituent loads and concentrations in highway runoff throughout the United States.

Geographic information on factors included in the estimation techniques can be used to obtain a national distribution of estimated contaminant loads and concentrations. These estimates and geographic information on water resources, including ground water, could then be used to determine which water resources could be adversely affected by highways. Ground water that is shallow and is used or has the potential of being used for drinking water could be affected by water-soluble compounds like MTBE.

Deterministic studies and modeling are also needed to understand the physical and chemical processes controlling highway-runoff quality, contaminant transport and fate, and impacts on biological and drinking-water resources. For example, Hewitt and Rashed (1990) and Stotz (1987) found that 70 percent of PAHs from highways are dispersed and 30 percent are transported in runoff. The majority of PAHs could be transported through the atmosphere into water-supply reservoirs. Modeling could help determine the transport and fate of dispersed PAHs and potentially affected waters.

SUMMARY

This review evaluated the quality and geographic distribution of existing data on SVOCs and VOCs, summarized significant findings, compared concentrations in highway runoff and urban stormwater with current (1998) water-quality criteria, and identified areas where additional information is needed. A total of 44 articles and reports were reviewed. Only 17 studies were related to highways, and 5 of these are review papers. Most of the data were collected during the late 1970's to mid-1980's. SVOCs in urban stormwater and sediments was the subjects of most studies.

Only 10 percent of studies described where in the stream cross section water samples were collected. This was the largest deficiency in documenting the sampling protocol. About 80 percent of SVOCs in runoff are in the suspended solids. Because suspended solids can vary significantly in the stream cross section even in narrow channels, the representativeness of discrete point samples and interpretations based on those data, especially load estimates, are questionable

without information regarding sample location, how samplers were used, or how well the streamflow was mixed.

Only 30 percent of studies documented the MRL or MDL of the analytical method and only 15 percent of studies used field quality-control samples. The lack of MRL and MDL documentation hinders the ability to compare stormwater quality from different parts of the country. Evaluating the quality of environmental data, especially low concentrations, is difficult because few studies collected QC data and documented that samplers were cleaned.

PAHs, petroleum hydrocarbons, and oil and grease are the major SVOCs in urban stormwater and highway runoff. Suspended solids concentrations is the most significant factor affecting SVOCs in water. In sediment, the most significant factors affecting SVOC concentrations are organic carbon content and distance from sources, such as highways and power plants. Rainfall intensity, storm volume, and land use also are important factors affecting concentrations and loads of SVOCs. The highest SVOC concentrations in runoff, snow, and bottom sediment were measured from highways and industrial areas. Crankcase oil and vehicle emissions are the primary sources of SVOCs. The few loading factors and regression equations that were developed in the 1970's and 1980's are inadequate to estimate current (1998) loads of SVOCs because they use inconsistent units, some are independent of rainfall and have limited application, and they are based on few data. Also, more cars have catalytic converters and fuels are cleaner than when loading factors and regression equations were developed. PAHs, phenolic compounds, and phthalates in runoff exceeded drinking-water and aquatic-life standards. PAHs exceeded upper threshold concentrations in sediments near highways, indicating adverse effects on receiving streams.

VOCs were detected in precipitation adjacent to a highway in England, and chloromethane, toluene, xylenes, 1,2,4-trimethylbenzene, and 1,2,3-trichloropropane were detected in runoff from a highway in Texas. VOCs were detected in as many as 23 percent of the urban stormwater samples; gasoline-related compounds were the most frequently detected VOCs. Land use could be the most significant factor affecting the occurrence of VOCs. The highest concentrations of VOCs were found in industrial areas, suggesting urban land surfaces are the primary nonpoint source of most VOCs. Temperature is another important factor affecting the occurrence of VOCs. MTBE, benzene, xylenes, and 1,2,4-trimethylbenzene were detected more frequently during winter than summer. The seasonal detection could be due to the increased partitioning of VOCs in air into water at cold temperatures, suggesting that the atmosphere could be a nonpoint source of some VOCs. Tetrachloroethene, dichloromethane, and benzene were the only VOCs in stormwater that exceeded drinking-water standards.

Information deficiencies identified during the review included a need to determine if highways are a source of phenolic compounds and VOCs and if the occurrence and concentrations of SVOCs and VOCs vary regionally. A better understanding of the factors that affect SVOCs and VOCs is needed to estimate contaminant loads and concentrations at unmonitored sites and to identify potentially affected water resources. Deterministic studies and modeling also are needed to understand the physical and chemical processes controlling highway-runoff quality and contaminant transport and fate.

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TABLES 1–7

Table 1 . Documented quality criteria of data on semivolatile and volatile organic compounds in urban stormwater and highway runoff

[°C, degrees Celsius; cm, centimeters; m, meters; µg/L, micrograms per liter; mg/L, milligrams per liter; ng/L, nanograms per liter; ng/g, nanograms per gram; ppb, parts per billion; NA, not applicable; ND, not described; SS, stainless steel; O+G, oil and grease; GC/FID, gas chromatography/flame-ionization detector; GC-MS, gas chromatography-mass spectrometry; HCl, hydrochloric acid; HPLC, high performance liquid chromatography; IR, infrared spectrometry; EWI, equal-width increment; MRL, minimum reporting limit; NaCl, sodium chloride; NPDES, National Pollutant Discharge Elimination System; NURP, Nationwide Urban Runoff Program; %, percent; ~, approximate; ---, no comment]

Reference	Where	Years data were collected	Water sampling protocol					Sediment and soil sampling protocol				Comment
			Sampler type	Material	Manual or automatic	Discrete or composite	Where in stream	Sampler type	Material	Discrete or composite	Depth (cm)	
Baldys and others, 1997	Dallas–Ft. Worth, Texas	1992–94	auto-sampler + bottles	Teflon, steel, glass	both	both	ND	NA	NA	NA	NA	Flow-weighted composites; not known if splitter used. Sampled where storm drain well mixed.
Baldys and others, 1998	Dallas–Ft. Worth, Texas	1992–93	auto-sampler + bottles	Teflon, steel, glass	both	both	ND	NA	NA	NA	NA	Flow-weighted composites; not known if splitter used. Sampled where storm drain well mixed.
Barrett and others, 1993	Review paper	1976-92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bjorseth and Ramdahl, 1985	Review paper	1775–84	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bomboi and others, 1990	Madrid, Spain	1985–86	tray	metal	manual	discrete	assume all flow	NA	NA	NA	NA	Simulated rain for runoff samples; extracted water, solids separately.
Bomboi and Hernandez, 1991	Madrid, Spain	ND	tray	metal	manual	discrete	assume all flow	NA	NA	NA	NA	Same data as Bomboi and others, 1990.
Boom and Marsalek, 1988	Ontario, Canada	1986–87	corer for snow	SS	manual	discrete	NA	NA	NA	NA	NA	NA
Brown and others, 1985	Tampa	1982–83	ND	ND	ND	both	ND	ponar	ND	composite	0–5	Discrete samples of first flush, composite-type unknown; whole water and suspended solids analyzed.
Butler and others, 1984	England	ND	NA	NA	NA	NA	NA	ND	ND	discrete	0–4, 4–8	Samples sieved to 18 mesh.
Cole and others, 1984	15 NURP cities	1979–82	ND	ND	ND	both	ND	NA	NA	NA	NA	Compilation of coordinated studies; low-weighted composites.
Delzer and others, 1996	16 NPDES cities	1991–95	vials	glass	manual	discrete	ND	NA	NA	NA	NA	Compilation of independent studies; sampling procedures varied.
Edwards, 1983	Review paper	1956–82	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eganhouse and Kaplan, 1981a	Los Angeles, California	1978	ND	steel	manual	discrete	center, below surface	NA	NA	NA	NA	Whole and filtered water analyzed.
Eganhouse and Kaplan, 1981b	Los Angeles, California	1978	ND	steel	manual	discrete	center, below surface	NA	NA	NA	NA	Same data as Eganhouse and Kaplan, 1981a.
Ellis and others, 1985	London, England	ND	NA	NA	NA	NA	NA	grab sampler	SS	composite	surface	NA

Table 1. Documented quality criteria of data on semivolatile and volatile organic compounds in urban stormwater and highway runoff—*Continued*

Reference	Where	Years data were collected	Water sampling protocol: Sampler type	Water sampling protocol: Material	Water sampling protocol: Manual or automatic	Water sampling protocol: Discrete or composite	Water sampling protocol: Where in stream	Sediment and soil sampling protocol: Sampler type	Sediment and soil sampling protocol: Material	Sediment and soil sampling protocol: Discrete or composite	Sediment and soil sampling protocol: Depth (cm)	Comment
Evans and others, 1990	United Kingdom	1987–88	NA	NA	NA	NA	NA	jars	glass	discrete	0–10	Collected bottom sediment monthly for 1 year.
Fam and others, 1987	San Francisco, California	ND	bottles + buckets	glass + metal	manual	discrete	ND	NA	NA	NA	NA	Particulates and filtrate analyzed.
Gavens and others, 1982	London, England	ND	ND	ND	ND	ND	ND	corer	SS	discrete	0–10, 290–300	Whole water analyzed; sediment samples sieved into several fractions.
Gjessing and others, 1984	Norway	1981–82	cans	aluminum	manual	discrete	ND	gravity corer	acrylic	discrete	0–2	NA
Gupta, 1981	Milwaukee, Harrisburg, Nashville, Denver	1975–78	ISCO	ND	both	both	ND	NA	NA	NA	NA	Oil and grease sampled manually; whole water analyzed. Flow-weighted composites.
Harrison and Johnston, 1985	England	1981-83	funnel	plastic, glass	passive auto-sampler	composite	NA	NA	NA	NA	NA	Includes data from Johnston and Harrison, 1984.
Herrmann, 1981	Germany	1979	auto-sampler	ND	auto	discrete	ND	pan	ND	NA	surface	Sampled stream, snow, street dust, bed load, rain. Mostly whole water analyzed.
Hewitt and Rashed, 1990	England	ND	funnel, auto-samplers	ND	passive auto-sampler	discrete	NA	trowel	ND	discrete	0–10, 10–20, 20–30	Bulk deposition sampled; autosampler for SWRO.
Hoffman and others, 1983	Narraganset Bay	1979–81	bucket	metal	manual	discrete	ND	NA	NA	NA	NA	Samples collected at about 30-minute intervals; suspended solids and filtrate analyzed.
Hoffman and others, 1984	Narraganset Bay	1979–81	bucket	metal	manual	discrete	ND	NA	NA	NA	NA	Same data as Hoffman and others, 1983.
Hoffman and others, 1985	Rhode Island	1979–81	bucket	metal	manual	discrete	ND	NA	NA	NA	NA	Samples collected at about 30-minute intervals; suspended solids and filtrate analyzed.
Hoffman and Quinn, 1987	Review paper	1969–87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hunter and others, 1979	Philadelphia, Pennsylvania	1974	ND	ND	manual	both	ND	NA	NA	NA	NA	Flow-weighed composites; centrifuged water and particulates analyzed separately.
Johnston and Harrison, 1984	England	1982–83	funnel	plastic	passive auto-sampler	composite	NA	NA	NA	NA		Bulk deposition sampled biweekly.
Latimer and others, 1990	Warwick, Rhode Island	1979–81	bucket	metal	manual	discrete	ND	trowel	SS	discrete	ND	Suspended solids and filtrate analyzed. Soil, vegetation, street dust sampled.
Line and others, 1997	North Carolina	1993–94	auto-sampler	ND	auto-sampler	discrete	ND	NA	NA	NA	NA	Only first-flush samples. Samples iced after collection and preserved at lab.

Table 1. Documented quality criteria of data on semivolatile and volatile organic compounds in urban stormwater and highway runoff—*Continued*

Reference	Where	Years data were collected	Water sampling protocol					Sediment and soil sampling protocol				Comment
			Sampler type	Material	Manual or automatic	Discrete or composite	Where in stream	Sampler type	Material	Discrete or composite	Depth (cm)	
Lopes and Bender, 1998	16 NPDES cities	1991–95	vials	glass	manual	discrete	ND	NA	NA	NA	NA	Includes data from Delzer and others, 1996.
Lopes and others, 1995	Phoenix, Arizona	1991–93	auto-samplers	Teflon, steel, glass	both	both	ND, EWI for stream	NA	NA	NA	NA	Discrete manual samples for VOCs, phenols, O+G. Flow-weighted composites from churn splitter.
Makepeace and others, 1995	Review paper	1970–94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Marsalek and Schroeter, 1988	Canada, Great Lakes region	1979–83	auto-samplers	metal, glass	pumping and passive auto-samplers	flow-weight composite	bank, ND	filtered water	ND	ND	ND	Filtered at 5 micron due to high solids. Also collected street sediments.
Prahl and others, 1984	Seattle, Washington and Columbia River	1979–80	pump	glass	manual	discrete	middle, 1–2 m deep	filtered water	NA	NA	NA	Only analyzed suspended sediment filtered from water using nitrogen. Also sampled air.
Schondorm and Herrmann, 1987	Germany	1986	snow lysimeter	Aluminum foil covered plywood	manual	discrete	NA	NA	NA	NA	NA	NA
Stenstrom and others, 1984	Richmond, California	1980–81	bottles	glass	manual	discrete	ND	NA	NA	NA	NA	Sampled at turbulent locations for uniform sample.
Stotz, 1987	Germany	1978–81	ND	ND	ND	composite	ND	NA	NA	NA	NA	Whole water and centrifuged samples analyzed; unknown composite type.
von Guerard and Weiss, 1995	Colorado Springs, Colorado	1992	auto-samplers	Teflon, glass	both	depth integrated manual	ND, flow turbulent, mixed	NA	NA	NA	NA	Discrete manual samples for VOCs, phenols, O+G. Flow-weighted composites from churn and cone splitter.
Wakeham and others, 1980	Switzerland, Seattle, Washington	1976–77	NA	NA	NA	NA	NA	gravity, piston corers	ND	NA	max 6.4 m	Gravity cores for shallow (<1 m) cores, piston for deep cores.
Wiland and Malina, 1976	Austin, Texas	1976	bottle	glass	manual	discrete	ND	NA	NA	NA	NA	Simulated rainfall for runoff
Yamane and others, 1990	Tokyo, Japan	ND	bottle	glass	manual	discrete	ND	ND	ND	ND	ND	Whole water analyzed; sediment, street dust and highway dust analyzed.
Zawlocki and others, 1980	Seattle, Washington	1979–80	tank, drum	poly-ethylene	automatic	composite	used flow-splitter	NA	NA	NA	NA	Samples taken from well-mixed tank, drum. Flume, flow splitter made of fiberglass, contamination assumed negligible. Filtrate, particulates analyzed.

Table 1 . Documented quality criteria of data on semivolatile and volatile organic compounds in stormwater and highway runoff—*Continued*

Reference	Laboratory methods			Quality assurance				Quality control		
	Instrument	MRL	Comment	Cleaned sampler?	Container	Preser-vation	Comment	Field QC	Lab QC	Comment
Baldys and others, 1997	ND	mostly 0.2–10 mg/L	USGS analytical methods	ND	ND	ND		equipment, trip blanks, matrix spikes, replicates	ND	QC data provided
Baldys and others, 1998	ND	mostly 0.2–10 µg/L	USGS analytical methods	ND	ND	ND	---	blanks, replicates, spikes	reference	No QC results discussed
Barrett and others, 1993	NA	NA	---	NA	NA	NA	---	NA	NA	---
Bjorseth and Ramdahl, 1985	NA	NA	---	NA	NA	NA	---	NA	NA	---
Bomboi and others, 1990	GC-FID, GC-MS	ND	---	ND	ND	ND	---	ND	ND	---
Bomboi and Hernandez, 1991	GC-FID, GC-MS	ND	---	ND	ND	ND	---	ND	ND	---
Boom and Marsalek, 1988	GC-FID	0.05 µg/L	---	ND	stainless steel	ND	Slowly melted snow	ND	ND	---
Brown and others, 1985	GC-FID	ND	1 µg/L	ND	glass	chilled 4°C	Teflon-lined lids	ND	all analyses duplicated, blanks, recovery samples	Teflon-lined lids
Butler and others, 1984	GC-fluorescence	ND	---	ND	ND	ND	---	ND	ND	---
Cole and others, 1984	ND	varied	Many labs used	ND	ND	ND	Guidelines for consistent sample collection, but details not given	blanks, replicates, spikes	performance evaluation samples, surrogates	Summarized QC evaluation
Delzer and others, 1996	GC-MS	0.2–1 µg/L	USGS analytical methods	ND	glass	ND	---	ND	ND	---
Edwards, 1983	NA	NA	---	NA	NA	NA	---	NA	NA	---
Eganhouse and Kaplan, 1981a	gravimetric	ND	---	ND	glass	ND	Samples shaken and split into 2 bottles	ND	ND	---
Eganhouse and Kaplan, 1981b	gravimetric	ND	---	ND	glass	ND	Samples shaken and split into 2 bottles	ND	ND	---
Ellis and others, 1985	GC-FID, GC-MS	ND	---	yes	ND	ND	---	ND	ND	---
Evans and others, 1990	HPLC, GS-MS	ND	Recovery 83–131%	yes	glass	chilled	Covered w/ foil, capped w/metal lid	ND	blanks, recovery samples	Blank, recovery corrections made
Fam and others, 1987	GC-FID	ND	Standard methods	ND	glass	acidify, chill	---	ND	ND	---

Table 1. Documented quality criteria of data on semivolatile and volatile organic compounds in stormwater and highway runoff—*Continued*

Reference	Laboratory methods			Quality assurance				Quality control		
	Instrument	MRL	Comment	Cleaned sampler?	Container	Preser-vation	Comment	Field QC	Lab QC	Comment
Gavens and others, 1982	GC-FID, GC-MS	ND	---	yes	ND	sediment frozen; water ND	---	ND	ND	Suggest naphthalene lost during workup
Gjessing and others, 1984	GC-ND, reference	ND	---	ND	ND	ND	---	ND	ND	---
Gupta, 1981	Standard methods	ND	---	ND	ND	chilled	Overnight shipping	ND	ND	---
Harrison and Johnston, 1985	HPLC, GC-MS	ND	---	yes	glass	ND	Plastic samplers, 2 weeks w/o chilling	ND	blanks	Blank corrections made
Herrmann, 1981	HPLC, fluorescence	ND	ND	ND	ND	ND	Snow, street dust frozen in polyethylene bags	ND	ND	---
Hewitt and Rashed, 1990	HPLC	ND	---	ND	ND	ND	---	ND	ND	---
Hoffman and others, 1983	GC-FID, GC-MS	ND	Precision ~15%	ND	glass	ND	Teflon-lined lids	ND	blanks	No blank corrections needed
Hoffman and others, 1984	GC-FID, GC-MS	ND	Precision mostly 11–25%	ND	glass	ND	Teflon-lined lids	ND	blanks	---
Hoffman and others, 1985	GC-FID, GC-MS	ND	Precision mostly 11–25%	ND	glass	ND	Teflon-lined lids	ND	blanks	---
Hoffman and Quinn, 1987	NA	NA	---	NA	NA	NA	---	NA	NA	---
Hunter and others, 1979	GC-FID	ND	85–95% recovery	ND	glass	ND	---	ND	ND	---
Johnston and Harrison, 1984	HPLC	ND		yes	glass	ND	Plastic samplers, 2 weeks w/o chilling	ND	ND	43–87% recovery, corrections made
Latimer and others, 1990	GC-FID	ND	Relative deviation <20%	yes	glass	none	---	ND	blanks	Blank data given
Line and others, 1997	Standard methods	5 to 100 µg/L	---	yes	ND	chilled	Sometimes hours before samples were retrieved, chilled; autosampler for VOCs	Automatic sampler blanks	lab-split duplicates, spikes for about 10% of samples	---

Table 1. Documented quality criteria of data on semivolatile and volatile organic compounds in stormwater and highway runoff—*Continued*

Reference	Laboratory methods			Quality assurance				Quality control		
	Instrument	MRL	Comment	Cleaned sampler?	Container	Preser-vation	Comment	Field QC	Lab QC	Comment
Lopes and Bender, 1998	GC-MS	0.2–1 µg/L	USGS analytical methods	ND	glass	ND	---	ND	ND	---
Lopes and others, 1995	ND	mostly 0.2–10 µg/L	USGS analytical methods	yes	ND	chilled	Autosampler checked with concurrent manual samples	Automatic sampler and trip blanks, matrix spikes, replicates	ND	Some compounds may degrade; blanks clean
Makepeace and others, 1995	NA	NA	---	NA	NA	NA	---	NA	NA	---
Marsalek and Schroeter, 1988	GC/FID, ECD	water MDL 0.001–0.05 ppb. sediment 5–50 ppb	Recovery 60–110%, precision 12–83%	ND	reference	reference	---	ND	ND, but done	---
Prahl and others, 1984	GC-FID air samples, HPLC sediment samples	ND	---	yes	glass	air samples refrigerated, sediment frozen	Nitrogen used for filtering	ND	ND	GC, HPLC ± 15%
Schondorm and Herrmann, 1987	HPLC, fluorescense	MDL 0.03–0.15ng/L	85-90% recovery	ND	ND	ND	---	ND	ND	---
Stenstrom and others, 1984	IR, GC-FID	ND	---	yes	glass	ND	Sampled turbulent area for well mixed sample	ND	ND	---
Stotz, 1987	reference	ND	---	ND	ND	ND	---	ND	ND	---
von Guerard and Weiss, 1995	ND	mostly 0.2–10 µg/L	USGS analytical methods	yes	ND	chilled	Manual samples from turbulent, well-mixed flow	blanks, spikes	ND	Low spike recovery, blanks clean
Wakeham and others, 1980	GC-FID	1-2 ng/g	Reproducibility ± 25%	ND	ND	frozen or chilled at 4°C	Preservation for samples from 2 lakes not described	ND	blanks	Data blank and recovery corrected
Wiland and Malina, 1976	IR	ND	---	ND	glass	chilled at 4°C	Plastic sheet under truck used for simulated rain	ND	ND	---
Yamane and others, 1990	GC-FID, HPLC	ND	---	ND	glass	NaCl, HCl pH<2.0	Preserved on site	ND	ND	---
Zawlocki and others, 1980	GC/MS, Standard Methods	100 µg/L for trace organics	Trace organics precision ± 50%, results summed into compound class	ND	glass	chilled	Samples well mixed, but don't know if they are of entire storm	ND	lab-split replicates, system blanks, recoveries	Particulate replicates ± 5%, total organic extracts within 20%

Table 2. Semivolatile and volatile organic compounds not detected in stormwater

[IUPAC, International Union of Pure and Applied Chemistry; NURP, Nationwide Urban Runoff Program; NR, not reported]

IUPAC compound name (common name)	Minimum reporting limit (range), in micrograms per liter	Location	Reference
Semivolatile organic compounds			
Benzidine	40	Maricopa County, AZ	Lopes and others, 1995
	40	Colorado Springs, CO	von Guerard and Weiss, 1995
	40	Dallas/Fort Worth, TX	Baldys and others, 1998
4-Bromophenyl phenyl ether	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
0-Chlorobenzene	5	Colorado Springs, CO	von Guerard and Weiss, 1995
4-Chloro-3-methylphenol	30	Dallas/Fort Worth, TX	Baldys and others, 1998
bis(2-Chloroethoxy)methane	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
bis(2-Chloroethyl)ether	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
bis(2-Chloroisopropyl)ether	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
4-Chlorophenyl phenyl ether	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
1,2,5,6-Dibenzanthracene	10	Colorado Springs, CO	von Guerard and Weiss, 1995
3, 3'-Dichlorobenzidine	20	Maricopa County, AZ	Lopes and others, 1995
	20	Colorado Springs, CO	von Guerard and Weiss, 1995
	20	Dallas/Fort Worth, TX	Baldys and others, 1998
2,4-Dichlorophenol	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
Dimethylphthalate	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
4,6-Dinitro-2-methylphenol	30	Dallas/Fort Worth, TX	Baldys and others, 1998
4,6-Dinitro-ortho-cresol	30	Colorado Springs, CO	von Guerard and Weiss, 1995
	NR	Summary–NURP	Cole and others, 1984
2,4-Dinitrophenol	20	Maricopa County, AZ	Lopes and others, 1995
	20	Colorado Springs, CO	von Guerard and Weiss, 1995
	20	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
2,4-Dinitrotoluene	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
2,6-Dinitrotoluene	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
1,2-Diphenyl hydrazine	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998

Table 2 . Semivolatile and volatile organic compounds not detected in stormwater—*Continued*

IUPAC compound name (common name)	Minimum reporting limit (range), in micrograms per liter	Location	Reference
	Semivolatile organic compounds—	***Continued***	
Hexachlorobutadiene	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2–10	Dallas/Fort Worth, TX	Baldys and others, 1998
Hexachlorocyclopentadiene	5	Maricopa County, AZ	Lopes and others, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
Hexachloroethane	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
Isophorone	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
Nitrobenzene	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
2-Nitrophenol	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
n-nitrosodi-n-propylamine	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
n-nitrosodiphenylamine	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
n-nitrosodimethylamine	5	Maricopa County, AZ	Lopes and others, 1995
	5	Colorado Springs, CO	von Guerard and Weiss, 1995
	5	Dallas/Fort Worth, TX	Baldys and others, 1998
Parachlorometacresol	30	Colorado Springs, CO	von Guerard and Weiss, 1995
Phenol	3	Colorado Springs, CO	von Guerard and Weiss, 1995
	3	Dallas/Fort Worth, TX	Baldys and others, 1998
2,4,6-Trichlorophenol	20	Maricopa County, AZ	Lopes and others, 1995
	20	Colorado Springs, CO	von Guerard and Weiss, 1995
	20	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1984
	Volatile organic compounds		
Bromobenzene	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
Bromochloromethane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
Bromomethane (Methyl bromide)	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
Chloroethane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
2-Chloroethyl vinyl ether	1.0	Maricopa County, AZ	Lopes and others, 1995
	1.0	Colorado Springs, CO	von Guerard and Weiss, 1995
	1.0 - 50	Dallas/Fort Worth, TX	Baldys and others, 1998
Chloromethane	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
1-Chloro-2-Methylbenzene (0-Chlorotoluene)	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995

Table 2. Semivolatile and volatile organic compounds not detected in stormwater—*Continued*

IUPAC compound name (common name)	Minimum reporting limit (range), in micrograms per liter	Location	Reference
	Volatile organic compounds— *Continued*		
1,2-Dibromo-3-chloropropane (Dibromochloropropane)	1.0	Maricopa County, AZ	Lopes and others, 1995
	1.0	Colorado Springs, CO	von Guerard and Weiss, 1995
	1.0 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
1,2-Dibromoethane	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
1,2-Dichlorobenzene	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
1,3-Dichlorobenzene	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
1,4-Dichlorobenzene	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
Dichlorodifluoromethane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
1,3-Dichloropropane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
2,2-Dichloropropane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
1,1-Dichloropropene	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
cis-1,3-Dichloropropene	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
trans-1,3-Dichloropropene	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
(1,1-Dimethylethyl)benzene (tert-Butylbenzene)	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
1,1,2,3,4,4-Hexachloro-1,3-butadiene (hexachlorobutadiene)	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary-NURP	Cole and others, 1995
(1-Methylpropyl)benzene (sec-Butylbenzene)	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
Parachlorotoluene	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
2-Propenal (Acrolein)	20	Maricopa County, AZ	Lopes and others, 1995
	20	Colorado Springs, CO	von Guerard and Weiss, 1995
	20 - 1000	Dallas/Fort Worth, TX	Baldys and others, 1998
2-Propenenitrile (Acrylonitrile)	20	Maricopa County, AZ	Lopes and others, 1995
	20	Colorado Springs, CO	von Guerard and Weiss, 1995
	20 - 1000	Dallas/Fort Worth, TX	Baldys and others, 1998
1,1,1,2-Tetrachloroethane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998

Table 2 . Semivolatile and volatile organic compounds not detected in stormwater—*Continued*

IUPAC compound name (common name)	Minimum reporting limit (range), in micrograms per liter	Location	Reference
	Volatile organic compounds— *Continued*		
1,2,3-Trichlorobenzene	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
1,2,4-Trichlorobenzene	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998
	NR	Summary–NURP	Cole and others, 1995
1,2,3-Trichloropropane	0.2	Maricopa County, AZ	Lopes and others, 1995
	0.2	Colorado Springs, CO	von Guerard and Weiss, 1995
	0.2 - 10	Dallas/Fort Worth, TX	Baldys and others, 1998

Table 3. Loading factors for semivolatile organic compounds as a function of land use

[kg, kilogram; km^2, square kilometer; km, kilometer; yr, year; cm, centimeter; m^2, square meter; PAHs, polycyclic aromatic hydrocarbons; µg, microgram; m, meter; hwy, highway; E-5, 10 to the exponent -5; --, factors were not estimated]

Compound class	Residential	Commercial	Industrial	Highway	Bridges	Reference
			Stormwater			
Petroleum hydrocarbons	180 $(kg/km^2)/yr$	580 $(kg/km^2)/yr$	14,000 $(kg/km^2)/yr$	7,800 $(kg/km^2)/yr$	--	Hoffman and Quinn, 1987
	--	--	--	2.5E-5 (kg/vehicle)/km	--	Hoffman and others, 1985
	--	--	--	126 (kg/km^2)/cm rain	--	Hoffman and others, 1985
	2,560 $(kg/km^2)/yr$	--	--	--	--	Hunter and others, 1979
Oil and grease	--	--	--	485-76,700 $(kg/km^2)/yr$	4.1 kg/yr	Barrett and others, 1993
	--	--	--	9-16 (kg/km^2)/event	--	Barrett and others, 1993
	--	--	--	27-298 (kg/km^2)/cm rain	--	Wiland and Malina, 1976
	9.8 (kg/km^2)/cm rain	239 (kg/km^2)/cm rain	--	--	--	Stenstrom and others, 1984
PAHs	[1]0.009 $(kg/km^2)/yr$	[1]0.100 $(kg/km^2)/yr$	[1]2.42 $(kg/km^2)/yr$	[1]1.22 $(kg/km^2)/yr$	--	Hoffman and Quinn, 1987
	[2]0.258 $(kg/km^2)/yr$	[2]0.589 $(kg/km^2)/yr$	[2]3.97 $(kg/km^2)/yr$	[2]16.9 $(kg/km^2)/yr$	--	Hoffman and Quinn, 1987
	--	--	--	0.5-1.8 $(kg/km^2)/yr$	--	Stotz, 1987
	--	--	--	5.8E-8 (kg/vehicle)/km	--	Hoffman and others, 1985
	--	--	--	0.151 (kg/km^2)/cm rain	--	Hoffman and others, 1985
			Bulk deposition			
Petroleum hydrocarbons	61.4 (summer) $(\mu g/m^2)$/day	--	1,130 (winter) 4,120 (summer) $(\mu g/m^2)$/day	--	--	Latimer and others, 1990
Oil and grease	--	--	--	--	8.1 kg/yr	Barrett and others, 1993
PAHs	--	--	--	[3]15.6-48 µg/m of hwy/day	--	Hewitt and Rashed, 1990
	--	--	--	29-71 $(\mu g/m^2)/yr$	--	Harrison and Johnston, 1985

[1]Low-molecular-weight PAHs.
[2]High-molecular-weight PAHs.
[3]Within 50 meters of highway.

Table 4. Upper threshold concentrations of selected semivolatile organic compounds in sediment

[CAS, Chemical Abstracts]

Compound name	CAS number	Threshold concentration, in micrograms per kilogram of sediment
Acenaphthene	83-32-9	[1]1,300
Acenaphthylene	208-96-8	640
Anthracene	120-12-7	1100
Benz[a]anthracene	218-00-9	693
Benzo[a]pyrene	50-32-8	782
Bis(2-ethylhexyl)phthalate	117-81-7	2,650
Butylbenzylphthalate	85-68-7	11,000
Chrysene	218-00-9	862
Dibenz[a,h]anthracene	53-70-3	260
1,2-Dichlorobenzene	120-83-2	350
1,4-Dichlorobenzene	95-50-1	340
Diethylphthalate	84-66-2	630
Di-n-butylphthalate	84-74-2	11,000
Fluoranthene	206-44-0	[1]6,200
Naphthalene	91-20-3	470
Phenanthrene	85-01-8	[1]1,800
Pyrene	129-00-0	1,398
1,2,4-Trichlorobenzene	120-82-1	9,200

[1]Assumes 1 percent sediment organic carbon.

Table 5. Comparison of volatile organic compounds detected in the NURP and NPDES studies

[NURP, Nationwide Urban Runoff Program; NPDES, National Pollutant Discharge Elimination System; NA, not analyzed]

Compound	Frequency of detection, in percent, NURP[1]	Frequency of detection, in percent, NPDES[2]
Toluene	2	23
Xylenes	NA	17.5
Chloroform	12	13
Trimethylbenzene	NA	12
Tetrachloroethene	5	8
Naphthalene	11	7
methyl-*tert* butyl ether	NA	7
Dichloromethane	10	6
Bromodichloromethane	1	6
Ethylbenzene	4	5

[1]Cole and others, 1984.
[2]Delzer and others, 1996.

Table 6. Comparison of volatile organic compounds in stormwater to drinking-water standards

[µg/L, micrograms per liter; IUPAC, International Union of Pure and Applied Chemistry; CAS, Chemical Abstracts; NPDES, National Pollutant Discharge Elimination System; MCL, maximum contaminant level; HAL, health advisory level (U.S. Environmental Protection Agency, 1996c)]

IUPAC name	CAS number	Maximum concentration in NPDES samples	Standard, in µg/L	Type of standard
Methylbenzene	108-88-3	6.6	1,000	MCL
Dimethylbenzenes	1330-20-7	15	10,000	MCL
Trichloromethane	67-66-3	7.0	[1]100	MCL
Tetrachloroethene	127-18-4	42	5	MCL
Naphthalene	91-20-3	5.1	20	HAL
Methyl *tert*-butyl ether	1634-04-4	8.7	[2]20	HAL
Dichloromethane	75-09-2	13	5	MCL
Bromodichloromethane	75-27-4	2.8	[1]100	MCL
Ethylbenzene	100-41-4	2.0	700	MCL
Benzene	71-43-2	0.8	5	MCL

[1]Total for all trihalomethanes combined cannot exceed the 100 µg/L.
[2]Standard varies from 20 to 40 µg/L.

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil

[NPDES, National Pollutant Discharge Elimination System; NURP, Nationwide Urban Runoff Program; NR, not reported; ND, not detected; <, less than reporting limit; --, no data]

Compound name	Location	Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter																	
Acenaphthene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.97	Marsalek and Schroeter, 1988
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.098	NR	--	--	--	Boom and Marsalek, 1988
Acenaphthylene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	NR	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	NR	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.96	Marsalek and Schroeter, 1988
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.153	NR	--	--	--	Boom and Marsalek, 1988
Anthracene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	9	NR	<5	10	NR	--	--	NR	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	7	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	10	--	Cole and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Anthracene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.009	10	NR	Makepeace and others, 1995
	Norway																
	Oslo	ND	0.379	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Benz(*a*) anthracene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	<10	NR	<10	<10	NR	<10	37	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<10	<10	NR	<10	13	NR	<10	26	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0003	10	NR	Makepeace and others, 1995
	Japan																
	Tokyo	--	--	--	NR	NR	5	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Norway																
	Oslo	ND	0.677	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.1	Bomboi and Hernandez, 1991
Benzo(*b*) fluoranthene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	19	NR	<10	<10	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	15	NR	<10	11	--	<10	73	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<10	<10	NR	<10	15	NR	<10	23	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	2	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0034	1.9	NR	Makepeace and others, 1995

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Benzo(*b*) fluoranthene	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.1	0.647	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	1	1.171	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Benzo(*k*) fluoranthene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	14	NR	<10	<10	NR	<10	90	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<10	28	NR	<10	13	NR	<10	22	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	4	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0012	10	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.1	0.99	NR	--	--	--	Boom and Marsalek, 1988
	Japan																
	Tokyo	--	--	--	NR	NR	5	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Norway																
	Oslo	1	1.171	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.6	Bomboi and Hernandez, 1991
Benzo(*b*) fluorene	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.7	Bomboi and Hernandez, 1991
Benzo(*ghi*) perylene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	16	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	<10	--	<10	11	NR	<10	31	NR	--	--	--	von Guerard and Weiss, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Benzo(*ghi*) perylene	Texas																
	Dallas-Fort Worth	--	--	--	<10	<10	NR	<10	15	NR	<10	25	NR	--	--	--	Baldys and others, 1998
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0024	1.5	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.1	0.466	NR	--	--	--	Boom and Marsalek, 1988
	Japan																
	Tokyo	--	--	--	NR	NR	1.2	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Norway																
	Oslo	ND	0.551	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.3	Bomboi and Hernandez, 1991
Benzo(*a*) pyrene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	11	NR	<10	<10	NR	<10	46	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<10	<10	NR	<10	11	NR	<10	20	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0025	10	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.1	0.558	NR	--	--	--	Boom and Marsalek, 1988
	Germany																
	Bayreuth	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	52	Herrmann, 1981
	Japan																
	Tokyo	--	--	--	NR	NR	NR	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Norway																
	Oslo	ND	0.602	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
		Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*															
Benzo(*a*) pyrene	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.1	Bomboi and Hernandez, 1991
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	ND	4.75	NR	Bomboi and others, 1990
Benzo(*e*) pyrene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.4	0.609	NR	Makepeace and others, 1995
	Norway																
	Oslo	ND	0.609	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Butylbenzyl phthalate	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	11	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	10	NR	<5	8	NR	<5	14	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	10	NR	Cole and others, 1984
p-Chloro-*m*-cresol	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	1.5	NR	Cole and others, 1984
2-Chloro naphthalene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.5	0.5	NR	--	--	--	Boom and Marsalek, 1988
B-Chloro naphthalene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.97	Marsalek and Schroeter, 1988
2-Chloro phenol	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
2-Chloro phenol	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	2	NR	Cole and others, 1984
Chrysene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	17	NR	<10	<10	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	--	NR	<10	12	NR	<10	61	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<10	<10	NR	<10	23	NR	<10	49	3.2	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.6	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0038	10	NR	Makepeace and others, 1995
	Norway																
	Oslo	ND	1.147	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.4	Bomboi and Hernandez, 1991
Dibenzanthra-cene	United States																
	Texas																
	Dallas–Fort Worth	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Baldys and others, 1998
	Norway																
	Oslo	ND	0.214	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Dibenz(*a,h*) anthracene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0006	0.9	NR	Makepeace and others, 1995
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.5	Bomboi and Hernandez, 1991
Dibenzofuran	Norway																
	Oslo	ND	0.001	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Dibenzothiophene	Norway																
	Oslo	ND	0.136	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
1,2-Dichloro benzene	United States																
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<5	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.39	Marsalek and Schroeter, 1988
1,3-Dichloro benzene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<5	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0074	Marsalek and Schroeter, 1988
1,4-Dichloro benzene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<5	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0089	Marsalek and Schroeter, 1988

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Diethylphthalate	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	2	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	1	1.4	NR	Makepeace and others, 1995
9,10-Dimethyl-anthracene	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1	Bomboi and Hernandez, 1991
2,4-Dimethyl phenol	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	10	NR	Cole and others, 1984
Di-n-butyl phthalate	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	15	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.5	11	NR	Cole and others, 1984
Di-n-octyl phthalate	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Lopes and others, 1995

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Di-n-octyl phthalate	Colorado																
	Colorado Springs	--	--	--	<10	11	NR	<10	11	NR	<10	11	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<10	<10	NR	<10	<10	NR	<10	<10	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.4	1	NR	Cole and others, 1984
bis(2-Ethyl hexyl) phthalate	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	8	NR	<5	9	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	7	13	NR	11	100	NR	9	24	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<5	24	5.7	<5	20	NR	<5	140	6.9	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	7	39	NR	Cole and others, 1984
Fluoranthene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	18	NR	<5	7	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	32	NR	10	25	NR	<5	120	NR	--	--	--	von Guerard and Weiss, 1995
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.1609	NR	--	--	--	--	--	--	Hoffman and others, 1984
	Texas																
	Dallas-Fort Worth	--	--	--	<5	13	NR	<5	23	3.6	<5	52	6.5	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.3	12	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.03	56	NR	Makepeace and others, 1995
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1	Marsalek and Schroeter, 1988
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.5	2.95	NR	--	--	--	Boom and Marsalek, 1988
	Germany																
	Bayreuth	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.106	Herrmann, 1981

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Fluoranthene	Norway																
	Oslo	4	2.665	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	2.7	Bomboi and Hernandez, 1991
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	0.4	10.65	NR	Bomboi and others, 1990
Fluorene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	1	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.096	1	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.135	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	ND	0.96	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Hexachloro benzene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<5	--	NR	<5	<5	NR	<5	<5	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.00073	Marsalek and Schroeter, 1988
Indene	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.05	NR	--	--	--	Boom and Marsalek, 1988

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Indeno (1,2,3-cd) pyrene	United States																
	Arizona																
	Maricopa County	--	--	--	<10	<10	NR	<10	<10	NR	<10	27	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<10	11	NR	<10	13	NR	<10	38	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<10	<10	NR	<10	15	NR	<10	27	NR	--	--	--	Baldys and others, 1998
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.31	0.5	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.1	0.496	NR	--	--	--	Boom and Marsalek, 1988
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.2	Bomboi and Hernandez, 1991
1-Methyl anthracene	Norway																
	Oslo	ND	0.133	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
2-Methyl anthracene	Norway																
	Oslo	ND	0.036	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.7	Bomboi and Hernandez, 1991
1-Methyl naphthalene	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.177	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	ND	0.045	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
2-Methyl naphthalene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.01	1.6	NR	Makepeace and others, 1995
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.95	Marsalek and Schroeter, 1988
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.251	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	ND	0.025	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Methylphenanthrene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	2.9	3.4	NR	Makepeace and others, 1995
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	2.9	Bomboi and Hernandez, 1991
Naphthalene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<5	NR	<0.2	<5	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.8	2.3	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.036	2.3	NR	Makepeace and others, 1995
	Norway																
	Oslo	ND	0.067	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
4-Nitrophenol	United States																
	Arizona																
	Maricopa County	--	--	--	<30	<30	NR	<30	<30	NR	<30	<30	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<30	<30	NR	<30	<30	NR	<30	<30	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<30	<30	NR	<30	<30	NR	<30	<30	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	19	NR	Cole and others, 1984
PAH (total)	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.24	13	NR	Makepeace and others, 1995
	Germany																
	Obereisesheim	NR	NR	2.97	--	--	--	--	--	--	--	--	--	--	--	--	Stoltz, 1987
	Pleidelsheim	NR	NR	2.61	--	--	--	--	--	--	--	--	--	--	--	--	Stoltz, 1987
	Ulm	NR	NR	2.51	--	--	--	--	--	--	--	--	--	--	--	--	Stoltz, 1987
	United Kingdom																
	NW London	--	--	--	--	--	--	--	--	--	--	--	--	5830	18210	NR	Gavens and others, 1983

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
	Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																
Pentachloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.001	Marsalek and Schroeter, 1988
Pentachloro phenol	United States																
	Arizona																
	Maricopa County	--	--	--	<30	<30	NR	<30	<30	NR	<30	<30	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<30	<30.	NR	<30	<30	NR	<30	<30	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<30	<30	NR	<30	<30	NR	<30	<30	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	115	NR	Cole and others, 1984
Perylene	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.05	0.5	NR	Makepeace and others, 1995
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.5	Bomboi and Hernandez, 1991
Phenanthrene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	23	NR	<5	14	NR	<5	67	NR	--	--	--	von Guerard and Weiss, 1995
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.0906	NR	--	--	--	--	--	--	Hoffman and others, 1984
	Texas																
	Dallas–Fort Worth	--	--	--	<5	10	NR	<5	10	NR	<5	33	3.6	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.3	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.045	10	NR	Makepeace and others, 1995
	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	3.56	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	3	1.385	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Phenanthrene	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	2.9	Bomboi and Hernandez, 1991
Phenol	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	3	10	NR	Cole and others, 1984
0-Phenyl enepyrene	Norway																
	Oslo	ND	0.432	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
Pyrene	United States																
	Arizona																
	Maricopa County	--	--	--	<5	<5	NR	<5	13	NR	<5	<5	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<5	24	NR	8	19	NR	<5	94	NR	--	--	--	von Guerard and Weiss, 1995
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.1367	NR	--	--	--	--	--	--	Hoffman and others, 1984
	Texas																
	Dallas-Fort Worth	--	--	--	<5	10	NR	<5	18	NR	<5	43	5.4	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.3	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.045	10	NR	Makepeace and others, 1995
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1	Marsalek and Schroeter, 1988
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	3.75	NR	--	--	--	Boom and Marsalek, 1988
	Norway																
	Oslo	5	2.002	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.9	Bomboi and Hernandez, 1991
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	0.5	8.5	NR	Bomboi and others, 1990
Quinoline	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.124	NR	--	--	--	Boom and Marsalek, 1988
1,2,3,4-Tetra hydronaph-thalene	Canada																
	Sault Ste Marie	--	--	--	--	--	--	--	--	--	<0.05	0.05	NR	--	--	--	Boom and Marsalek, 1988

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, whole water, in micrograms per liter—*Continued*																	
1,2,4-Trichloro benzene	United States																
	Colorado																
	Colorado Springs	--	--	--	<5	<5	NR	<5	<5	NR	<5	<5	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<5	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0015	Marsalek and Schroeter, 1988
1,3,5,-Trichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.00099	Marsalek and Schroeter, 1988
Semivolatile organic compounds, filtered/centrigured water, in micrograms per liter																	
Fluoranthrene	United States																
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.0034	NR	--	--	--	--	--	--	Hoffman and others, 1984
Phenanthrene	United States																
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.0263	NR	--	--	--	--	--	--	Hoffman and others, 1984
Pyrene	United States																
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	0.0056	NR	--	--	--	--	--	--	Hoffman and others, 1984
Semivolatile organic compounds, suspended sediment, in micrograms per gram																	
Acenaphthylene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.7	Marsalek and Schroeter, 1988
Benzo(*b*) fluoranthene	United States																
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.021	0.35	0.07	Prahl and others, 1984
Benzo(*k*) fluorenthene	United States																
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.008	0.14	NR	Prahl and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, suspended sediment, in micrograms per gram—*Continued*																	
Benzo(*ghi*) perylene	United States																
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.007	0.15	0.019	Prahl and others, 1984
Benzo(*a*) pyrene	United States																
	Rhode Island																
	Cranston	0.28	7.78	1.35	--	--	--	--	--	--	--	--	--	--	--	--	Hoffman and others, 1985
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.005	0.097	0.016	Prahl and others, 1984
1,2-Dichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.12	Marsalek and Schroeter, 1988
1,3-Dichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.027	Marsalek and Schroeter, 1988
1,4-Dichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.4	Marsalek and Schroeter, 1988
Fluoranthene	United States																
	Rhode Island																
	Cranston	3.2	45.7	12	--	--	--	--	--	--	--	--	--	--	--	--	Hoffman and others, 1985
	Cranston	--	--	--	--	--	--	NR	3.32	NR	--	--	--	--	--	--	Hoffman and others, 1984
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.025	0.38	0.052	Prahl and others, 1984
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	2.4	Marsalek and Schroeter, 1988
Hexachloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.075	Marsalek and Schroeter, 1988
Indene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.44	Marsalek and Schroeter, 1988
2-Methylnaph-thalene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.53	Marsalek and Schroeter, 1988

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, suspended sediment, in micrograms per gram—*Continued*																	
Pentachloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0098	Marsalek and Schroeter, 1988
Perylene	United States																
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.021	0.17	0.051	Prahl and others, 1984
Phenanthrene	United States																
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	1.35	NR	--	--	--	--	--	--	Hoffman and others, 1984
Phenanthrene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.7	Marsalek and Schroeter, 1988
Pyrene	United States																
	Rhode Island																
	Cranston	--	--	--	--	--	--	NR	2.76	NR	--	--	--	--	--	--	Hoffman and others, 1984
	Washington																
	Columbia River	--	--	--	--	--	--	--	--	--	--	--	--	0.026	0.41	0.056	Prahl and others, 1984
	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	2.2	Marsalek and Schroeter, 1988
1,2,3,5-Tetra chloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.005	Marsalek and Schroeter, 1988
1,2,3,4-Tetra chloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0044	Marsalek and Schroeter, 1988
1,2,4,5-Tetra chloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.005	Marsalek and Schroeter, 1988
1,2,3-Trichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0076	Marsalek and Schroeter, 1988
1,2,4-Trichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.0085	Marsalek and Schroeter, 1988
1,3,5-Trichloro benzene	Canada																
	Canadian Great Lakes	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	0.019	Marsalek and Schroeter, 1988

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, bottom material/soil, in micrograms per gram																	
Anthracene	Norway																
	Olso	ND	0.16	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.25	2.1	NR	Ellis and others, 1985
Benzo(*a*) anthracene	Japan																
	Tokyo	--	--	--	NR	NR	0.075	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	United Kingdom																
	Midlands	0.169	2.97	1.165	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Benzo(*b*)fluor anthene	Norway																
	Olso	0.03	0.096	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.5	4	NR	Ellis and others, 1985
Benzo(*k*)fluor anthene	Japan																
	Tokyo	--	--	--	NR	NR	0.14	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.5	4	NR	Ellis and others, 1985
Benzo(*ghi*) perylene	Japan																
	Tokyo	--	--	--	NR	NR	0.42	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.1	4.5	NR	Ellis and others, 1985
Benzo(*a*) pyrene	US–summary	--	--	--	--	--	--	--	--	--	--	--	--	0.04	7	NR	Edwards, 1983
	Canada–summary	NR	0.866	NR	--	--	--	--	--	--	--	--	--	--	--	--	Edwards, 1983
	Czechoslovakia–summary	--	--	--	--	--	--	--	--	--	--	--	--	0.0083	0.0421	--	Edwards, 1983
	Germany–summary	--	--	--	--	--	--	--	--	--	0.8	650	NR	0.0015	0.004	NR	Edwards, 1983
	Japan																
	Tokyo	--	--	--	NR	NR	0.08	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Russia																
	Moscow–summary	--	--	--	--	--	--	--	--	--	0.058	0.2997	NR	ND	200	--	Edwards, 1983
	Switzerland																
	Greifebsee	--	--	--	--	--	--	--	--	--	--	--	--	ND	2	NR	Wakeham and others, 1980
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.2	2.9	NR	Ellis and others, 1985

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Semivolatile organic compounds, bottom material/soil, in micrograms per gram—*Continued*																	
Benzo(*a*) pyrene	Midlands	0.165	3.196	0.781	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
	Yugoslavia–summary	--	--	--	--	--	--	--	--	--	--	--	--	0.029	0.9	--	Edwards, 1983
Benzo(*e*) pyrene	Norway Olso	ND	0.8	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	United Kingdom Midlands	0.164	2.293	0.731	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Chrysene	Norway Olso	0.02	0.1	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	United Kingdom Midlands	0.251	2.703	1.949	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Coronene	United Kingdom Midlands	0.032	0.322	0.117	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Fluoranthene	Norway Olso	0.066	0.248	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Switzerland Greifebsee	--	--	--	--	--	--	--	--	--	--	--	--	ND	3.5	NR	Wakeham and others, 1980
	United Kingdom Midlands	0.2	3.734	1.313	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Fluorene	United Kingdom N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.3	3.9	NR	Ellis and others, 1985
PAH (total)	United States Washington Lake Washington	--	--	--	--	--	--	--	--	--	--	--	--	1	6.5	NR	Wakeham and others, 1980
	Canada–summary	--	--	--	--	--	--	--	--	--	--	--	--	NR	1.109	NR	Edwards, 1983
	Switzerland Greifensee	--	--	--	--	--	--	--	--	--	--	--	--	0.3	6	NR	Wakeham and others, 1980
	Lake Lucerne	--	--	--	--	--	--	--	--	--	--	--	--	1	5.5	NR	Wakeham and others, 1980
	Lake Zurich	--	--	--	--	--	--	--	--	--	--	--	--	0.4	15	NR	Wakeham and others, 1980

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Semivolatile organic compounds, bottom material/soil, in micrograms per gram—*Continued*																	
PAH (total)	Summary	5	300	NR	--	--	--	--	--	--	--	--	--	4	8	NR	Edwards, 1983
	United Kingdom																
	Derwent River	1.51	26.76	8.32	0.02	2.45	0.58	2.65	63.75	34.55	2.91	209.59	25.75	--	--	--	Evans and others, 1990
	NW London	--	--	--	--	--	--	--	--	--	--	--	--	310	1100	NR	Gavens and others, 1983
Phenanthra-cene	Norway																
	Olso	0.07	0.18	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	Switzerland																
	Greifebsee	--	--	--	--	--	--	--	--	--	--	--	--	ND	5	NR	Wakeham and others, 1980
Pyrene	Norway																
	Olso	0.11	0.122	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gjessing and others, 1984
	United Kingdom																
	N.W. London	--	--	--	--	--	--	--	--	--	--	--	--	0.1	3.3	NR	Ellis and others, 1985
	Midlands	0.145	4.515	1.386	--	--	--	--	--	--	--	--	--	--	--	--	Butler and others, 1984
Extractable organic compounds, whole water, in milligrams per liter																	
Hydrocarbons	United States																
	California																
	Los Angeles	--	--	--	--	--		--	--	--	--	--	--	0.99	19.5	NR	Eganhoues and Kaplan. 1981
	San Francisco Bay	--	--	--	--	--	--	--	--	--	2.98	9.75	NR	1.606	10.83	NR	Fam and others, 1987
	Florida																
	Tallahassee	--	--	--	--	--	--	0.064	16.4	3.44	--	--	--	0.17	1.35	0.58	Hoffman and Qunin, 1987
	Pennsylvania																
	Philadelphia	--	--	--	--	--	--	--	--	--	--	--	--	2.18	5.3	3.69	Hunter and others, 1979
	Rhode Island	0.03	6.85	3.28	0.02	1.95	1.09	0.04	5.71	0.99	0.32	58.4	19.82	--	--	--	Hoffman and Qunin, 1987
	Cranston	2	6	NR	--	--	--	--	--	--	--	--	--	--	--	--	Hoffman and others, 1983
	Cranston	--	--	--	--	--	--	--	1.14	--	--	--	--	--	--	--	Hoffman and others, 1984
	Washington																
	Seattle	--	--	--	--	--	--	--	--	--	--	--	--	6	24	NR	Hoffman and Qunin, 1987

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Extractable organic compounds, whole water, in milligrams per liter—*Continued*																	
Hydrocarbons	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.64	19.71	NR	Makepeace and others, 1995
	Japan																
	Tokyo	--	--	--	NR	NR	0.75	--	--	--	--	--	--	--	--	--	Yamane and others, 1990
	Spain																
	Madrid	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	1.154	Bomboi and Hernandez, 1991
	Switzerland	1.7	10	3.9	--	--	--	--	--	--	--	--	--	--	--	--	Hoffman and Qunin, 1987
	United Kingdom																
	NW London	--	--	--	--	--	--	--	--	--	--	--	--	0.36	1.1	NR	Gavens and others, 1983
Extractable organic compounds, filtered/centrigured water, in milligrams per liter																	
	United States																
	California																
	Los Angeles	--	--	--	--	--	--	--	--	--	--	--	--	0.302	0.49	NR	Eganhouse and Kaplan, 1981
	San Francisco Bay	--	--	--	--	--	--	--	--	--	1.29	4.32	NR	1.18	3.98	NR	Fam and others, 1987
	Pennsylvania																
	Philadelphia	--	--	--	--	--	--	--	--	--	--	--	--	0.67	0.16	0.4	Hunter and others, 1979
	Rhode Island																
	Cranston	ND	0.5	NR	--	--	--	--	--	--	--	--	--	--	--	--	Hoffman and others, 1983
	Cranston	--	--	--	--	--	--	--	0.0954	--	--	--	--	--	--	--	Hoffman and others, 1984
Extractable organic compounds, suspended sediment, in micrograms per gram																	
	United States																
	Rhode Island	8,750	51,800	24,800	15,700	59,800	42,000	16,400	34,000	24,800	61,900	507,000	211,000	--	--	--	Latimer and others, 1990
	Cranston	--	--	--	--	--	--	--	21,900	--	--	--	--	--	--	--	Hoffman and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	8.75	507	NR	Makepeace and others, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Extractable organic compounds, bottom material/soil, in micrograms per gram																	
Hydrocarbons	United States																
	Florida																
	Tampa	--	--	--	--	--	--	--	--	--	--	--	--	152	485	258	Brown and others, 1985
	Japan																
	Tokyo	--	--	--	--	--	--	--	--	--	--	--	--	NR	NR	69	Yamane and others, 1990
	United Kingdom																
	NW London	--	--	--	--	--	--	--	--	--	--	--	--	43	690	NR	Gavens and others, 1983
Extractable organic compounds, whole water, in milligrams per liter																	
Oil and grease	United States																
	Arizona																
	Maricopa County	--	--	--	<1	10	NR	<1.0	5	NR	<1	6	NR	<1	8	NR	Lopes and Fossum, 1995
	California																
	Richmond	4.2	89.09	16.05	0.57	24.55	3.92	1.98	--	10.9	1.49	21.11	7.26	2.1	71.97	7.87	Stenstrom and others, 1984
	Colorado																
	Boulder	--	--	--	1.7	25.9	NR	8.9	155	NR	--	--	--	--	--	--	Hoffman and Qunin, 1987
	Colorado Springs	--	--	--	<1	10	NR	<1.0	10	NR	<1	6	NR	--	--	--	von Guerard and Weiss, 1995
	Michigan																
	Southeast Michigan	--	--	--	--	--	--	--	--	--	--	--	--	ND	0.28	NR	Hoffman and Qunin, 1987
	North Carolina	--	--	--	--	--	--	--	--	--	<5	51	6	--	--	--	Line and others, 1997
	Texas																
	Austin	1.4	7.8	3.65	--	--	--	--	--	--	--	--	--	--	--	--	Wiland and Malima, 1976
	Dallas–Fort Worth	--	--	--	<1	19	2.2	<1.0	8	2.3	1	1.2	3.5	--	--	--	Baldys and others, 1998
	Washington																
	Seattle	146	480	NR	--	--	--	--	--	--	--	--	--	--	--	--	Zawlocki and others, 1980
	Wisconson																
	Milwaukee	1	20	NR	--	--	--	--	--	--	--	--	--	--	--	--	Gupta, 1981
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.001	110	NR	Makepeace and others, 1995
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	2.7	27	NR	Barrett and others, 1993

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Extractable organic compounds, bottom material/soil, in micrograms per gram																	
Oil and grease	United States																
	Arizona																
	Maricopa County	--	--	--	--	--	--	--	--	--	--	--	--	<100	2,200	NR	Lopes and Fossum, 1995
Volatile organic compounds, whole water, in micrograms per liter																	
Benzene	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	0.4	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	<0.2	NR	<0.2	0.8	0.12	<0.2	0.6	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	3.5	13	NR	Cole and others, 1984
Bromodichloromethane	United States																
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	0.2	NR	<0.2	<10	NR	<0.2	0.5	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	2	NR	Cole and others, 1984
	Summary-NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	2.8	NR	Delzer and others, 1996
n-Butylbenzene	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	0.4	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	0.2	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
Chlorobenzene	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Volatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Chlorobenzene	Colorado Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary–NURP United States	--	--	--	--	--	--	--	--	--	--	--	--	1	10	NR	Cole and others, 1984
Chloroethene (vinyl chloride)	Arizona Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	110	NR	--	--	--	Baldys and others, 1998
1,2-Chloro toluene	United States Texas Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	0.2	NR	--	--	--	Baldys and others, 1998
1,4-Chloro toluene	United States Texas Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	0.2	NR	--	--	--	Baldys and others, 1998
Dibromochloro-methane (chloro dibromo-methane)	United States Arizona Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas Dallas–Fort Worth	--	--	--	<0.2	<0.2	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary–NURP United States	--	--	--	--	--	--	--	--	--	--	--	--	2	2	NR	Cole and others, 1984
Dibromo methane	United States Arizona Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995

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Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Highway			Residential			Commercial			Industrial			Unspecified			Reference
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
		Volatile organic compounds, whole water, in micrograms per liter—*Continued*															
Dibromo methane	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.2	NR	<0.2	0.4	NR	<0.2	0.7	NR	--	--	--	Baldys and others, 1998
1,1-Dichloro ethane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	8.3	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1.5	3	NR	Cole and others, 1984
1,2-Dichloro ethane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	4	NR	Cole and others, 1984
1,1-Dichloro ethene (1,1-Dichloro ethylene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	5.9	NR	<0.2	<10	NR	<0.2	13	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1.5	4	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	1.5	4	NR	Makepeace and others, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
		Volatile organic compounds, whole water, in micrograms per liter—*Continued*															
cis-1,2-Dichloro ethene	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	1200	25.7	--	--	--	Baldys and others, 1998
trans-1,2-Dichloro ethene (*trans*-1,2-Dichloro ethylene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	27	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	3	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	1	3	NR	Makepeace and others, 1995
Dichloro methane (methylene chloride)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<20	NR	<0.2	0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.8	NR	<0.2	<0.2	NR	<0.2	0.09	0.09	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	4	14.5	NR	Cole and others, 1984
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	13	NR	Baldys and others, 1998
1,2-Dichloro propane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
		Volatile organic compounds, whole water, in micrograms per liter—*Continued*															
1,2-Dichloro propane	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary-NPDES	--	--	--	--	--	--	--	--	--	--	--	--	NR	3	NR	Cole and others, 1984
1,3-Dichloro propene (isomer not specified)	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	2	NR	Cole and others, 1984
Ethenyl benzene (Styrene)	United States																
	Arizona	--	--	--	<0.2	<0.2	NR	<0.2	<20	NR	<0.2	0.5	NR	--	--	--	Lopes and others, 1995
	Maricopa County																
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	<5	NR	<0.2	0.6	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
Ethylbenzene	United States																
	Arizona	--	--	--	<0.2	<0.2	NR	<0.2	<20	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Maricopa County																
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	0.6	NR	<0.2	0.6	NR	<0.2	1.5	NR	--	--	--	Baldys and others, 1998
	Summary-NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	2	NR	Cole and others, 1984
	Summary-NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	2	NR	Delzer and others, 1996
Isopropyl benzene	United States																
	Arizona	--	--	--	<0.2	<0.2	NR	<0.2	<20	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Maricopa County																
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Volatile organic compounds, whole water, in micrograms per liter—Continued																	
Isopropyl benzene	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	--	NR	<0.2	<10	NR	<0.2	4.6	NR	--	--	--	Baldys and others, 1998
1-Isopropyl-4-methyl benzene (P-isopropyltoluene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<20	NR	<0.2	0.7	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	0.9	NR	<0.2	0.2	NR	--	--	--	Baldys and others, 1998
Methyl benzene (Toluene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<1	0.2	NR	<0.2	0.3	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	1.2	NR	<0.2	1.7	NR	<0.2	0.4	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	1.8	0.08	<0.2	2.4	0.25	<0.2	1.8	0.11	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	9	12	NR	Cole and others, 1984
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	6.6	NR	Delzer and others, 1996
2-Methoxy-2-methyl-propane (Methyl *tert*-butyl ether)	United States																
	Alabama																
	Birmingham	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	1.9	NR	Delzer and others, 1996
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<5	2.5	NR	<0.2	0.3	NR	--	--	--	Lopes and others, 1995
	Phoenix	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	2.5	NR	Delzer and others, 1996
	Colorado																
	Colorado Springs	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	3	NR	Delzer and others, 1996
	Denver	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	1.5	NR	Delzer and others, 1996

Table 7 . Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
	Volatile organic compounds, whole water, in micrograms per liter—*Continued*																
2-Methoxy-2-methyl-propane (Methyl *tert*-butyl ether)	Georgia																
	Atlanta	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	1.5	NR	Delzer and others, 1996
	Louisana																
	Baton Rouge	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	0.4	NR	Delzer and others, 1996
	Texas																
	Dallas–Fort Worth	--	--	--	<1	<25	NR	<1	8.7	1.2	<0.2	5.4	NR	--	--	--	Baldys and others, 1998
	San Antonio	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	1.8	NR	Delzer and others, 1996
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	8.7	NR	Delzer and others, 1996
Naphthalene	United States																
	Colorado																
	Colorado Springs	--	--	--	<0.2	0.4	NR	<0.2	--	NR	<0.2	1.1	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.6	NR	<0.2	<5	NR	<0.2	1.3	NR	--	--	--	Baldys and others, 1998
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	5.1	NR	Delzer and others, 1996
n-Propyl benzene	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas- Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	0.5	NR	--	--	--	Baldys and others, 1998
1,1,2,2-Tetra chloro ethane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<01	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	2	3	NR	Cole and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Volatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Tetrachloro ethene (Tetrachlor-oethylene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	42	1.2	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	4.5	43	NR	Cole and others, 1984
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	42	NR	Delzer and others, 1996
Tetrachloro methane (Carbon tetra chloride)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1	2	NR	Cole and others, 1984
Tribromo methane (Bromo form)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<10	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	NR	1	NR	Cole and others, 1984
1,1,1-Trichloro ethane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	0.7	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
		Land use															
Volatile organic compounds, whole water, in micrograms per liter—*Continued*																	
1,1,1-Trichloro ethane	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<0.2	NR	<0.2	0.2	NR	<0.2	5.4	<0.24	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	1.6	10	NR	Cole and others, 1984
1,1,2-Trichloro ethane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<5	NR	<0.2	<10	NR	<0.2	<0.2	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	2	3	NR	Cole and others, 1984
Trichloro ethene (Trichloro ethylene)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.2	NR	<0.2	<10	NR	<0.2	28	1.3	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.3	10	NR	Cole and others, 1984
	Summary	--	--	--	--	--	--	--	--	--	--	--	--	0.3	10	NR	Makepeace and others, 1995
Trichloro fluoro methane	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.5	<13	NR	<0.5	<25	NR	<0.2	<25	NR	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.6	0.27	NR	Cole and others, 1984

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use: Highway Min	Highway Max	Highway Mean	Residential Min	Residential Max	Residential Mean	Commercial Min	Commercial Max	Commercial Mean	Industrial Min	Industrial Max	Industrial Mean	Unspecified Min	Unspecified Max	Unspecified Mean	Reference
Volatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Trichloro methane Chloroform	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<0.2	<0.2	NR	<0.2	<0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	2.1	NR	<0.2	<0.2	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.7	0.06	<0.2	1.1	NR	<0.2	0.7	0.15	--	--	--	Baldys and others, 1998
	Summary–NURP	--	--	--	--	--	--	--	--	--	--	--	--	0.2	12	NR	Cole and others, 1984
	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	7	NR	Delzer and others, 1996
1,1,2-Trichloro-1,2,2-trifluoro ethane	United States																
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	0.4	NR	<0.2	<10	NR	<0.2	<0.2	NR	--	--	--	Baldys and others, 1998
1,2,4-Trimethyl benzene	United States																
	Colorado																
	Colorado Springs	--	--	--	<0.2	0.9	NR	<0.2	2.8	NR	<0.2	0.4	NR	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	2	NR	<0.2	0.4	NR	<0.2	15	NR	--	--	--	Baldys and others, 1998
1,3,5-Trimethyl benzene	United States																
	Colorado																
	Colorado Springs	--	--	--	<0.2	<0.2	NR	<0.2	0.9	NR	<0.2	<0.2	--	--	--	--	von Guerard and Weiss, 1995
	Texas																
	Dallas–Fort Worth	--	--	--	<0.2	<0.2	NR	<0.2	<10	NR	<0.2	6.3	NR	--	--	--	Baldys and others, 1998
Trimethyl benzene	Summary–NPDES	--	--	--	--	--	--	--	--	--	--	--	--	<0.2	15	NR	Delzer and others, 1996
Dimethyl benzene (total xylenes) (isomer not specified)	United States																
	Arizona																
	Maricopa County	--	--	--	<0.2	<0.2	NR	<1	0.3	NR	<0.2	0.2	NR	--	--	--	Lopes and others, 1995
	Colorado																
	Colorado Springs	--	--	--	<0.2	1.5	NR	<0.2	4.4	NR	<0.2	0.7	NR	--	--	--	von Guerard and Weiss, 1995

Table 7. Concentrations of detected semivolatile and volatile organic compounds in stormwater, suspended sediment, and bottom material/soil—*Continued*

Compound name	Location	Land use															Reference
		Highway			Residential			Commercial			Industrial			Unspecified			
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Volatile organic compounds, whole water, in micrograms per liter—*Continued*																	
Dimethyl benzene (total xylenes) (isomer not specified)	Texas																
	Dallas-Fort Worth	--	--	--	<0.2	3.7	0.12	<0.2	1.9	0.23	<0.2	<0.2	0.43	--	--	--	Baldys and others, 1998
	Summary-NPDES	--	--	--	--	--	--	--	--	--	<0.2	10	--	<0.2	15	NR	Delzer and others, 1996
Volatile organic compounds, suspended sediment, in micrograms per gram																	
Benzene	United States																
	New York																
	Love Canal	--	--	--	--	--	--	--	--	--	--	--	--	NR	0.232	NR	Makepeace and others, 1995

District Chief,
South Dakota District
U.S. Geological Survey
Water Resources Division
1608 Mt. View Road
Rapid City, SD 57702

Stormwater Sampling – StormFilter™ Performance Results

Burwell/Straley's Union 76 Station
Bremerton, Washington

Storms Captured - April through October 2000 (3 storms)

Overview: The following is a summary of the stormwater sampling results obtained from the StormFilter unit located at Straley's Union 76 Station, 308 North Montgomery Avenue, Bremerton, Washington. Sampling and reporting provided by EnCo Environmental Corporation, Puyallup, Washington.

Site and System Description: Straley's BP is a typical gasoline station with accompanying convenience store. The site is 2.53 acres with 1.99 acres being impervious surface. The site drains to a Type II 54" upstream manhole followed by an 8' x 16' StormFilter containing 23 filtration cartridges. The cartridges contain CSF® leaf media that is composed of granulated deciduous leaf compost. The systems peak treatment flow is 0.78 cfs (350 gpm) based on the 6 month – 24 hour storm event. (*Note: Each cartridge filters at 15 gpm.*)

Sampling: Samples consisted of first flush and flow weighted composite samples. The first flush samples were collected during the first hour of runoff (3 samples) with flow weighted composite samples taken in 20-minute intervals during the course of the storm. Samples were composited based on flow rates and volumes passing through the system over the 20-minute interval. (*Note: Influent samples were taken as flow entered the StormFilter unit rather than the upstream manhole such that the reported efficiencies reflect the filtration unit and not total system efficiency. Effluent samples were taken as water exited the unit.*)

Storm Sample Results: Three storms were captured between the months of April and October 2000. The tables below present the acquired data with a brief description of the storm following each table.

Table One: Storm Event – April 25th 2000 (Peak Flow = 0.91 cfs)

Sample	pH (IN)	pH (OUT)	Dissolved Zinc (IN) (mg/l)	Dissolved Zinc (OUT) / % Removed (mg/l)	Total Zinc Influent (IN) (mg/l)	Total Zinc Effluent (OUT) / % Removed (mg/l)
First Flush	6.5	6.5	0.27	0.076 / 71.9%	0.30	0.086 / 71.3%
Flow Composite	6.5	6.5	0.24	0.11 / 54.2%	0.27	0.12 / 55.5%

Table One (Cont.): Storm Event – April 25th 2000 (Peak Flow = 0.91 cfs)

Sample	Total Phosphorus (IN) (mg/l)	Total Phosphorus (OUT) (mg/l)	Oil and Grease – HEM* (IN) (mg/l)	Oil and Grease – HEM (OUT) / % Removed (mg/l)	TSS (IN) (mg/l)	TSS (OUT) (mg/l) / % Removed
First Flush	<0.25	<0.25	10	4 / 60%	18	4 / 77.8%
Flow Composite	<0.25	<0.25	2	3 / -50%	24	10 / 58.3%

* HEM = Hexane Extractable Method (EPA 1664)

Table One presents the acquired data from April 25th 2000. The storm was fairly low intensity with a total rainfall accumulation of 0.165" producing a treated volume of 10,853 gallons (1,450 ft^3). Rainfall started at 5:00 am and was spotty through 1:30pm (0.1" accumulation occurred at 1:00pm). Some hail occurred at the onset of the storm with light rain in patches occurring during the remainder of the event. Temperature was recorded to be 59°F.

Table Two: Storm Event – June 6th 2000 (Peak Flow = 0.20 cfs)

Sample	pH (IN)	pH (OUT)	Dissolved Zinc (IN) (mg/l)	Dissolved Zinc (OUT) / % Removed (mg/l)	Total Zinc Influent (IN) (mg/l)	Total Zinc Effluent (OUT) / % Removed (mg/l)
First Flush	5.74	5.82	0.23	0.11 / 52.2%	0.39	0.11 / 71.8%
Flow Composite	5.61	5.81	0.13	0.085 / 34.6%	0.18	0.11 / 38.9%

Table Two (Cont.): Storm Event – June 6th 2000 (Peak Flow = 0.20 cfs)

Sample	Total Phosphorus (IN) (mg/l)	Total Phosphorus (OUT) / % Removed (mg/l)	Oil and Grease – HEM (IN) (mg/l)	Oil and Grease – HEM (OUT) / % Removed (mg/l)	TSS (IN) (mg/l)	TSS (OUT) (mg/l) / % Removed
First Flush	0.50	0.71 / -42%	4	6 / -50%	93	9 / 90.3%
Flow Composite	0.35	0.59 / -68.6%	5	12 / -140%	14	9 / 35.7%

June 6, 2000 storm event lasted 5 ½ hours with a total accumulation of 0.10" producing 5,522 gallons (738 ft^3) of runoff. The intensity was a light drizzle with spotty patches of rain. Temperature recorded at 68°F.

Table Three: Storm Event – October 19th 2000 (Peak Flow = 0.60 cfs)

Sample	pH (IN)	pH (OUT)	Dissolved Zinc (IN) (mg/l)	Dissolved Zinc (OUT) / % Removed (mg/l)	Total Zinc Influent (IN) (mg/l)	Total Zinc Effluent (OUT) / % Removed (mg/l)
First Flush	6.62	6.53	0.078	0.009 / 88.5%	0.18	0.11 / 39%
Flow Composite	6.67	6.62	0.070	<0.006 / 91.4%	0.16	0.091 / 43.1%

Table Three (Cont.): Storm Event – October 19th 2000 (Peak Flow = 0.60 cfs)

Sample	Total Phosphorus (IN) (mg/l)	Total Phosphorus (OUT) (mg/l)	Oil and Grease – HEM (IN) (mg/l)	Oil and Grease – HEM (OUT) (mg/l)	TSS (IN) (mg/l)	TSS (OUT) (mg/l) / % Removed
First Flush	<0.5	<0.5	<2.0	<2.0	6	9 / -50%
Flow Composite	<0.5	<0.5	<2.0	<2.0	14	8 / 42.9%

Total rainfall recorded over 3.5 hours was 0.165" with a peak flow of 0.60 cfs. First flush samples were collected within 15 minutes of initial flow. Moderate rain was still occurring at the end of the sample event. Last rainfall recorded at the site was October 15th 2000. A total volume of 12,073 gallons (1,614 ft^3) passed through the system.

Discussion: As presented above, the StormFilter located in Bremerton is functioning well under its designed treatment conditions. Reductions in both total and dissolved zinc were observed for each event. Removal of the metal is associated with physical straining of suspended particles that carry the non-dissolved metal as well as cation exchange of the dissolved zinc for calcium or magnesium within the filtration media.

Total Suspended Solids (TSS) concentrations were low for most storm (*Note: Influent samples were taken as water entered the StormFilter and not he upstream manhole. A site assessment was performed December 21, 2000. Negligible amounts of sediments were observed in the upstream manhole.*)

As presented above each table is the peak flow rate observed during each storm event. The designed flow rate for the system is 0.78 cfs. Table One – April 25, 2000 shows a peak flow of 0.91 cfs, which is over the designed storm but this flow only occurred briefly. The storm was reported to be fairly low in intensity and showed good treatment.

June 6, 2000 – Table Two produced a peak flow of 0.20 cfs and produced excellent treatment of all parameters except phosphorus. Elevations in effluent phosphorus concentrations may arise from decaying organic matter within the cartridge bay of the StormFilter.

October 19, 2000 – Table Three produced a peak flow of 0.60 cfs that falls under the designed parameters of the StormFilter. Treatment for this storm showed reductions in all parameters except of TSS during the first flush. It must be noted however that the influent TSS concentration observed for this event approached the detection limit of 5 mg-TSS/l. Removal of concentrations this low are difficult due to the particles being extremely fine (clays and silts).

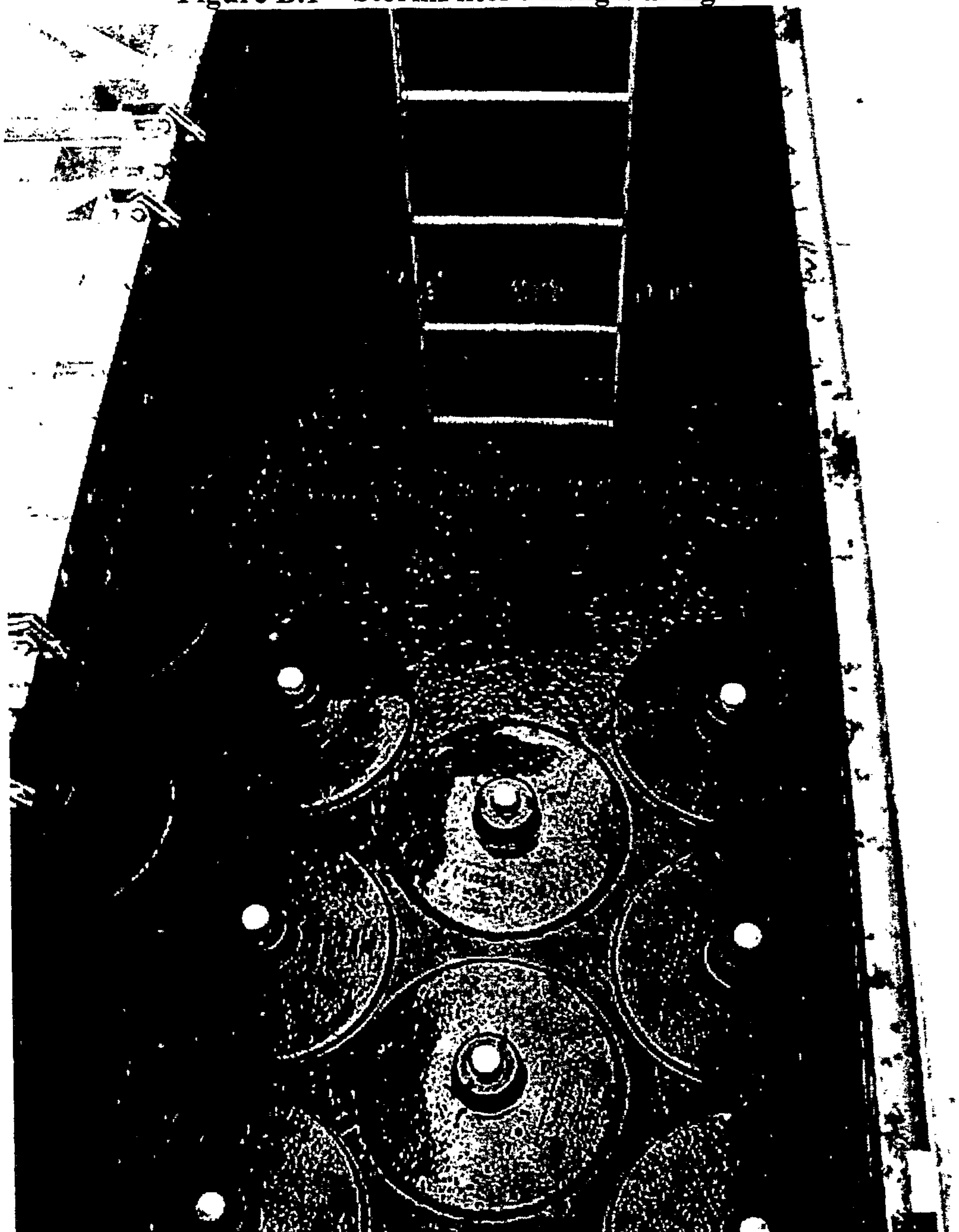
Oil and Grease concentrations were low for each storm event with changes in concentrations from the influent to the effluent being near the detection limit for analytical instrumentation.

Appendix A

Figure A.1 – Straley's 76 Station (StormFilter™ and Site)

Appendix B

Figure B.1 – StormFilter Filling During Storm



LEGISLATIVE ANALYSIS

Committee Hearing: Economic Development, Transportation and Technology
File Number: 97-97-057 - Motor Fuel Prices
Origin: Supervisor Yaki

Summary of Requested Action:

By adding Chapter 80 (Sections 80.1 through 80.9) to the San Francisco Administrative Code, this measure would:

1. Require oil refining companies to incrementally relinquish control of **gasoline** service stations in the City and County of San Francisco and ultimately prohibit refining companies from owning or operating any **gasoline** service station on or after 1/1/2000. This policy is commonly referred to as "divorcement."

2. Require oil refiners to allow dealers of their branded **gasoline** to purchase fuel from any location, or through any vendor, in that refiner's wholesale fuel network.

3. Prohibit oil companies from charging service station operators differing wholesale prices.

Policy Question:

1. Should the City prohibit specified companies from controlling and/or operating certain **retail** businesses?

2. Should the City prohibit specified companies from establishing contractual agreements with the distributors of their product as to how the product will be delivered?

3. Should the City dictate the pricing structure specified companies establish for the sale of their product?

Current Law:

While there are a number of state and federal laws dealing with the marketing of motor fuel and/or the relationship between major oil companies and service station dealers, there do not appear to be any state or federal laws which directly prohibit refinery operation of service stations; nor do there appear to be any state or federal laws which directly regulate the wholesale or **retail** price of motor fuel, or the distribution agreements between refiners and service stations. Additionally, there do not appear to be any statutes which directly prohibit local jurisdictions from imposing regulatory control in these policy areas

R0009343

However, there is considerable debate on the whether existing price discrimination laws preempt provisions of this ordinance prohibiting zone pricing.

An in-depth discussion of these existing laws can be found in "Policy Issue #6" below.

Proposed Legislative Action

This measure would:

1. Make findings that (a) address the importance of motor vehicle transportation in the lives of San Franciscans, (b) declare the relatively high **retail** price of **gasoline** in San Francisco, (c) suggest that the relatively high price of **gasoline** in San Francisco is due to artificially high wholesale prices charged by refiners, and (d) declare that higher gas prices and the practices by refiners resulting in higher **gasoline** prices are injurious to the general health, safety and welfare of San Franciscans.

2. Prohibit any oil company from owning or operating any new or additional **retail** service stations on or after 1/1/98.

3. Incrementally require refiners to relinquish ownership and/or the operation of service stations within the City and County of San Francisco. By 1/1/99, refiners would be required to relinquish control/operation of at lease one-half (1/2) of the service station the refiner owned or operated on 1/1/98. By 1/1/2000, refiners would be required to relinquish control/operation of any and all service stations in the City and County of San Francisco.

4. Provide an exception to the divorcement provisions by allowing refiners to operate service stations after 1/1/2000 for 90 days under specified circumstances.

5. Prohibit oil companies from charging service station operators differing wholesale prices at the same tanker truck loading terminal unless the difference is related to the actual cost of doing business. "Tanker truck loading terminal" refers to the location at which **gasoline** is sold at wholesale and loaded onto tanker trucks that transport the fuel to service stations

6. Require refiners to allow **retail** dealers of the refiner's branded **gasoline** to purchase the branded **gasoline** from any location, or through any vendor, in that refiner's wholesale fuel network.

7. Prohibit refiners from setting, controlling or economically influencing the **retail** prices and profit margins of service stations operators.

8. Specify that this ordinance will not effect the provisions of the San Francisco Planning Code requiring Planning Commission or Zoning Administrator approval of the conversion of a service station to another use.

9. Provide that the ordinance would be enforceable by local, county or state prosecutors.

10. Provide that the maximum penalty for a violation of this ordinance would be a misdemeanor punishable by a fine not to exceed $500 or by imprisonment in the county jail for up to six months or both fine and imprisonment.

11. Provide any private person the right to bring civil action under the provision of this measure.

Background and Discussion:

IS THERE A RELATIVELY HIGHER **RETAIL** PRICE FOR **GASOLINE** IN THE SAN FRANCISCO BAY AREA. Based on price comparisons compiled by independent petroleum consultant, Tim Hamilton, San Francisco has seen higher prices for **retail gasoline** relative to the Los Angeles area throughout the past fifteen month period (see the attached Chart 1). Price comparisons where conducted every two weeks from January 10, 1997 to March 6, 1998. The observed price differential ranged from a low of $.01 per gallon (August 22, 1997 and September 19, 1997) to a high of $0.29 per gallon (March 6, 1998). It should be noted that of the 29 price comparison days, the price differential rarely dropped below $.08 per gallon (on only 7 of the 29 comparison dates). The average differential for the 15 month period was approximately $.10 per gallon. The mode and median price differential was also $.10 per gallon.

When looking at the price differential since the beginning of 1998, we see a much different story. Since the beginning of this year, the higher price differential of gas sold in San Francisco relative to Los Angeles has continually increased from $.16 per gallon on January 9, 1998 to $.29 per gallon on March 6, 1998. The average higher price paid for **gasoline** in San Francisco since the first of the year has been approximately $.22 per gallon.

WHAT ARE THE FORCES DRIVING THESE HIGHER PRICES? Proponents (led by the Automotive Trade Organizations of California) of this measure argue that the higher relative price of **gasoline** in San Francisco is driven by anti-competitive practices conducted by oil companies in San Francisco **gasoline retail** market.

The opponents of this measure (led by the Western States Petroleum Association), instead argue that the relative price differential is the result of lack of competition resulting from the barriers to entry that exist in entering the **gasoline retail** business in San Francisco and the relatively high cost of doing any type of business in the City.

<u>**PROPONENTS:**</u> ANTI-COMPETITIVE FORCES RESULT IN ARTIFICIALLY HIGHER PRICE. The anti-competitive practices that the proponents argue lead to artificially higher prices are closed supply, zone pricing and vertical integration. The following is a brief discussion of each::

> **Closed supply**. Current petroleum industry contracts limit a **gasoline retail** dealer's ability to purchase branded fuel from sources other than the local wholesale distributor. This practice permits oil companies to charge station-specific, neighborhood-specific or City-specific wholesale prices that need not reflect broader wholesale market conditions.
>
> For example, if a San Francisco lessee station dealer of a given branded **gasoline** finds that a Stockton wholesale distributor of the same branded **gasoline** is offering the branded **gasoline** at a price so low that the dealer could pay the added transportation costs and still offer the **gasoline** at a lower **retail** price than if the dealer purchased the **gasoline** from the local wholesaler, under current business operation agreements, the dealer is prohibited from purchasing from the Stockton provider and passing the saving onto the consumer.
>
> This proposed ordinance would apply free market principles to the wholesale distribution of **gasoline** in San Francisco by requiring refiners to allow **retail** dealers of the that refiner's branded **gasoline** to purchase **gasoline** from any location or through any vendor in the refiners wholesale fuel network.
>
> COUNTER-ARGUMENT - CURRENT DISTRIBUTION SYSTEM PROTECTS DEALERS AND IMPROVES DELIVERY EFFICIENCY. Major oil companies argue that the bill will disrupt the present **retail** distribution system for **gasoline** products that allow for greater efficiencies. They state that these greater efficiencies result in lower prices and reliable supply which are due to the major

investments that have been made in transportation and distribution systems.

They argue that this proposed ordinance would undermine these benefits by interfering with existing contractual relationships. They further contend that refiners would no longer be able to enter into agreements that create stable dependable **outlets** in which they have a vested interest in ensuring survive. This would remove the major reason that refiners have to support lessee service stations and other **retail outlets**, possibly causing their elimination.

Wholesale price differentials or zone pricing. Proponents of this proposed ordinance argue that oil companies set wholesale prices through a complex set of pricing zones which exert significant control over **retail** prices. They argue that the companies draw zones between which they charge different prices on a community-by-community, neighborhood-by-neighborhood, or even a station-by-station basis. The oil companies can then set the zone price for each zone at the tanker truck loading terminal. The retailer must purchase the gas at that wholesale price due to the wholesale purchasing obligation explained above which prohibit **retail** dealers from purchasing their supply of **gasoline** from any source other than the local distributor.

The proposed ordinance would ban wholesale price differentials. When delivering **gasoline** to service stations from the same loading terminal, oil companies would be limited to setting only one price for wholesale **gasoline** and then only add to the price the actual additional cost of delivering the fuel.

COMPANIES ARGUE THAT ZONE PRICING ALLOWS DEALERS TO REMAIN COMPETITIVE - ELIMINATION WOULD RESULT IN LOST JOBS AND HIGHER PRICES. Rather than using zone pricing to force station operators to charge higher prices, the oil companies assert that they employ zone pricing to allow retailers to offer lower prices and remain competitive in areas of high competition. If zone pricing is eliminated, it is argued that the companies would not longer be able to offer lower prices in more competitive areas and the prices would raise and stabilize at a higher overall level.

They also assert that by prohibiting the companies from offering lower wholesale prices to stations that are having trouble competing at a higher wholesale price, the station is at risk of going out of business. If the station closes its doors, San Francisco would experience a loss of jobs and possibly an increase in prices due to the tightening of competition.

Vertical integration. Vertical integration is a practice whereby oil companies can control the price of **gasoline** from the ground to the pump by (1) extracting crude oil, (2) refining it into **gasoline**, (3) delivering the **gasoline** to **retail outlets**, and (4) setting the price the **gasoline** is offered at the **retail** level through contractual agreements with the **retail** operator or by actually operating the **retail** outlet.

The proponents argue that in areas where there are a significant number of service stations operated or controlled by a specific company, the **retail** price for a large portion of the service stations in the area is established by one entity, the company. They go on to argue that the oil companies use their wholesale pricing power to charge franchise or lessee dealers prices that force them to meet the **retail** prices the oil companies charge at their company operated stations.

In an October, 1997, hearing of the State Senate Energy, Utilities and Communications Committee, the independent service station associations stated that some major oil companies are engaged in a deliberate campaign to replace franchisee operations with company-owned service stations. One important tool in this effort seems to be lease agreements which limit the amount that franchisees can make from the operations of the station. The associations state that these lease agreements can severely reduce the market value of the franchise and act as an inducement for the franchisee to sell the franchise back to the company.

The associations also charged that company operated stations have, in some cases, been subsidized using station-specific prices to be able to offer **gasoline** at prices that force adjacent franchisees of the same company to operate at a loss. The association believes that a further loss of franchise dealers would enhance the ability of the oil companies to shield pricing in regional **gasoline** markets from normal market forces.

In an effort to reverse this trend, this proposed ordinance would require the "divorcement" of service stations from oil companies and ultimately prohibit oil companies from operating **retail** service stations and controlling **retail** fuel prices through any type of contractual agreement.

OPPONENTS ARGUE THAT THE SAN FRANCISCO MARKET HAS FEW COMPANY-OPERATED STATIONS. The Western State Petroleum Association provided figures showing the only 6 of the 123 service stations in San Francisco are company operated (5%). With such a small portion of the market being comprised by company operated stations, the industry questions their ability to overwhelmingly influence **retail** prices with such a small relative share of the **retail** market. They argue that with such a small share of the market, they must price their company operated stations to be competitive with their own dealers and the retailers of competing oil companies.

OPPONENTS ARGUE THAT DIVORCEMENT REDUCES COMPETITION RESULTING IN INCREASED PRICES. The free market system allows any group or individual to offer goods and services for sale. One of the basic tenets of economics stipulate that the greater the number of competitors in a free market, the lower the prices. In most competitive markets, price competition is a major factor in attracting customers. If there are only a few competitors in a given market, price is not as an important factor in attracting customers. However, as competition grows, price distinction becomes a greater factor.

In a completely free market, the exclusion of any group or individual from entering and operating in a given market in which they would otherwise operate, limits competition. If the basic tenets of competitive markets addressed above hold true, then it follows that this reduction in competition would result in increased prices as there are fewer purchasing options available to the consumer.

The oil industry argues that by prohibiting them from owning and operating **gasoline retail outlets**, divorcement eliminates an entire class of competitors, thereby, reducing purchasing options which leads to higher prices.

ANALYSIS OF THIS ASSERTION: This would hold true if it could be shown that the competitors that were being removed for the market (1) would not be replaced by other competitors or (2) had offered a product distinction that others could not provide. In this case, it would be hard to prove that the stations currently operated by companies would close and no other competitors would assume operation of the vacant stations.

In fact, the proponents of divorcement would argue that the opposite would occur. For example, Chevron currently operates three (3) service stations in San Francisco. If they were forced to cease operation of these stations, there is the possibility that the operation of three stations would be assumed by three different dealers, thereby, increasing competition. However, there is the possibility that the operation of all three stations would be assumed by a single dealer that already operates multiple stations in San Francisco. In such a case, competition would decease.

OPPONENTS: LACK OF COMPETITION, COST OF DOING BUSINESS, OPPORTUNITY COSTS RESULT IN HIGHER PRICES. The opponents argue that the higher price of **gasoline** in San Francisco is due to the following:

Lack of competition. The oil industry argues that one of the major reasons San Francisco gas prices are higher than other California cities is because of the relatively fewer stations that exist in the City. There are 1.5 **retail gasoline** stations per 10,000 residents, compared to 2.7 stations per 10,000 residents in Los Angeles. As discussed above, one of the basic tenets of economic stipulates that the greater the number of competitors in a free market, the lower the prices. With the relatively fewer amount of stations per capita, the oil companies argue that economic theory would predict higher prices within a free market.

While these figures appear to be correct, it is interesting to note the reduction in the number of **retail** stations operating in the Bay Area. According to the Bay Area Air Quality Management District (BAAQMD) there were 3309 **retail** gas stations in the Bay Area in 1978, currently there are 1420. This decrease in service stations has not necessarily resulted in a commensurate reduction the number of gas dispensing nasals.

According to BAAQMD personnel, the common Bay Area gas station in 1978 contained 6 to 8 dispensing nozzles. Today, stations commonly have 24 to 36 nozzles per station, thereby, allowing more drivers to be serviced at fewer stations. The following is data generated by the BAAQMD presenting this information in table form:

YEAR	NUMBER OF SERVICE STATIONS	AVERAGE NUMBER OF NOZZLES	TOTAL NUMBER OF NOZZLES	NUMBER OF CARS	NUMBER OF NOZZLES PER CAR
1978	3309	6-8	23,163	no data	--
1988	2265	11	24,300	4.17 million	.0058/car
1998	1420	20	29,000	4.60 million	.0063/car

High costs of doing business. The Western States Petroleum Association commissioned Kosmont & Associates to provide an economic assessment of the costs of developing **retail gasoline outlets** in various California jurisdictions, including San Francisco.

The study reviewed issues including (i) zoning and land use regulations, (ii) environmental regulations, (iii) entitlement process and time requirements, and (iv) building department and construction issues. Kosmont & Associates found "that there are substantially higher land development costs in San Francisco, than in Southern California."

The study provides a comparative analysis of the cost of service station development in San Francisco relative to Los Angeles and Orange Counties. The study found that in San Francisco "costs associated with land acquisition are almost 100% higher, ...while overall construction costs are 15% higher." Consequently, few new stations are built which limits competition. According to the BAAQMD, new **gasoline** station construction in San Francisco has been relatively low. Records show that the Air District issued 6 new permits in the last 10 years.

The study contends that intense urban development and the scarce supply of readily available land for development, make **gasoline** prices, along with home prices and the overall cost of living higher in San Francisco than in Southern California.

Opportunity costs. In a completely free market, the owner of property is free to use that property for any use the owner chooses. In economic theory, it is assumed that the property owner will use the property in such a fashion that will maximize profit.

Under current City law, it is difficult for property containing service stations to be redeveloped into another use. Consequently, the property owner of a parcel on which a service station currently exists cannot change the use of the property in order to take advantage of a use that could realize greater economic return. Therefore, due to City regulations, there could be an opportunity cost associated with owning property containing a **gasoline** service station. This places pressure on rent prices which are passed on to the consumers through higher gas prices.

The oil industry argues that the opportunity costs associated with service stations is one of the reasons there are so few stations in San Francisco. The inability to change property use out of the service station business places financial burden on property owners where **retail gasoline** services are not the best economic use for the property. Therefore, property owners are reluctant to allow their property to be used for service station operations as they will have difficulty in converting the property to another use in the future.

Policy Issues:

1. APPROPRIATE ROLE OF GOVERNMENT IN THE FREE MARKET. When is it appropriate for government to exert control over the participation, pricing structure and other business practices of a given industry?

   The proposed ordinance exerts substantial control over participation in the **gasoline retail** business. It also limits the ability of oil companies to make wholesale pricing decisions and regulates how oil companies deliver their product to distribution centers.

   There is precedence for government to exert this type of control in the market system. This primarily occurs when a good or service is viewed as a utility or when it is determined that the market is conducive to monopolistic practices.

   Evidence suggests that the wholesale **gasoline** pricing and distribution system in not a purely "free market" in the San Francisco area. It appears that there is no price competition within the wholesale market for branded **gasoline**. Once a retailer enters into a contract to sell a specific branded **gasoline**, that retailer is required to purchase their supply of **gasoline** from only one designated tanker truck terminal.

   Furthermore, these contractual obligations allow oil companies to charge different prices to stations within the same area through "zone pricing" as retailers are denied the opportunity to shop around for a cheaper price that may be offered in another location or by another wholesaler.

   The only entities that are free to shop around for the best price are independent dealers that are not associated with branded companies. Due to the fact that there are so few independent dealers in San Francisco, the independents have a very limited effect on the market

   Does the Board believe that the high price of **gasoline** in San Francisco relative to Los Angeles is due to monopolistic-like practices that result in prices that would not be as high in a free wholesale market?

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If the answer to this question is yes, then there is precedence for government to regulate an industry with the potential to implement these characteristics -- some examples include cable television, residential natural gas, and solid waste disposal.

2. HOW MANY STATIONS DO THE OIL COMPANIES CONTROL? One of the basic components to support the accusation that a given company or individual controls the price at the **retail** market level, is to prove that that entity controls a substantial number of **retail outlets**. In the case of **retail** stations in San Francisco, the number of company operated **retail** stations is minimal at 5%.

   However, the Automotive Trade Organizations Association suggests that while the oil companies do not actually operate a large number of stations, they do have direct control over the actual **retail** price of the **gasoline** offered at branded stations. It is suggested that the companies enter into contractually agreements with the operators of **retail** stations that require the operator to offer the price set by the oil company.

   The Board may want clarification from oil industry representatives if these type of contractual agreements exist, and if so, the number of stations currently operating under this type of agreement.

3. WILL THIS ORDINANCE ACHIEVE ITS GOAL - LOWER GAS PRICES IN SAN FRANCISCO? The major stated goal of the proponents of this ordinance is low gas prices in San Francisco. There are a number of studies examining the effects of similar measures that have been implemented in other areas, including the jurisdictions described in #4 below. The results of these various studies are conflicting. Some studies show that "divorcement" laws have resulted in lower gas prices, while other show that they have increased overall prices.

   Many of the other "divorcement" measures do not contain all the provisions contained in the proposal before the Board, therefore, it is extremely difficult to rely on past studies to conclusively determine whether or not the ordinance will result in lower **gasoline** prices.

4. OTHER AREAS WITH "DIVORCEMENT" MEASURES ENACTED. Other areas that have enacted measure containing provisions similar to provision contained in the proposed ordinance include:

   - State of Maryland
   - State of Nevada
   - State of Connecticut
   - State of Virginia
   - State of Delaware
   - State of Hawaii
   - Washington DC

5. ENFORCEMENT ISSUES. The fine for violation of this ordinance is $500, six months in the county jail, or both. It is hard to imagine that a $500 fine would serve as a great deterrent to companies the size of the oil companies operating in the San Francisco market.

   The one apparent deterrent contained in the ordinance is the possibility of sending a high ranking company executive to county jail. However, it seems it would be hard to place an executive in jail based on the provisions of this measure.

   How would the pricing discriminations provisions be enforced? Which agency would monitor the price charged to the various service stations and who would calculate the actual transportation costs

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for delivery from the terminal to station?

6. DO EXISTING LAWS PREEMPT THIS ORDINANCE? There are a number of state and federal laws dealing with the marketing of motor fuel and/or the relationship between major oil companies and service station dealers. These include:

   - Chapter 14 of Division 5 of the California Business and Professions Code which establishes various rules regulating the business operations of service stations (i.e. false advertising, posting of business hours, **gasoline** standards, and price indicators on dispensers). This section of the law does not prohibit or restrict refiner operation of service stations.
   - Chapter 7.5, Division 8 of the California Business and Professions Code deals with the termination and non-renewal of service stations franchises, however, does not prohibit or restrict refiner operation of service stations.
   - The California Franchise Disclosure Law (Corporations Code 31000 *et seq.*) which require a franchiser to make specified disclosures to a franchisee when a franchise is sold.
   - Division 7.8 of Division 8 of the Business and Professions requiring franchise fair practices.
   - Chapter 7.9 of Division 8 of the California Business and Professions Code specifies the circumstances under which a service station may be closed during late night and early morning hours. This section does not prohibit the operation of a service station by an oil company nor does it mention motor fuel pricing or wholesale distribution.
   - Chapter 8 of Division 8 of the California Business and Professions Code prohibits price discrimination in the sale of **gasoline** and oil, when the discrimination injures competition.
   - There are a number of state and federal antitrust laws which deal with vertical price fixing and restraints on trade.

   There do not appear to be any state laws which directly prohibit refiner operation of service stations, directly regulate the wholesale or **retail** price of motor fuel, or directly regulate the distribution agreements between refiners and service stations; however, it is unclear as to whether existing price discrimination laws preempt the zone pricing provisions of this ordinance.

   The Board may wish to seek a City Attorney's opinion on this question.

7. EFFECTIVE DATE. The de facto effective date of this ordinance would be 1/1/98 as that is when the ordinance prohibits any oil company from assuming the operation of any new or additional **retail** service stations in the City. Does the Board wish to make this measure retroactive?

   Also, the measure requires oil companies to relinquish control of 50% of their current **retail** holdings by 1/1/99 and all of their holdings 1/1/2000. The earliest this measure could become effect is mid-June. Does the Board feel this is an adequate amount time. The Board may wish to consider amending the legislation to change the effective dates of these provisions to allow a year for the 50% deadline and two years for the final deadline.

8. REGIONAL EFFECT. There is some debate as to whether this type of ordinance can be effected when implemented within a single jurisdiction. Some economist suggest that for an ordinance such as this to be effective, it must be implemented on a regional basis (see discussion of San Diego County's experience below). With this in mind, the Association of Bay Area Governments and the Bay Area Economic Forum are currently preparing studies on the issue (it is anticipated that Supervisor Yaki will amend this proposal in Committee to stipulate that it will not become effective unless 2/3 of the nine (9) Bay Area counties adopt similar measures).

9. SAN DIEGO COUNTY AND MUNICIPALITIES CONSIDERING REGIONAL

R0009351

IMPLEMENTATION OF SIMILAR LEGISLATION. The County of San Diego recently approved a county ordinance that would ban oil companies from operating **retail** service station **outlets** in unincorporated areas of the county by 2000 if similar legislation is approved by enough of the county's 18 municipalities to constitute at least two-thirds of the county's total population.

The ordinance includes a regional component because of the minimal number of stations within the unincorporated areas relative to those in incorporated areas – stations in unincorporated areas represent 12% of the total stations in San Diego County. It is extremely difficult for such a small percentage of the **retail** market to affect regional practices. The county believes that in order for the ordinance to be effective, a large majority of stations within a region must be included in the provisions of the measure.

According to San Diego Supervisor Ron Roberts' office, the requisite number of cities have approved the ordinance and it would be expected to become effective in 2000. However, the County of San Diego has decided to test the legal validity of the ordinance before it becomes effective by requesting a declaratory judgment from the courts. A decision in this matter is expected this summer.

10. STATE MEASURES. There are currently two measures before the California State Legislature dealing with this issue to varying degrees – Assembly Bill 2228 (Davis) and House Resolution 58 (Sweeney).

    AB 2228 would provide that nothing in state law invalidates or prohibits a local ordinance regulating competition in the refining, wholesale or **retail** distribution, pricing, manufacturing, or transporting of motor vehicle fuel or oil.

    HR 58 requests that the California Attorney General, in cooperation with the United States Attorney General, United States Secretary of Energy, and the Federal Trade Commission, investigate "anti-competitive" practices in the oil industry and in the **retail gasoline** marketplace. It also requests that the California Attorney General report the findings of the investigation to the Legislature and take any necessary legal actions against those engaged in illegal acts.

    Two measures were introduced last year to address the issue of oil company control over the **retail** price of gas. They were SB 52 (Kopp) and SB 404 (Peace), which would have allowed a franchised **gasoline** dealer to purchase branded **gasoline** from a supplier other than its franchiser. Both bills were defeated in the Senate last year.

Options:

1. Approve the ordinance in its current form.
2. Amend the ordinance to change deadlines for divorcement as outlined in "policy issue" #7 above and approve the measure.
3. Delay action on the measure until the Association of Bay Area Government and the Bay Area Economic Forum have completed their analysis of the issue.
4. Delay action on the measure until a decision is handed down on the declaratory judgment requested by the County of San Diego.
5. Reject the ordinance.

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BOE-378 REV. 1 (1-99)

STATE OF CALIFORNIA
BOARD OF EQUALIZATION

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FUEL TAXES

TABLE 25 - TAXABLE DISTRIBUTIONS OF GASOLINE AND TAX ASSESSMENTS, BY DISTRIBUTOR, 1997-98 AND 1998-99

Name of company[a]	Gallons (in thousands)		Tax[b] (in thousands)	
	1997-98	1998-99	1997-98	1998-99
1	2	3	4	5
Amerada Hess Corporation	-	51	-	$9
Atlantic Richfield Company	2,807,059	2,943,006	$505,271	529,741
AVFuel Corporation	397[r]	520	71	94
C. L. Bryant, Inc.	182	59	33	11
Burns Brothers, Inc.	17	17	3	3
Chevron USA, Inc.	2,691,714	2,739,434	484,508	493,098
Coltrin Processing Facility	3,336	13,887	600	2,500
W. P. Davies Oil Company	103[r]	78	19	14
Eastern Sierra Oil Company	210	765	38	138
Equilon Enterprises, L.L.C.	-	2,259,542	-	406,718
Exxon Corporation	1,145,961	1,195,347	206,273	215,162
Ford Motor Company	2,717	3,291	489	592
Fortum Oil and Gas (formerly Neste Oy)	7,396	23	1,331	4
Huntway Refining Company	-	17	-	3
Inyo Crude, Inc.	5	21	1	4
Kern Oil and Refining Company	46,446[r]	37,070	8,360	6,673
Koch Refining Company, L.P.	11,480	17,990	2,066	3,238
May-Slade Oil Company	232	119	42	21
McNeece Bros. Oil Company, Inc.	112	88	20	16
Mobil Oil Corporation	1,332,704	1,387,403	239,887	249,733
Mohave Oil Company	431	173	78	31
MT Transportation, Inc.	84	53	15	9
National Oil and Burner Company	25	24	5	4
Nella Oil Company	220	314	40	57
Parker Oil Products, Inc.	159	214	29	39
Passmore Gas and Oil, Inc.	82[r]	53	15	9
Paul Oil Company, Inc.	25	51	5	9
Petro America, Inc.	17	17	3	3
Petro-Diamond, Inc.	13,725	5,796	2,471	1,043
Phillips Petroleum Company	112	76	20	14
Rebel Oil Company, Inc.	412	422	74	76
River City Petroleum, Inc.	14	16	3	3
Seaport Petroleum Corporation	781	1,647	141	296
Shell Oil Company	1,573,454	25,365	283,222	4,566
The Soco Group, Inc.	120	32	22	6
The Southland Corporation	811[r]	674	146	121
Specified Fuels and Chemicals, L.L.C.	-	128	-	23
Tesoro Northwest Company	-	27,673	-	4,981
Tesoro Refining, Marketing and Supply Company	5	24,324	1	4,378
Texaco Refining and Marketing, Inc.	800,573	50,898	144,103	9,162
Time Oil Company	17,048	1,607	3,069	289
Tosco Refining Company	2,493,297	2,518,202	448,793	453,276
Trafigura AG	-	18,005	-	3,241
Ultramar, Inc.	942,697	1,024,714	169,686	184,448
Vitol S. A., Inc.	1,276	58,966	230	10,614
VP Racing Fuels, Inc.	-	16	-	3
12 other distributors paying less than $2,000 in 1998-99	29,495	70	5,309	13
Adjustments[c]	1,076	-133,483	-8,678	10,993
Total	13,926,011	14,224,772	$2,497,810	$2,595,479

[a] "Distributors" are companies or individuals who make the first distribution of gasoline in California, and are responsible for payment of the tax. (Aircraft manufacturers and certificated or licensed carriers by air may be included within the definition of distributor.) "Broker" includes every person, other than a distributor or a retailer, who deals in lots of 200 or more gallons of gasoline.

[b] Refunds for nonhighway use totaling $24,121,000 in 1997-98 and $17,380,000 in 1998-99 have not been deducted.

[c] Adjustments include temperature-corrected gallonage from broker returns, late returns, audits, interest, and penalties.

[r] Revised.

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Estimates of Highway Gasoline Use by County (1,000 gallons)

	1995	1996	1997	1998	1999
Alameda	566,296	583,923	603,712	610,461	630,765
Alpine	738	849	809	1,020	887
Amador	12,311	12,659	12,808	12,714	12,997
Butte	70,002	70,495	71,858	70,829	72,764
Calaveras	12,649	13,350	13,751	13,743	14,140
Colusa	9,625	9,701	9,842	9,494	9,619
Contra Costa	361,843	374,796	377,468	403,691	443,851
Del Norte	8,156	8,210	8,359	8,357	9,108
El Dorado	59,341	60,519	61,881	62,376	64,498
Fresno	265,569	259,283	272,735	268,328	274,174
Glenn	11,052	10,686	10,795	10,237	10,432
Humboldt	49,366	49,977	50,826	50,633	52,646
Imperial	47,225	46,251	46,647	45,752	47,764
Inyo	12,153	12,556	12,942	12,436	12,804
Kern	238,101	242,301	242,941	240,559	249,177
Kings	33,473	34,115	34,918	34,073	35,055
Lake	18,636	18,920	19,009	18,730	19,296
Lassen	12,026	12,350	12,268	11,537	11,618
Los Angeles	3,554,238	3,517,400	3,669,186	3,600,156	3,714,849
Madera	35,619	35,460	37,479	37,451	39,174
Marin	117,549	119,226	122,953	122,557	125,584
Mariposa	6,828	6,841	6,741	5,455	6,701
Mendocino	36,708	37,463	38,288	37,697	38,337
Merced	67,576	66,419	70,105	69,511	72,790
Modoc	4,838	4,848	4,179	4,226	4,366
Mono	7,924	8,237	8,224	8,000	8,201
Monterey	141,356	144,763	150,726	149,659	155,453
Napa	48,154	49,593	51,770	52,879	55,789
Nevada	37,471	37,994	38,902	38,738	40,010
Orange	1,150,721	1,177,909	1,219,016	1,246,735	1,288,243
Placer	98,001	102,039	108,123	111,623	118,044
Plumas	8,750	8,830	8,763	9,021	9,127
Riverside	507,836	822,414	538,999	547,176	577,506
Sacramento	449,893	455,803	467,411	455,152	480,311
San Benito	14,016	14,823	15,908	16,244	17,270
San Bernardino	596,278	612,929	628,125	620,606	649,334
San Diego	1,061,265	1,088,679	1,122,893	1,136,281	1,187,277
San Francisco	341,283	373,961	401,081	381,425	364,119
San Joaquin	188,416	189,066	201,687	202,140	211,111
San Luis Obispo	97,111	100,138	103,135	104,344	108,003
San Mateo	333,491	344,031	362,389	371,387	377,808
Santa Barbara	157,357	159,147	159,399	163,412	168,473
Santa Clara	727,756	767,312	810,117	816,048	830,994
Santa Cruz	95,817	97,941	101,383	101,902	104,961
Shasta	68,828	66,740	66,609	65,798	68,727
Sierra	1,563	1,641	1,618	1,637	1,663
Siskiyou	20,785	20,621	20,627	20,305	20,237
Solano	142,898	147,072	149,647	150,874	157,114
Sonoma	178,435	183,753	190,362	192,938	199,417
Stanislaus	147,434	151,151	156,579	153,774	159,401
Sutter	25,454	26,185	26,962	26,829	27,562
Tehama	21,810	21,895	22,110	21,705	22,620
Trinity	4,432	4,508	4,449	4,415	4,474
Tulare	107,837	108,942	110,281	108,878	112,696
Tuolumne	20,237	20,385	20,527	20,161	20,854
Ventura	282,533	291,233	296,059	295,726	306,520
Yolo	66,094	67,174	69,026	68,680	71,669
Yuba	13,138	15,554	18,605	18,564	19,138
Total	12,794,720	13,105,946	13,481,725	13,496,210	13,924,078

Note: These estimates are based on the 1999 data except for taxable sales (not available at the time of analysis)

Source: Office of Transportation Economics, Transportation Planning Program, Caltrans July 2000

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home key topics **California** Energy **Commission** site index search

California Retail Service Stations, Fleet Fueling Facilities and Private Storage Tank Sites and Other Statistical Data by County

Note: Clicking on each of the counties below will take you to a complete list of ALL the retail gasoline and diesel services stations, fleet fueling facilities and private storage tank sites in each county in 1999. **(Most of the fleet and private sites do not sell fuel to the public.)** Facilites are alphabetically arranged, first by city or town in which they are located, and then by site name.

Some of these files may be very large and may take some time to download depending on the type of connection you have to the Internet. For example, the Los Angeles file is about 1.2 megabytes in size.

For convenience, the number of **retail** gasoline and diesel service stations only (including also marinas and cardlocks) is provided on the table of county statistics below.

The fueling facilities data files are also available to download as Microsoft Excel spreadsheets. Please note that the spreadsheet for the entire state is 6.7 megabytes in size and should only be downloaded if you have a high speed Internet connection. Otherwise your download times may be excessive. Spreadsheets for each county are also available.

1999 California Retail, Fleet and Private Fueling Facilities Spreadsheet
(Excel file, 6.7 megabytes)

Individual Counties' Retail, Fleet and Private Fueling Facilities Spreadsheets
(Excel Spreadsheets)

Please also read our DISCLAIMER about these lists.

County Information and Link to HTML Page Listing ALL Fueling Facilities in Each County

County	Retail Service Stations 1999	County Population 1998	Total Paid Vehicle Registrations 1998	Miles of Surface Road 1997	Gallons of Gasoline Consumed 1998
STATEWIDE TOTALS	9,520	33,226,000	24, 281,404	170,495.62	13,496,210,000
Alameda	322	1,413,400	1,020;402	3,495.36	610,461,000

Alpine	5	1,190	1,474	267.60	1,020,000
Amador	27	33,300	34,135	678.75	12,714,000
Butte	97	199,100	153,065	2,149.99	70,829,000
Calaveras	31	38,100	42,917	1,022.55	13,743,000
Colusa	18	18,600	15,820	959.80	9,494,000
Contra Costa	257	906,500	708,424	3,124.41	403,581,000
Del Norte	21	28,100	18,620	735.77	8,357,000
El Dorado	67	148,800	135,286	2,119.00	62,376,000
Fresno	300	781,900	484,796	7,025.58	268,328,000
Glenn	23	26,850	21,412	1,091.47	10,337,000
Humboldt	74	126,000	104,261	2,480.62	50,633,000
Imperial	76	143,000	96,610	3,361.67	45,752,000
Inyo	31	18,300	18,988	4,778.73	12,436,000
Kern	334	637,200	418,846	6,855.50	240,859,000
Kings	55	121,000	66,382	1,417.52	34,073,000
Lake	31	55,100	54,362	1,152.34	18,730,000
Lassen	21	33,650	23,138	2,012.97	11,537,000
Los Angeles (2.2 Mb HTML file)	2,133	9,587,300	5,870,715	20,989.90	3,660,156,000
Madera	64	114,100	77,198	2,113.55	37,451,000
Marin	60	244,100	214,212	1,245.26	122,557,000
Mariposa	15	16,000	17,696	911.03	6,445,000
Mendocino	51	86,100	77,777	1,908.71	37,897,000
Merced	81	203,200	131,317	2,413.86	69,511,000
Modoc	12	9,975	8,307	1,968.71	4,226,000
Mono	14	10,550	10,777	1,471.40	8,000,000
Monterey	131	381,000	261,640	2,257.47	149,558,000
Napa	29	121,900	101,651	851.63	52,879,000
Nevada	35	89,200	85,278	1,173.25	38,738,000
Orange (512 kb HTML file)	588	2,734,500	2,015,296	7,056.26	1,246,735,000
Placer	96	219,400	201,956	2,048.14	111,623,000
Plumas	26	20,450	22,656	1,833.41	9,021,000
Riverside	443	1,441,000	944,054	7,541.17	547,176,000
Sacramento	295	1,156,500	832,090	4,338.73	465,152,000
San Benito	18	46,950	36,835	986.63	16,244,000
San Bernardino (512 kb HTML file)	565	1,631,500	1,058,681	10,969.65	620,606,000
San Diego (744 kb HTML file)	704	2,795,800	1,981,345	8,620.76	1,136,281,000
San Francisco	110	783,400	427,884	892.13	381,425,000
San Joaquin	183	546,900	360,360	3,221.31	202,140,000
San Luis Obispo	103	236,400	191,275	2,520.33	104,344,000
San Mateo	186	716,500	657,263	2,057.34	371,087,000
Santa Barbara	118	402,900	293,475	2,002.42	163,412,000
Santa Clara	370	1,686,400	1,317,476	4,853.61	816,048,000

Santa Cruz	78	249,000	198,230	1,136.84	101,902,000
Shasta	122	164,100	133,879	2,760.99	65,798,000
Sierra	8	3,340	3,547	781.44	1,637,000
Siskiyou	35	44,200	44,298	3,578.27	20,305,000
Solano	128	382,000	272,260	1,778.99	150,374,000
Sonoma	136	436,700	373,910	2,663.83	192,938,000
Stanislaus	173	428,300	297,937	2,743.93	153,774,000
Sutter	31	76,400	58,562	1,072.41	26,829,000
Tehama	32	54,900	41,918	1,642.87	21,705,000
Trinity	23	13,200	13,036	2,109.54	4,415,000
Tulare	193	359,900	226,889	4,780.00	108,878,000
Tuolumne	37	52,500	50,725	1,146.88	20,161,000
Ventura	198	732,700	565,087	2,684.26	295,425,000
Yolo	73	155,500	113,681	1,414.01	68,588,000
Yuba	27	60,800	41,475	791.79	18,584,000

Sources:

- Retail Gasoline and Diesel Service Stations: California Energy Commission, Fuels Office.
- Population: Department of Finance.
- Automobiles: Department of Motor Vehicles. (Includes automobiles, commercial vehicles and motorcycles. Excludes trailers. State total includes IRP/ID/Prorate - 904,988, out of state registrations - 148,654, and fee exempt - 376,176.)
- Roads: Department of Transportation (Caltrans).
- Gasoline consumption: Statewide -- State Board of Equalization. County information -- Caltrans, Transportation Planning Program, Transportation Economics Branch. Includes fuel consumed on state highways, local streets and roads, but excludes aviation gasoline where tax refunds wer made (e.g. agricultural, boating, off highway uses) and gasoline that is delivered to out-of-state distrbution points.

Go to Gasoline/Diesel Status Page.

Go to Gasoline Page.

| Homepage | Commission Info | Site Index | Search Site | Links |

Page Updated: March 21, 2000

R0009360

From: "O'Leary, Dan" <OLeary@pbworld.com>
To: "'Dan Radulescu'" <DRADULES@rb4.swrcb.ca.gov>
Date: 3/7/01 5:43AM
Subject: RE: Background Information on Impact of Gas Stations to Storm Water

Dan-

Sorry for the delayed response on your inquiry. I do not have pollutant loading numbers from gas stations myself. I would contact Mr. Stewart Comstock at the Maryland Department of the Environment for information on those numbers at (410) 631-3563. Ernie Shepp at Metropolitan Washington Council of Governments (unknown telephone number, ask Stew Comstock for it) is another person I would ask. I do have some photos of Delaware Sand Filters in practice, one at a gas station (photos 18 and 19) and one at a fast food restaurant(photos 14-17), both land uses are considered "hotspots" in Maryland regulations. Photos attached. I have also attached an Internet Explorer file with links to non-point source pollution websites where you may be able to gain more information on Gas Stations.

Please contact me if I can be of further assistance.

Daniel J. O'Leary, P.E.
Parsons Brinckerhoff Quade & Douglas, Inc.
Baltimore, Maryland
(410) 385-4178

-----Original Message-----
From: Dan Radulescu [mailto:DRADULES@rb4.swrcb.ca.gov]
Sent: Wednesday, February 21, 2001 12:48 PM
To: O'Leary, Dan
Subject: Background Information on Impact of Gas Stations to Storm Water

Hello,

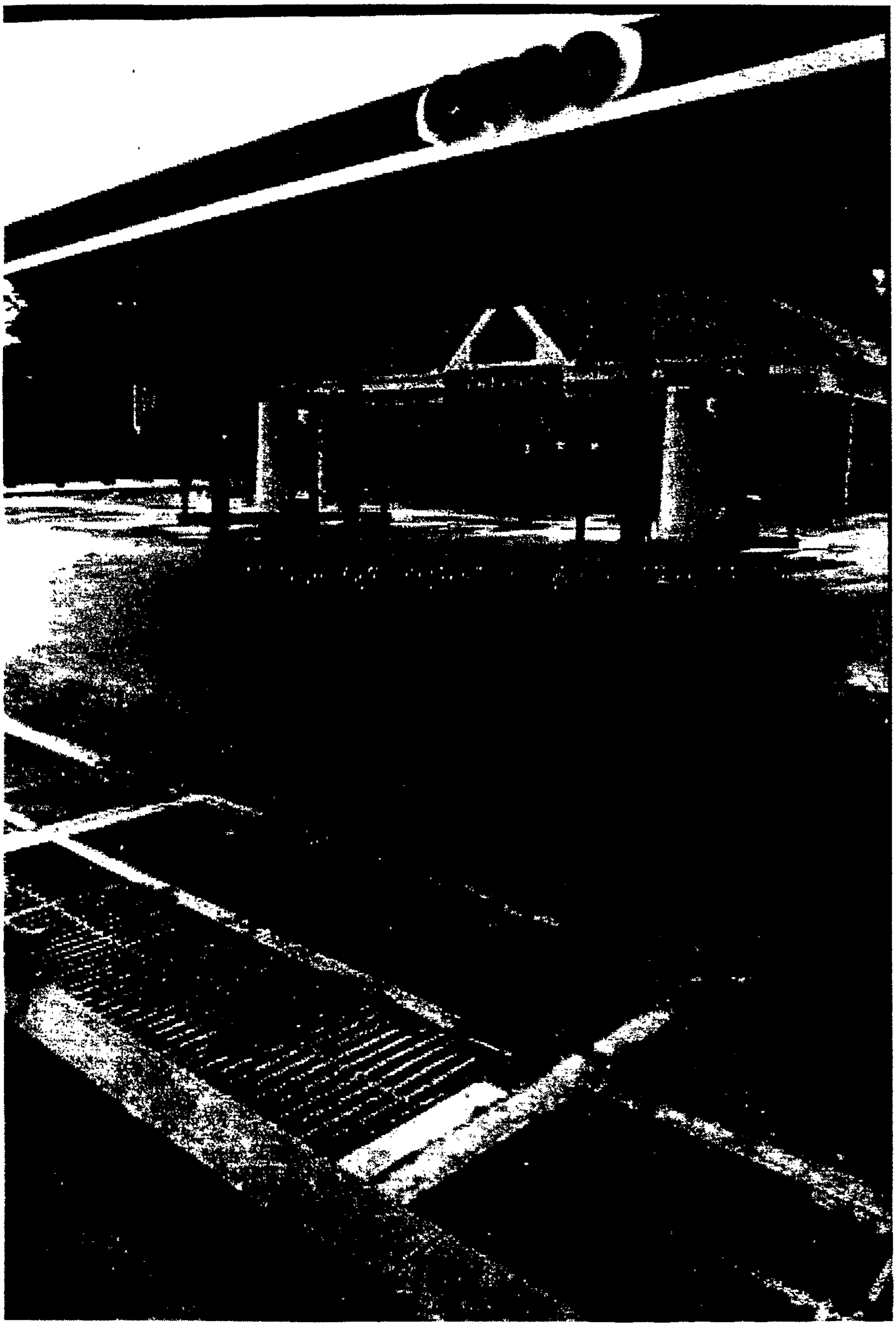
My name is Dan Radulescu and I am a Water Resources Control Engineer at the CAL-EPA Regional Water Quality Control Board in Los Angeles. We are renewing the MS4 Permit for LA County and I need background information on the impacts of gas stations on the quality of storm water runoff.

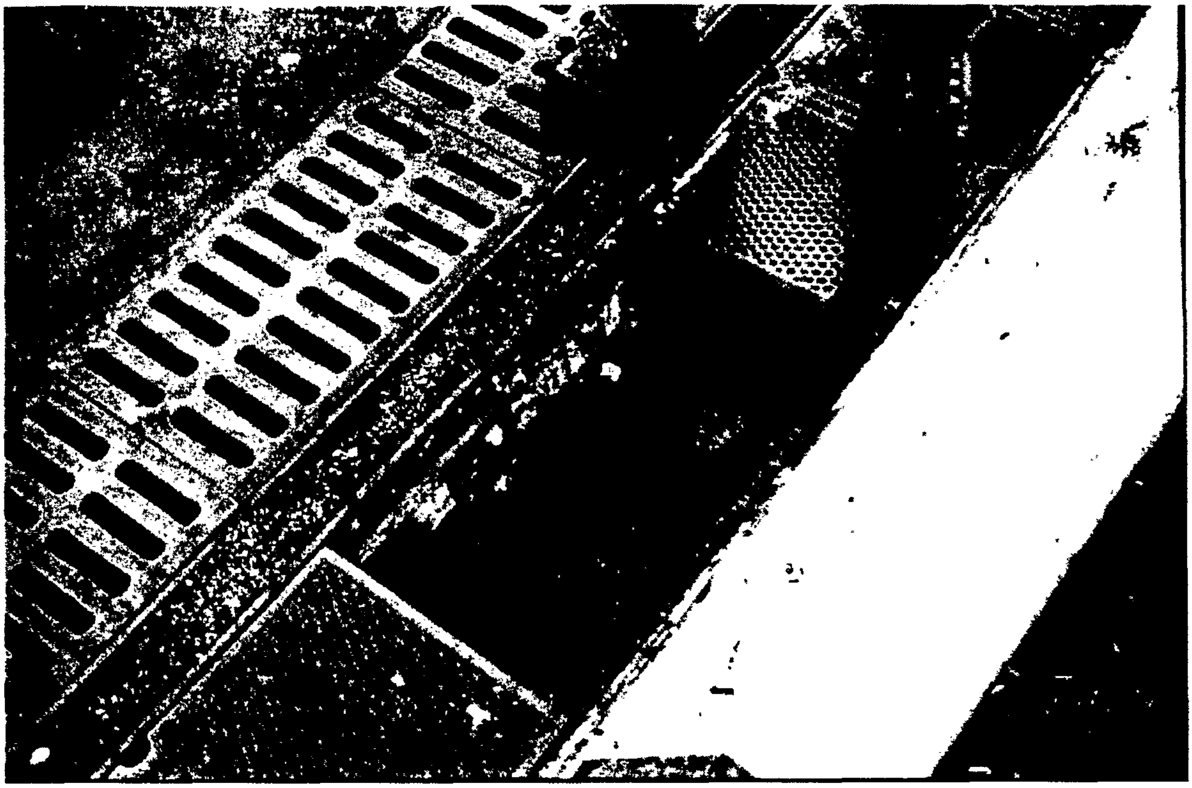
We've met at the ASCE Workshop on Friday, and you mentioned that you may have some slides and background information on the efficiency of filters as BMPs at gas stations (Delaware filters). You also mentioned that you may have some contact persons who studied this problem and may have some additional information on the impact of gas stations (referred to as hot spots) on the quality of storm water runoff, and how the requirements for gas stations have developed in the East Coast area States.

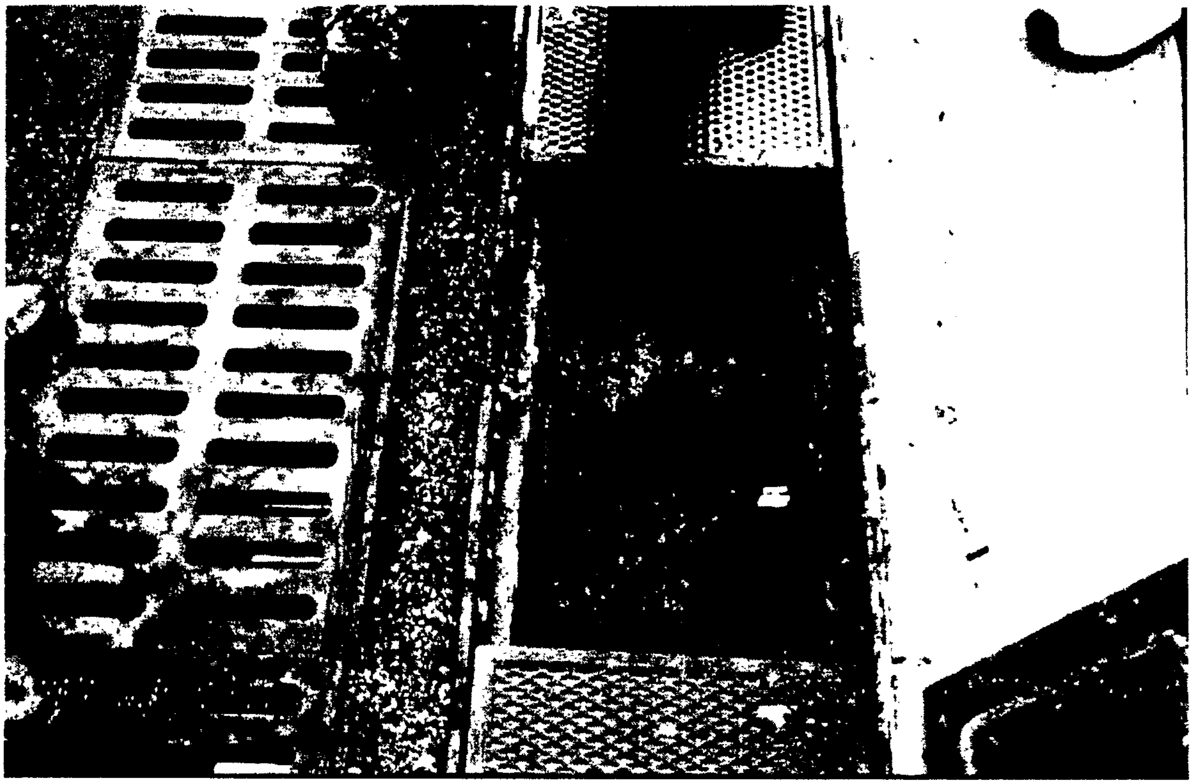
I appreciate your help and Dr. Xavier Swamikannu also extends his thanks for your support.

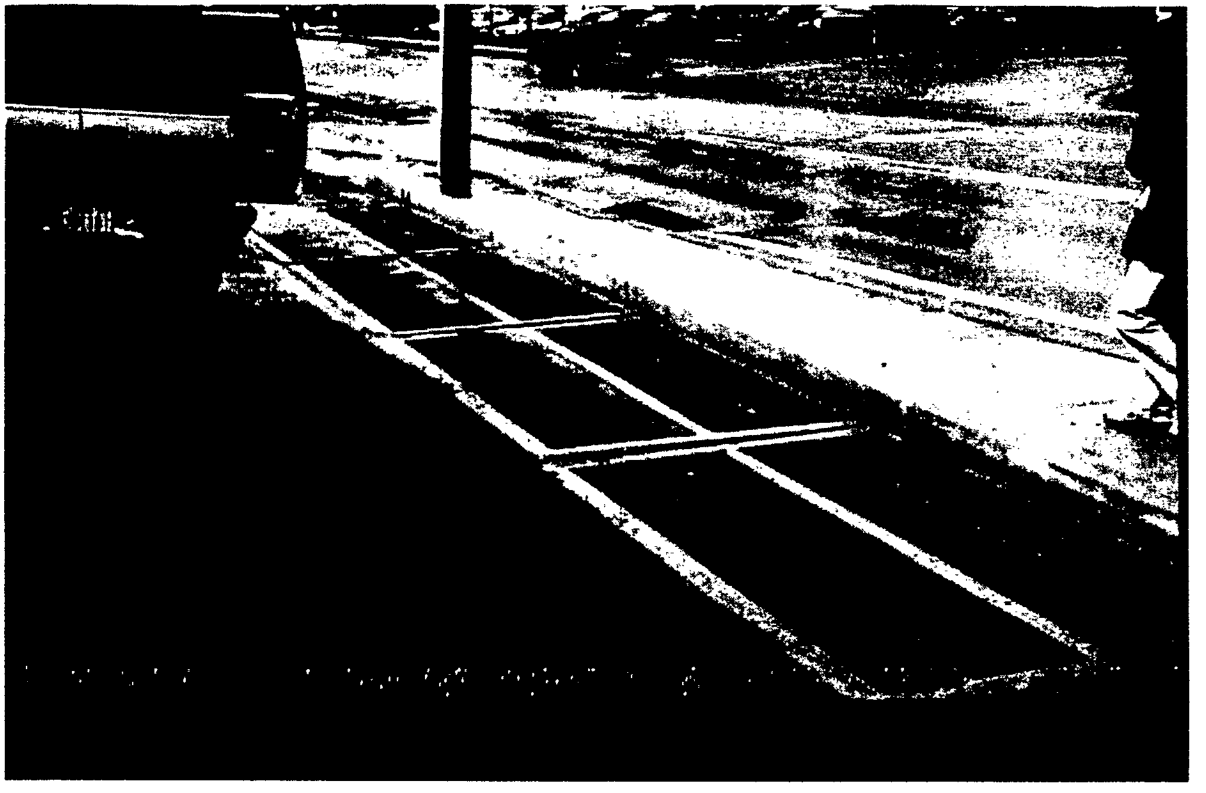
Dan Radulescu
dradules@rb4.swrcb.ca.gov

Ph: (213) 576-6668
Fax: (213) 576-6660
The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption
***For a list of simple ways to reduce demand and cut your energy costs, see the tips at: http://www.swrcb.ca.gov/news/echallenge.html ***









Article 2

Feature article from Watershed Protection Techniques. 1(1): 3-5

Hydrocarbon Hotspots in the Urban Landscape

Two central paradigms emerged from the EPA's Nationwide Urban Runoff Study in the early 1980s. One was that pollutant concentrations in urban runoff were more or less the same regardless of the contributing land use. The second was that urban runoff carried relatively few priority pollutants, most of which were metals.

Subsequent monitoring has generally reinforced both paradigms, particularly for conventional pollutants such as sediments, nutrients, and organic carbon. However, two recent research studies suggest that there may be major exceptions to these paradigms. The studies point to the existence of *hotspots* in the urban landscape that produce significantly greater loadings of hydrocarbons and trace metals than other areas.

Hotspots are often linked to places where vehicles are fueled and serviced, such as gas stations, bus depots, and vehicle maintenance areas. Others occur where many vehicles are parked for brief periods during the day (convenience stores and fast food outlets), or where large numbers of vehicles are parked for a long time (commuter parking lots).

Hotspots are evident in the data of Schueler and Shepp (1992). Their survey of oil and grit separators in suburban Maryland show the differences in the quality of pool water and trapped sediments in separators draining five different paved areas (Table 1). Gas stations and convenience stores had much higher levels of hydrocarbons and metals both in the water column and the sediments. Streets and residential parking lots, on the other hand, had much lower hydrocarbon and metal concentrations.

Gas stations were found to be an extremely significant hotspot for hydrocarbons. Composite priority pollutant scans at the gas station sites revealed the presence of 37 potentially toxic compounds in the sediment and 19 in the water column. Many compounds were polycyclic aromatic hydrocarbons (PAHs) that are thought to be harmful to both humans and aquatic organisms (Table 2). Non-gas station sites, on the other hand, recorded far fewer priority pollutants that had much lower concentrations.

Pitt and Field (1991) monitored metal and PAH levels in runoff from a number of sites in Mobile,

Table 1: Sediment and Pool Water Quality Found in Oil Grit Separators at Various Urban Locations (Schueler and Shepp, 1992)

Parameter	Gas Stations	Convenience Stores	All-Day Parking Lots	Streets	Residential Parking
Comparative Sediment Quality (reported in mg/kg of sediment)					
Total P	1,056	1,020	466	365	267
TOC	98,071	55,167	37,915	33,025	32,392
Hydrocarbons	18,155	7,003	7,114	3,482	892
Cadmium	35.6	17.0	13.2	13.6	13.5
Chromium	350	233	258	291	323
Copper	788	326	186	173	162
Lead	1,183	677	309	544	180
Zinc	6,785	4,025	1,580	1,800	878
Comparative Pool Water Quality (reported in µg/l)					
Total P*	0.53	0.50	0.30	0.06	0.19
TOC*	95.51	26.8	20.6	9.9	15.8
HC*	22.0	10.9	15.4	2.9	2.4
Cadmium	15.3	7.9	6.5	ND	ND
Chromium	17.6	13.9	5.4	5.5	ND
Copper	112.6	22.1	11.6	9.5	3.6
Lead	162.4	28.8	13.0	8.2	ND
Zinc	554	201	190	92	ND

ND = Not Detected   * in units of mg/l

Table 2: Some Priority Pollutants Detected in Gas Station Oil Grit Separator Sediments or Pool Water (Schueler and Shepp, 1992)	
Napthalene	Di-n-octyl pthalate
2-Methylnapthalene	Benzo(b) flouranthene
Acenapthene	Indeno (123-cd) pyrene
Flourene	Di-n-butyl pthalate
Phenathrene	Toulene
Flouranthrene	Ethyl benzene
Pyrene	Total xylenes
Butylbenzylpthalate	Methylene chloride
Chrysene	Benzene
	Acetone phenols

Alabama, including vehicle service areas, parking lots, salvage yards, landscaped areas, and loading docks. They employed the rapid Microtox procedure to assess the possible toxicity of several hundred runoff samples.

Although their monitoring data was variable, they reported that many of the maximum PAH and metals concentrations in runoff samples were found at vehicle service areas and parking lots, as opposed to street surfaces. Of greater concern, nearly 60% of the hotspot runoff samples were classified as moderately to most toxic, according to their relative toxicity screening procedure.

Are Hotspots Environmentally Significant?

The mere presence of high pollutant concentrations at hydrocarbon hotspots does not always imply actual toxicity. Indeed, acute toxicity to aquatic organisms exposed to hotspot runoff is probably a rare event. This is due to relatively brief exposures during storm events, large dilution factors in urban creeks, and the fact that many pollutants are strongly bound to sediments and thus are not readily available to aquatic life. Pitt and Field (1992) reviewed a series of studies that provide convincing evidence of longer-term chronic toxicity to aquatic organisms when exposed to urban runoff.

The greatest environmental risk appears to occur when metal and hydrocarbon-laden sediments are deposited in downstream lakes and estuaries. The bottom sediments of many small, highly urbanized estuaries are heavily contaminated with metals and PAHs. Runoff from urban hotspots appears to be a major contributing factor to sediment contamination in these cases, as witnessed in both the Anacostia and Delaware estuaries (Schueler and Shepp, 1992; McKenzie and Hunter, 1979). The consequences of sediment contamination often include greatly reduced benthic diversity and transfer of pollutants into fish tissue. Techniques to remedy bottom sediment contamination are in their infancy, and have yet to be proven effective.

Difficulty in Treating Hotspots

Few stormwater technologies are currently available to effectively control the runoff from hydrocarbon hotspots. Most hotspot source areas are less than an acre in size, exist in already developed areas, and are widely scattered across the urban landscape. Nichols (1993) notes that there are over 1,500 vehicle maintenance operations in the Washington, DC area alone.

The most common method to control hydrocarbon loadings from small sites has been the oil grit separator (OGS). It consists of a concrete structure linked to the storm drain system with two pools used to trap oil and grit (Figure 1). Recent research, however, indicates that oil grit separators are not effective in trapping pollutants (see article 119). For example, in field inspections of over 100 OGS systems, the average depth of trapped sediment was found to be a mere two inches.

Further, the mass of trapped sediments in OGS systems did not increase over a five year time frame. Monthly sampling revealed sharp reductions in the depth of trapped sediments of as much as 25 or 50% from one month to the next. Dye tests indicated that OGS systems had a residence time of less than 30 minutes during even minor storms. In contrast, Pitt *et al.* (1991) conclude that at least 24 hours of settling are needed to achieve any meaningful reduction in potential toxicity from hotspot areas.

The poor performance of oil grit separators can be attributed to three key flaws: (1) an on-line design that promotes frequent resuspension of previously deposited oil and sediments, (2) insufficient treatment volume, and (3) poor internal geometry.

Prospects for Improving On-Site Technology

Can the dismal performance of the current generation of oil grit separators be improved? New off-line designs have been developed in a number of communities to reduce resuspension (Shepp, 1992). Not much performance data are yet available to evaluate the performance of these new designs. However, it is reasonable to expect that they will be more retentive than current designs, but the question remains—by how much?

Ultimately, the effectiveness of any design is dependent on regular and frequent clean-out of trapped sediments. This, unfortunately, has been the "Achilles heel" of existing OGS technology. For example, in a recent Maryland study not a single OGS system out of over 100 inspected had ever been maintained.

Four factors explain this poor track record. First, a market does not yet exist to clean out and dispose of sediments. Few vendors are available to perform the task themselves. Second, many local governments have been slow in enforcing clean-out requirements on small business owners. Third, clean-outs are quite expensive, ranging from as much as $1,000 to $2,000

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per site each year. Lastly, concerns about the actual or perceived toxicity of the trapped sediments have limited options for safe and economical disposal. Many landfill operators are loath to accept wet sediments with pollutant concentrations on the order of those reported in Table 1.

Sand filters may turn out to be a better alternative for treating runoff from hydrocarbon hotspots than OGS systems. As a filtering medium, sand is very effective in "straining" out hydrocarbons and metals. Also, most sand filters are designed to treat a much greater volume of runoff than OGS systems. Perhaps most importantly, clean-out of sand filters is easier and less frequent. On the downside, sand filters are more expensive to construct, and may still be subject to disposal problems at some hotspot sites.

Source control may hold the greatest promise to reduce the delivery of pollutants from hotspots. This pollution prevention approach stresses the importance of eliminating the spills, leaks, and emissions that create the hotspot in the first place. A series of better handling, recycling, storage and disposal practices can reduce the chance that automotive fluids and cleaning solvents come into contact with rainwater and run off the site. The Santa Clara Valley Nonpoint Source Program has published an excellent summary of pollution prevention practices for gas stations (see article 136).

Summary

Although small in size, pollution hotspots are prevalent in the urban landscape. More monitoring is needed to define the magnitude of the metal and PAH loads they deliver to downstream waters. Currently, few effective techniques are available to treat hydrocarbon hotspots. Further testing of new designs of oil grit separators and sand filters is warranted.

In the end, our capability to reduce hotspots may well depend on solving institutional problems—assuring regular and environmentally safe sediment clean-outs, and preventing pollutants from being exposed to stormwater runoff at hotspot areas. **See also articles 119 and 120.**

References

Hoffman, *et al.* 1982. "Petroleum Hydrocarbons in Urban Runoff From a Commercial Land Use Area." *JWPCF.* 54(11): 1519-1528.

Mackenzie and Hunter. 1979. "Sources and Fates of Aromatic Compounds in Urban Stormwater Runoff." *ES&T.* 13(2): 179-183.

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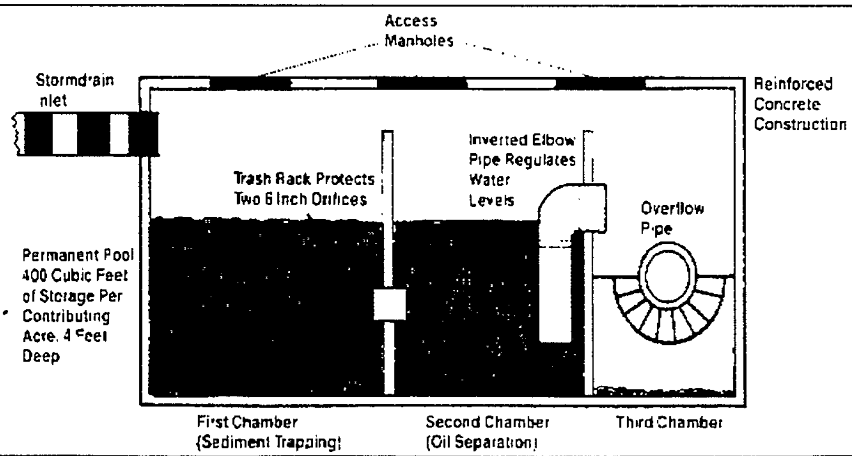
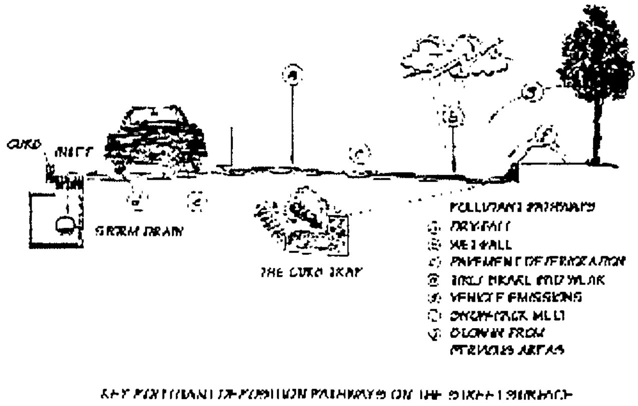


Figure 1: A Typical Oil and Grit Separator (Schueler, 1987)



Numerous types of pollutants can enter a stream from the street surface.

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Notes:

The sources of pollutants in stormwater are predominately associated with impervious areas. Impervious areas act as a collector and conveyor for pollutants that arrive from many pathways. Pollutants can fall out of the sky during dryfall. They may also arrive in rain or snow as wetfall. Automobiles are also sources of pollutants. Wear of tires (a known source of zinc), deteriorating brake pads, or just leaks, drips and spills of oil and other pollutants from the car can accumulate on impervious surfaces. Pollutants can also be blown in from adjacent pervious areas. Pollutants land on the street where they often stay in curbs, cracks and other areas until the next rain storm where they are washed off the surface and into the storm drain system and ultimately to receiving streams.

R0009372

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Notes:

Stormwater hotspots are areas which produce higher concentrations of pollutants than normally found in urban runoff. Certain areas of the urban landscape are known to be hotspots of stormwater pollution. Examples include gas stations, parking lots, and auto recycling facilities. Generally, stormwater hotspots contribute 5 to 10 times higher concentrations of trace metals and hydrocarbons in stormwater runoff. These hotspots merit special management and pollution prevention activities.

Slide 45 of 75

Notes:

Gas stations are one example of a land use classified as a stormwater hotspot.

R0009374

Article 6

Technical Note #13 from Watershed Protection Techniques. 1(1): 28

Cars Are Leading Source of Metal Loads in California

Metals can follow many pathways before they become entrained in urban stormwater run off. A recent California study sponsored by the Santa Clara Valley Nonpoint Source Program suggests that cars are the dominant loading source for many metals of concern, such as cadmium, chromium, copper, lead, mercury, and zinc.

Researchers examined the significance of various metal pathways into the Lower San Francisco Bay. Specifically, the comparative loading potential of five urban source areas were studied using a mass balance approach. The sources were atmospheric deposition, automotive leaks and wear, runoff from industrial and residential sites, and water supply.

Cars and other vehicles were found to produce over 50% of the total load of three metals: copper, cadmium and zinc. This number was generated even without accounting for tailpipe emissions that produce further atmospheric deposition of metals. For example, 50% of the total copper load to the Bay was attributed solely to brakepad wear.

Atmospheric deposition accounted for an additional 25% of the total copper load, much of which came from mobile emission sources, such as cars. Copper consistently ranks as a metal of great concern because it can be acutely toxic to aquatic species even at low concentrations.

Another major metal loading pathway was the wear and tear of automobile tires. The authors conclude that tire wear alone could account for at least half of the total cadmium and zinc loads delivered to the Bay each year. Since both brakepads and tires wear directly onto impervious surfaces, it is likely that the delivery of the metals into the storm drain system is almost 100%.

The authors note that the most effective, and perhaps the only, technique to reduce copper, cadmium, and zinc loads would be to get the automotive industry to reduce the metal content of tires and brakepads. This "pollution prevention" approach has historically worked in such cases as unleaded gas and engine coolants.

Atmospheric deposition, however, remains the primary loading pathway for lead. The chief culprit appears to be exhaust from diesel-fueled vehicles. Diesel fuel exhaust also factored as a significant source for chromium, silver, mercury, copper, and zinc. Again, a pollutant prevention strategy that focused on cleaner fuels or reducing vehicle emissions was recommended.

The authors made an attempt to calculate metal loadings from leaks of motor oil, gasoline, and coolant leaks from cars, as well as illegal disposal from oil and coolant changes. The data on leak and illegal disposal rates is extremely sketchy. For example leak rates of 0.3, 0.01, and 1.2% of all cars were cited for gasoline, motor oil and coolant, respectively. The rate of illegal disposal of motor oil was estimated to be 15%.

Based on these rates, leaks and illegal disposal were not believed to be a major pathway for metals into stormwater drains (about eight and 2% of the copper and zinc load, respectively).

The metal load contained in stormwater runoff from industrial sources could not be calculated due to a lack of data. However, the authors ranked the potential importance of different industrial source areas to contributing metal loads. The industrial categories with the highest risk for metal loading included mining activities, metal plating and galvanizing operations, metal scrap processing, boat building/repair, and automotive repair. Automotive repair was by far the most prevalent "industrial" activity in the basin.

—*TRS*

Reference

Santa Clara Valley Nonpoint Source Control Program. 1992. *Source Identification and Control Report.* Woodward Clyde Consultants. 96 pp.

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Article 111

Technical Note #87 from Watershed Protection Techniques. 2(3): 11-13

Multi-Chamber Treatment Train Developed for Stormwater Hot Spots

Stormwater runoff from paved urban "hot spots," particularly automotive service and repair stations, can contain pollutant concentrations three to 600 times greater than those found in other urban sources. The higher potential for heavy stormwater pollutant loading becomes apparent when one also considers the multitude of potential hot spots located throughout urban areas (Table 1). This being the case, it becomes prudent to treat a relatively small amount of runoff at the source as opposed to allowing contaminated runoff to become part of a much larger volume that may or may not be effectively treated at the end of the pipe.

Effective, on-site treatment of stormwater hot spots has been a problem for several reasons. First, most hot spots tend to be small in size and lack adequate space for the installation of typical stormwater management practices such as ponds and wetlands. Second, the use of gravitational settling as a sole pollutant removal mechanism does not provide sufficient hot spot pollutant removal. Third, infiltration is not an option due to risks of groundwater contamination. Lastly, the traditional underground approaches using oil grit separators have not been reported to be effective (Schueler, 1994).

To help solve the hot spot treatment problem, Robert Pitt and his colleagues at the University of Alabama-Birmingham have developed and tested a prototype known as the multi-chambered treatment train (MCTT). This device employs screening in the first chamber, settling in the next, and filtration in the last (Figure 1). It is designed for underground use. It can be sized to contain runoff from various rain events and typically requires between 0.5 and 1.5% of the paved drainage area. Present information places construction costs of the MCTT ranging from $10,000 to $20,000 per one-quarter acre of drainage area, assuming use and availability of prefabricated units (Pitt, personal com-

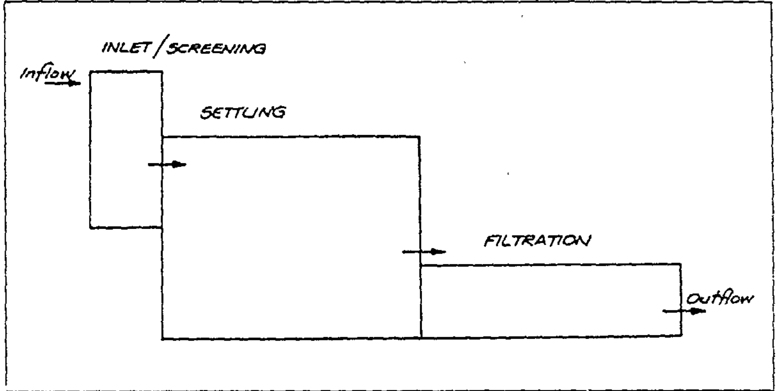


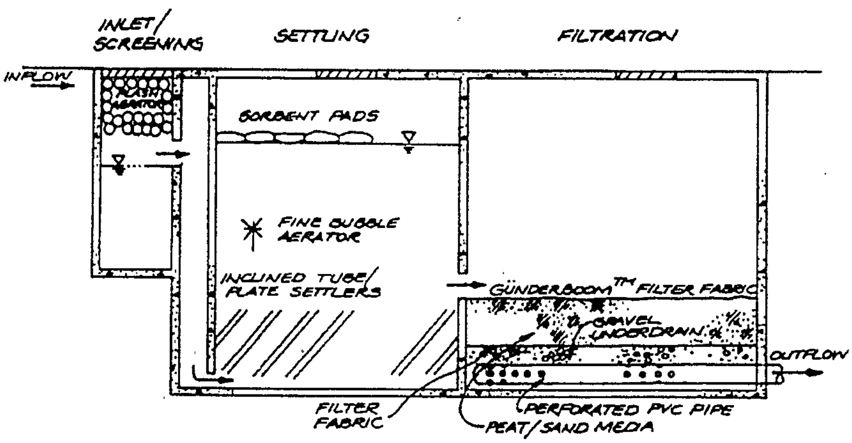
Figure 1: Three Main Chambers of the MCTT

Table 1: Potential Stormwater Hot Spots (Schueler, 1996)

- Commercial nursery
- Auto recycle facilities
- Commercial parking lots
- Fueling stations
- Fleet storage areas
- Industrial rooftops
- Marinas
- Outdoor container storage of liquids
- Outdoor loading/unloading facilities
- Public works storage areas
- SARA Title III Section 312 hazmat generators (if containers are exposed to rainfall)
- Vehicle service and maintenance areas
- Vehicle and equipment washing/steam cleaning facilities

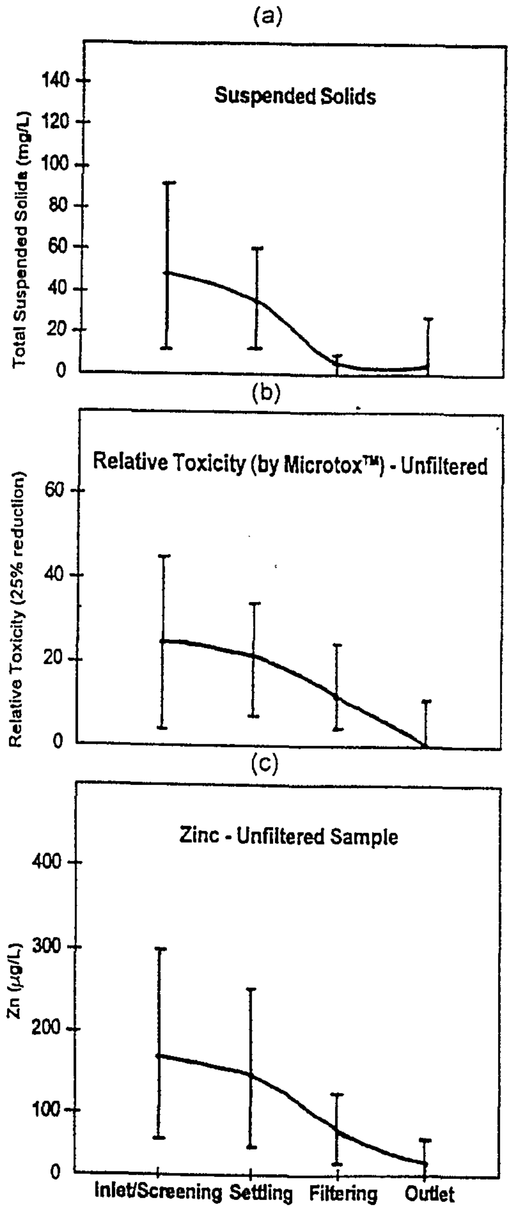
Table 2: Specialized Components of the MCTT

Chamber	Component	Description	Function
Inlet	flash aerator	small column packing balls with counter current air flow	removes volatile pollutants and traps trash
	catch basin sump	conventional catch basin sump	traps grit and sand-size particles
Settling	sorbent pads	floating absorbent pads	traps oil and grease
	fine bubble aerator	generator powered fish farm aeration stone	enhances aeration
	inclined tube or plate settlers	plastic tubes 2" x 2', inclined 30-45 degrees, arranged in rows ofopposing direction	increases surfaces area of settling chamber; enhances sedimentation and prevents scour
Filtration	Gunderboom™ filter fabric	covers top of filter	reduces channelization, slows infiltration, sorbs oils
	peat/sand filter media	50/50 mix, at least 12" depth	removes small and dissolved particles, provides ion exchange
	filter fabric	separates peat/sand layer from gravel and pipe layer	prevents gravel layer from clogging
	gravel packed under drain	perforated PVC pipe and gravel	provides additional filtration/outlet



The multi-chamber treatment train (MCTT) consists of three treatment units in sequence—an inlet screening chamber, a sedimentation chamber and a filtration chamber. Most of the high pollutant removal occurs in the last two chambers.

Figure 2: Detailed Schematic of the MCTT



Depending on the nature of the pollutant, the MCTT provides greatest removal in the settling chamber (panel a) or the filtration chamber (panel b and c).

Figure 3: MCTT Pollutant Removal Profile by Chamber

munication). Additional data on operation and maintenance costs of the MCTT is currently being collected.

The MCTT is divided into three main chambers (Figure 2). Stormwater enters the first chamber where the largest particulates are screened out and the bulk of highly volatile materials are removed when they pass over a flash aerator (additional, innovative components within each chamber are listed in Table 2). The stormwater then either flows under gravity or is pumped into the settling chamber. Here, settling of fine sediment is enhanced through the use of inclined tube or plate settlers while floating hydrocarbons and additional volatile compounds are removed by sorbent pads and bubble diffusers. Next, the stormwater flows, or is pumped slowly into, the filtration chamber containing a sand and peat filter bed for final removal of dissolved toxicants. The filter also functions in the partial treatment of runoff that may have bypassed prior chambers in the event of excess stormwater flow. To ensure that the water volume is distributed evenly over the filter bed, a fabric covers the top of the filter.

The size of this device varies according to the climatic conditions of the geographic region being served. Parameters considered include: rainfall amount, intensity, and elapsed time between storms as well as suspended sediment load and desired maintenance regime. Pitt has developed a computer model to aid in the site-specific design.

A pilot-scale MCTT was constructed by Pitt on the campus of the University of Alabama- Birmingham. This device, designed to catch runoff from a vehicle service area and parking facility, was tested over a six-month monitoring period from May to October of 1994. Two additional full-scale units have since been constructed in Wisconsin for testing how this technology functions in a colder climate. Preliminary pollutant removal data from the Wisconsin site is presented in Table 4.

Preliminary performance results of the pilot-scale MCTT for 13 storm events indicate substantial reductions of total suspended solids, heavy metals, and both dissolved and suspended stormwater toxicity from the unit overall (Table 4). Toxicity values were obtained using a Microtox™ screen that analyzes specific toxins in both dissolved and suspended forms. This test not only detects nonconventional pollutants in stormwater but establishes a standard by which to measure their "treatability."

Of notable significance is the inlet chamber where screening occurs. Screening has little effect on pollutant removal (it has virtually none) but serves an important role in trapping large materials, thereby reducing problematic maintenance concerns throughout the device and enhancing the ability of other chambers to remove pollutants.

Table 3: Prototype (Alabama) MCTT Pollutant Removal Efficiency Rates Based on Concentration Changes from Inflow to Outflow

Pollutant	Screening Chamber	Settling Chamber	Filtration Chamber	Overall Performance
TSS	nsd*	91	-44	83
Turbidity	(some reduction)	50	-150	40
COD	nsd	56	-24	60
Nitrate	nsd	27	-5	14
Ammonia	nsd	-155	-7	-400
Phosphate	nsd	nsd	1c	-
Toxicity (suspended)	nsd	18	70	96
Toxicity (dissolved)	nsd	64	43	98
Lead	nsd	89	38	100
Zinc	nsd	39	62	91
n-Nitro-di-n-propylamine	nsd	82	100	100
Pyrene	nsd	100	NA	100
bis (2-ethylhexy) phthalate	nsd	99	-190	99

*nsd = inflow and outflow concentrations were not significantly different at the 0.05 level

The settling chamber was responsible for most of the pollutant reductions in suspended solids, lead, zinc, polycyclic aromatic hydrocarbons (PAHs), turbidity, COD and to a lesser degree, nitrate and toxicity. The filter chamber provided additional removal of most toxicity and heavy metals. Ammonia nitrogen was increased by several times and nitrate-nitrogen had a very low removal rate. However, this finding is to be expected given the anaerobic nature of the filter system.

Preliminary monitoring data from two full-scale application of the MCTT in Wisconsin appear to confirm that it can achieve consistently high removal for solids, nutrients, metals and two polycyclic aromatic hydrocarbon (see Table 4). The Wisconsin test sites involved a similar design that treated stormwater runoff from a quarter-acre maintenance yard and a newly paved parking lot.

Based on the initial monitoring of the prototype and full-scale system, it appears that the design provides superior performance to conventional sand filter systems (see Table 4), which is reasonable considering that the sand filters employ much less sophisticated measures for screening, settling and filtration.

Pitt's study design was arranged to isolate the relative contribution of each of the three chambers—screening, settling and filtration—to the overall pollutant removal of the system (Figure 3). Pitt found that the importance of each chamber depended on the type of pollutant entering the system. For example, many suspended pollutants were removed quite efficiently using just the settling process, whereas the filtration chamber was responsible for further reduction of those same pollutants as well as the additional removal of dissolved pollutants. Suspended solids were reduced somewhat by screening but were almost totally reduced by settling while filtration was of no consequence (Figure 3, panel a).

Toxicity was basically unaffected by screening, received slight treatment in the settling chamber but was reduced significantly by filtration. This comparison is a clear illustration of the relative importance of settling versus filtration for certain types of pollutants. As shown in panel c of Figure 3, screening accomplished in the inlet chamber only achieved negligible zinc reductions. Pollutant removal was attained through settling followed by more extensive removal from filtration.

Further analysis of MCTT pollutant removal capabilities may be obtained through testing the efficiencies of the innovative components within each chamber and the effects they have on improving and enhancing the three processes of screening, settling and filtration. Given variable climates and pollutant concentrations present at hot spots, a full application of the MCTT may only be needed when a very high level of treatment is desired.

—TJL

Table 4: Preliminary Pollutant Removal Efficiency for Two Full-Scale Multi-Chamber Treatment Train (MCTT) Systems in Wisconsin

	Ruby Street MCTT[1]	Minoqua MCTT[2]	Sand Filters Mean[3]
No. of Storms [4]	5-6	7	226
		Pollutant Removal (%)	
Suspended Solids	98	85	85
Total Phosphorous	84	80	50
Total Zinc	93	90	71
Total Copper	89	65	43
Flouranthene	92	>90	no data
Pyrene	>80	>75	no data

1 Full-scale MCTT installed in Ruby Street Garage in Milwaukee, Wisconsin, that treats runoff from maintenance garage (drainage are 0.25 acres). Pollutant removal computed in total load bases. (Data from Corsi and Greb, personal communication).

2 Full-scale MCTT installed at 2.5 acre new commercial parking lot. Pollutant removal computed on median EMC removal method. Data from Pitt (1996).

3 Mean removal efficiency of 12 independent monitoring studies analyzed in Claytor and Schueler (1996).

4 Number of paired storm events sampled.

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IMPACT OF ANNUAL AVERAGE DAILY TRAFFIC ON HIGHWAY RUNOFF POLLUTANT CONCENTRATION

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ABSTRACT

This study was initiated with the specific objective to evaluate the impact of AADT on highway pollutants concentration. Analysis of data collected from Caltrans 3-Year (1997-00) highway runoff characterization program revealed that, in general, pollutant concentrations in urban highways were 2 to 10 times higher than those found in non-urban highways. For some pollutants, however, the pollutants in non-urban highways were found to be higher than the pollutant concentration in urban highways. No linear correlation could be found between highway runoff pollutant's event mean concentrations (EMCs) and the AADT. Correlation coefficient in linear regression between pollutant concentration and AADT is a measure of their linear relationship, not a lack of association or influence. In fact, by conducting multiple regression analysis it was shown that AADT was found to have some influence or association with most highway runoff constituent concentration. AADT was not the only factor that could influence the accumulation of pollutants in highways. Other noticeable factors were antecedent dry period, drainage area, maximum rain intensity, and land use.

Keywords: Average annual daily traffic (AADT), highway runoff, linear regression model, multiple regression model, and pollutants.

INTRODUCTION

Caltrans is engaged in a multi-year program of research and monitoring on the environmental effects of stormwater quality from their facilities. Part of the Caltrans storm water quality research and monitoring program relates to the characterization of highway runoff (Kayhanian et al., 2001). These monitoring studies are principally undertaken to comply with the statewide National Pollution Discharge Elimination System (NPDES) storm water permit. The information presented in this paper is based on three-year highway stormwater runoff characterization study that was undertaken during the 1997-00 winter seasons. Data generated from these monitoring studies were compiled into three broad categories of sample description, event description and site description in a database.

These monitoring data are analyzed on a regular basis to assess Caltrans storm water runoff characteristics. One question that is continuously asked is whether annual average daily traffic (AADT) impacts concentration of highway runoff pollutants. This paper is prepared to address this issue. To achieve the stated objective, this paper is organized to present: (1) methods, (2) results and discussions, and (3) conclusions.

METHODS

Highway Runoff Monitoring

Caltrans highway storm water runoff monitoring was accomplished using the specification presented in the Caltrans Guidance Manual: Storm Water Monitoring Protocols (Second Edition, July 2000). The highway runoff characterization was carried out by preparing an extensive Sampling and Analysis Plan (SAP) covering the detail information on: project overview/description, site selection, analytical constituents, data quality objectives, field equipment maintenance, monitoring preparation and logistics, sample collection, sample preservation, sample delivery, quality assurance/quality control, laboratory sample preparation and analytical methods, data management and reporting procedures. Description of each of the above topics is beyond the scope of this paper. However, a brief description of monitoring sites, analytical methods, and steps taken to evaluate the monitoring data are briefly described below.

Monitoring Sites

During the span of 1997 to 2000 monitoring seasons, fifty (50) highway sites were monitored for water quality characteristics. These highway sites were located in 7 of the 12 Caltrans districts (see Figure 1). General physical characteristics of these sites including the AADT are summarized in Table 1.

Analytical Method

Stormwater samples were collected as flow-weighted composite samples. These flow-weighted composite samples were analyzed for constituent event mean concentration (EMC). Different types of constituents that were analyzed during the course of monitoring are summarized in Table 2. These constituents are organized as: (1) conventionals, (2) metals (total and dissolved), (3) nutrients (4) major ions and minerals, (5) microbiological, (6) oil and grease, and (7) pesticides. All laboratory analyses were conducted according to the *Standard Methods* and the USEPA analytical methods specified in the Caltrans Guidance Manual (Second Edition, July 2000). Standard lab QA/QC procedures were followed and analytical results were qualified as necessary based on the results of the QA/QC evaluations.

Highway Runoff Data Evaluation

The following key steps were taken to evaluate the Caltrans highway storm water characterization data.

Data Reporting: To aid in development of a statewide monitoring database and to maintain consistency, Caltrans has established a data reporting protocol (July 2000) that is being used by all monitoring teams collecting and reporting data as Excel spreadsheets to the Caltrans. To ensure uniformity, entries into the data fields have been as standardized as possible.

Database: Once the Excel® spreadsheets are reported to Caltrans per the data reporting protocols, data are imported into an Access® database that holds statewide monitoring data. Data is stored in three main tables:

- Sample Description,
- Sampling Event Description, and
- Site Description

Sample description consists information specific to individual samples including lab results, analysis methods and date information. Event description consists of precipitation event descriptions for each monitoring site such as start and end time, maximum intensity, antecedent dry period, and total flow volume. Site description describes location of the site along with some physical characteristics of the site.

Quality Assurance/Quality Control: All the data reported by the laboratory is reviewed to ensure that the project's data quality acceptability limits and objectives (DQOs) have been met. QA/QC parameters that are reviewed include: reporting limits, holding times, contamination check results, precision and accuracy analysis results. In addition, automatic data checker is used to ensure referential integrity of the database and compliance with data reporting protocols.

Working Data File: The statewide database was queried to extract an Excel file that contained all the highway monitoring sites along with their characteristics like Annual Average Daily Traffic (AADT), land use (LU) and drainage area (DA). For the sampling events antecedent dry period (ADP) and maximum intensity (MI) information was tabulated. Finally for all the highway sites, laboratory analysis results including reported value, units and reporting limit were extracted for the constituents listed in Table 2.

Data Analysis: In most part, the concentrations of highway runoff were reported above the designated reporting limit. Under these conditions, conventional statistical approaches were used to analyze data. For the constituents for which the reported value was below reporting limit the constituent concentration were considered to be non-detect. For the purpose of this report all non-detect value were substituted with one-half of the reporting limit for the conventional statistical analysis.

RESULTS AND DISCUSSIONS

Urban and Non-Urban Highway Runoff Characteristics

The results of AADT values for all fifty highway sites were previously shown in Table 1. As shown, the AADT values ranges from as low as 2200 vehicle per day (VPD) to as high as 307,000 VPD. A report prepared by Driscoll et al (1990) for the Federal Highway Administration (FHWA) attempt to divided highway sites into two general categories of urban and non-urban. According to the report, the highways with AADT values greater than 30,000 are considered as "urban" and those with AADT value less than 30,000 are "non-urban."

Due to large variation in urban AADT values (AADT>30,000 VPD), a single classification for urban highway was found to be impractical in terms of finding a correlation between pollutants and AADT. For this reason the urban highways were further classified into four categories of low, medium, medium high, and high based on the number of vehicles per day (VPD) as shown in Table 3.

Table 3
Classification of Non-Urban and Urban Highways Based on AADT

Classification	AADT Values
Non-Urban Highways	AADT<30,000
Urban Highways	
Low	60,000>AADT>30,000
Medium	100,000>AADT>60,000
Medium High	200,000>AADT>100,000
High	AADT>200,000

A general highway runoff characteristic for both urban and non-urban highways is summarized in Table 4. Results of the average runoff pollutants for both urban and non-urban highways are presented in Table 5. As shown in Table 5, there is a significant difference in the constituents' concentrations at sites with AADT greater than 30,000 (urban highways) and those with AADT less than 30,000 (non-urban highways). On average the concentration of most pollutants in urban highway runoff are 2 to 5 times higher than non-urban highway runoff. Concentrations of more than ten times were noticed for total lead, sodium, and turbidity for urban highway runoff compared to non-urban highways. The higher concentration of pollutants in urban highways will not necessarily address the issue of correlating pollutant with AADT. This aspect of the study is further discussed below.

Correlation Between Highway Runoff Pollutants and AADT

Single Linear Regression Model

A single linear regression analysis was performed to determine the correlation between AADTs and different highway runoff pollutants. The result of this analysis based on R-squared (R^2) value is shown in Table 6. As can be seen, extremely low R^2 values were obtained for all constituents. The low R^2 value suggests weak or no correlation between AADTs and pollutant concentration.

Single linear regression analysis is a useful, but relatively crude form of data analysis. For better understanding of the relationship being examined and to avoid faulty conclusions produced by regression, it is important to examine the data sets by plotting. Two sets of plots were prepared. One is bar graph and the other is scattered plot. The bar and scattered plots for Copper and Lead is shown in Figures 2 and 3, respectively. Bar graphs present the average pollutant concentration against the defined range of urban AADT values and the scattered plots show the pollutant EMC from urban highway sites against their respective AADT values. Nearly all other data plotting examined, no strong correlation between AADT and pollutant concentration could be found.

Several studies attempt to correlate AADT to highway runoff pollutants, most of which could not find a good correlation. For example, Chuiet et al (1982) found only weak correlation. A study conducted by FHWA (Driscoll et al. 1990) suggests that there is no strong and definitive relationship between differences in traffic density and the pollutant level for a site. They conclude that, other than the use of AADT as a surrogate measure to distinguish between "urban" and "non-urban" highways, further use of AADT to refine estimates of pollutant levels in runoff has no supporting basis. Another study conducted by Stotz (1987) on highway runoffs in Germany, also concluded that the amount of pollutants concentration is not dependent on traffic frequency. The results obtained from Caltrans highway storm water runoff monitoring data support those findings that there is no strong relationship between AADT and the highway runoff pollutant.

Other investigators found a weak or somewhat better correlation between AADT and highway runoff pollutants. For example, Dormen et al. (1988) found a direct correlation between pollutants and AADT. In another study McKenzie and Irwin (1983) found that the concentration of lead and zinc are related to AADT and COD concentration is strongly related to AADT. Quantitatively, the positive or negative correlations of pollutants with AADT can be explained if the source of contaminants is taken into consideration. For example, zinc, cadmium, copper, lead, and oil&grease are known to be related to transportation activities and hence is expected to have a positive correlation with AADT (Laxen and Harisson 1977, Gupta et al. 1981, Kim and Fergusson 1994, Moe et al. 1982). On the other hand, nitrogen associated with atmospheric deposition is expected to have little or no correlation with AADT (Young 1996). Pesticides are other pollutants that are commonly found in highway runoff that are considered with atmospheric deposition.

Consider the average concentration of ammonia and TKN against non-urban and urban AADTs (see Figure 4). As expected, no correlation could be found between these pollutants and AADTs. Similarly, the concentration of Diazinon and Chlorpyrifos found in highway runoff are also considered to be associated with atmospheric deposition and has nothing to do with AADT values. But, the results have shown in Figure 4 indicate both Diazinon and Chlorpyrifos concentration increased as the values of AADT increased. This correlation can be problematic since the pesticide source can not be related to the transportation activities. It is, however, possible that there are higher atmospheric deposition of these pollutants in urban compared to non-urban areas.

Results obtained for metals concentrations, which can quantitatively be related to transportation activities, revealed opposite conclusions as presented in the literature. For instance, as shown in Figure 5, the average Cadmium (Cd) concentration decreased as AADT values increased (only dissolved Cd is shown). Similarly, looking at 5 a proportional increase in total and dissolved Cu, Pb, and Zn average concentration (only total concentration is shown) relative to AADT values could not be established. Oil and grease (see Figure 16) is the only pollutant concentration showed a strong correlation with AADT and quantitatively be related to transportation activity.

Previous linear regression analysis performed on most highway runoff pollutants showed that there is a weak or no correlation between constituents' concentration and AADT. It is important to remember that the correlation coefficient between pollutant concentration and AADT is a measure of their linear relationship, and that the value of $R^2 = 0$ implies a lack of linearity and not a lack of association. It is however, possible to argue that these lack of linear correlation is due to unusual data point in specific data set known as *outlier.*

Close examination of plotted data (for example see Figure 3) indicate that for some pollutant there is one or more outlier data, substantially higher than all other values in data set. Even though the data was processed through vigorous QA/QC, the validity of these data for those specific sites is questionable. Clearly these data are not consistent with the remaining data, and at best suggest an unusual or atypical situation. The inclusion of these data points in regression analyses may influence the correlation relationship between pollutant concentration and AADT.

Consider the possible outliers for TSS, Pb, and Ortho-P shown in Figures 7, 8 in which, removing these outliers did not improve the regression coefficient. Similar results were obtained for other conventionals, metals, nutrients, and major ions in which exclusion of the possible outliers did not result in any significant improvement in R-squared value. On the contrary, removal of possible outliers resulted in reduction of R-squared value in some cases. In conclusion, the presence of outliers in data sets was found to have little or no influence on constituent's correlation with AADT.

From the findings of this study and information presented in the literature, the validity of AADT as a predictor in regression type analysis should only be considered on a broad-scale measure of pollutant loads. Possible reason for the lack of regression correlation, are may be due to factors such as wind, vehicular turbulence, volatilization, and oxidation process. These factors will limit the accumulation of pollutants on road surfaces and thereby decreasing the importance of AADT for short time (Irish et al. 1995, Winstrom and Matsumoto, 1999). In the absence of strong correlation between AADT and pollutant, few investigators (Keri et al. 1985, Chui et al. 1982) suggest that AADT during storm event, vehicle during storm (VDS), is a better independent variable for estimating total runoff loads for certain pollutants. Literature reviewed by Winstrom and Matsomoto (1999), however, conclude that AADT is not generally expected to be useful as a control variables for the design, operation, and maintenance of specific runoff control structure as traffic intensity on a particular stretch of highway is expected to fairly constant from day to day.

Multiple Regression Model

Evaluation of the plotted data and linear regression analysis revealed that there is no strong correlation between the highway runoff pollutant concentration and AADTs. Therefore, one can assume that the AADT is not the sole factor of pollutant accumulation in highway sites. It appears that there are other parameters that can influence the pollutant accumulation in highway sites. These parameters may include but are not limited to: drainage area, antecedent dry period, rain intensity, and land use.

In the absence of a strong relationship between AADT and highway runoff pollutants, a search for a better model shifted to a multiple regression where variables other than AADT were considered. The choice of an appropriate method for doing the multiple regression analysis wasn't that straightforward, since the statistical methods give the ability to adjust for variability in one or more confounding factors, but are still have to decide whether we *want* to adjust for the impact of a given variable. For example, the antecedent dry period (how long it's been since it last rained) is one confounder that would have little if anything to do the average daily traffic. Thus it makes sense to adjust for this variable. On the other hand local land use might be associated with AADT, since the more urbanized areas would tend to have certain types of land use, compared to more rural areas. Thus it might *not* be appropriate to adjust for this variable. A third consideration here is that a given analysis can involve only the observations for which all of the relevant variables were measured. Since one of these (the storm's maximum intensity) was not reported for about half of the data, this variable was not adjusted, since by doing so, it would reduce the available data by about half. Three different multiple regression models are used to evaluate the impact of AADT on highway runoff pollutants. These models include: analysis of covariance, stepwise regression, and partial correlation.

Analysis of Covariance: Analysis of covariance (ANOCOVA was selected since the predictors were both continuous and categorical variables. This analysis included all of the predictor variables in the model, along with both linear and quadratic terms in AADT. The results of the ANOCOVA analysis for selected constituents based on *p*-value and R-squared (R^2) is summarized in Table 6.

The effect of AADT on pollutant concentration for all pollutants could not be estimated because there was a lot of confounding in these models. Major confounding factors were largely due to the fact that AADT is a site characteristic and there were enough other site characteristics that can impact AADT. In addition, the rain intensity and antecedent dry period were not reported for all monitoring sites. For these reasons, the ANOCOVA could not be performed for all pollutants. The significance of this analysis was strictly reported in terms of a *p*-value for the effect of AADT in the model, along with an overall R^2 value for the predictive power of the entire model. It is important to note that if p-value is less than 0.05, then the observed relationship is not attributable to chance alone and hence there is nontrivial relationship between the pollutant and the AADT. For those pollutants with p-value greater than 0.05, we can not, however, conclude that AADT is unimportant given the amount of confounding in the model.

Comparing the R^2 of the ANOCOVA model to those predicted by a linear regression model (see Table 5), it can be seen that the correlation relationship has been improved significantly. This improved correlation is assumed to be due to the continuous and categorical predictor variables that were included in the ANOCOVA analysis. The influence of these predictor parameters is evaluated by stepwise regression as discussed below.

Stepwise Regression Analysis: This model was chosen to evaluate the impact of the most important predictors for a given pollutant from the full set of predictors, and then assess the impact of AADT on the outcome after adjusting for that shortened list of predictors. The result of this analysis is presented in Table 7.

The significance of each predictor variable in the stepwise regression analyses were evaluated in terms partial R^2 value and the *p*-value for testing whether a predictor is impacting the dependent variable (pollutant). The partial R^2 value indicates how much of the variation in the dependent variable can be explained in terms of the predictor variable, apart from variation that can be explained in terms of other predictors in the model. In general, low partial R^2 value was obtained for the predictor variables evaluated for common highway runoff pollutants. The low partial R^2 values indicate that no single predictor can uniquely attribute to dependent variable. The results, however, revealed that AADT and ADP, and MI (maximum intensity) are among the common predictor variables for most pollutants.

The *p*-value is interpreted as the probability that the amount of variability attributable to a predictor would have been at least as large as the observed value, if there was in fact no relationship and this was due to chance alone. If the p-value is small (traditionally 0.05 or less), then the observed relationship is not attributable to chance alone, and we conclude that there is in fact a non-trivial relationship between the predictor and the response. Referring to Table 7, impact of predictors on each pollutant are reported as positive, negative, concave, or convex response. Interpretation of these responses is shown as table footnote.

Interspersed with the stepwise regression results, a series of equations were developed to show the non-trivial relationships. These equations indicate both the *direction* of each relationship (i.e., whether the response increases or decreases as a function of the predictor) as well as its strength or elasticity. For example the stepwise correlation relationship predicted for Cadmium is shown in Equation 1.

Equation 1:

Cadmium concentration

$$= 97.647 - 0.00149 \times AADT + 0.0000000038 \times AADT^2 + .0795 \times ADP - 0.00126 \times ADP^2 - 0.214 \times MI + 1.908 \times DA - 0.0499 \times DA^2 + 8.734 \times LU_C + 43.569 \times LU_I + 7.204 \times LU_R + 47.145 \times LU_T + \epsilon$$

Where,

AADT=	Annual average daily traffic, vehicles/day
ADP=	Antecedent dry period, day
MI=	Maximum rain intensity, mm/hr
DA=	Drainage area, hectares
LU_c=	Land use-Commercial (if the monitoring site was commercial, use 1 for LU_c and 0 for others)
LU_I =	Land use-Industrial (if the monitoring site was industrial, use 1 for LU_I and 0 for others)
LU_R =	Land use-Residential (if the monitoring site was residential, use 1 for LU_R and 0 for others)
LU_T =	Land use-Transportation (if the monitoring site was transportation, use 1 for LU_T and 0 for others)

From Equation 1 it can be seen that AADT has negative impact, whereas the quadratic AADT has positive impact on Cadmium concentration. Opposite relationship was found for antecedent dry period (ADP) and drainage area (DA). The maximum rain intensity (MI) has negative impact on Cadmium concentration. The impact of land use on Cadmium concentration is found to be positive.

It is important to note that direct comparison between different predictors can not be done since they represent the expected change in the response. For instance an increase of 1 unit might be a big change for land use, which can only be equal to zero or one, and a small change for AADT or ADP.

Partial Correlation Analysis: The last analysis performed was partial correlation. This model looked at the strength of the relationship between the constituents and AADT, after adjusting for either all of the other predictors, or else just the antecedent dry period. Because the normality of the data is questionable both parametric (Pearson) and nonparametric (Spearman) correlations were performed. These results are summarized in terms of a correlation and an associated *p*-value in Tables 8 and 9.

Significance of this test can be evaluated in terms of adjusted R^2 correlation and associated *p*-value. As with other correlation measures, the adjusted squared correlation can be interpreted as the proportion of the variability in the response, which can be explained in terms of the predictor. This analysis was performed to limit the risk of concluding significance of a pattern and relating that to AADT, when the pattern observed is in fact due to land use, or drainage area, or something else. Referring to Tables 8 and 9, adjusting the dry period and maximum intensity, as predictor variables, did not significantly improve the correlation coefficient.

In summary, while no direct relationship could be found, significant numbers of pollutants were found to be effected by AADT. In general, however, it's safe to say that while the regression relationship may be significant, they still don't account for that large a fraction of the variability in the dependent variables.

CONCLUSIONS

The following conclusions can be drawn from this study:

- In general, the pollutant concentrations in urban highways (AADT>30,000 vehicle per day) are found to be 2 to 10 times higher than those found in non-urban (AADT<30,000 vehicle per day) highways. However, some of the pollutants in non-urban highways were found to be higher than the pollutant concentration in urban highways.
- No linear correlation could be found between highway runoff pollutant's event mean concentrations (EMCs) and the AADT including those pollutants that are known to be related to transportation activities (e.g., Pb, Cu, Zn).
- Correlation coefficient in linear regression between pollutant concentration and AADT is a measure of their linear relationship, not a lack of association or influence. In fact, the AADT was found to have some influence or association with most highway runoff constituent concentration.
- AADT is not the only factor that can influence the accumulation of pollutants in highways. Other noticeable factors include antecedent dry period, drainage area, maximum rain intensity, and land use.

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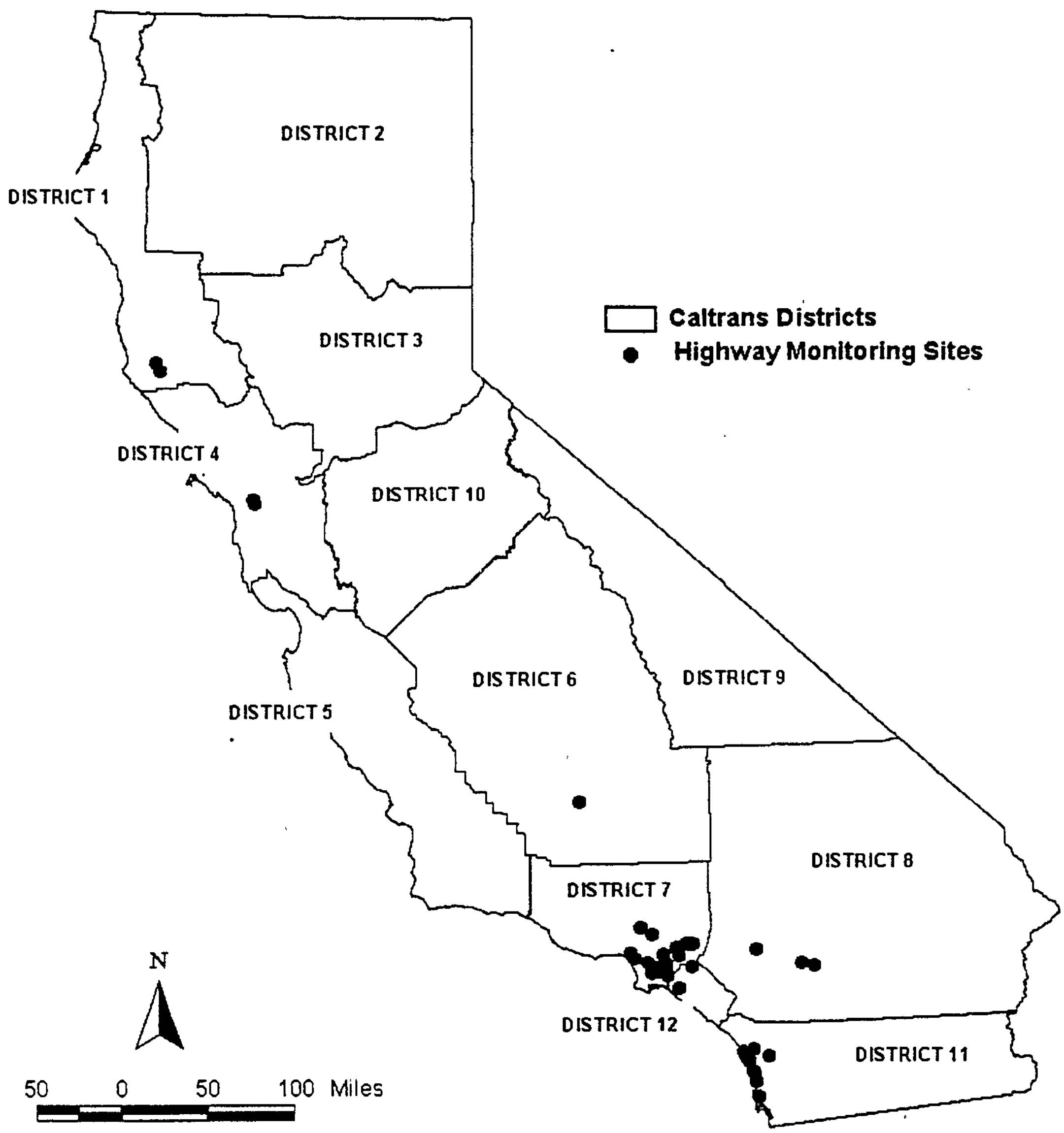

Figure 1
Highway Monitoring Sites

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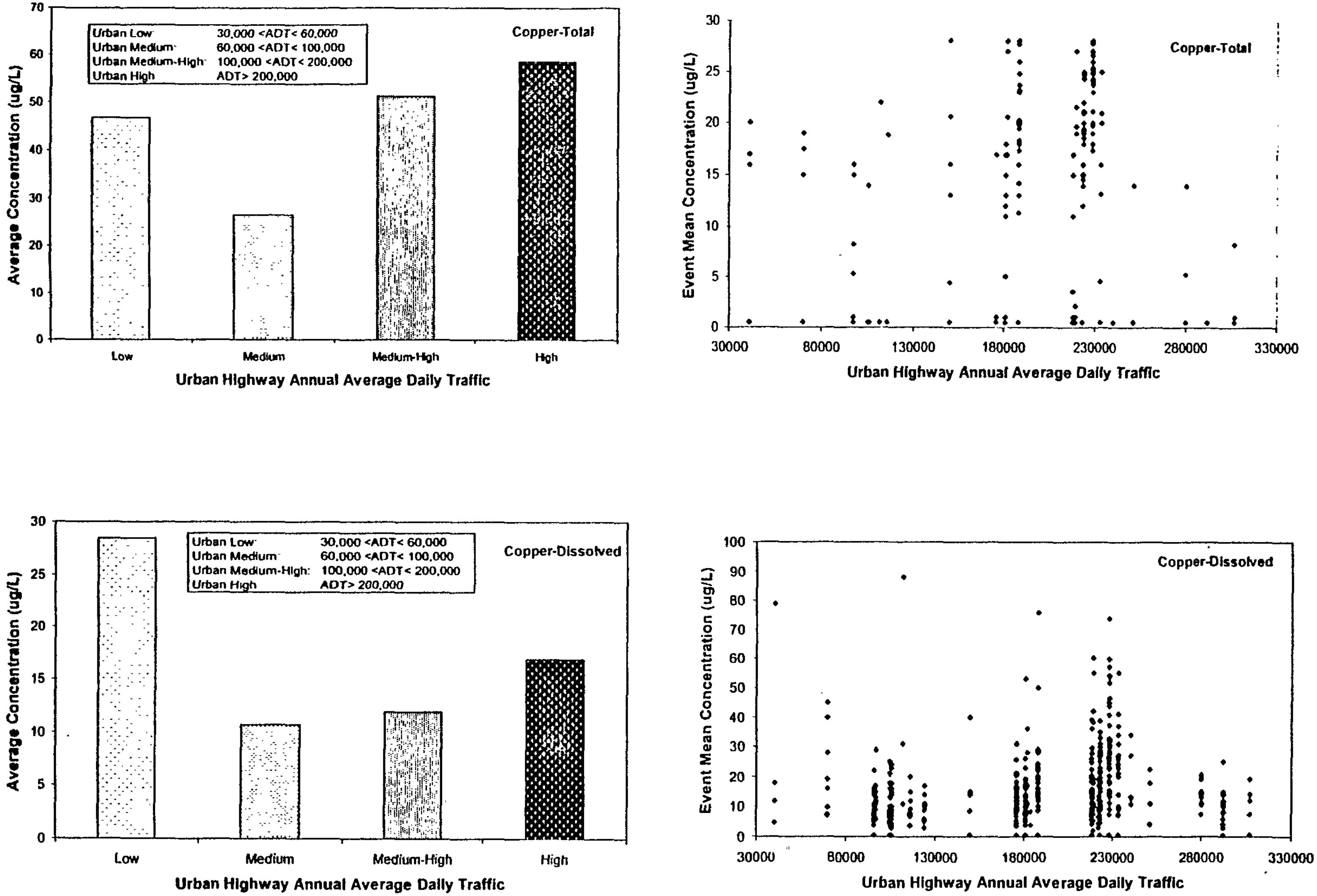


Figure 2
Average and EMC Values of Copper in Urban Highways

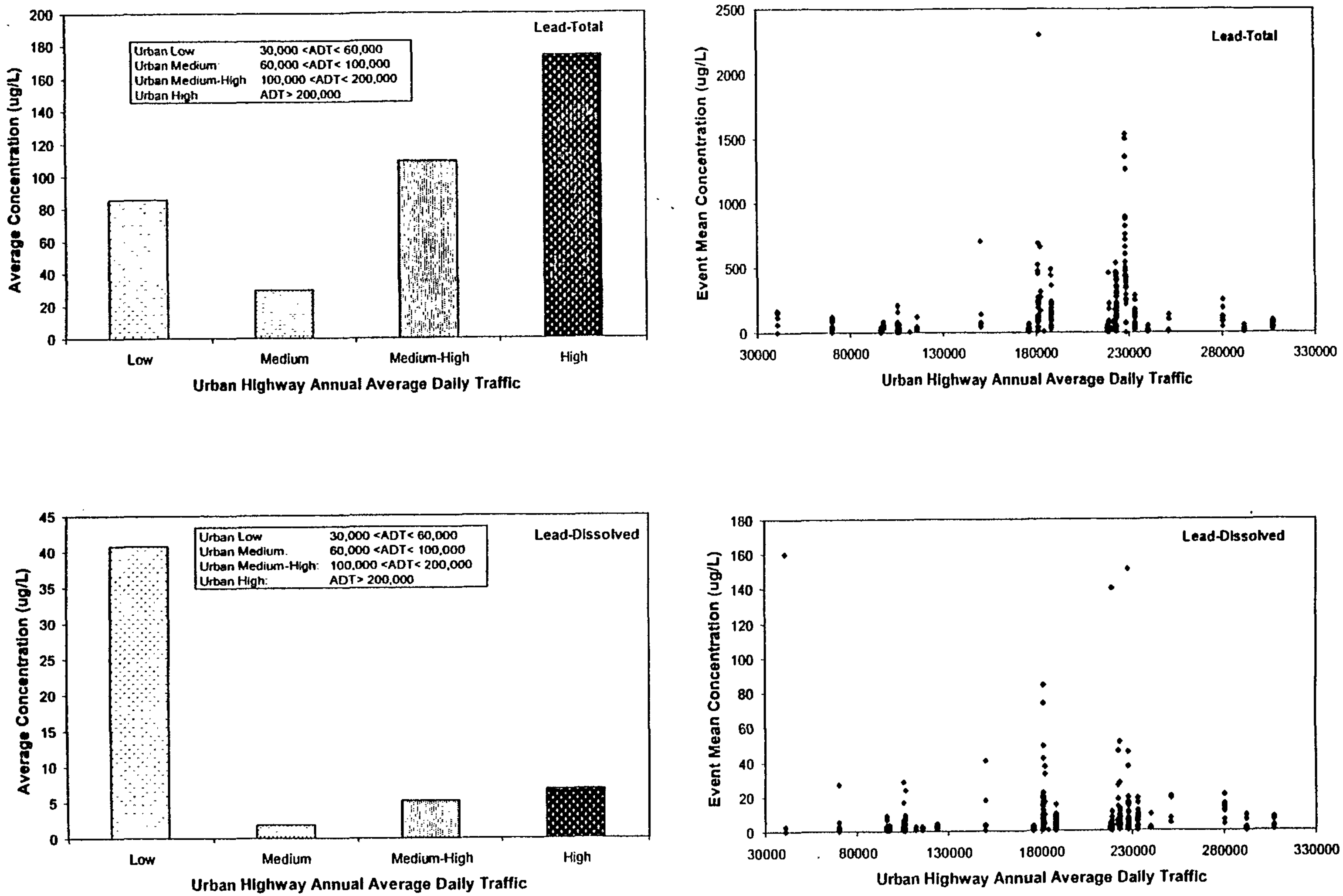


Figure 3
Average and EMC Values of Lead in Urban Highways

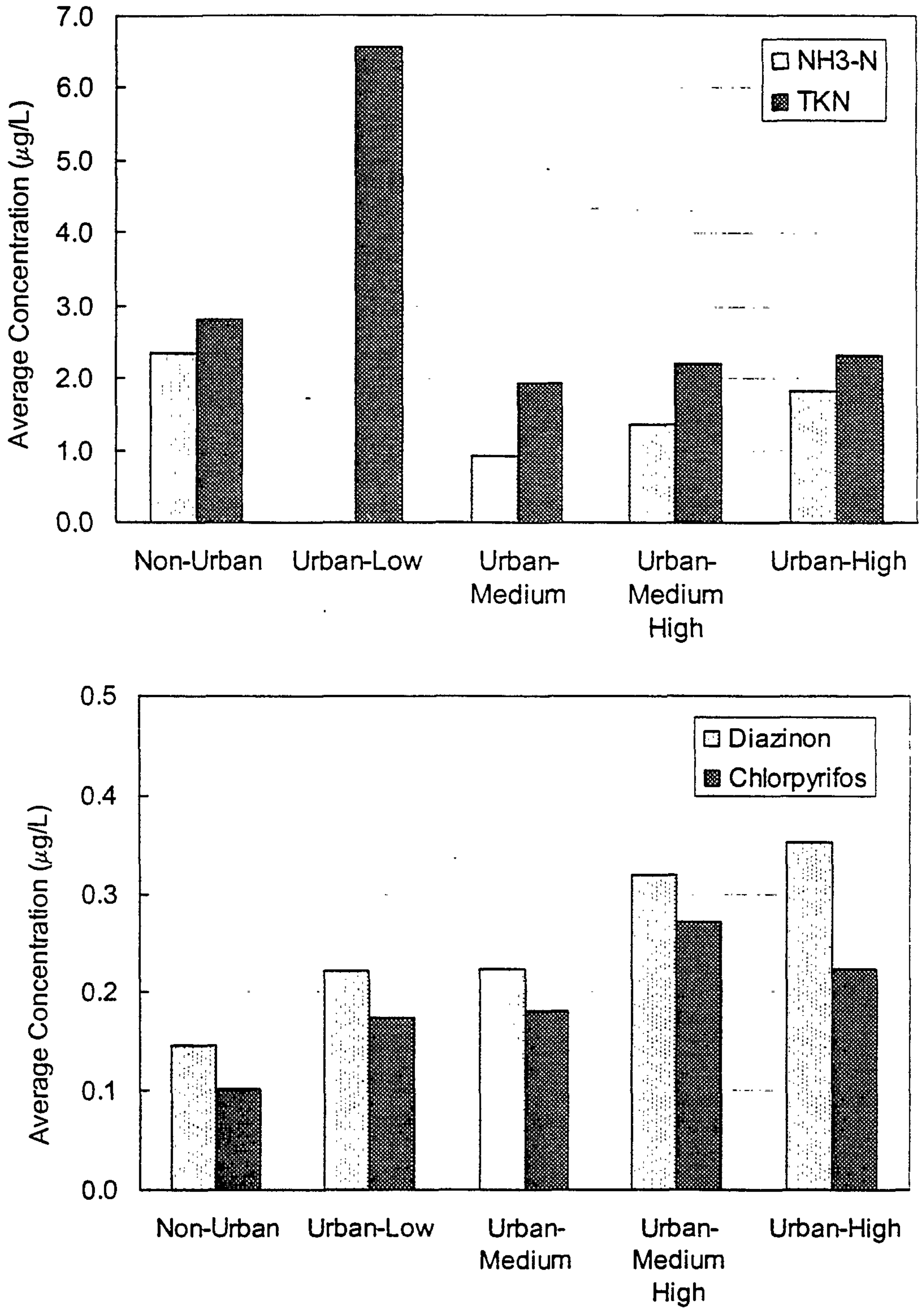


Figure 4
Average EMC Values of Selected Nutrients and Pesticides in Non-Urban and Urban Highways

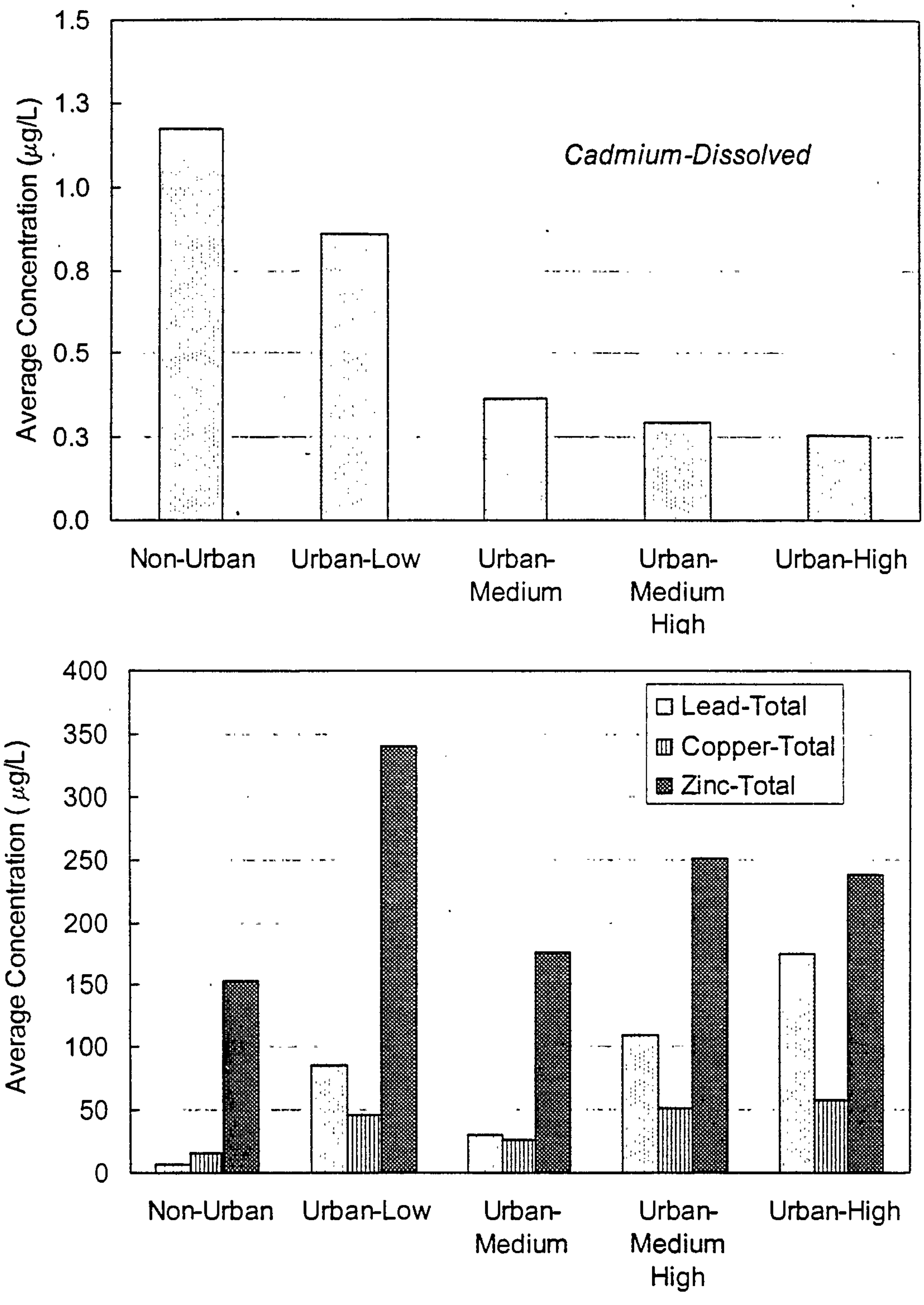


Figure 5
Average EMC Values of Selected Metal Pollutants in Non-urban and Urban Highways

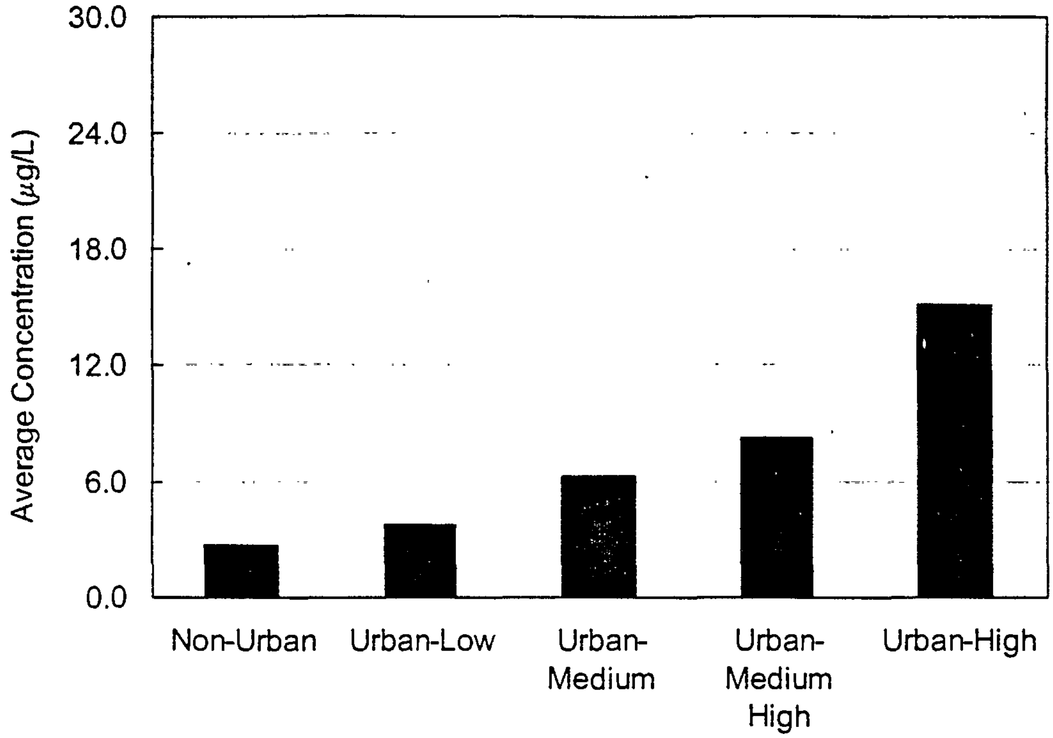


Figure 6
Average EMC Values of Oil & Grease in Non-Urban and Urban Highways

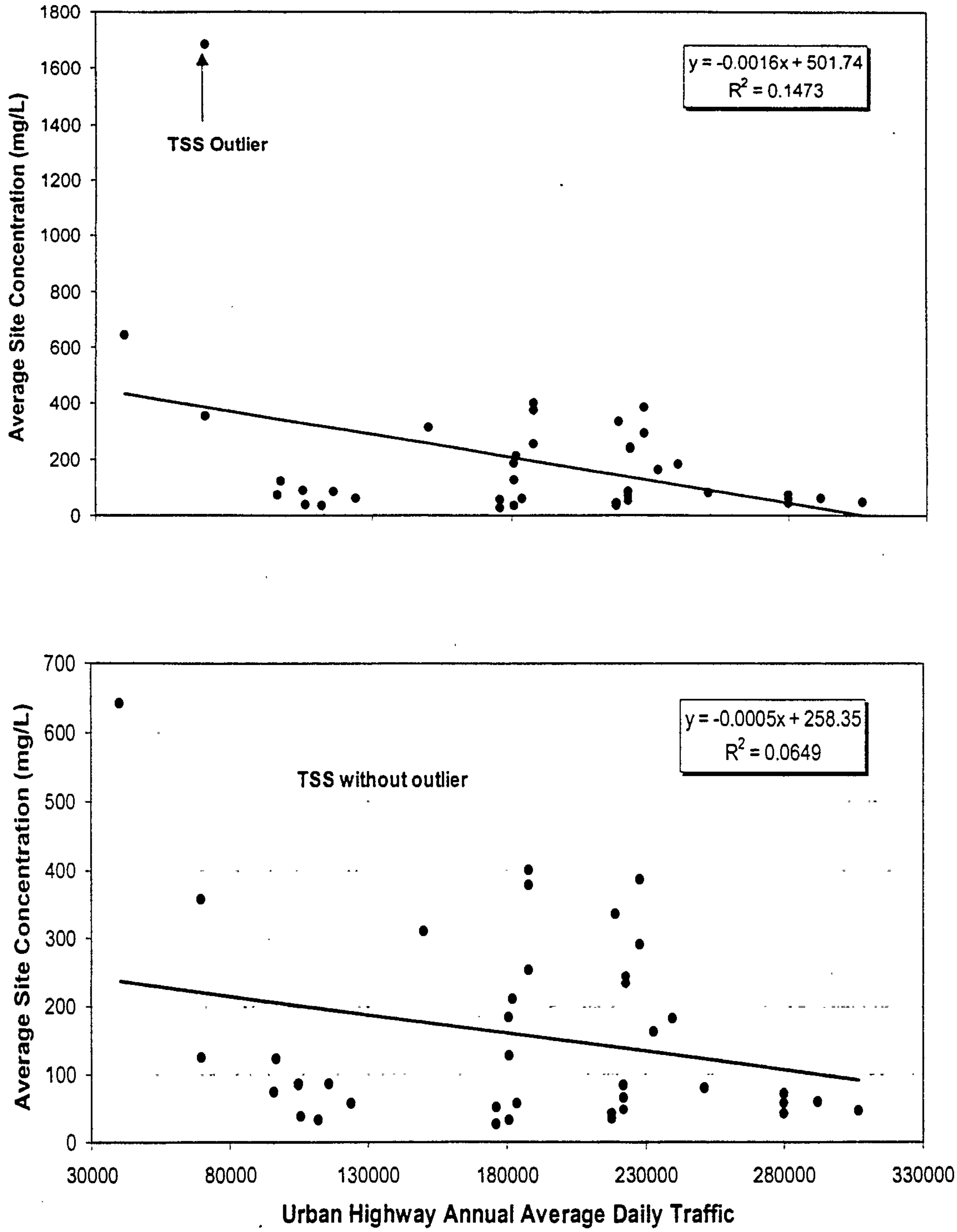


Figure 7
Correlation Between Average TSS Concentration and Urban AADT With and Without Outlier(s)

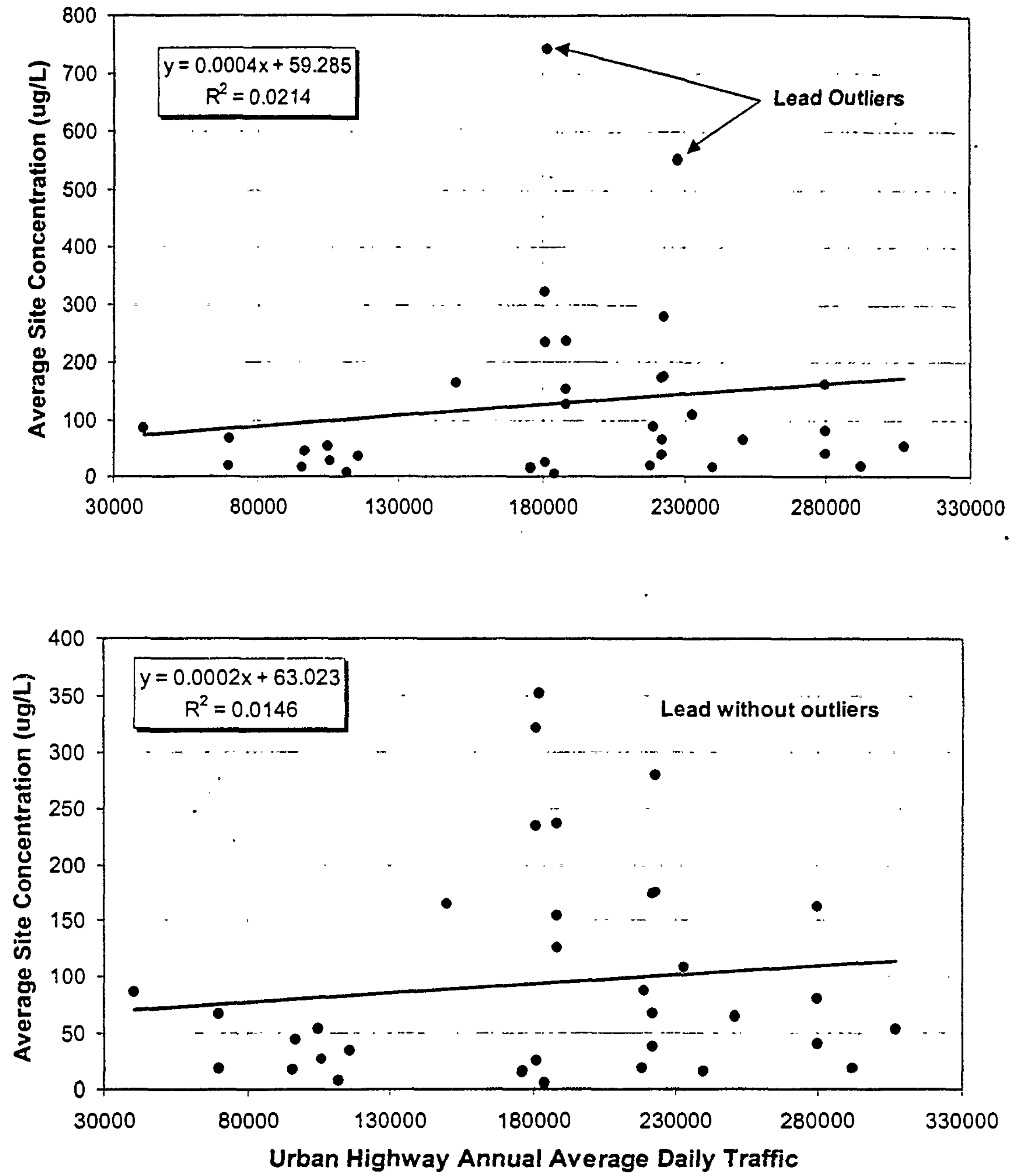


Figure 8
Correlation Between Average Lead Concentration and Urban AADT With and Without Outlier(s)

Table 1
AADT Values and other General Characteristics of the Monitoring Sites

Highway	County	Post Kilometer	Drainage Area (hectares)	Land Use	1999 AADT
128	Mendocino	45.1	1.0	Transportation	4,550
128	Mendocino	54.4	0.6	Transportation	2,200
80	Alameda	5.4	0.8	Open	226,000
80	Alameda	9.3	1.2	Open	215,000
58	Kem	92.6	17.3	Transportation	405,00
405	Los Angeles	62.2	0.4	Transportation	219,000
210	Los Angeles	65.3	4.8	Residential	181,000
605	Los Angeles	34.0	4.1	Agriculture	150,000
210	Los Angeles	16.2	12.6	Agriculture	96,000
210	Los Angeles	65.3	0.4	Transportation	181,000
91	Los Angeles	14.3	0.4	Transportation	188,000
105	Los Angeles	19.9	0.1	Transportation	218,000
210	Los Angeles	29.0	12.8	Residential	105,000
105	Los Angeles	20.4	0.2	Transportation	176,000
105	Los Angeles	20.4	0.2	Transportation	176,000
105	Los Angeles	19.9	0.1	Transportation	218,000
110	Los Angeles	25.5	1.4	Commercial	292,000
60	Los Angeles	24.5	0.2	Transportation	228,000
60	Los Angeles	9.2	0.2	Transportation	223,000
60	Los Angeles	9.0	0.1	Transportation	223,000
405	Los Angeles	42.8	2.1	Residential	307,000
605	Los Angeles	8.1	0.2	Transportation	280,000
605	Los Angeles	8.1	0.1	Transportation	280,000
91	Los Angeles	27.3	0.2	Transportation	251,000
91	Los Angeles	21.7	1.0	Commercial	230,000
5	Los Angeles	11.1	0.3	Transportation	222,000
605	Los Angeles	3.2	0.3	Transportation	222,000
91	Los Angeles	14.3	1.6	Industrial	188,000
91	Los Angeles	27.3	0.2	Transportation	251,000
210	Los Angeles	71.9	3.6	Residential	124,000
210	Los Angeles	29.5	2.9	Residential	106,000
5	Los Angeles	10.9	2.8	Transportation	222,000
605	Los Angeles	7.5	0.3	Transportation	280,000
10	Riverside	34.4	0.2	Transportation	70,000
10	Riverside	48.8	0.4	Transportation	70,000
111	Riverside	97.0	0.6	Transportation	13,600
5	San Diego	48.7	2.1	Transportation	116,000
15	San Diego	50.4	5.4	Residential	97,000
5	San Diego	81.9	0.3	Commercial	184,000
78	San Diego	9.5	1.0	Transportation	112,000
5	San Diego	34.4	1.4	Residential	217,000
5	San Diego	58.0	10.5	Commercial	209,000
5	San Diego	74.2	87.0	Residential	181,000
5	San Diego	61.8	1.9	Transportation	188,000
5	San Diego	70.5	1.7	Multiple	182,000
5	San Diego	75.2	0.9	Transportation	181,000
142	Orange	4.0	0.4	Transportation	16,000
405	Orange	25.0	0.4	Transportation	240,000

Table 2
Chemical Constituents, Analytical Methods, and Reporting Limits

Constituent	Abbreviation	Analytical Method	Reporting Limit	Unit
Conventional				
Biological Oxygen Demand	BOD	SM 5210B	3	mg/L
Chemical Oxygen Demand	COD	EPA 410.4	10	mg/L
Hardness	Hard.	EPA 130.2	2	mg/L as CaCo4
Electric Conductivity	EC	EPA 120.1	1	Umhos/cm
Total Dissolved Solids	TDS	EPA 160.1	1	mg/L
Total Suspended Solids	TSS	EPA 160.2	1	mg/L
Turbidity	Turb.	EPA 180.1	0.05	NTU
Metals (Total and Dissolved)				
Aluminum	Al	EPA 200.8	25	µg/L
Arsenic	As	EPA 200.8	0.5	µg/L
Cadmium	Cd	EPA 200.8	0.5	µg/L
Chromium	Cr	EPA 200.8	1	µg/L
Copper	Cu	EPA 200.8	1	µg/L
Iron	Fe	EPA 200.9	25	µg/L
Lead	Pb	EPA 200.8	1	µg/L
Nickel	Ni	EPA 200.8	2	µg/L
Silver	Ag	EPA 200.8	0.5	µg/L
Zinc	Zn	EPA 200.8	5	µg/L
Nutrients				
Ammonia (N)	NH_3	EPA 300.2	0.1	mg/L
Nitrate (N)	NO_3	EPA 300.0	0.1	mg/L
Nitrite (N)	NO_2	EPA 300.0	0.1	mg/L
Ortho-phosphate (P)	Ortho-P	EPA 365.2	0.05	mg/L
Total Kjeldahl Nitrogen	TKN	EPA 351.3	0.1	mg/L
Total Phosphorus	TP	EPA 365.2	0.05	mg/L
Major Ions and Minerals				
Calcium (Ca)	Ca	SM 3111B	1	mg/L
Magnesium, Total and Dissolved	Mg	SM 3111B	1	mg/L
Sodium, Total and Dissolved	Na	SM 3111B	1	mg/L
Total Chlorine Residual	Cl	EPA 300	1	mg/L
Sulfate	SO_4	EPA 300	2	mg/L
Microbiological				
Total Coliform	TC	EPA 9211E	2	MPN/100/mL
Fecal Coliform	FC	EPA 9221B	2	MPN/100/mL
Oil and Grease	O&G	EPA 1664	5	mg/L
Pesticides				
Diazinon		EPA 8141	0.05	µg/L
Chlorpyrifos		EPA 8141	0.05	µg/L
Glyphosate		EPA 8321	0.05	µg/L

[a] Arsenic is not a metal. For the purpose of this paper Arsenic is organized under metal pollutant.

Table 3
General Urban and Non-Urban Highways Runoff Characteristics

Constituent	Unit	Range	Mean	Median	Sample Size	Non-Detects
Conventionals						
Biological Oxygen Demand	mg/L	18 - 36.2	22.8	23	4	1
Chemical Oxygen Demand	mg/L	10 - 390	117.9	100	55	1
Hardness	mg/L as CaCO3	3.3 - 448	58.4	42	472	8
Total Dissolved Solids	mg/L	14 - 470	109.4	87.5	55	0
Total Suspended Solids	mg/L	3 - 4800	157.9	76	486	3
Turbidity	NTU	9.9 - 290	118.1	106	8	0
Metals-Total(Metals-Dissolved)[a]						
Aluminum	µg/L	29 – 12600 (2.2 – 2500)	2610.3 (59,5)	1900 (19.2)	59 (28)	0 (1)
Arsenic	µg/L	1 – 17 (0.5 – 10)	2.5 (1.6)	1.4 (1)	42 (36)	16 (16)
Cadmium	µg/L	1 – 378 (0.5 - 13.14)	4.5 (0.33)	0.69 (0.25)	378 (446)	37 (196)
Chromium	µg/L	1 – 100 (0.5 – 22)	10.9 (2.3)	6.7 (2.1)	390 (460)	23 (72)
Copper	µg/L	1 – 800 (1 - 153.9)	48.5 (14.4)	29.1 (11)	469 (525)	55 (76)
Iron	µg/L	4.1 – 24000 (1 – 7500)	4283.5 (114.4)	2301 (50)	70 (68)	0 (24)
Lead	µg/L	1 – 2300 (1 – 160)	113.6 (4.68)	31 (1.6)	470 (525)	22 (104)
Nickel	µg/L	0.91 – 317 (0.5 – 36)	12.6 (3.85)	7.9 (2.5)	400 (461)	54 (107)
Silver	µg/L	0.5 – 82 (0.5 – 1)	3.2 (0.3)	0.25 (0.25)	28 (28)	24 (27)
Zinc	µg/L	5 – 2400 (1 – 1176)	227.5 (73.7)	147 (44.6)	469 (524)	13 (13)
Nutrients						
Ammonia-N	mg/L	0.19 - 6.4	1.4	1.1	51	0
Nitrate-N	mg/L	0.1 - 9.5	1.2	1	418	9
Nitrite-N	mg/L	0.1 - 1.7	0.13	0.05	62	28
Ortho-P	mg/L	0.03 - 1.03	0.15	0.14	116	8
Total Kjeldahl Nitrogen	mg/L	0.1 - 57	2.1	1.8	489	59
Total Phosphorus	mg/L	0.05 - 10	0.26	0.18	527	107
Major Ions and Minerals						
Calcium, total	mg/L	3.4 - 66.8	11.9	8.6	41	0
Magnesium, Total	mg/L	1 - 218,00	2325	1350	57	4
Sodium, Total	mg/L	1 - 56	12.26	4.8	17	2
Total Chlorine Residual	mg/L	1 - 17	5.0	2.8	8	1
Sulfate	mg/L	1.9 - 57	6.8	5.8	31	5
Microbiological						
Total Coliform	MPN/100/mL	20-500,000	10013	1300	369	12
Fecal Coliform	MPN/100/mL	17-160,000	2664	230	456	63
Oil and Grease	mg/L	1 - 226	10.9	6	350	56
Pesticides						
Diazinon	µg/L	0.013-2.31	0.25	0.19	63	30
Chlorpyrifos	µg/L	0.0047 - 1	0.21	0.08	62	33
Glyphosate	µg/L	5 - 530	20.8	9.6	17	5

[a] Number in parenthesis are dissolved metals.

Table 4
Average Constituent Concentration for Urban and Non-urban Highway Sites

Constituent	Unit	Average Concentration	
		Non-urban (AADT < 30,000)	Urban (AADT > 30,000)
Conventionals			
Biological Oxygen Demand	mg/L	No data	22.8
Chemical Oxygen Demand	mg/L	128.5	124.4
Hardness	mg/L as CaCO3	14.5	58.3
Total Dissolved Solids	mg/L	57.1	118.2
Total Suspended Solids	mg/L	318	156.8
Turbidity	NTU	12.9	153.2
Metals-Total (Metals-Dissolved)			
Aluminum	µg/L	1718 (35.4)	3824 (187.9)
Arsenic	µg/L	0.6 (0.5)	3.7 (1.9)
Cadmium	µg/L	31.6 (1.2)	1.2 (0.3
Chromium	µg/L	7.3 (0.8)	11.3 (2.5)
Copper	µg/L	16.3 (14.9)	52.4 (14.2)
Iron	µg/L	2530 (56)	6366 (411)
Lead	µg/L	6.5 (1)	133 (6)
Nickel	µg/L	15.3 (6.6)	13.1 (3.5)
Silver	µg/L	0.2 (0.25)	3.6 (0.3)
Zinc	µg/L	153 (86.4)	238 (72.9)
Nutrients			
Ammonia (N)	mg/L	2.3	1.5
Nitrate (N)	mg/L	0.9	1.3
Nitrite (N)	mg/L	0.05	0.2
Ortho-phosphate (P)	mg/L	0.11	0.16
Total Kjeldahl Nitrogen	mg/L	2.8	2.3
Total Phosphorus	mg/L	0.16	0.31
Minerals			
Calcium (Ca)	mg/L	5.6	13.7
Magnesium, Total and Dissolved	mg/L	592	2911
Sodium, Total and Dissolved	mg/L	1.5	16.7
Total Chlorine Residual	mg/L	No data	5
Sulfate	mg/L	No data	8.4
Microbiological			
Total Coliform	MPN/100/mL	No data	11341
Fecal Coliform	MPN/100/mL	4586	3686
Oil and Grease	mg/L	2.6	12.4
Pesticides			
Diazinon	µg/L	0.14	0.31
Chlorpyrifos	µg/L	0.1	0.22
Glyphosate	µg/L	No data	50.7

[a] Number in parenthesis are dissolved metals.

Table 5
Correlation between AADT and constituent concentrations based on linear regression R-squared value

Constituent	R^2 value
Conventionals	
Chemical Oxygen Demand	0.070
Hardness as $CaCO_3$	0.002
Total Dissolved Solids	0.023
Total Suspended Solids	0.003
Turbidity	0.372
Metals-Total (metals-Dissolved)[a]	
Arsenic	0.010 (0.077)
Cadmium	0.035 (0.040)
Chromium	0.013 (0.035)
Copper	0.011 (0.004)
Lead	0.054 (0.007)
Nickel	0.001 0.016)
Zinc	0.008 (0.000)
Nutrients	
Ammonia-N	0.000
Nitrate-N	0.001
Nitrite-N	0.004
Ortho-Phosphate	0.017
Total Kjeldahl Nitrogen (TKN)	0.001
Total Phosphorus	0.000
Major Ions	
Calcium	0.009
Magnesium	0.013
Sodium	0.523
Sulfate	0.001
Microbiological	
Total Coliform	0.000
Fecal Coliform	0.000
Oil & Grease	0.034
Pesticides	
Diazinon	0.042
Chlorpyrifos	0.037
Glyphosate	0.046

[a] Number in parenthesis are dissolved metals.

Table 6
Analysis of Co-Variance Results for Selected Constituents

Constituent	*p* value(AADT)	Model R^2
Conventionals		
Hardness as $CaCO_3$	0.145	0.27
Total Suspended Solids	0.0019	0.24
pH	0.0508	0.18
Metals (Total)		
Cadmium	<0.0001	0.58
Chromium	<0.0001	0.56
Copper	0.1533	0.25
Nickel	0.4112	0.23
Lead	0.0970	0.22
Zinc	0.1014	0.24
Metals (Dissolved)		
Cadmium	0.0477	0.12
Chromium	0.1723	0.13
Copper	0.0161	0.46
Nickel	0.0101	0.33
Lead	0.0326	0.15
Zinc	0.0115	0.21
Nutrients		
Nitrate-N	0.6773	0.22
Ortho-phosphate	0.0410	0.31
Phosphorus-total	0 .4712	0.09
Total Kjeldahl Nitrogen	0.0297	0.36
Microbiological		
Fecal Coliform	0.5526	0.49
Oil and Grease	<0.0001	0.28

Table 7
Stepwise Regression Model Results

Constituent	Predictor [a,b]	*p*-value	Comment
Conventionals			
COD	AADT	0.5092	
	drainage	0.0846	positively associated with response[c]
	land use (R)	0.0222	negatively associated with response[d]
Hardness	AADT	0.0216	positively associated with response
	dry period	0.0006	positively associated with response
	dry period^2	0.0358	concave response[e]
	max intensity	0.0002	negatively associated with response
	max intensity^2	0.0915	convex response[f]
	land use (A)	<0.0001	positively associated with response
	land use (T)	<0.0001	positively associated with response
TSS	AADT	0.0003	positively associated with response
	AADT^2	0.0022	concave response
	dry period	<0.0001	positively associated with response
	dry period^2	0.0291	concave response
	max intensity	0.0047	negatively associated with response
	drainage^2	0.0754	convex response
	land use (I)	0.0013	positively associated with response
Metals (Total)			
Arsenic	AADT	0.1558	
	drainage^2	<0.0001	convex response
	land use (I)	0.0599	positively associated with response
Cadmium	AADT	<0.0001	negatively associated with response
	AADT^2	<0.0001	convex response
	dry period	<0.0001	positively associated with response
	dry period^2	0.0002	concave response
	max intensity	0.0080	negatively associated with response
	drainage	0.0286	positively associated with response
	drainage^2	0.0262	concave response
	land use (C)	0.0009	positively associated with response
	land use (I)	<0.0001	positively associated with response
	land use (R)	<0.0001	positively associated with response
	land use (T)	<0.0001	positively associated with response
Chromium	AADT	<0.0001	negatively associated with response
	AADT^2	<0.0001	convex response
	dry period	<0.0001	positively associated with response
	dry period^2	<0.0001	concave response
	max intensity	0.0012	negatively associated with response
	drainage	0.0566	positively associated with response
	drainage^2	0.0517	concave response
	land use (C)	0.0059	positively associated with response
	land use (I)	<0.0001	positively associated with response
	land use (R)	<0.0001	positively associated with response
	land use (T)	<0.0001	positively associated with response
Copper	AADT	0.0091	positively associated with response
	AADT^2	0.0327	concave response
	max intensity	0.0082	negatively associated with response
	land use (M)	<0.0001	positively associated with response

Table 7 Continued

Constituent	Predictor	*p*-value	Comment
Nickel	AADT	0.0911	
	dry period	<0.0001	positively associated with response
	dry period^2	0.0074	concave response
Lead	AADT	<0.0001	positively associated with response
	dry period	0.0479	positively associated with response
	max intensity	0.0058	negatively associated with response
	land use (C)	0.0206	negatively associated with response
	land use (M)	<0.0001	positively associated with response
Zinc	AADT	0.0113	negatively associated with response
	AADT^2	0.0088	convex response
	max intensity^2	0.0967	concave response
	land use (I)	<0.0001	positively associated with response
	land use (R)	<0.0001	positively associated with response
	land use (T)	0.0008	positively associated with response
Metals (Dissolved)			
Arsenic	AADT	0.2870	
	drainage	0.1138	negatively associated with response
	drainage^2	0.0095	convex response
Cadmium	AADT	0.3936	
	dry period	0.1085	positively associated with response
	max intensity	0.0006	negatively associated with response
	max intensity^2	0.0438	convex response
Chromium	AADT	0.4429	
	max intensity	<0.0001	negatively associated with response
	land use (C)	0.0335	positively associated with response
	land use (I)	0.0103	positively associated with response
	land use (R)	0.0008	positively associated with response
Copper	AADT	<0.0001	positively associated with response
	AADT^2	0.0002	concave response
	dry period	<0.0001	positively associated with response
	dry period^2	<0.0001	concave response
	max intensity	<0.0001	negatively associated with response
	max intensity^2	0.0010	convex response
	land use (R)	0.0004	negatively associated with response
	land use (T)	0.0121	positively associated with response
Nickel	AADT	0.3589	
	dry period	<0.0001	positively associated with response
	dry period^2	<0.0001	concave response
	max intensity	0.0004	negatively associated with response
	max intensity^2	0.0460	convex response
	land use (I)	0.0376	positively associated with response
	land use (R)	<0.0001	negatively associated with response
Zinc	AADT	0.0063	negatively associated with response
	AADT^2	0.0029	convex response
	dry period	0.0014	positively associated with response
	dry period^2	0.0548	concave response
	max intensity	0.0005	negatively associated with response

Table 7 Continued

Constituent	Predictor	*p*-value	Comment
	max intensity²	0.0769	convex response
	land use (A)	0.0035	negatively associated with response
	land use (I)	0.0127	negatively associated with response
	land use (R)	<0.0001	negatively associated with response
Nutrients			
NO_3	AADT	0.1050	
	dry period	0.0013	positively associated with response
	dry period²	0.0632	concave response
	max intensity	<0.0001	negatively associated with response
	max intensity²	0.0079	convex response
	land use (C)	0.0405	positively associated with response
	land use (M)	0.0016	positively associated with response
	land use (T)	<0.0001	positively associated with response
Ortho-P	AADT	0.0342	positively associated with response
	dry period	0.0596	negatively associated with response
	drainage	0.0076	positively associated with response
	max intensity	0.0252	positively associated with response
	land use (M)	0.0037	positively associated with response
TKN	AADT	0.0070	positively associated with response
	AADT²	0.0079	concave response
	dry period	<0.0001	positively associated with response
	dry period²	<0.0001	concave response
	max intensity	<0.0001	negatively associated with response
	max intensity²	0.0069	convex response
	land use (M)	0.0562	positively associated with response
Microbiological			
Fecal Coliform	AADT	0.5316	
	max intensity	0.0445	negatively associated with response
	drainage²	0.0193	concave response
Total Coliform	AADT	0.0080	positively associated with response
	AADT²	0.0063	concave response
	max intensity	0.0079	negatively associated with response
	drainage²	0.0009	convex response
	land use (R)	0.0006	negatively associated with response
Oil and Grease	AADT	<0.0001	positively associated with response
	AADT²	<0.0001	concave response
	dry period	0.0086	positively associated with response
	dry period²	0.0317	concave response
	max intensity	0.0004	negatively associated with response
	drainage	<0.0001	negatively associated with response
	land use (R)	0.0012	negatively associated with response
	land use (T)	0.0138	positively associated with response

[a] Power 2 indicate the predictor variable in the model is quadratic
[b] Lan use are identified as, A = agricultural, C = commercial, I = industrial, R= residential, and T = transportation
[c] Positively associated with the response = Predictor variable has positive impact on pollutant concentration
[d] Negatively associated with the response = Predictor variable has negative impact on pollutant concentration
[e] Concave response = Predictor variable is quadratic and has negative impact on pollutant concentration
[f] Convex response = Predictor variable is quadratic and has positive impact on pollutant concentration

Table 8
Partial Correlation Results Adjusting for all Variables Excluding Rain Intensity

Constituent	Parametric Analysis Pearson R^2	Parametric Analysis *p*-value	Non-Parametric Analysis Spearman R^2	Non-Parametric Analysis *p*-value
Conventionals				
COD	-0.1558	0.3307	-0.0798	0.6110
Hardness	0.1016	0.0237	0.1042	0.0201
TDS	0.3067	0.0511	0.2213	0.1538
TSS	-0.1258	0.0045	0.2343	<0.0001
Metals (Total)				
Arsenic	0.1429	0.3921	0.2589	0.1067
Cadmium	0.1204	0.0205	0.3069	<0.0001
Chromium	0.1320	0.0108	0.2786	<0.0001
Copper	0.1076	0.0235	0.2483	<0.0001
Lead	0.1792	0.0001	0.4165	<0.0001
Mercury	-0.0276	0.9054	-0.1989	0.3630
Nickel	0.1103	0.0311	0.2873	<0.0001
Zinc	0.0912	0.0552	0.2534	<0.0001
Metals (Dissolved)				
Aluminum	0.0686	0.7559	0.1388	0.5177
Arsenic	0.1070	0.5601	0.2012	0.2539
Cadmium	-0.0241	0.6065	0.0258	0.5806
Chromium	0.0357	0.4450	0.0093	0.8413
Copper	0.0093	0.8323	0.0787	0.0733
Lead	0.0912	0.0381	0.3061	<0.0001
Nickel	-0.0108	0.8165	0.0614	0.1876
Zinc	0.0561	0.2032	0.1830	<0.0001
Nutrients				
Ammonia	0.1395	0.4102	0.2116	0.1961
Nitrite	0.1772	0.2336	-0.0143	0.9223
Nitrate	0.0050	0.9174	-0.0501	0.3018
Phosphorus-Total	0.0176	0.6778	0.0367	0.3861
Ortho-Phosphate	-0.0344	0.7318	0.1435	0.1462
TKN	-0.0131	0.7673	0.0425	0.3366
Major Ions				
Calcium	0.3928	0.0134	3526	0.0237
Sodium	0.7331	0.0019	0.9120	<0.0001
Magnesium	0.5428	<0.0001	0.5812	<0.0001
Sulfate	0.0230	0.9057	-0.3151	0.0899
Microbiological				
Fecal Coliform	-0.0297	0.5595	0.0275	0.5872
Total Coliform	-0.0289	0.6023	-0.0729	0.1863
Oil and Grease	0.0679	0.2369	0.2064	0.0003
Pesticides				
Diazinon	0.1887	0.1560	0.1129	0.3905
Chlorpyrifos	0.1753	0.1922	0.1354	0.3066
Glyphosat	0.0085	0.9770	-0.2327	0.4039

Table 9

Partial Correlation Results Adjusting Antecedent Dry Period Only

Constituent	Parametric Analysis Pearson R^2	*p*-value	Non-Parametric Analysis Spearman R^2	*p*-value
Conventionals				
COD	-0.2571	0.0882	-0.0807	0.5942
Hardness	-0.0519	0.2446	-0.0073	0.8696
TDS	0.2011	0.1853	0.1959	0.1920
TSS	-0.0527	0.2321	0.1437	0.0011
Metals (Total)				
Arsenic	-0.0839	0.5974	0.1767	0.2569
Cadmium	0.1872	0.0002	0.2639	<0.0001
Chromium	0.1447	0.0039	0.2121	<0.0001
Copper	0.1549	0.0008	0.2641	<0.0001
Lead	0.2003	<0.0001	0.3676	<0.0001
Nickel	0.0815	0.1012	0.1196	0.0157
Zinc	0.1138	0.0136	0.2550	<0.0001
Metals (Dissolved)				
Arsenic	-0.2957	0.0800	0.1308	0.4404
Cadmium	0.0002	0.9968	0.0681	0.1353
Chromium	0.1354	0.0029	0.1991	<0.0001
Copper	0.1056	0.0139	0.2307	<0.0001
Nickel	-0.0468	0.3032	0.0072	0.8737
Lead	0.0593	0.1678	0.3110	<0.0001
Zinc	0.1062	0.0134	0.2181	<0.0001
Nutrients				
Ammonia	-0.0254	0.8749	0.1720	0.2760
Nitrite	0.0730	0.6108	0.0332	0.8153
Nitrate	-0.0130	0.7879	-0.0409	0.3963
Ortho-Phosphate		-0.1662	0.0886	0.1592
Phosphorus-Total	0.0052	0.9019	0.0085	0.8405
TKN	-0.0074	0.8658	0.0615	0.1611
Major Ions				
Calcium	-0.0614	0.6887	0.0152	0.9201
Magnesium	0.1253	0.3359	0.3540	0.0048
Sodium	0.7331	0.0019	0.9120	<0.0001
Sulfate	0.0414	0.8248	-0.1741	0.3408
Microbiological				
Fecal Coliform	0.0164	0.7447	0.0522	0.2985
Total Coliform	0.0101	0.8539	0.0685	0.2109
Oil and Grease	0.1858	0.0010	0.3220	<0.0001
Pesticides				
Chlorpyrifos	0.1278	0.3262	0.1550	0.2289
Diazinon	0.1616	0.2094	0.1390	0.2774
Glyphosate	0.1879	0.4859	0.0420	0.8729

Article 119

Technical Note #101 from Watershed Protection Techniques. 2(3): 539-542

Performance of Oil-Grit Separators in Removing Pollutants at Small Sites

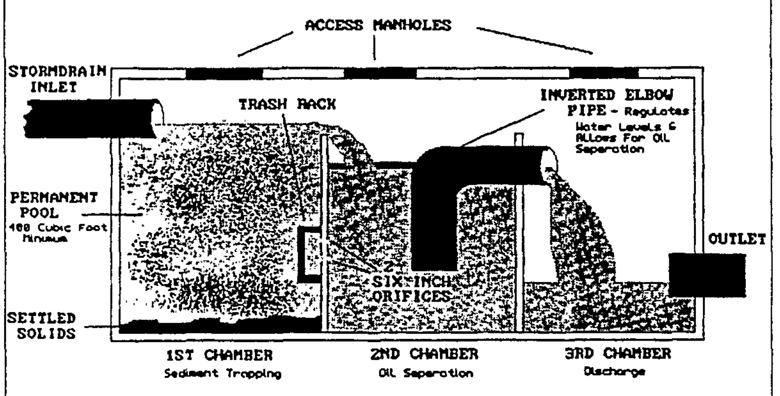
Despite our best hopes, some dogs just won't hunt. The same is true with the performance of some stormwater practices. A case in point is the standard oil-grit separator, or OGS (Figure 1). These underground structures consist of three chambers, two of which are wet. An inverted elbow pipe drains the second chamber, under the theory that oil and grease will initially float on the surface, but then adhere to suspended particles, which eventually settle to the bottom of the chamber. The first chamber is designed to trap grit, coarse sediments, trash and debris. The contents of both chambers are removed on a quarterly basis as part of the normal maintenance regime.

Oil-grit separators are popular because they are relatively cheap and can be easily installed at many small sites without sacrificing land. Unlike other stormwater practices that are sized to handle a half inch or more of runoff, the total design storage volume within an OGS is about a tenth of an inch. While it has always been acknowledged that such a small treatment volume limits overall pollutant removal, it was reasoned that the basic design should at least be capable of trapping oil, grit or trash generated at parking lots. Consequently, OGS systems have enjoyed wide application at gas stations, fast food joints and other small, but highly impervious development sites. Over the last decade, several hundred OGS have been installed across the Washington D.C. metropolitan area, and they are still routinely included in many stormwater practice manuals in other parts of the country.

Our understanding about the pollutant removal capability of the OGS has been fundamentally changed as a result of a five-year research study by Dave Shepp and his colleagues at the Metropolitan Washington Council of Governments. In the first phase of the study, Shepp discovered four indirect lines of evidence that suggest OGS pollutant removal performance is extremely limited. First, dye tests revealed that OGS had very short residence times during small storms (often less than 30 minutes). Second, an average of only two inches of sediment accumulation in the two pool chambers was measured in 109 installed OGSs, and deposition did not increase no matter how long an OGS had been in service. Third, the initial finding that OGS systems did not retain sediments was confirmed by monitoring the accumulation of sediment in 17 OGSs on a monthly basis. Shepp found sediment depths frequently changed within the OGS, but seldom accumulated over time. A characteristic profile is shown in Figure 2. Lastly, none of the 109 OGS surveyed in field were found to have had sediment cleanouts specified in their maintenance agreements.

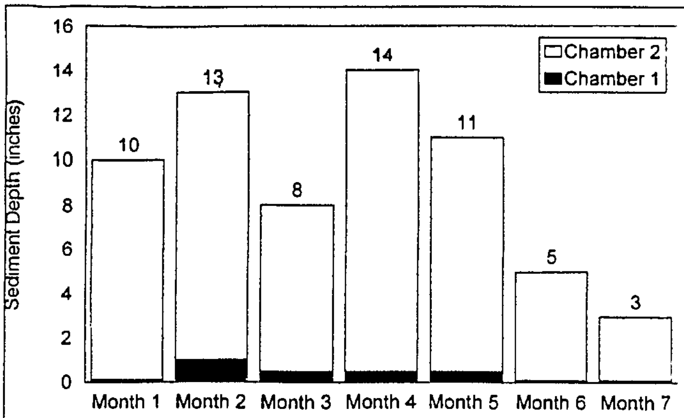
In the second phase of the study, the pollutant removal performance of a typical OGS was directly measured in the field. The OGS served a one-acre parking lot of a fast food joint. Prior small site monitoring revealed that fast food parking lots generated above normal concentrations of many urban pollutants, such as hydrocarbons, nutrients, metals and carbon—giving new meaning to the term "a greasy spoon" (see Table 1). Thirteen storm samples were collected at the OGS site, using innovative sampling techniques within the confined spaces of the practice. Rainfall during the monitored storms ranged from 0.2 to 1.96 inches in depth (median 0.61 inches, mean duration three hours). Inflow and outflow event mean concentrations (EMCs) were then compared to examine pollutant removal performance for 18 different water quality parameters.

By almost any measure of performance, the oil-grit separator did not show any capability to remove pollutants in storm runoff (Table 2). Net negative removal efficiency was computed for suspended sediment, total organic carbon, hydrocarbons, total phosphorus, organic nitrogen, and extractable and soluble copper. Negative removal efficiencies were observed in over half the



An oil grit separator is an underground structure used to treat stormwater runoff at very small sites. Recent research demonstrates that this practice has little or no pollutant removal capability.

Figure 1: Schematic of Standard Design of Oil-Grit Separator



Poor sediment retention in an OGS is evident in the month-by-month fluctuation in the two main chambers.

Figure 2: Change in Sediment Depth in an Oil-Grit Separator over a Seven-Month Period (Shepp, 1995)

Table 1: Mean of Storm Runoff EMCs for Takoma Park McDonald's Site (Shepp, 1995; Rabinal and Grizzard, 1995)

Stormwater Pollutant	Median Concentration (mg/l)	Mean Concentration (mg/l)
Total Suspended Solids	20.8	42.9
Total Hydrocarbons	7.0	12.4
Total Organic Carbon	18.6	41.3
Total Phosphorus	0.27	0.49
Ortho phosphorus	0.06	0.101
Total Nitrogen	2.22	2.85
Total Zinc	0.144	0.452
Total Copper	0.010	0.021

storms sampled for these parameters (with the exception of suspended sediment and soluble copper). Positive removal rates were calculated for a few parameters, most notably ortho-phosphorus, nitrate, lead and zinc, but the improvement in pollutant concentration was often very minor. This is evident when the mean outflow concentrations from the OGS are considered (last column of Table 2). The concentration of nearly every water quality parameter remains well above levels frequently encountered in "untreated" urban stormwater runoff. OGS also appear to have little capability to retain litter and debris, as less than 30% of the OGS surveyed in the project had accumulated moderate to high levels of trash and debris.

Taken together, the four different performance indicators suggest that the OGS tested was a modest exporter of several key storm water pollutants. At first glance, this finding seems physically impossible, as it is hard to imagine an internal source of pollutants within an underground concrete vault. The likely answer to this mystery involves parking lot maintenance. It seemed to be a daily practice for employees to wash down the parking lot to provide a cleaner atmosphere for customers. It is speculated the wash water may have been the source of the missing pollutants.

Based on his research, Shepp recommends that the use of standard OGS design be abandoned at small sites. Performance monitoring has shown sand filters to be a much more effective practice. He contends that no practice is likely to be effective on small sites unless it is designed to capture 0.25 to 0.5 inches of runoff at a bare minimum. Further, such practices should be designed to be off-line from the major storm water conveyance systems. Otherwise, Shepp maintains that the flows from pipes designed to carry the ten-year peak discharge rate will "hydraulically doom" any small site practice.

This contention is supported by recent performance monitoring of a modified oil-grit separator in Austin, Texas. Tom Curran sampled 17 storm events at an OGS that served a parking lot (LCRA, 1996). The modified two chamber tank contained sorbent pillows to adsorb oils, and was regularly maintained. Designed to pretreat runoff for a peat sand filter, the off-line OGS appeared to perform the pretreatment function reasonably well. Curran found that it was able to remove about 10 to 40% of stormwater pollutants that entered it (see Table 3).

Much higher removal rates were recently reported for three full-size, off-line underground structures known as multiple chamber treatment trains or MCTTs (see article 111). The design of these advanced structures stand in sharp contrast to the typical OGS. For example, the MCTT has up to ten times more storage volume than standard OGS design and is equipped with numerous other internal design features to promote greater removal.

In summary, the evidence overwhelmingly suggests that oil-grit separators are a very poor stormwater practice and should probably be dropped as a treatment option, unless these systems are designed off-line and with the same treatment volume of other stormwater practices.

—TRS

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Table 2: Summary of Performance Data at McDonald's Oil-Grit Separator in Seat Pleasant, MD (Shepp, 1995)

Stormwater Pollutant	Mean Individual Storm Efficiency	Mean Group Storm Efficiency	Majority of Storms Show Export	Mean OGS Outflow Concentration (mg/l)
Total Suspended Solids	(-21.2)	(-7.5)	NO	48.3
Total Organic Carbon	(-73.4)	(-36%)	YES	17.5
Total Hydrocarbons	(-35.4)	(-29)	YES	4.82
Total Phosphorus	(-75.5)	(-41)	YES	0.41
Ortho-phosphorus	7.6	40	NO	0.05
Total Kjeldahl Nitrogen	(-19.8)	(-44)	YES	1.74
Nitrate-Nitrogen [b]	34.7	47	NO	0.20
Ammonia-Nitrogen	(-44.2)	20	NO	0.11
Total Cadmium	(0)	(0)	NO	0.0011
Total Chromium	(-21.8)	(-19)	YES	0.0065
Total Copper	(-40.7)	(-11)	YES	0.013
Soluble Copper	(-58.5)	3.5	NO	0.004
Total Mercury	35.6	20	NO	0.001
Total Lead	7	8.2	NO	0.008
Total Zinc	3.3	17.0	NO	0.174
Soluble Zinc	1.6	21.1	NO	0.071

[a] Calculated as the mean of all inflow EMCs compared to the mean of all outflow concentrations.

[b] Includes nitrite.

Table 3. Pollutant Removal Performance of an Off-Line Oil-Grit Separator in Austin, TX (Curran, 1996)

Pollutant	Removal Efficiency (EMC)%
Total Suspended Solids	41
Total Organic Carbon	22
Total Phosphorus	37
Ortho-phosphorus	(-14)
Total nitrogen	15
TKN	21
Nitrate	14
Lead	10
Zinc	39

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R0009412

Petroleum Hydrocarbon Concentrations Observed in Runoff From Discrete, Urbanized Automotive-Intensive Land Uses.

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Introduction

This documents a portion of work performed by the Metropolitan Washington Council of Governments (MWCOG) for the State of Maryland Department of the Environment (MDE) and EPA's Chesapeake Bay Program Office (CBPO) pertaining to a comprehensive study of the generation and control of petroleum hydrocarbons in urban runoff. The purpose of this particular study task was to characterize the relative contribution of petroleum hydrocarbons and other typically encountered urban pollutants contained within stormwater runoff from small, single land use catchments. The following four automotive-intensive land uses were evaluated: (1) all-day parking lots, (2) streets, (3) gas stations, and (4) convenience commercial. The study was conducted from October, 1992 through December, 1993. The study area encompassed the District of Columbia and Suburban Prince George's County, Maryland.

Methodology

Due to budgetary constraints, only one site per land use was studied. The following prerequisite conditions were met for each site: (1) the selected site had to be representative of the general land use classification, (2) the selected site had to be uncontrolled from the perspective of stormwater management, (3) the selected site had to be feasible for discrete land use monitoring (e.g. all stormwater flows had to emanate exclusively from the targeted land use).

The study monitoring contractor, the Occoquan Watershed Monitoring Laboratory (OWML) suggested the use of Cashockton Wheel samplers due to their ability to sample a vertical "slice" of the influent stormwater column. Due to the known partitioning of various petroleum hydrocarbon fractions in stormwater runoff, OWML felt the Cashockton Wheel samplers were superior to traditional automated samplers in obtaining a representative characterization of petroleum hydrocarbons from each site's runoff. They consist of a small "H" flume connected to a gravity-driven, rotating flow splitting device. As runoff flows from the impervious surface to the monitoring station, it is collected and funneled to the sampler by the "H" flume. The elevational differential between the flume and the horizontally-oriented platter-like wheel turns the wheel, via energy imparted to turning vanes from the falling inflow. As the wheel spins (similar to a record player), it splits a fraction, or "slice" of the stormwater inflow into a collection vessel through a small slot in its surface. This configuration yields a flow-weighted composite runoff sample and associated event mean concentrations (EMC) for each of the evaluated constituents. The Cashockton Wheels were deployed inside catch basins (3 sites) and within a locked fiberglass monitoring shed in a surface installation (1 site). Notable operation and maintenance constraints were encountered with the use of the Cashockton Wheel samplers in the study context. Urban grit and organics were found to impede the normal rotation of the samplers. For this reason, all samplers were temporarily removed from service and retrofitted with sealed, Teflon-coated central bearings. Even following retrofitting, the problem persisted, requiring close attention and frequent cleaning following storm events and regularly-scheduled weekly maintenance visits.

Rainfall measurements (rain depth) for 3 of the 4 sites were collected at the nearby USDA National Arboretum raingage. Due to the distance to the gas station site (located in Laurel, Maryland) an additional gage was installed on the stations' rooftop. Storm samples were retrieved following rainfall events and transported to OWML in Manassas, Virginia for laboratory analysis. A technique, utilizing non-dispersive infrared spectrometry, was developed for the purpose of evaluating the concentration of total hydrocarbons. OWML staff developed a functional relationship between petroleum hydrocarbon concentration and associated light transmittance in the infrared wavelength of 3.5 microns. It represents an improvement over standard gravimetric methods for oil and grease since it requires less lab time, reduced sample volumes and avoids "noise" from non-target solids in the sample volume. Associated limitations for this methodology include its lack of specificity (the results cannot be compared with results from studies which generate a higher degree of fractional resolution) and the potential for a lack of accounting for as much as 50% of the lighter fractions (due to their loss via volatilization during extraction); this can result in a conservative estimate of the total hydrocarbons. In a practical context, the total hydrocarbon concentration represents a changable, dynamic index where, due to field volatilization rates, the lighter fractions escape within a few days from the surface of the water column to the atmosphere.

Results

The following include the most important findings of the study:

1. While the total imperviousness for each site was virtually equivalent (estimated values ranged from 95-100%), the observed median EMC's for each site exhibited substantial differences (see Figure 1). The observed mean EMC's for each site exhibited a similar pattern as evidence... arraying the studied land uses in descending order of total hydrocarbon concentration: (... Convenience Commercial, mean observation: 12.4 milligrams per liter, range: 2.7 to 56.0 milligrams per liter, (2) Gas Station, mean observation 3.7 milligrams per liter, (3) Street, m... 2.2 milligrams per liter, range: 0.8 to 4.7 milligrams per liter, and (4) All day Parking, mean milligrams per liter, range: 0.3 to 4.4 milligrams per liter.

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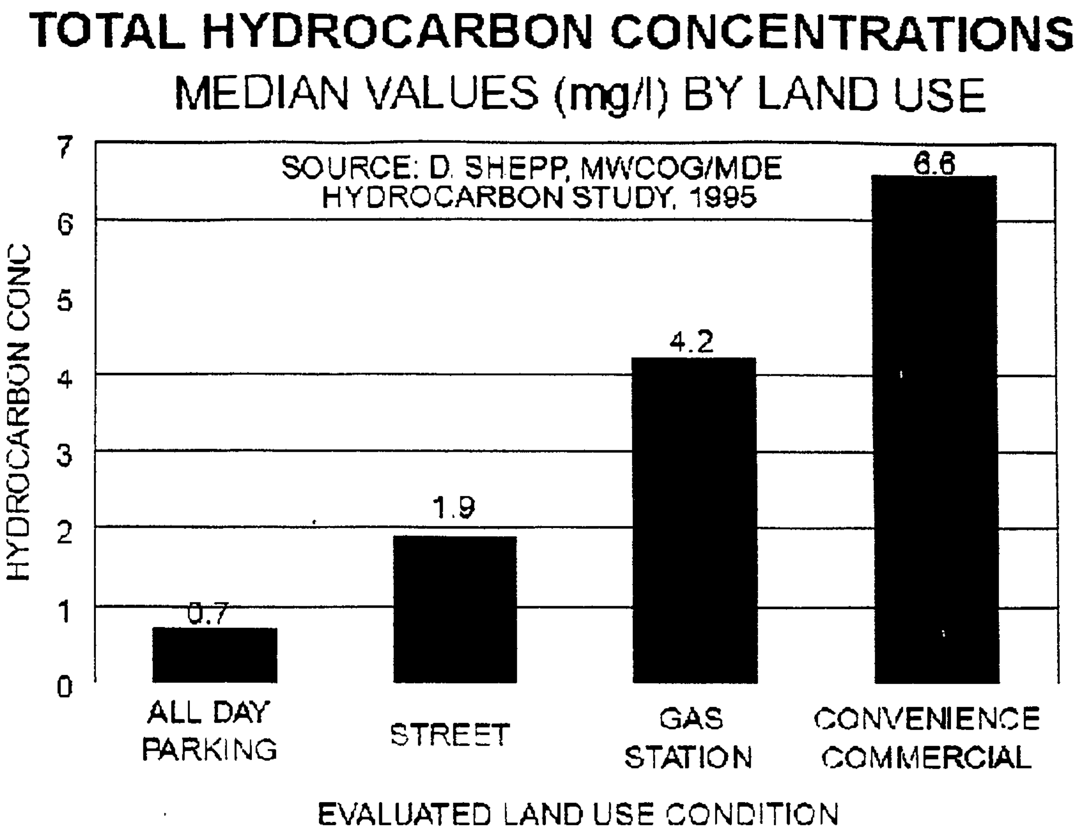

2. Analysis of variance (ANOVA) indicated that significant differences exist between the observed means. Two-sample F-Tests of significance revealed that the majority of the means were significantly different from each other. Only the comparison of street and gas station means lacked sufficient significance to accept the null hypothesis. This suggests that imperviousness is not an acceptable singular indicator for predicting total hydrocarbon concentrations associated with automotive-intensive land use.

3. Data scatter plots revealed the following observed relationships:

   - Rainfall Depth vs. Total Hydrocarbons. The All day parking, Street and Convenience commercial sites exhibited a negative relationship, whereas the gas station site exhibited a positive relationship.

   - Rainfall Depth vs Total Suspended Solids. The All day parking, Gas Station and Convenience commercial sites exhibited a negative relationship, whereas the Street site exhibited a positive relationship.

   - Total Hydrocarbons vs Total Suspended Solids. All sites exhibited a positive relationship.

4. Observed data suggests a relationship between automotive exposure and total hydrocarbon concentration. Thermal expansion and contraction of oil-bearing regions of automotive drive trains is thought to be the primary source of petroleum hydrocarbons, via seepage. Duration of automotive exposure (i.e. the time a given impervious surface is exposed to hot vehicles in a thermal expansion mode) as well as volume of automotive exposure (i.e. the number of hot

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vehicles in a thermal expansion mode exposed to a given impervious surface) are suggested as the principal factors in the generation of petroleum hydrocarbon pollution upon automotive intensive land uses (see Table 1).

Table 1. Automotive Exposure and Observed Hydrocarbon Concentraions by Land Use.

Land Use	Duration of Automotive Exposure	Volume of Automotive Exposure	Observed Median Conc.
ALL DAY PARKING *National Arboretum*	LONG (4 to 8 Hours per Car per Day)	LOW (1 to 2 Cars per Parking Space per Day)	0.7 mg/l
GAS STATION *Laurel Texaco*	MODERATE (5 to 10 Minutes per Car per Day**No Repair/Maint. Service Provided**Pump & Pour Your Own "Micro Spills" Anticipated)	MODERATE (A Steady Stream of Cars Throughout Day)	4.2 mg/l
STREET *20th @ Franklin St.*	BRIEF (10 to 60 Seconds, Depending on the Traffic Light Cycle)	HIGH (1,000 plus Cars Estimated; AM & PM Rush Hr. Peaks, Steady Midday Use as Secondary Roadway)	1.9 mg/l
CONVENIENCE COMM. *N.h. Ave. Mcdonald's*	MODERATE (10 to 30 Minutes per Car per Day Estimated)	MODERATE/HIGH (Breakfast, Lunch & Dinner Peaks, Steady Throughout Day)	6.6 mg/l

5. Many of the highest observed concentrations were associated with rainfall depths less than 0.25 inch, with accompanying durations spanning 2 to 3 days. Concentrations associated with such low volume, low intensity events clearly underscore the relative ease of mobilization of petroleum hydrocarbons from impervious surfaces. Examination of rainfall patterns in the middle Atlantic region show that on average, (approximately every 3 to 4 days) precipitation events, with the potential to mobilize surprisingly high concentrations of petroleum hydrocarbons, occur. Furthermore, given their relative ease of mobilization, the potential for the delivery of substantial concentrations of petroleum hydrocarbons from automotive-intensive land uses to receiving waters exists both regionally and nationally for the majority of measurable annual rainfall events. The observed data suggest the principal source (automotive), its associated accumulation medium (imperviousness) and delivery mechanism (normal rainfall) central to this cycle.

6. Two separate items of information serve to provide a useful context for understanding the importance of the observed median total hydrocarbon concentrations presented in Figure 1 and the previously-mentioned range of observed concentrations for each land use (i.e. 0.3 to 2.4 milligrams per liter for the All day parking site, 0.8 to 4.7 milligrams per liter for the Street site, 1.2 to 5.5 milligrams per liter for the Gas station site, and 2.7 to 56.0 milligrams per liter for the Convenience Commercial site). First, maximum concentrations observed from the Convenience commercial site, 56.0 milligrams per liter, exceeded recently monitored observations for Hickey Run in the District of Columbia (50.0 milligrams per liter). Hickey Run has the dubious distinction as the most polluted subwatershed in the degraded Anacostia Watershed (due pri

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to a history of chronic and episodic waste oil dumping) and as one of the most polluted urban subwatersheds in the entire Chesapeake Bay drainage. Secondly, recommended maximum concentrations of petroleum hydrocarbons for drinking water supplies and fisheries protection typically range from 0.01 to 0.1 milligrams per liter; crude oil concentrations of 0.3 milligrams per liter can cause toxic effects in freshwater fish (D. Chapman and V. Kimstach, 1992).

7. Evaluation of rank and percentile of observed rainfall and hydrocarbon concentrations occuring over the span of an entire year indicated that 23 of 30 (or 77%) of the top half, or highest, observed total hydrocarbon concentrations could be managed via effective stormwater controls designed to treat the first 0.5 inch of runoff from the studied sites. If a 0.25 inch design treatment volume was utilized, 12 of 30 (or 40%) of the top half of the highest observed concentrations could be managed. These values stand in stark contrast when compared to the currently prevailing design rules for target treatment volumes relative to the control of petroleum hydrocarbons in urban runoff. Typical oil-grit separator design is based upon a 0.10 inch treatment volume of runoff. Utilizing the same overall dataset, this level of control equates to treating 2 of 30 (or 7%) of the highest hydrocarbon generating events of the evaluated annual rainfall.

Implications

Based upon analysis of the study observations, the following conclusions were reached:

1. Evaluation of the observations suggest that runoff concentrations of petroleum hydrocarbons from automotive-intensive land uses typically range from 0.7 to 6.6 milligrams per liter. Given the recommended maximum petroleum hydrocarbon concentrations of petroleum hydrocarbons for drinking water supply and fisheries protection (0.01 to 0.1 milligrams per liter) and the reported toxic effects observed in freshwater fish from crude oil concentrations of 0.3 milligrams per liter (D. Chapman and V. Kimstach, 1992), the observed total hydrocarbon concentrations suggest their substantial national impact as a nonpoint source pollutant. This suggestion is futher reinforced by the knowledge that many of the monitored automotive-intenstive land uses are commonly found throughout all, but the most rural and remote areas, of the United States.

2. Evaluation of the observations and their respective catchment areas suggest that the degree of automotive exposure (a combination of duration of exposure and volume of exposure) is the primary factor in the generation of petroleum hydrocarbons in runoff from automotive-intensive land uses. The pollutant pathway: (1) originates via drive train seepage from automotive vehicles, (2) accumulates upon highly impervious surfaces designed for automotive conveyance or parking, and (3) is readily mobilized via runoff produced by low volume, low intensity storms. The measured and visual observations gathered throughout the course of the study suggested, with the notable exception of expensive, new cars (W. Bell, et.al., 1995), virtually all motorized vehicles seep a measurable volume of petroleum hydrocarbon based lubricating agents. Casual visual observation suggests a wide range in the relative rates of seepage exists from vehicle-to-vehicle. Further visual observation suggests this variability is primarily a function of the age and relative degree of mechanical upkeep associated with a given vehicle.

3. Application of BMP's effective in the control of petroleum hydrocarbons is suggested for the treatment of runoff from automotive-intensive catchments as small as 0.5 acres. Recent performance evaluations of sand filtration BMP's , independently conducted by the District of Columbia (H. Troung, et. al.,1993) and the City of Alexandria, Virginia (W. Bell , et.al., 1995), suggest removal efficiencies for total hydrocarbons in excess of 77 per-cent. In addition to their reported removal efficiencies, the local availability of sand and gravel resources in the Middle

Atlantic's Coastal Plain enhances the attractiveness of filtration-based treatment of runoff from automotive-intensive land uses. Design treatment storage volumes up to the first 0.5 inch of runoff are suggested for the treatment of petroleum hydrocarbons in the Middle Atlantic region.

4. A seepage evaluation is suggested as a new pollution prevention component of regularly-scheduled vehicular safety/emissions inspections. A simple, relatively "low tech" approach could be developed, possibly using kraft paper as an evaluation medium. The diameter and number of seepage stains accumulated over a pre-determined evaluation period could potentially be utilized to develop an evaluation metric for identifying unacceptably high petroleum hydrocarbon seepage rates. A possible hierarchy of corrective actions could include: (1) mechanical tightening of drive train mating surfaces containing petroleum hydrocarbon lubricants, (2) the external application of petroleum hydrocarbon and heat resistant flexible sealants to seeping areas and (3) replacement of deteriorated and/or hardened gaskets and seals (this represents the last choice due to its associated disassembly time and related expense). An accompanying public education/outreach initiative as an additional component of a comprehensive pollution prevention program is suggested. The effort could be specifically targeted for the general public and the automotive repair and service industry. Its focus could revolve around the need to raise the public's awareness of the ubiquitous nature and potential environmental damage associated with uncontrolled/untreated petroleum hydrocarbons in runoff from automotive-intensive land uses.

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Characteristics of Parking Lot Runoff Produced by Simulated Rainfall

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CHARACTERISTICS OF PARKING LOT RUNOFF PRODUCED BY SIMULATED RAINFALL

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Appendix F (Final)
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EXECUTIVE SUMMARY

Urban stormwater runoff is currently one of the largest sources of pollutants discharged to the coastal oceans of southern California. However, the quality and quantity of stormwater runoff are highly variable. In particular, impervious (paved) surfaces directly affect a watershed's water quality. The goal of this study was to: (1) identify and measure constituent concentrations and toxicity found in parking lot surface runoff; (2) measure the effect of antecedent conditions on constituent accumulation between storms; and (3) investigate the effects of rainfall intensities and duration on runoff composition. A secondary objective was to assess the effects of traffic use and maintenance on the chemical composition and toxicity of parking lot runoff.

In order to control natural variability in precipitation, periodic rainfall simulations were used to quantify pollutant accumulation and washoff on two parking lots in the City of Long Beach for three months during the summer of 2000. Samples of surface runoff were analyzed for suspended solids, trace metals (Cd, Cr, Cu, Fe, Ni, Pb and Zn) in dissolved and particulate-bound phases, and 25 polycyclic aromatic hydrocarbons (PAHs). Among the metals studied, the highest mean concentrations in surface runoff samples were for Fe, Zn, Cu and Pb (810, 620, 40 and 40 µg/L, respectively). The Zn, Pb and Cu in the dissolved phase accounted for 65 to 81% of concentrations in surface runoff samples. Mean total PAH concentrations in surface runoff samples ranged from 0.08 to 180 µg/L.

Significant accumulation of mean constituent concentrations were observed for all constituents after 28 antecedent dry days, with the exception of total PAHs. Of the trace metals studied, Zn showed the largest accumulation in parking lot surface runoff, increasing by a factor of 3. Factors such as parking lot usage and maintenance did not affect the accumulation of runoff constituents. Similar concentrations of total suspended solids (TSS), trace metals, and total PAHs were found among high-use and low-use parking lots. Street sweeping as a maintenance activity did not reduce or improve runoff concentrations. However, the use of pressure washing did appear to reduce, but not completely remove, suspended solid and trace metal concentrations.

Washoff of all constituents was strongly inversely correlated with rainfall intensity and duration. Parking lot runoff samples collected during the first 10 min of a rain event contained the highest constituent concentrations indicative of a first-flush event. A "first flush" occurs when initial runoff during a storm has substantially higher concentrations than runoff later in the storm. Longer, simulated storms appeared to dilute parking lot runoff, and significantly lowered the average concentration of most constituents. Increases in rainfall intensity decreased the magnitude of the first flush, but the importance of rainfall intensities decreased with longer duration. Simulated rainfall, regardless of intensity, washed off most loose particles collected on the parking lot surface after approximately 15 min; concentrations of constituents collected after 15 min were generally low and less variable.

One hundred percent of simulated runoff samples were toxic, but not all species responded similarly after exposure to runoff samples. The sea urchin and marine bacteria were the most sensitive organisms; the mysid was the least sensitive organism. Toxicity patterns were consistent with the accumulation and rainfall duration/intensity patterns of constituent concentrations. After 28 d of accumulation, toxicity in runoff samples increased by a factor of 6. When comparing runoff from either high-use or low-use parking lots, the magnitude of toxicity did not change. Similarly, the magnitude of toxicity between parking lots with and without street sweeping showed no difference. However, toxicity was reduced, but not completely eliminated, after pressure washing. A toxicity "first-flush" effect was present in runoff samples collected during the first 10 min of the simulated rain event. Runoff samples collected during this time interval were twice as toxic as runoff samples taken later during the storm event. This finding is in agreement with the results of chemical analyses of the samples, which showed the first portion of the runoff event to contain the highest constituent concentrations.

The toxicant characterization and identification experiments suggested that trace metals were an important contributor to toxicity. These evaluations targeted trace metals, particularly zinc, as constituents responsible for toxicity in the purple sea urchin fertilization test. This conclusion was based upon the following findings: (1) complexation of trace metals completely removed toxicity; (2) concentrations of dissolved zinc were sufficient to induce toxic responses; and (3) variations in zinc concentrations among samples were significantly correlated with toxic responses.

The rapid accumulation, the nearly complete washoff of constituent concentrations, and the level of toxicity observed from parking lot runoff in this study indicate that uncontrolled discharges of parking lot runoff have the potential to impact receiving water quality and may require remediation by appropriate stormwater BMPs. Targeting the first flush appears to be the most effective management scenario based upon the results herein. Additional simulated rainfall events are recommended for other constituents and for various land uses besides parking lots.

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I. INTRODUCTION

Urban stormwater runoff has been recognized as a leading source of contaminants to coastal oceans and inland waterways (U.S. EPA 1995a). Research has found a direct relationship between the amount of impervious surface in a watershed and the watershed's water quality (City of Olympia 1994). This research, which has been conducted in many geographic areas using many different variables and employing widely different methods, has yielded a surprisingly similar conclusion: stream degradation occurs at relatively low levels of imperviousness (~10%) (Booth and Reinelt 1993 and Shaver *et al.* 1995). In southern California, watersheds average 25% imperviousness; hence, the impacts of land development on the quality of surface runoff and on aquatic organisms are likely to be found in southern California.

Streets and parking lots comprise a large proportion of impervious area; runoff from these areas is therefore considered to be a significant source of chemical contamination to receiving waters. These pollutants are derived from wear of automotive parts (e.g., tires and brake pads), spills and leaks of automotive fluids (e.g., motor oil and coolant), and materials deposited on parking lots from the air (e.g., atmospheric deposition and wind transported pollutants) (Hoffman *et al.* 1985, Ellis *et al.* 1987, and Muschack 1990). During rainstorms, a portion of these pollutants are washed off and transported from the street surfaces to the urban storm drain system and discharged to local receiving waters. In a nationwide coring study of aquatic sediment quality by the U.S. Geological Service (Van Metre *et al.* 2000), a clear relationship was reported between increasing traffic volume and increasing PAH concentration. Traffic volume, therefore, seems to be an important factor affecting the type and accumulation of contaminant concentrations and is valuable as a measure for predicting runoff quality.

Contaminant accumulation and washoff are commonly assumed to be effective measures of runoff contamination in our semi-arid environment; however, the effectiveness of these measures has not been well quantified in southern California. The accumulation of contaminants on southern California streets and parking lots has become a focal point since periods of infrequent rainfall (long, dry periods without rain) followed by intense rainfall are common. Other factors have been shown to influence the quality of surface runoff including surface maintenance practices, the time of the year (season), and the intensity and duration of the storm. Storm intensity is strongly correlated to the type and quantity of pollutants found in stormwater runoff (Pitt and Shawley 1981, Spangberg and Niemczynowicz 1992). Measurements of stormwater discharges sampled in 1997-98 from the Santa Ana River in Santa Ana, California (Leecaster *et al.* 2001, Schiff and Tiefenthaler 2001, and Tiefenthaler *et al.* 2001) showed evidence of a seasonal flush of contaminants.

The goal of this report is to evaluate the effects of rainfall characteristics and antecedent conditions on the composition of parking lot surface runoff. The primary objective is to identify and measure contaminant and toxicity concentrations found in runoff from parking lots, assess the length of time required for constituents to re-accumulate once washed off, and investigate how variations in intensity and duration of rainfall affect runoff composition. A secondary objective is to assess the effects of traffic use and parking lot maintenance on the chemical composition and toxicity of runoff.

II. METHODS

Experimental Design

This study was grouped into two major components: (1) The assessment of accumulation rates of selected contaminants over time and during discrete time periods. (2) The investigation of variations in rainfall intensities and durations affecting parking lot surface runoff concentrations to determine whether similar quantities of rainfall cause similar effects on contaminant concentrations over time (i.e., 6 millimeters of rainfall per hour [mm/h] for 40 min vs. 25 mm/h for 10 min). Possible interactions between treatments (i.e., low-use/maintained stations vs. high-use/unmaintained stations) were also examined.

A randomized factorial design was selected to measure the effects of a variety of treatments on contaminant accumulation and washoff on parking lots over time including: (1) low use (1 car/4 h--i.e., faculty parking); (2) high use (5 or more cars/h--i.e., public parking); (3) maintained stations vs. unmaintained stations (defined as the presence or absence of street sweeping); (4) rainfall intensities; and (5) rainfall durations. All rainfall simulations for the accumulation study were run for 20-min durations with a constant storm intensity of 13 mm/h). The rainfall duration/intensity study had simulations that were run for the following time intervals: 0-10, 10-20, 20-40 and 0-20 min, using rainfall intensities of 6 (0.25 inches/hr), 13 (0.5 in/hr), and 25 (1 in/hr) mm/hr. Treatments were assigned randomly among 27 test stations. The "first-flush" effect of storms was also evaluated.

Study Area

All samples were collected within the City of Long Beach, the fifth largest city in California with an estimated population of 440,000 citizens living in a 50-square-mile area. (City of Long Beach, Economic Development Bureau 1999). Long Beach is a port city bounded on its southern border by the Pacific Ocean. It has a semi-arid climate with an annual precipitation of only 30.5 centimeters (cm). An average 0.4 cm of rain falls each month from May to October, with 4.6 cm/month falling from November to April.

Sampling Sites

Two parking lots located within the Long Beach City College Liberal Arts Campus (LBCC LAC) at 4901 E. Carson Street in the City of Long Beach, California, were selected for monitoring runoff from parking lots (Figure II-1). The parking lots differed in daily traffic flow and maintenance practices. The parking lots have a combined capacity of 150 cars with a dimension of approximately 8 meters by 76 meters and a 4% grade. The lots operate seven days per week with five days at full capacity. A total of 9 replicate sampling stations were located on the site off of Lew Davis Street, which received no maintenance. Eighteen sampling stations, representing both low-use and high-use as well as maintained and unmaintained conditions, were located on the lot at Faculty Street. Six maintained stations (3 low use and 3 high use) were located in the southern portion of this lot and comprised approximately 30% of the total parking lot area. The land around the sites is mostly commercial. The sites, which were constructed of 100% asphalt, were used for both visitor and staff parking. Accessibility for runoff sampling was a consideration in site selection. Every effort was made to select sites which were as similar as possible in terms of condition and slope. The prevailing weather conditions were similar at all sites.

Dry conditions were prevalent in Long Beach from May to October of 2000, with less than a trace of rain at any of the two sites for a period of 160 d. Manual observation of traffic counts were recorded 1 d prior to each simulated rainfall event and averaged approximately 100 vehicles per day.

Rainfall Simulator

Rainfall simulation equipment and techniques were used for assessing the effects of rainfall on surface runoff. In this study, sampling was carried out using three identical rainfall simulators (spray rigs) designed to duplicate natural rainfall intensities. Each spray rig was comprised of polyvinylchoride (PVC) pipes with its own pressure gauge, flow meter, control valve, and fixed-rate Rainbird or Hunter PGM rotating polyurethane spray heads. One fixed-rate Rainbird spray head at 45/36 pounds per square inch (psi) and 5.0 liters per minute (L/min) produced a 3.8 m radius semicircle with an intensity of 13 mm/h (Figures II-2 and II-3). This system provided a relatively uniform simulated rainstorm washing off 2 parking stalls measuring 18 m^2. Approximated rainfall intensities were determined for two types of storm events that occur in southern California. Typical (6 mm/h) and worst-case (25 mm/h) rainfall intensities were simulated using 2 Hunter spray heads with 0.75 gallon-per-minute (gpm) emitters while also varying the pressure and flow rate. Simulating rainfall for a period of 20 min at an intensity of 13 mm/h resulted in a total runoff volume of 26.4 liters.

The rainfall simulators were designed to isolate and capture the entire portion of the surface runoff traveling off each sampling site. The surface runoff generated by the rainfall simulators was collected continuously during each run using a vacuum system that transferred the runoff into a 55-gallon plastic barrel. At the end of each simulation run, the runoff collected in each barrel was stirred vigorously to distribute the sediment evenly in the sample. Chemistry and toxicity samples were taken.

The source water for the rainfall simulators was obtained from hose bibs located around the perimeter of the campus' "Q & R" building. All test water passed through a portable filtration system to ensure removal of chlorine and sediments from the source water before it was supplied to the simulated rainfall systems (Figure II-4).

A series of quality assurance and quality control (QA/QC) performance evaluations were conducted on all rainfall simulators including evenness of spread and precision of pressure, flow rate and volume to determine accuracy of reproducibility among spray rigs. Rainfall simulator measurements were designed to be within approximately 20% coefficient of variation and were verified prior to the onset of each simulated rainfall run. At time zero (T0) all parking lots were cleaned using cold, high-pressure washing to establish background values for contaminants. All simulated rainfall equipment was thoroughly cleaned after each simulation. Chemistry and toxicity blank samples were taken from the source water prior to each sampling period.

Parking Lot Maintenance

The effectiveness of street sweeping in improving the quality of parking lot runoff was measured by comparing runoff concentrations between maintained and unmaintained stations. Maintained test stations were cleaned on a weekly basis using the following procedure. One individual operated both the backpack blower and the brooms, and either blew or swept all visible loose debris and surface dirt into the path of a power vacuum truck for collection and removal.

Surface Runoff Sampling

From July 2000 until October 2000, 155 rainfall runoff samples were collected periodically from two parking lots located on a college campus in Long Beach, California. All samples were stored under refrigeration and analyzed for TSS, both total and dissolved metals (cadmium, chromium, copper, iron, lead, nickel, and zinc), 26 selected PAHs, and toxicity to 3 species. The rainfall intensity/duration experiment was conducted during the third month of the study in order to allow contaminants to accumulate.

During this study, three different duration type samples were collected. In order to generate the TSS pollutograph, discrete samples were taken every 2 min for 20 min at 6, 13, and 25 mm/h rainfall intensities. This sampling scheme continued for 40 min at the 6 mm/h intensity. For the accumulation study, rainfall simulations with an intensity of 13 mm/h were run for a fixed time period (20 min) and a composited sample was taken. In the rainfall duration/intensity experiment, composited samples represented discrete time intervals. Samples representing 0-10 min and 10-20 min durations were taken at 6 and 25 mm/h rainfall intensities, respectively. An additional rainfall duration sample representing 20-40 min was taken at the 6 mm/h intensity. To facilitate a comparison with the accumulation study, simulations were also run for 20 min at a rainfall intensity of 13 mm/h.

Analytical Chemistry

Suspended Solids

Total suspended solids were analyzed by filtering a 10 to 100 mL aliquot of stormwater through a tared 1.2 µm (micron) Whatman GF/C filter (EPA Method 160.2). The filters plus solids were dried at 60° C for 24 h, cooled, and weighed.

Polycyclic Aromatic Hydrocarbons

The PAHs were extracted, isolated, and analyzed using the procedures documented by EPA Method 8270C (U.S. EPA 1991). The PAHs were separated, identified, and quantified by capillary gas chromatography (GC) coupled to mass spectrometry (MS). Acenaphthene and

Pyrene were used for quality control check standards. Twenty-five specific PAHs were determined for this study. Total PAHs (∑PAH) was computed as the sum of these values.

Trace Metal Analysis

Samples for total and dissolved trace metal analysis were prepared by digestion. Dissolved metals were defined as passing through a 0.45 µm filter. A well-mixed, 25 mL aliquot of acidified sample was dispensed to a Teflon digestion vessel and 2 mL of ultra-pure HNO3 (Optima, Fisher Scientific) were added, and the vessel was capped and sealed. The acidified samples were digested in a CEM MSP1000 Microwave Oven by ramping to 100 psi over 15 min and then holding at 100 psi for 10 min. After cooling, the digestate was centrifuged to remove any remaining residue from the sample. The supernatant with sample digest was transferred to a 15 mL test tube prior to analysis.

Inductively coupled plasma-mass spectroscopy (ICP-MS) was used to determine total and dissolved concentrations of inorganic constituents (aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, and zinc) from sample digest solutions using a Hewlett Packard Model 4500 with Hewlett Packard Data Systems software and following protocols established by EPA Method 200.8, EPA Method 236.1 and 236.2, and by EPA Modified Method 245.1. The internal standard solution included rhodium and thulium. Instrument blanks were processed to identify sample carry-over. A spiked sample of known concentration was used as the laboratory control material. . The Certified Reference Material was ERA 9970 and ERA 9977 (Environmental Resource Associates, WasteWatR Lot No. 9970 and 9977, respectively).

Data Analysis

Significant differences among mean concentrations were determined using one-way ANOVA, Kruskall-Wallace and Tukey tests ($p = 0.05$). This study examined potential differences between low-use and high-use stations and maintained and unmaintained stations. General comparisons were made for all treatments. To provide a more accurate assessment of the magnitude and trends of contaminant contributions from parking lot surface runoff, the mean contaminant concentrations from the combined low-use treatments from maintained and unmaintained stations were pooled and compared with those of the high-use treatments from maintained and unmaintained stations from the same time period.

Toxicity Measurement

Since the ultimate destination for most runoff from the City of Long Beach is the ocean, toxicity testing was conducted using three marine species: sea urchin, mysid, and bacteria. The toxicity testing program was designed to accomplish three objectives. The first objective was to determine the magnitude of toxicity in each runoff sample collected from either the accumulation or rainfall intensity and duration experiments. The sea urchin fertilization test was used to accomplish this objective. The second objective was to determine the relative sensitivity of various species to parking lot runoff. Selected samples from the accumulation experiment were tested with all three species (sea urchin, mysid, and bacteria) to accomplish this objective. The final objective was to investigate the nature of the toxic components in parking lot runoff. To address this objective, Phase I toxicity identification evaluations (TIE) were conducted on selected samples using the sea urchin fertilization test.

All samples were adjusted to a constant salinity so only the effect of toxic constituents, not the effect of freshwater, was evaluated. Each sample was tested at a minimum of two concentrations in order to estimate the magnitude of toxicity present. The maximum sample concentration tested was 50% (i.e., 50% runoff sample and 50% seawater or salinity adjustment solution). The concentrations tested in the accumulation experiment varied from test to test in order to maximize the value of the results for estimating the median effect concentration (EC50) and no observed effect concentration (NOEC). In general, runoff samples from the high-use treatment groups of the accumulation experiment were tested at concentrations of 50, 25, 12, 6, and 3%, while the low-use treatment groups were tested at a reduced number of concentrations. All samples from the rainfall intensity and duration experiment were tested at concentrations of 50% and 12%.

Prior to the start of the project and during each sampling period, samples of water from the simulated rainfall delivery and collection system were collected and tested to verify that they were not causing toxicity.

Seas Urchin Fertilization

The purple sea urchin sperm cell test was performed as described by Chapman *et al.* 1995. Gametes were obtained from adult specimens of the purple sea urchin, *StrongylocentroTU purpuraTU*, collected from a relatively uncontaminated area in northern Santa Monica Bay. In the test, sea urchin sperm are exposed to various concentrations of the test sample for 20 min at a temperature of approximately 15° C. Sea urchin eggs were then added to each sample and given 20 min for fertilization to occur. Preservative was then added to the samples and they were later analyzed under a microscope to determine the percentage of fertilized eggs. Comparing the fertilization success of the sample to that of the control determines the degree of toxicity.

Since the toxicity test uses a marine organism, the salinity of the runoff samples was adjusted to a typical seawater value by the addition of brine. Addition of the brine diluted the samples, restricting the highest concentration of sample tested to 50%. Additional test concentrations were prepared by adding laboratory seawater (filtered natural seawater collected from offshore Redondo Beach) to the samples. A brine control was included in the experiment to check for toxicity introduced by the salinity adjustment procedure. The brine control consisted of deionized water plus laboratory seawater and brine at the same concentration found in the most concentrated runoff sample tested.

A reference toxicant test was conducted concurrently with each test in order to document variability in test sensitivity. This test consisted of five concentrations of dissolved copper, ranging from 10 μg/L to 65 μg/L.

Mysid Survival and Growth

The mysid short-term chronic survival and growth bioassay was performed according to methods described in Klemm *et al.* 1994. Juvenile mysids of the species *Americamysis bahia* (formerly *Mysidopsis bahia*) were obtained from Aquatic Biosystems of Ft. Collins, CO. To perform the test, 5 animals are added to 250 mL polypropylene beakers containing 150 m of sample with 8 replicates per concentration. The mysids are fed newly hatched *Artemia* daily. Each day the solution in the beakers is removed and renewed. The exposure period of 7 d is conducted at 26° C with a salinity of 30 g/Kg. At the end of the exposure period, the number of surviving animals is recorded and the survivors are dried and weighed. The endpoints for this test are percentage of survival and average individual dry weight compared to the control values.

The salinity of the runoff samples was adjusted by the addition of Forty Fathoms bioassay grade sea salts. Various test concentrations were prepared by diluting the salinity-adjusted runoff sample with 30 g/kg of laboratory seawater. A salt blank was included in each experiment to check for toxicity introduced by the salinity adjustment procedure. The salt blank consisted of deionized water plus sea salts and laboratory seawater at the same concentration found in the most concentrated runoff sample tested.

A reference toxicant test was conducted concurrently with each of the runoff tests in order to document variability in test sensitivity. This test consisted of five concentrations of dissolved copper, ranging from 100 µg/L to 350 µg/L. Both the survival and growth endpoints were examined for the reference toxicant exposure.

Bacteria Luminescence

Toxicity of the runoff samples to marine bacteria (*Vibrio fischeri*) was measured using the Microtox™ Rapid Toxicity Testing System. Two different tests were conducted on each sample, a 15-min short-term acute test and 24-h long-term chronic test. Samples for both procedures were analyzed using a Microtox M500 analyzer following the Microtox Comparison Test Method (Microbics Corporation 1995).

For the acute test, bacteria were added to triplicate cuvettes containing 1.5 mL of sample and incubated at 15° C. The salinity of the samples was adjusted by adding a saline solution. Microtox diluent was added to the samples to produce various test concentrations. The luminescence of each replicate was measured at 0, 5 and 15 min. Mean percent luminescence was then calculated as the average of the replicates within each concentration as normalized to the time zero value of each sample and corrected for natural light loss between zero and 15 min. Reproducibility of the test organism response was determined by testing a copper reference toxicant solution at a series of concentrations.

The Microtox chronic test procedure was similar to the acute method, except that the samples were tested in quadruplicate and incubated at 27° C for 24 h. Nutrient media were added to the test solution, with dilutions made using DIW and the Microtox control media solution. Luminescence at 24 h was measured and compared to the control value. Reproducibility of the test organism response was determined by testing a copper reference toxicant solution at a series of concentrations.

Data Analysis

The NOEC (highest test concentration not producing a statistically significant reduction in fertilization or survival) and the EC50 or LC50 (concentration of runoff producing a 50% reduction in fertilization or survival, respectively) were calculated for each sample whenever suitable data were obtained. For the NOEC calculation, the data were arcsine transformed and then tested for homogeneity of variance and normal distribution. Data that met these criteria were then tested using the one-way analysis of variance (ANOVA) and Dunnett's multiple comparison test to identify differences between the control and each of the samples. Data that did not pass the test for homogeneity of variance and/or normal distribution were analyzed using the non-parametric Steel's Many-One Rank test. The EC50 or LC50 were calculated using probit analysis.

Toxicity Characterization

Phase I TIEs were conducted on runoff samples from months 2 and 3 of the accumulation experiment in order to determine the characteristics of the toxicants present. Each sample was subjected to treatments designed to remove selectively or neutralize classes of compounds (e.g., metals, nonpolar organics) and any associated toxins. Treated samples were then tested to determine the change in toxicity using the sea urchin fertilization test.

Four treatments were applied to each sample: particle removal, trace metal chelation, nonpolar organic extraction, and chemical reduction. With the exception of the organics extraction, each treatment was applied independently on a salinity-adjusted sample. A control sample (laboratory dilution water) was included with each type of treatment to verify that the manipulation itself was not causing toxicity. A reduced set of concentrations of untreated sample was tested at the time of the TIE to determine the baseline toxicity and control for changes in toxicity due to sample storage.

Ethylenediaminetetraacetic acid (EDTA), a chelator of metals, was added at a concentration of 60 mg/L to the test samples. Sodium thiosulfate (STS), a treatment that reduces oxidants such as chlorine and also decreases the toxicity of some metals, was added at a concentration of 50 mg/L to separate portions of each sample. The EDTA and STS treatments were given at least 1 h to interact with the sample prior to toxicity testing.

Samples were centrifuged for 30 min at 3000 X g to remove particle-borne contaminants and were then tested for toxicity. A portion of the centrifuged sample was also passed through a 12 mL Varian Mega Bond Elute C-18 solid phase extraction column in order to remove nonpolar organic compounds. The C-18 columns have also been found to remove some metals from aqueous solutions.

The used C-18 columns were stored under refrigeration for 1 to 2 months and then eluted in order to recover the retained toxic constituents. Each column was eluted sequentially with methylene chloride ($MeCl_2$) and hydrochloric acid (HCl) to recover the organic and metal fractions. Each column was rinsed with deionized water to remove excess salts. $MeCl_2$ (100%) was then passed through the column and the eluate was collected. The column was then rinsed with methanol to remove any residual $MeCl_2$. Finally, 2 M HCl was passed through the columns and the eluate was collected. The $MeCl_2$ eluates were solvent exchanged into isopropanol. Dilutions of the organic and acid eluates were tested for toxicity using the sea urchin fertilization test.

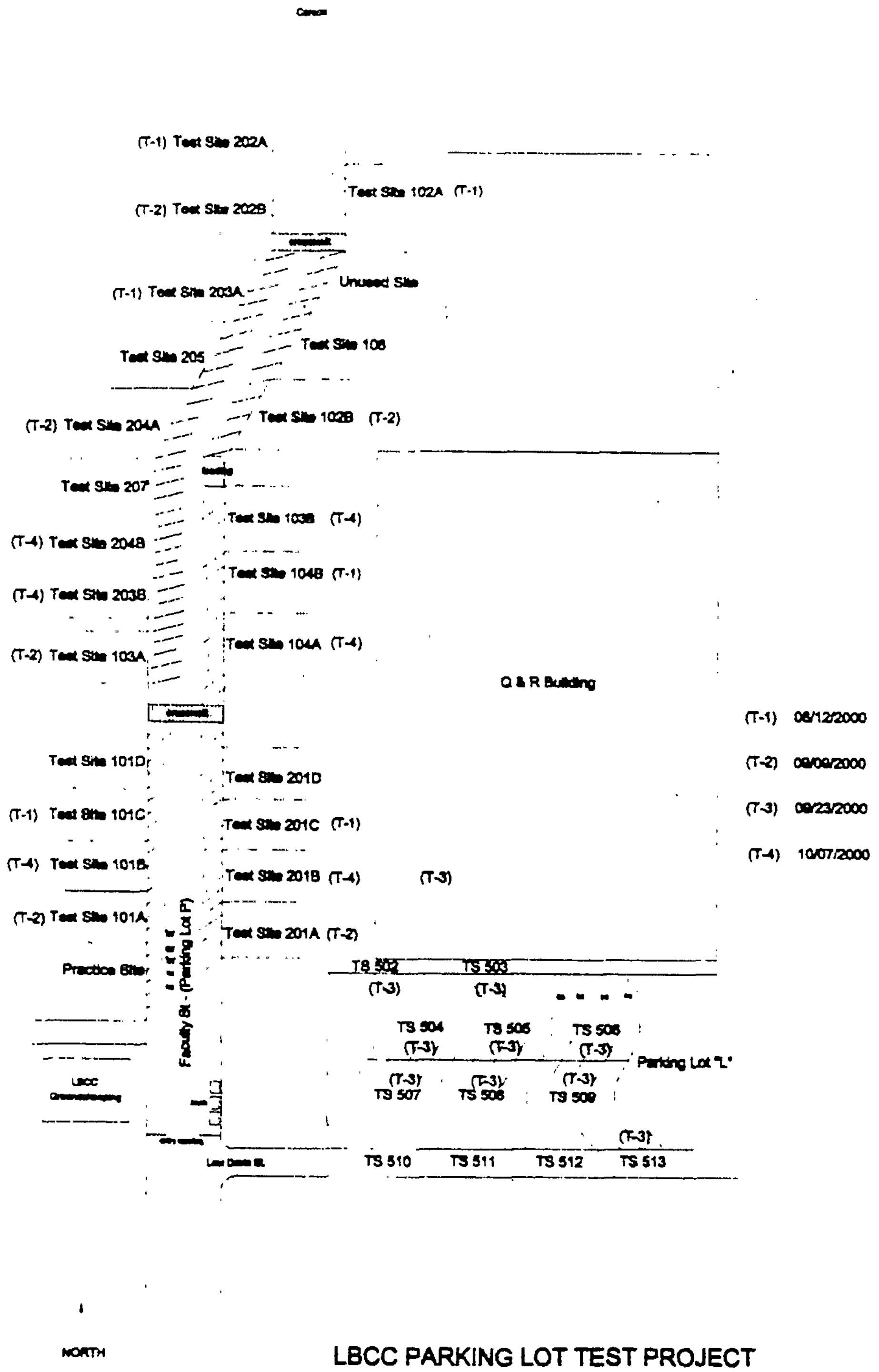

FIGURE II-1. Layout of the study area and sampling sites selected for monitoring runoff from parking lots located within the Long Beach City College Liberal Arts Campus (LBCC LAC) in the City of Long Beach, California.

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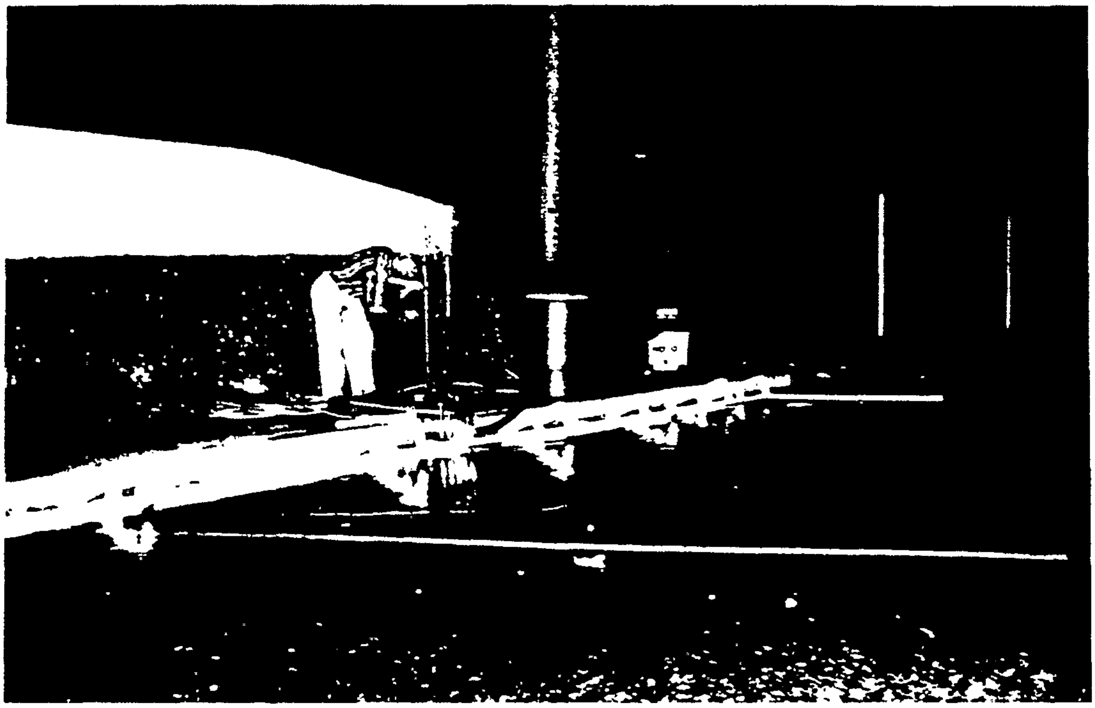

FIGURE II-2. The simulated rainfall delivery and water collection system used for assessing the effects of rainfall on surface runoff.

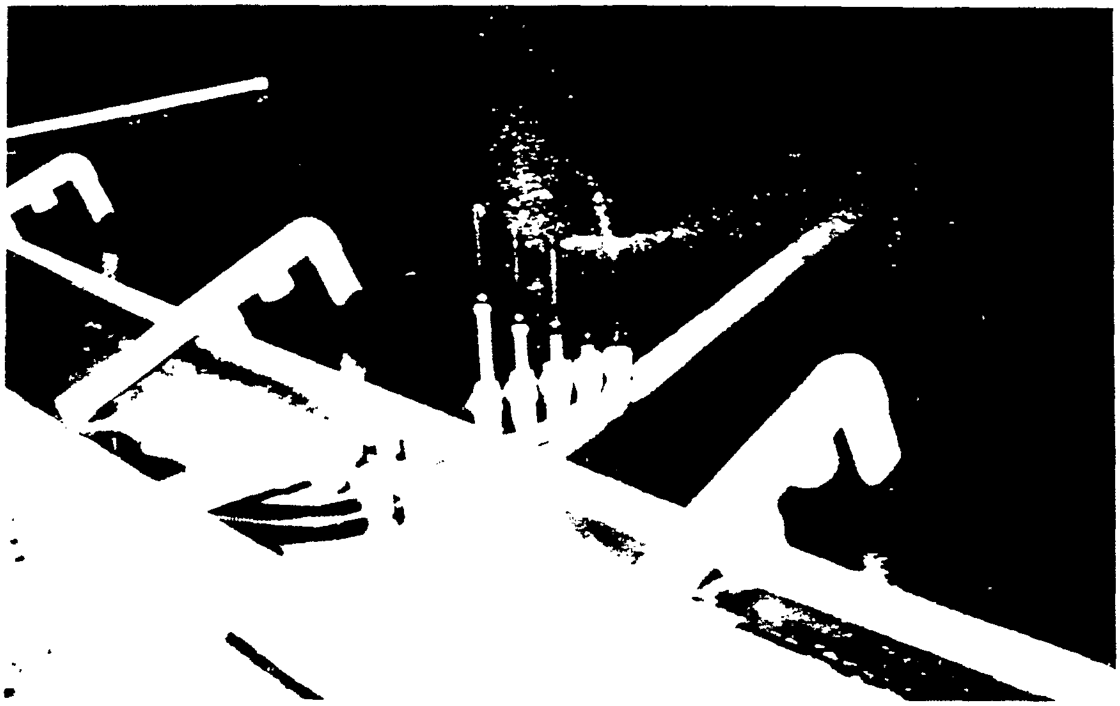

FIGURE II-3. Rainfall simulator in use.

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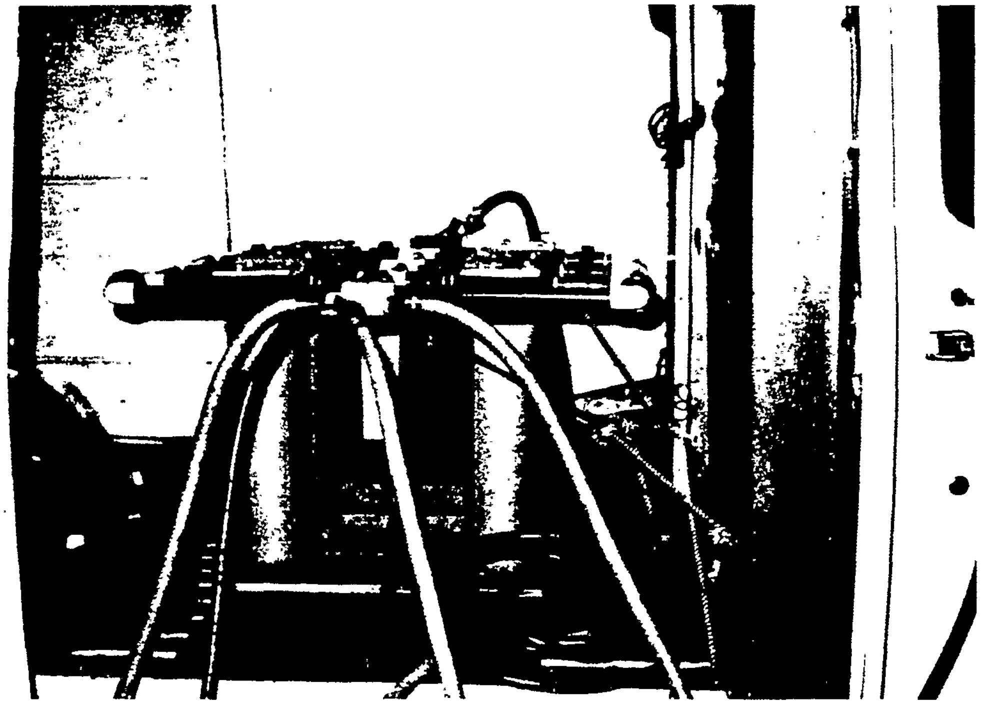

FIGURE II-4. Pre-treatment system used to ensure removal of chlorine and sediments from the source water before it was supplied to the simulated rainfall systems.

III. CONTAMINANT ACCUMULATION

Results

Rapid accumulation of all constituents was observed after 28 antecedent dry days (sampling month T1) with the exception of total PAHs (Figure III-1, Table III-1). Mean suspended solids concentrations increased from 29.2 mg/L to a maximum of 51.8 mg/L during this time period. Of the trace metals studied, zinc demonstrated the highest potential for accumulation in parking lot surface runoff (increasing by as much as 182%) at T1. After 28 d, all trace metals were detected in the dissolved phase and accounted for 31 to 81% of the total metals concentrations in parking lot runoff samples. Reported concentrations of dissolved zinc increased significantly from 200 μg/L to 553 μg/L between T0 and T1. In contrast, mean total PAH concentrations were highest (105 μg/L) at T0 and decreased 20% at T1 (Figure III-1, Table III-1).

Mean contaminant concentrations in subsequent sampling months (T2 and T3) tended to decrease relative to T1 (Figure III-1, Table III-1). For example, total zinc concentrations in parking lot surface runoff from T1 were about 1 to 4 times larger than the concentrations in runoff from other time periods. Monthly PAH concentrations gradually decreased to a minimum of 52.9 μg/L at T2 before a small increase to 53.3 μg/L at T3. Both of these time periods had significantly reduced mean concentrations from the initial (T0) pollutant concentration.

Average TSS concentrations measured at T0 were 26% lower than mean TSS precleaned concentrations (Figure III-1, Table III-1). All total and dissolved trace metals also had lower concentrations after the sites were cleaned, with the exception of cadmium and chromium, which increased by 30 and 8%, respectively. Mean total PAH concentrations decreased by 14% after cleaning. However, none of the lowered contaminant concentrations produced a statistically significant change.

Parking Lot Usage

Changes in parking lot use had little influence on surface runoff contaminant concentrations. Only 8 of 18 contaminants displayed higher runoff concentrations from the high-use stations compared to the low-use stations (Table III-2). However, no significantly different concentrations were found for any of the constituents among the treatments measured for parking lot runoff.

Mean contaminant concentrations followed similar temporal trends as observed in the accumulation study. Both low-use and high-use runoff within T1 had higher mean zinc concentrations (643 and 597 ug/L, respectively) than runoff from stations within T0 and T3. For copper, time periods T0 and T1 had much higher concentrations than T3. Suspended solids concentrations found in runoff from the high-use stations consistently increased from T0 to T2 (31.8 mg/L to 60 mg/L) before dipping during T3 (Figure III-2). On the low-use stations, TSS concentrations fluctuated from 29.2 to 51.8 mg/L. However, the monthly mean TSS concentrations did not vary significantly by use or time period. Concentrations of total PAHs exhibited a similar decreasing trend with respect to time.

Maintenance

Street sweeping was shown to have a minimal effect on parking lot runoff water quality because the sweeping practices used in this study removed very few contaminants. On the contrary, 15 of 18 contaminant concentrations were highest in runoff from maintained stations (Figure III-3, Table III-2). All constituent concentrations were not significantly different among maintenance sites.

As stated previously, the treatments within T1 exhibited higher monthly average TSS, total, and dissolved trace metal concentrations than any other month (Figure III-3). During T1, the mean total zinc concentration of 608 ug/L at the unmaintained stations was up to 4 times larger than zinc concentrations measured in runoff from unmaintained stations during all other time periods. Even though average total zinc concentrations from unmaintained parking lots decreased over the study period, concentrations were substantially higher than at T0. Dissolved zinc concentrations exhibited a similar trend. For TSS, no significant differences existed between time periods; however, mean TSS values from maintained stations (82 mg/L) at T2 were much higher than values measured from unmaintained stations (29 mg/L). Mean total PAH concentrations found in surface runoff from maintained stations decreased considerably during each time period from 143 µg/L at T0 to 47 µg/L at T3. Similar decreased mean total PAH concentrations were also observed between unmaintained stations within T1 (96 µg/L) and unmaintained stations within T2 (48 µg/L), as well as between maintenance levels within T0 (maintained = 143 µg/L, unmaintained = 67 µg/L).

Discussion

Accumulation of Contaminant Concentrations

Although short-term accumulation was observed in the present study, long-term accumulation was not found. Contaminants accumulated relatively quickly on the parking lot surface (within 28 d). As the study continued, however, monthly average contaminant concentrations slowly decreased, approaching initial T0 level concentrations. Research on urban stormwater quality has indicated that pollutants accumulate on a street surface between sweeping and storm events. Physical removal processes, however, such as winds and rain or human activity (e.g., from the turbulence of traffic or by street sweeping) can limit the accumulation of solids and other pollutants from road and parking lot surfaces, obscuring the relationship between traffic volume, pollutant loads, and concentrations in runoff (Kerri *et al.* 1985, Pitt and Shawley 1981, Asplund 1980). Pitt and Sutherland (1982) estimated that the total mass concentration of pollutants that can accumulate on street surfaces is limited, requiring approximately two to three weeks to reach maximum levels.

Rainfall has the greatest potential to affect the accumulation of constituents. Unmeasureable amounts of rain fell on the parking lots between the sampling periods, reducing the number of antecedent dry days for events T2 and T3. Although these rainfall events did not appear to be significant, the amount of dry days prior to each of the last two sampling events were both less than two weeks. The effect of these trace quantities of rainfall is assumed to be negligible since rainfall did not pool and no flow was observed. Furthermore, we found that it takes an intensity of 6 mm of rain to fall for 15 min in order to wash off nearly all contaminants from the parking lot surface during the duration/intensity study (See Section IV).

Chemical processes can also limit the accumulation of potential pollutants on parking lot surfaces. Mean total PAH concentrations dropped significantly over the 3-month period of study. Hewitt and Rashad (1992) reported that between 70 and 99% of PAHs were removed from the road environment either by the atmosphere, volatilization, photo-oxidation, or other oxidation processes.

Traffic Usage

Vehicles are one of the major sources of pollutants, both directly and indirectly, in parking lot runoff (Hahn and Pfeifer 1994, Asaeda *et al.* 1996). Therefore, the amount of traffic on a given lot should influence the accumulation of pollutants on the parking lot surface. Our study did not establish a strong relationship between traffic volume and increased contaminant concentrations. Similar results were found when comparing runoff concentrations from highways of different traffic densities in studies by McKenzie and Irwin (1983) and Boucier *et al.* (1980). These studies found a weak correlation between TSS concentrations and average daily traffic (ADT), and no correlation of metal loadings with ADT. In another study, Stotz (1986) concluded that the amount of pollutants discharged has a higher correlation to the physical characteristics of the area than the traffic frequency.

Compared to mean cadmium concentrations, the relatively large arithmetic mean concentrations of total and dissolved zinc in parking lot surface runoff from the different treatments observed in this study support previous findings that automobiles are a large potential source of these constituents. Vehicles contribute contaminants directly into the environment from normal operation and wear to parts caused by friction. Road dust contaminated by tire wear products and zinc-plated metal erosion material contributes the highest levels of zinc to urban runoff (Kobriger and Geinopolos 1984, Smith and Lord 1990 and Lorant 1992). It is likely that these sources may have caused the high zinc concentrations observed in this study. Indirect or acquired contaminants are solids that are acquired by the vehicle for later deposition. Indirectly, vehicles contribute to parking lot contaminants by carrying solids from urban roadways. Indeed, Shaheen (1975) demonstrated that more than 95% of solids on a given road originate from sources other than the vehicles themselves.

Maintenance Effectiveness

The street sweeping practices performed in this study did not prove to be an effective measure for reducing the concentrations of most constituents in parking lot surface runoff. The objective was to remove dry-weather accumulations of contaminants, especially fine particulate matter, before they were washed off by rainwater, and thus reduce the potential for contaminant impacts on receiving waters. Studies by Pitt (1985), Maestri *et al.* (1985) and Gupta *et al.* (1981) reported that intensive street cleaning conducted three times a week using the traditional mechanical street cleaners showed no significant improvement in runoff water quality and was only effective in removing large solids. Most recently, studies conducted in the Pacific Northwest by Sutherland and Jelen (1997) and reported in the Runoff Report (1998), have evaluated the use of vacuum-assisted sweepers and regenerative-air sweepers to determine an optimum sweeping frequency. These improved sweeping mechanisms removed finer street surface materials than the standard mechanical street cleaning equipment, with measureable improvements in pollutant removal efficiency obtained with a sweeping frequency once every week or two.

TABLE III-1. Comparison of constituent accumulation over time. Values given are means and their standard deviations.

	Washoff Events				
	15-Jul-00	15-Jul-00	12-Aug-00	9-Sep-00	7-Oct-00
	Preclean	T0	T1	T2	T3
Parameter	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Suspended Solids (mg/L)	50 (25.4)	29.2 (11.7)	51.8 (14.1)	46.7 (37.2)	41.0 (10.8)
Total Metals					
Aluminum (µg/L)	315 (134.4)	250 (82)	533.3 (119.2)	423.3 (100.7)	421.7 (97)
Cadmium (µg/L)	0.7 (0.9)	1.3 (1.4)	2.5 (1.4)	0.9 (1.0)	0.0 (0)
Chromium (µg/L)	1.2 (1.6)	1.4 (1.1)	3.6 (0.5)	2.3 (0.5)	3.2 (0.4)
Copper (µg/L)	37.5 (13.4)	32.0 (9.2)	40.3 (7.2)	28.7 (6.8)	19.2 (3.2)
Iron (µg/L)	835 (7.1)	546.7 (154.5)	810.0 (174.4)	496.7 (130.1)	485.0 (97.4)
Lead (µg/L)	20 (11.3)	35.0 (9.2)	41.8 (10.6)	19.5 (8.5)	10.9 (2.2)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	16.3 (9.5)	14.2 (5.8)	20.7 (2.4)	16.5 (4.5)	9.2 (1.9)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	530 (169.7)	220.0 (85.1)	620.0 (60.4)	395.0 (107.1)	230 (34.9)
Total PAHs (µg/L)	140 (14.1)	105 (46.0)	82.4 (33.7)	52.9 (10.7)	53.3 (6.8)
Dissolved Metals					
Aluminum (µg/L)	180 (70.7)	46.4 (27)	131.7 (62)	71 (33.4)	63.7 (4.2)
Cadmium (µg/L)	0 (0)	0.9 (1.0)	1.3 (1.2)	0.6 (0.8)	0.0 (0.0)
Chromium (µg/L)	0.9 (1.3)	1.0 (0.9)	2.3 (1.1)	1.5 (0.4)	1.9 (0.1)
Copper (µg/L)	32 (11.3)	27.3 (9.3)	28.5 (13.4)	19.3 (4.1)	13.5 (2.1)
Iron (µg/L)	285 (77.8)	263.3 (77.3)	286.7 (140.0)	118.7 (39.0)	66.2 (11.0)
Lead (µg/L)	9.7 (4.7)	32.3 (9.0)	22.8 (14.0)	10.9 (7.2)	3.6 (1.5)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	14.5 (7.8)	12.9 (5.8)	16.2 (7.7)	11.1 (2.6)	7.5 (1.1)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	405 (176.8)	200 (78.9)	553.3 (50.5)	270.0 (89.4)	158.3 (18.4)

TABLE III-2. Comparison of parking lot runoff concentrations among parking lot usage and maintenance practices. Time periods were pooled and means with their standard deviations are reported.

	Pooled Time Periods (T1-T3)			
	Use		Maintained	
	Low	High	Yes	No
Parameter	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Suspended Solids (mg/L)	44.9 (19.3)	46.4 (27)	59.7 (23.4)	36.7 (19.4)
Total Metals				
Aluminum (µg/L)	506.7 (135.9)	412.2 (83.2)	546.7 (138.4)	415.8 (84.8)
Cadmium (µg/L)	0.9 (1.5)	1.4 (1.3)	1.1 (1.2)	1.1 (1.4)
Chromium (µg/L)	3.1 (0.6)	3 (0.8)	3.4 (0.8)	2.8 (0.6)
Copper (µg/L)	29.6 (8.8)	29.2 (12.2)	28.2 (8.7)	27.9 (11)
Iron (µg/L)	556.7 (122.2)	637.8 (256.2)	690 (170.1)	552.7 (189.1)
Lead (µg/L)	21.2 (12.4)	27 (17.4)	21.5 (11.6)	32.6 (24.3)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	14.8 (4.5)	16.1 (6.7)	16.5 (5.8)	14.8 (5.1)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	427.8 (180.9)	402.2 (173.9)	426.7 (186.8)	359.3 (184.3)
Total PAHs (µg/L)	58.4 (9.8)	67.3 (33.3)	55.2 (9.9)	54.5 (35.7)
Dissolved Metals				
Aluminum (µg/L)	94.5 (54.7)	76.6 (47)	60.3 (9.1)	25.5 (36.1)
Cadmium (µg/L)	0.6 (1)	0.6 (1)	0.8 (0.9)	0.4 (0.9)
Chromium (µg/L)	2 (0.5)	1.8 (0.9)	2.1 (0.7)	1.7 (0.6)
Copper (µg/L)	22.2 (8.4)	18.7 (11.5)	22.3 (8.9)	18.7 (9.7)
Iron (µg/L)	166.6 (112.6)	147.8 (138.9)	183.2 (127.2)	142 (111.8)
Lead (µg/L)	11.3 (10)	13.6 (13.8)	11.8 (10)	19.3 (21.4)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	12.2 (4.8)	10.9 (6.8)	13.3 (5.1)	11 (5.5)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	320 (166.9)	334.4 (187.4)	318.3 (171.9)	286.3 (185.3)

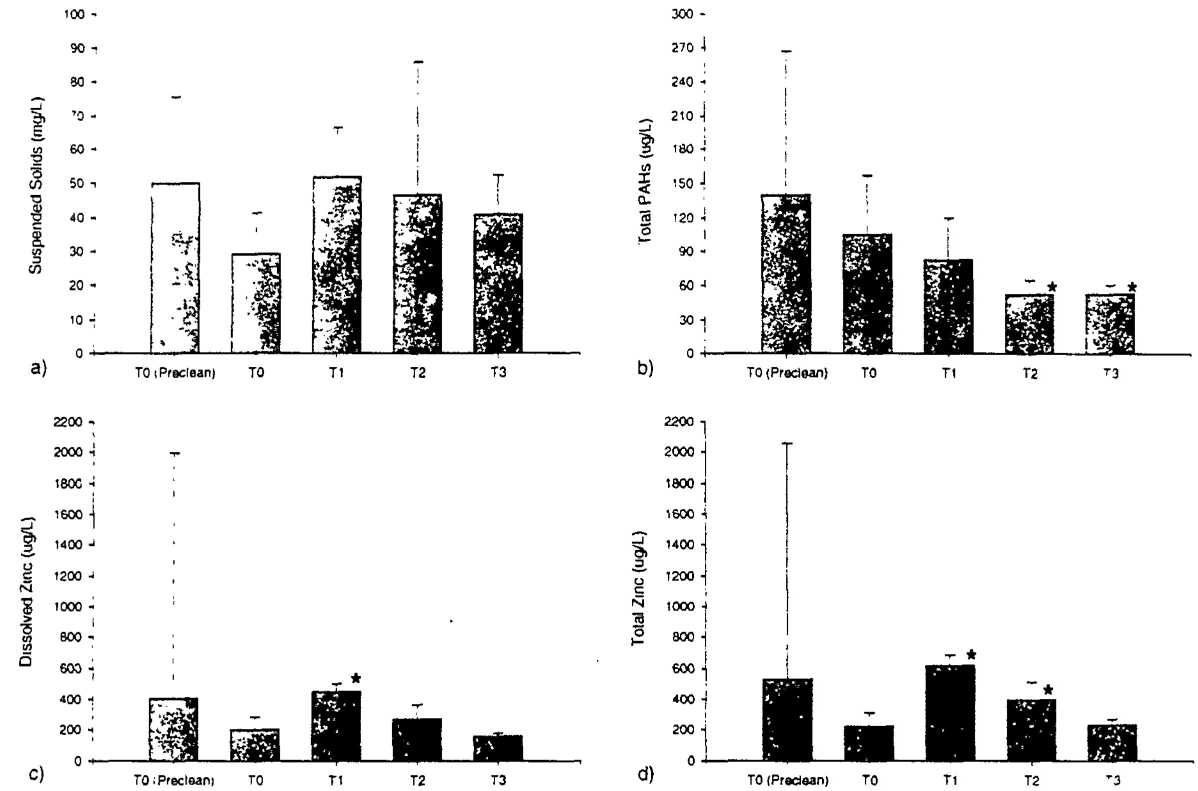

FIGURE III-1. Mean accumulation concentrations (± 95% C.I.) of (a) suspended solids, (b) total PAHs, (c) dissolved zinc and (d) total zinc in runoff from parking lots. Excluding precleaning, time steps are monthly. An asterisk denotes significant differences relative to the time zero sample.

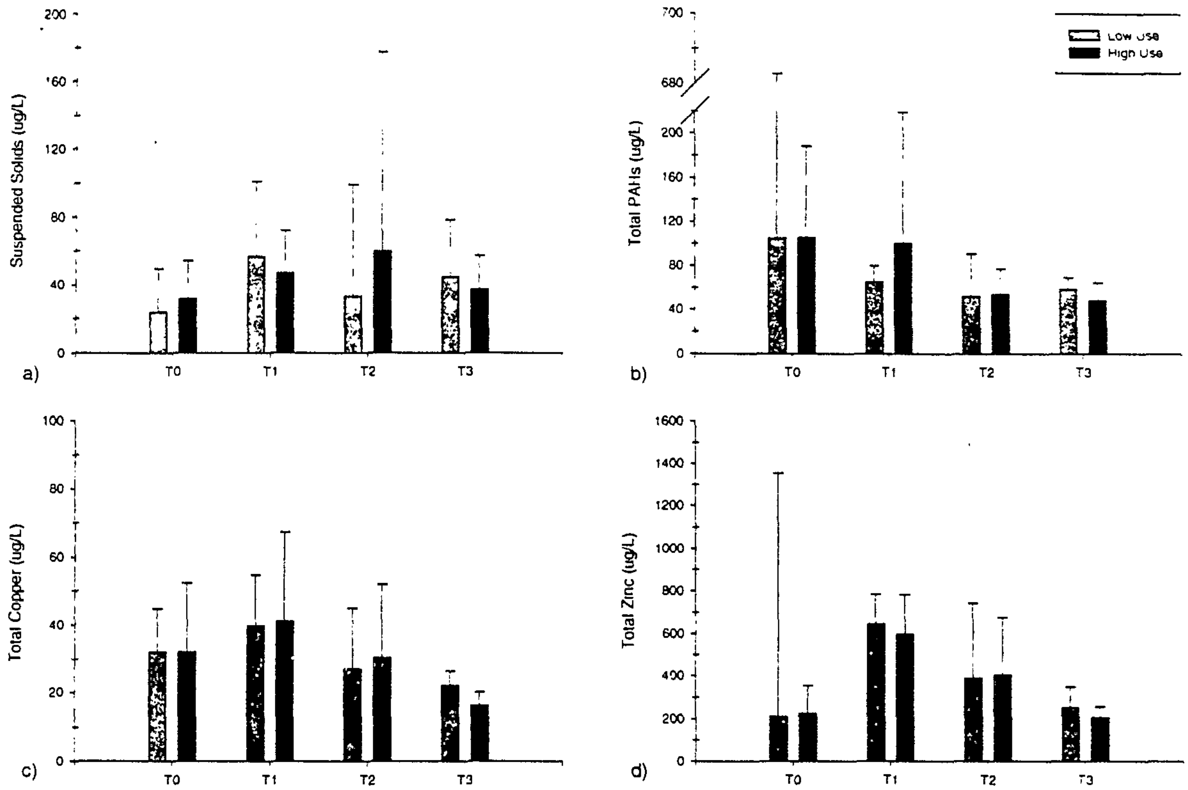

FIGURE III-2. Mean concentrations (± 95% C.I.) of (a) suspended solids, (b) total PAHs, (c) total copper and (d) total zinc in runoff from low-use and high-use parking lots over time.

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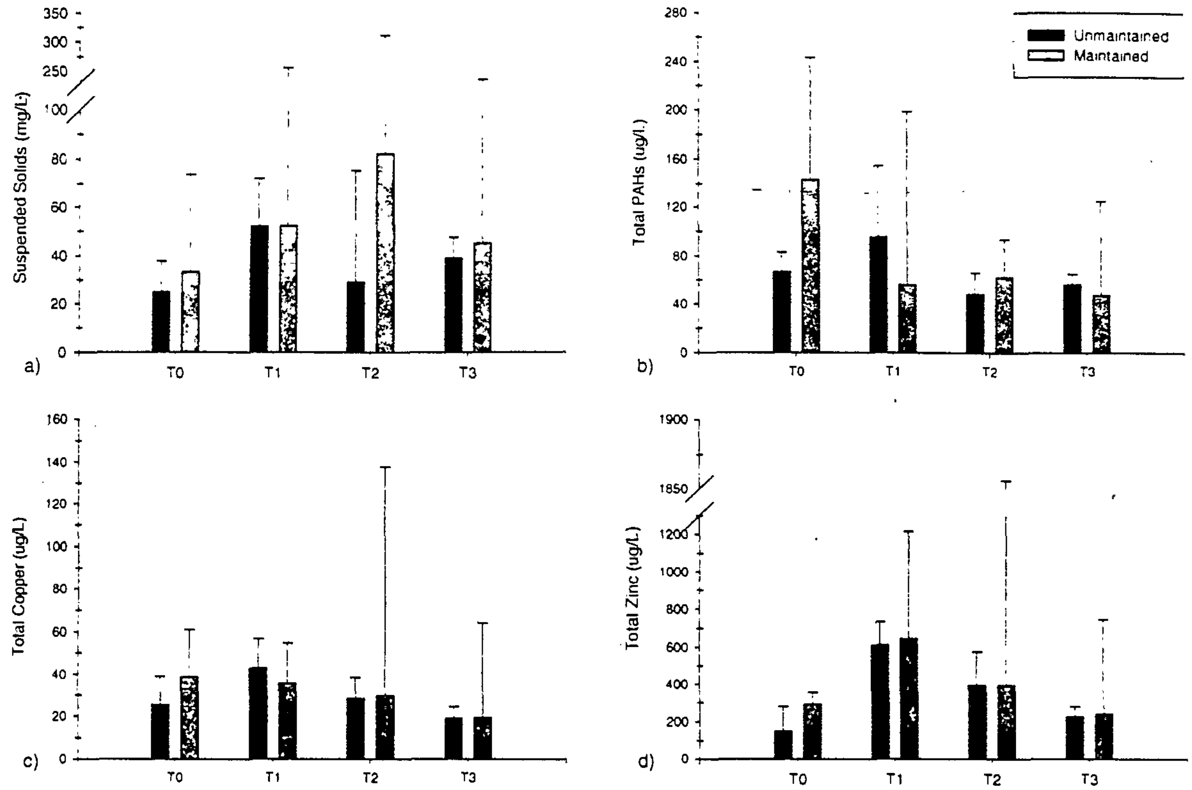

FIGURE III-3. Mean concentrations (± 95% C.I.) of (a) suspended solids, (b) total PAHs, (c) total copper and (d) total zinc in runoff from maintained and unmaintained parking lots over time.

IV. RAINFALL INTENSITY / DURATION

Results

Contaminant Washoff Patterns

Simulated rainfall washed off nearly all of the suspended solids that collected on the parking lot surface after approximately 15 min regardless of rainfall intensity. Higher concentrations were recorded during approximately the first 10 min for most constituents; however, the concentrations quickly reached a baseline concentration for the duration of the sampling period (Figure IV-1). The suspended solids concentrations varied from about 2 to 140 mg/L, with a decrease in concentrations with increasing rain intensity during these constant rain intensity tests. No concentrations higher than 52 mg/L occurred after approximately 10 min of rain. All TSS concentrations were less than 30 mg/L after approximately 15 min of rain. Suspended solids concentrations for all intensities showed slightly higher concentrations at the beginning (first flush) of the simulated storm events. The magnitude of the first-flush effect varied between intensities, ranging from 112 to 140 mg/L, and was more evident at the 6 mm/h rainfall intensity.

Rainfall duration was the most important factor we observed. Washoff of all measured constituent variables was inversely correlated with duration at single or lumped rainfall intensities (Table IV-1, Figure IV-2). Longer simulated storms diluted parking lot runoff and significantly lowered the concentrations of contaminants. For example, mean suspended solids concentrations measured after 10 minutes significantly decreased from 57 mg/L to 16.2 mg/L measured during the 10-20 minute interval of the simulated storm ($F = 7.95$, $p = 0.00$) (Figure IV-2). At the end of the simulated storm event (20-40 min interval), mean suspended solids concentrations decreased to 11.7 mg/L and were significantly different from concentrations measured after 10 min ($F = 7.95$, $p = 0.00$). Simulated storm events with 20 minute rainfall durations had a mean TSS concentration of 28.7 and were not significantly different relative to the other time intervals.

Washoff of contaminant concentrations exhibited trends similar to TSS over different durations, but the importance of intensity was only detected at the shortest durations (Table IV-1, Figure IV-3). When durations were pooled, mean total zinc concentrations were highest (240 ug/L) at the 6 mm/h rainfall intensity. More intense simulated storms had the same dilution effect on average pollutant concentrations, as did longer simulated storms, however, the concentrations were not significantly lower. Mean zinc concentrations were reduced to a minimum of 143 ug/L with 25 mm/h of rainfall (Figure IV-3). The mean dissolved zinc concentrations ranged from approximately 51 to 338 ug/L, comprising a large percentage of the total zinc loadings. For all rain intensities, dissolved metals comprised up to 90% of the total metals.

DISCUSSION

Urban stormwater runoff is comprised of discharges from many separate source area components (parking lots, streets and highways) that are combined within the watershed drainage area before entering the receiving water. Bannerman *et al.* (1993) characterized parking lots as critical source areas contributing most of the runoff and contaminant loads during small rain events. One study in Toronto, Ontario by Pitt and McLean (1986), evaluated specific source areas to identify any possible trends of concentrations with rain volume. They found that lead and zinc concentrations were highest in runoff from paved parking areas and streets. Several other studies (Barrett *et al.* 1995, Driscoll *et. al.* 1990, and Pitt 1985) measured runoff and contaminant concentrations on roads and highways.

To understand the potential impacts on water quality from surface runoff from parking lots, we compared the average constituent concentrations found in parking lot runoff to both the range of average national pollutant concentrations in highway runoff, and to the range of concentrations observed in the City of Long Beach's wet-weather stormwater monitoring program (Table IV-2). This comparison shows that the average concentrations in surface runoff from parking lots in Long Beach are at the lower end of range of concentrations for transportation land uses nationwide (FHWA 1998, Barrett *et. al.* 1995). However, parking lot runoff concentrations generated during simulated rainfall events were similar to the concentrations measured in wet-weather discharges from the City of Long Beach during the winter of 2001 (Kinnetic Laboratories, Inc and SCCWRP, 2001). For example, the average concentrations of lead in parking lot runoff were lower than the range of mean runoff concentrations in transportation areas nationwide, but were within the range of concentrations measured in City of Long Beach wet-weather runoff. Interestingly, the ranges of mean zinc concentrations were similar among national transportation areas and the City of Long Beach, approximately 50 to 900 µg/L. The zinc concentration measured during simulated rainfall on a parking lot within the City of Long Beach was below the mid-range near 300 µg/L.

In this study, changes in rainfall duration were found to have the greatest effect on constituent concentrations. Parking lot runoff samples collected during the first 10 min of a rain event contained the highest constituent concentrations, indicating that a first-flush effect was present. After peaking during the first flush, constituent concentrations decreased and then remained relatively stable after approximately 15 min when most loose particles were washed off. Longer storms were found to dilute parking lot runoff and lower the variability in measured contaminant concentrations during this study. Rainfall intensity was also an important variable in determining removal of runoff constituents during a storm, but only during shorter durations (i.e., less than 15 min). Higher intensity storms produced higher concentrations during these small duration events. Others (Athayde *et al.* 1983; Irish *et al.* 1996) have documented a similar correlation among rainfall duration and intensity. For example, Dorman *et al.* (1988) found that concentrations of runoff pollutants were higher during shorter, low-volume storms.

The results of the intensity and duration experiments indicate that stormwater treatment systems that capture or treat the initial portion of stormwater discharge from parking lots are likely to provide the greatest benefit in terms of reducing constituent concentrations. This will, in turn, help to reduce mass emissions, particularly for shorter storm events. However, several factors need to be considered when designing BMPs including sizing, trapping and treatment efficiency for specific constituents of concern, and flood protection among others.

TABLE IV-1. Comparison of constituent concentrations with varied intensities and durations. Mean concentrations with their standard deviations are reported.

	Intensity and Duration					
	6 mm/hr (0.25 in/hr)			13 mm/hr (0.5 in/hr)	25 mm/hr (1 in/hr)	
	0-10 min	10-20 min	20-40 (min)	0-20 min	0-10 min	10-20 min
Parameter	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Suspended Solids (mg/L)	72.7 (18.1)	20.3 (6.5)	11.7 (5.2)	28.7 (14.6)	41 (13.3)	12 (3.1)
Metals (Total)						
Aluminum (µg/L)	1036.7 (172.7)	233.3 (177.5)	180 (55.9)	316.7 (73.5)	540 (114.7)	143.3 (26.1)
Cadmium (µg/L)	2.4 (0.6)	1 (0.8)	0 (0)	0.8 (0.6)	0.5 (0.8)	0 (0)
Chromium (µg/L)	7.7 (0.7)	4.1 (0.3)	2.2 (0.2)	2.6 (0.4)	4 (1.2)	1.8 (0.3)
Copper (µg/L)	54.3 (6.4)	27.3 (4.2)	10.3 (0.5)	19.7 (1.3)	29.7 (7.6)	10.3 (2.2)
Iron (µg/L)	556.7 (56.8)	446.7 (27.4)	216.7 (71.5)	560 (115.4)	610 (195.4)	266.7 (35.5)
Lead (µg/L)	168.7 (84.2)	93 (58)	27.7 (14.5)	61.7 (28.6)	48.7 (18.4)	18.7 (6.6)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	44.7 (7.4)	21.3 (4.7)	6.8 (0.9)	14 (2.3)	23.7 (6.9)	6.6 (1.3)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	430 (47.5)	213.3 (35.5)	76.7 (3.2)	160 (8.5)	216.7 (26.1)	69.3 (10.6)
Total PAHs (µg/L)	8.5 (6.2)	4.3 (2.8)	2.7 (2.1)	5.5 (2.9)	3.3 (1)	1.6 (0.7)
Metals (Dissolved)						
Aluminum (µg/L)	78.7 (12.4)	92.7 (97.2)	0 (0)	0 (0)	0 (0)	25.7 (37.9)
Cadmium (µg/L)	2.1 (0.6)	0.9 (0.7)	0 (0)	0 (0)	0.5 (0.7)	0 (0)
Chromium (µg/L)	4.1 (0.4)	2.5 (0.2)	0.8 (0.7)	1.6 (0)	1.9 (0.6)	0.4 (0.5)
Copper (µg/L)	47.3 (5.2)	24.7 (4.8)	8.5 (0.9)	15.3 (1.8)	24.3 (9.4)	8 (2)
Iron (µg/L)	360 (64.4)	203.3 (40.3)	46.7 (35.5)	133.3 (26.1)	190 (30.7)	53.3 (39.4)
Lead (µg/L)	133.3 (77.4)	85.3 (63.1)	23.9 (16.4)	45.1 (28.7)	34 (12.6)	14.1 (7.2)
Mercury (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Nickel (µg/L)	41.3 (6.9)	19.3 (4.7)	6.4 (1.1)	12 (1.5)	21 (7.4)	5.8 (1.2)
Silver (µg/L)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Zinc (µg/L)	336.7 (52.1)	170 (47.5)	56 (11.2)	104.7 (22.6)	156.7 (34.5)	50.7 (13.9)

TABLE IV-2. Average values of constituent concentrations in parking lot runoff compared to both highway runoff and wet-weather stormwater runoff concentrations (FHWA 1996, Kinnetic Laboratories, Inc and SCCWRP 2001, Barrett *et al.* 1995).

Constituent	City of Long Beach Paved Parking Lot Mean Concentrations	Range of Mean FHWA Highway Runoff Concentrations	City of Long Beach Wet Weather Stormwater Runoff Range of Concentrations
Suspended Solids (mg/L)	36	437 – 1147	24 - 350
Metals (Total)			
Cadmium (µg/L)	1	ND – 40	0.5 - 3.3
Chromium (µg/L)	3.1	ND – 40	1.9 - 10
Copper (µg/L)	28	22 – 7,033	8.9 - 78
Iron (µg/L)	524	2,429 – 10,300	350 - 9,700
Lead (µg/L)	45	73 – 1,780	10 - 59
Nickel (µg/L)	17	53	2.1 - 18
Zinc (µg/L)	293	56 – 929	51 - 960

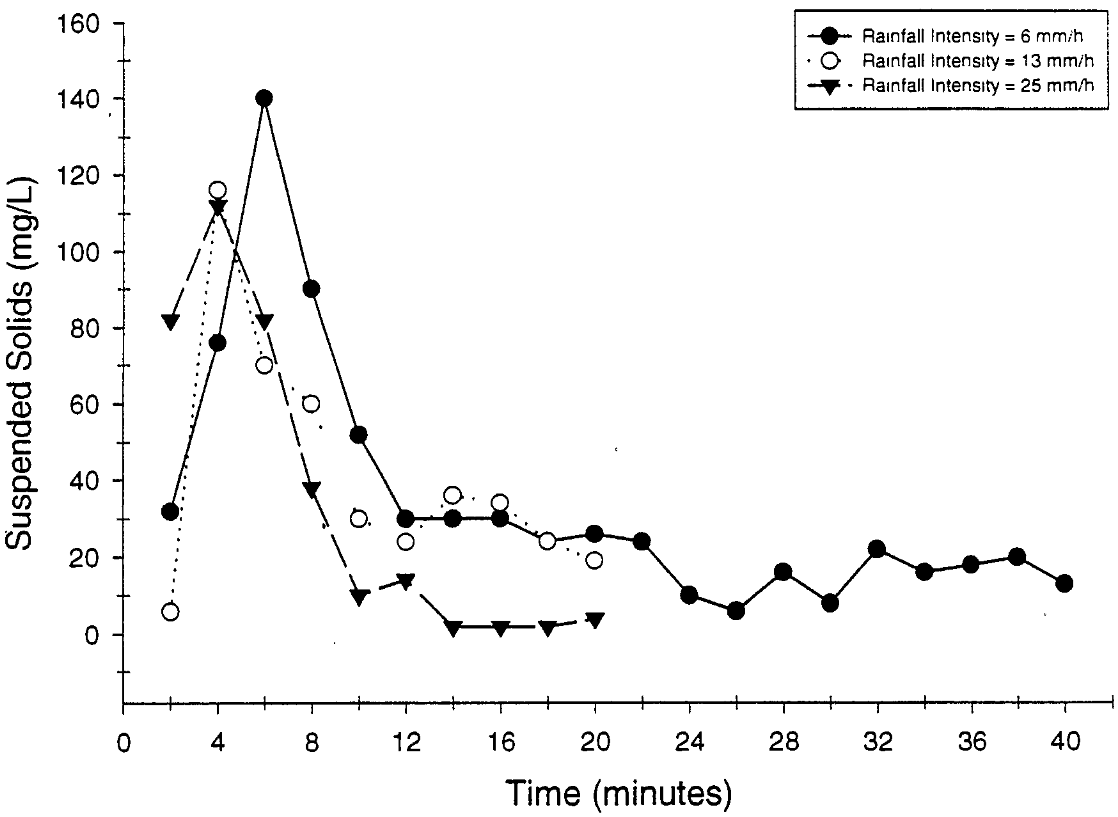

FIGURE IV-1. Wash-off patterns of suspended solids concentrations (mg/L) with 6, 13 and 25 mm/hr simulated rainfall intensities.

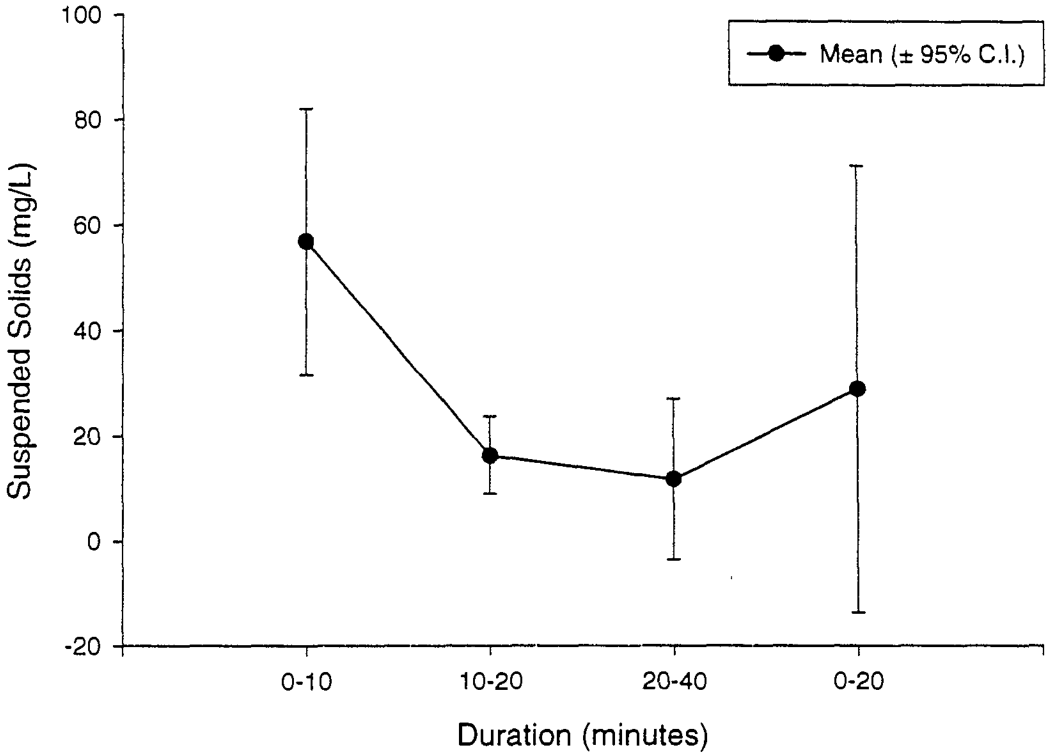

FIGURE IV-2. Concentrations of suspended solids (mg/L) versus rainfall duration. All intensities are pooled. Data are presented as mean values (± 95% C.I.).

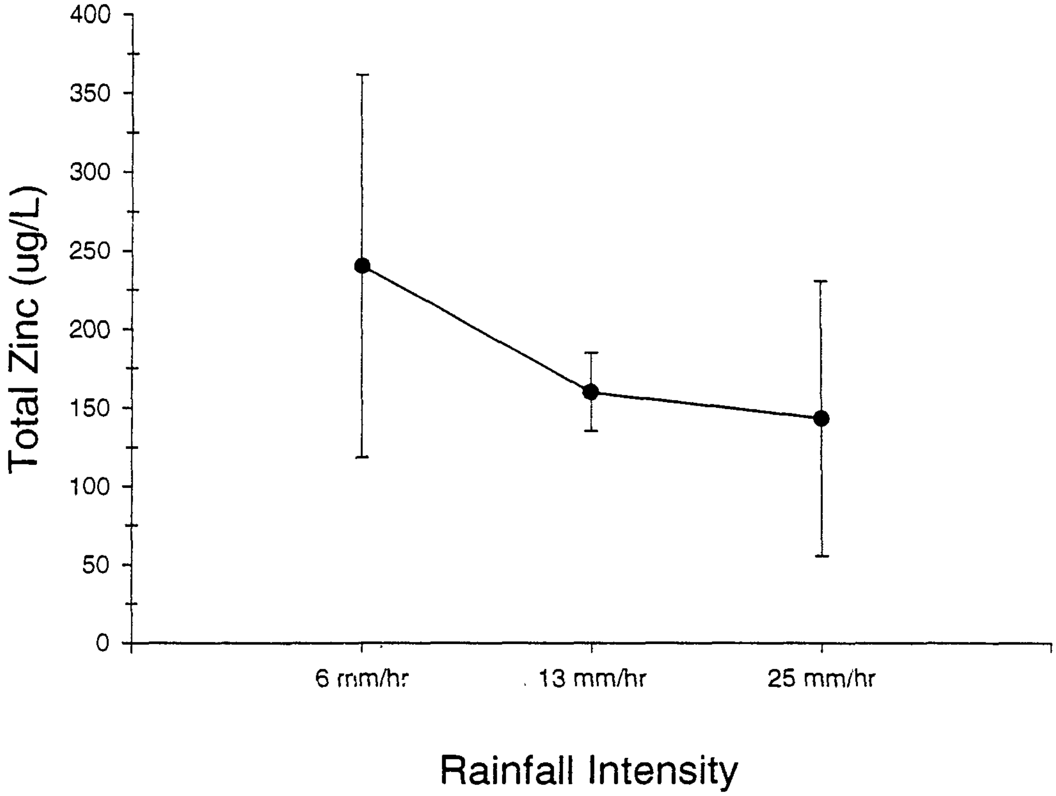

FIGURE IV-3. Mean concentration of total zinc (ug/L) (± 95% C.I.) versus rainfall intensities. All durations are pooled.

V. TOXICITY RESULTS

Comparative Toxicity to Marine Species

Each of the four test methods detected toxicity in the samples from sampling periods T2 and T3 (Table V-1). Toxicity was widespread among the three species used: sea urchins, mysids, and bacteria. Five of the six samples tested were toxic to all three species.

Responses to the month 2 samples (T2) were similar among the three samples tested (Figure V-1). Mysid survival was affected only at the highest concentration tested, 50%. The sea urchin fertilization and chronic Microtox tests always detected toxicity at lower concentrations, with the Microtox test showing the highest magnitude of response relative to the controls.

The relative responses of the three species showed a different pattern of response to the samples tested after 3 months of accumulation (Figure V-2). Mysid survival was less responsive, compared to the month 2 samples that were tested. In addition, the sea urchin test usually showed a greater relative response compared to the chronic Microtox test for the month 3 samples.

The mysid survival/growth and Microtox acute tests were the least sensitive methods overall. The NOECs for these two methods were usually ≥25% and no toxicity was detected in 1 or 2 samples (Table V-1). In many cases, less than a 50% response was measured in the highest sample concentration tested (EC50>50%). Mysid growth was a more sensitive response than survival in three of the five toxic samples (Table V-1). The reduction in mysid weight was relatively small, however, and did not exceed a 50% effect for any of the samples. The greatest growth effect was measured for sample 202B (T2), where the weight of mysids exposed to 25% sample was 57% of the control.

The sea urchin fertilization and chronic Microtox test methods were substantially more sensitive. Every sample tested was toxic to both species and the NOECs for these tests ranged from <3 to 12% (Table V-1). The magnitude of response was similar between these tests; the EC50s ranged from 14->25% and 7-31% for the sea urchin and chronic Microtox tests, respectively.

Accumulation Time Effects

Toxicity to sea urchin sperm was detected in every sample collected during the accumulation study (Table V-2). The magnitude of toxicity was similar among most samples collected within a time period. For example, the toxic units (TU) for the T3 samples were within a factor of 2 of each other and ranged from 4.3 TU to 8.8 TU. Samples collected at T2 showed the greatest variability in toxicity within a time interval. Toxicity for these samples ranged from <4 TU to 10.8 TU. In all other cases, there was no more than a two-fold range of toxicity within a time interval (Table V-2).

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Substantial differences in the mean level of toxicity were present among time intervals. The lowest level of toxicity and least variability were present in samples collected immediately after pressure washing the study sites (T0). All of the T0 samples had the highest NOEC (25%) and lowest toxic units (<2 TU to 2.7 TU) measured in the study (Table V-2). The mean toxicity in the T0 group (2.0 TU) was significantly lower than the average toxicity of all other groups, which ranged from 5.0 to 12.1 TU (Figure V-3).

The temporal variation of toxicity was similar to the pattern observed for most of the chemical constituents. The highest magnitude of toxicity was present in samples collected following 1 month of accumulation (T1). The average toxicity of these samples was significantly greater than the toxicity at T0 or prior to cleaning (Figure V-3). Toxicity in the T2 and T3 samples declined by approximately 50% relative to T1, but these differences were not statistically significant from the T1 mean.

Variations in traffic use did not have a consistent effect on toxicity. High traffic use sites tended to have greater toxicity in the T1 samples, but the differences were relatively small (Figure V-4). An opposite trend was observed for the T2 and T3 samples. Toxicity within these intervals tended to be approximately 50% lower in samples from high traffic areas (Figure V-4).

Variation in maintenance level produced no discernible effect on toxicity of samples from most of the sampling events. Maintained high use sites were approximately twice as toxic at T2 (Figure V-4). The difference in toxicity between maintained and unmaintained sites was much less for all other sampling events.

Rainfall Intensity and Duration Effects

Sea urchin fertilization tests of the runoff samples collected during the intensity and duration study detected toxicity in every sample. The magnitude of toxicity was quite variable among treatments, ranging from 2.6 to 13.8 TU (Table V-3). However, little variability in toxicity was present among the samples within a treatment group. Less than a two-fold difference in toxicity was found among the three replicate samples within each intensity/duration group (Table V-3).

Differences in both rain intensity and duration had a pronounced and predictable effect on toxicity. Toxicity was inversely related to both of these factors, as illustrated in Figure V-5. For the same duration interval (i.e., 10-20 min), toxicity decreased as rainfall intensity increased from 6 mm/hr to 25 mm/hr. Samples collected later in the rainfall event at the same intensity always contained less toxicity.

The toxicity data also indicated that an interaction between intensity and duration was present. For example, the relative decrease in toxicity between the 0-10 min and 10-20 min intervals at 6 mm/hr was less (31 %) than the change (54 %) measured at an intensity of 25 mm/hr.

The magnitude of toxicity present in the various intensity/duration groups was determined in large part by the portion of the rainfall event captured in the sample. This relationship is evident when toxicity is plotted relative to the volume of simulated rainfall represented by a sample (Figure V-6). For example, the highest toxicity was present in samples that contained runoff from the first 15 L of flow. A similar amount of toxicity was present in samples that contained runoff corresponding to 13.2-26.4 L of runoff. even though the intensity of the simulated rainfall varied four-fold (6-25 mm/hr).

Toxicant Characterization

Phase I TIEs were conducted on one runoff sample from each of the T2 and T3 sampling events. Similar results were obtained for each sample (Figures V-7 and V-8): both the EDTA addition and C-18 extraction treatments eliminated most of the toxicity. Extraction of nonpolar organic compounds from the samples using a C-18 column was the most effective treatment; this procedure eliminated essentially all of the toxicity. Addition of EDTA to complex cationic trace metals (e.g., copper and zinc) eliminated 44 to 76% of the toxicity.

The two other TIE procedures, the removal of particles and addition of sodium thiosulfate (to reduce oxidants), were not effective in reducing toxicity. The TIE results also indicated that toxicity in the samples was stable during short-term storage; no significant change in toxicity was found between the initial measurement and the TIE baseline measurement conducted 2 d later.

Chemical analysis of the TIE samples indicated that detectable concentrations of three potentially toxic constituents (zinc, copper, and total PAH) were present. Of these three constituents, only zinc was present at a sufficiently high concentration to cause substantial toxicity (Figures V-7 and V-8). Limited data are available that describe the toxicity of individual PAHs to sea urchin sperm, but unpublished SCCWRP data for several PAHs indicates that concentrations of ≥100 µg/L are needed to produce toxicity. The PAH concentrations in these samples were below 30 µg/L, which suggested that these organics were unlikely to be responsible for much of the sample toxicity.

Correlation analysis of the chemistry and toxicity data for all test samples supported the hypothesis that the runoff toxicity was likely related to trace metals. Significant correlations were obtained for both the total and dissolved forms of most metals, with no significant correlation between PAH concentration and toxicity (Table V-4). Correlations were highest (>0.6) for total and dissolved chromium, total aluminum, total nickel, and total and dissolved zinc.

Plots of the chemistry and toxicity data corroborate the correlation results. A clear trend of increased toxicity at higher concentrations of total Cr or dissolved Zn is evident (Figure V-9). However, variations in the concentration of TSS or PAH show little relationship with toxicity.

The correlation results indicate that the concentrations of the primary cause of toxicity in these samples covary with the metals concentrations, but they do not prove that metals are the cause. Other (unmeasured) constituents that occur with metals in runoff may be the cause of toxicity.

Elution of the C-18 columns with solvent recovered a portion amount of toxicity (Figure V-10). The eluate was toxic when tested at a concentration that was 1.5-3x greater than the original concentration of the test sample. The inability of solvent elution to recover all of the toxicity removed could be due to several factors, inability of the solvent to remove all of the organics from the column, degradation of the toxicants during storage of the column between extraction and elution, and the binding of inorganic toxicants that are not soluble in the solvent (e.g., metals) to the column.

The binding of copper and zinc to C-18 columns has been observed in a previous study (Schiff *et al.* 2001); thus, an attempt was made to elute metals from the C-18 columns with an acid solution. The acid eluate of both columns was much more toxic than the solvent eluates (Figure V-10). All of the acid eluates, tested at 0.8-3x of the original sample concentration, were highly toxic to sea urchin sperm. Some toxicity was present in the blank for the acid eluate sample, but the unusual dose response pattern for this sample suggests that this toxicity may be an outlier.

The concentration of dissolved zinc in the runoff samples ranged from 140 to 620 ug/L. The toxic units of zinc corresponding to these concentrations (calculated using laboratory-derived EC50s for these metals) is greater than the number of toxic units measured using the sea urchin fertilization test (Figure V-11). This result indicates that a sufficient concentration of zinc was present in each of the runoff samples to account for all of the toxicity measured. Dissolved copper in these samples ranged from 0 to 37 µg/L, corresponding to less than 10% of the toxicity of any sample.

Discussion

The results of this study indicate that runoff from transportation land uses, such as parking lots and roadways, are an important source of toxicity in urban runoff. All of the simulated runoff samples measured in the present study were toxic, and the magnitude of toxicity was usually higher than that measured in other urban stormwater samples. For example, composite stormwater samples collected from the Los Cerritos Channel in Long Beach, California, during 2001 contained fewer than 4 TU (Kinnetic Laboratories, Inc. and SCCWRP 2001), whereas nearly all parking lot runoff samples contained greater than 4 TU. Samples from the Los Cerritos Channel contained the highest magnitude of toxicity among the Long Beach stormwater sampling locations during the 2000/2001 NPDES monitoring program.

The high relative sensitivity of the sea urchin fertilization test found in this study are similar to those obtained in other recent studies. Two previous studies have used multiple marine species to measure the toxicity of urban stormwater. In each case, the sea urchin fertilization test was more sensitive than the 7-d mysid survival and growth test (Kinnetic Laboratories, Inc. and SCCWRP 2001, SCCWRP 1999).

The Microtox chronic test was similar in sensitivity to parking lot runoff as the sea urchin fertilization test. Both test methods detected toxicity in all six samples analyzed as part of the method comparison study (Table V-1). In addition, the magnitude of toxicity, as indicated by the EC50, was similar between these two test methods. These results indicate that the chronic Microtox test procedure may be useful for stormwater toxicity monitoring and research. However, the acute Microtox is of limited value for stormwater assessment in Long Beach. The acute test failed to detect toxicity in several samples that contained approximately 5 TU of chronic Microtox toxicity.

The accumulation study results indicated that typical street/parking lot maintenance activities (i.e., sweeping) were not effective for reducing runoff toxicity. Manual sweeping of the study sites did not significantly affect runoff toxicity levels. However, more rigorous cleaning activities may be effective in reducing stormwater toxicity. For example, pressure washing of the study sites at the beginning of the experiment reduced the toxicity of the runoff by a factor of 3. Toxicity was not eliminated by pressure washing, indicating that more research is needed to identify the most effective methods for eliminating stormwater toxicity.

Toxicity measurements at different time intervals indicated that a toxicity first-flush effect was present. Runoff samples collected during the first 10 min of a rain event were approximately twice as toxic as runoff from later portions of the simulated storm (Figure V-5). This finding was in agreement with the results of chemical analyses of the samples, which showed the first portion of the runoff event to contain the highest constituent concentrations. These results indicate that stormwater treatment systems that capture or treat the initial portion of stormwater discharge from parking lots are likely to provide the greatest benefit in terms of reducing toxic constituents.

The results of the intensity and duration experiment also illustrate the importance of collecting a sample of known and representative composition for stormwater monitoring programs. Failure to capture the initial phase of stormwater runoff may underestimate the magnitude of toxicity present and variations in sample compositing methods may increase the variability in the results.

The toxicant characterization and identification experiments, though limited in number, suggested that parking lot runoff toxicity to sea urchins was due primarily to metals, especially zinc. These results are similar to the results of TIEs from other studies, which have identified zinc as a primary toxicant of concern in stormwater runoff from Ballona Creek in Los Angeles, California, and Chollas Creek in San Diego, California (Bay *et al.* 1999, SCCWRP 1999). The TIE experiments also determined that the toxic constituents of parking lot runoff were confined to the dissolved fraction, which is usually a more biologically available form than particulate metals. This finding has implications for the design of BMPs to reduce stormwater toxicity. The BMPs that are based primarily on particulate removal are not likely to be effective in reducing the toxicity of stormwater runoff from parking lots.

TABLE V-1. Comparison of toxicity test responses for three marine species. Data for the mysid test are based on the most sensitive of either the survival (s) or growth (g) endpoints, as indicated by the letter following the value.

			NOEC (%)				EC50 (%)			
		Use/	Sea		Microtox		Sea		Microtox	
Sample	Time	Maintenance	Urchin	Mysid	Acute	Chronic	Urchin	Mysid	Acute/	Chronic
202B	T2	H/U	12.5	<25g	6	6	>25	36.8s	>50	10.4
204A	T2	H/U	12.5	25s	6	12	19.7	37.5s	>50	15.9
201A	T2	H/M	3	25s	25	<3	13.5	42.4s	>50	6.7
203B	T3	H/U	6	25g	≥50	6	20.5	>50	>50	20.0
204B	T3	H/U	6	≥50	≥50	12	22.4	>50	>50	31.0
201B	T3	H/M	3	25g	25	<3	23.2	>50	>50	15.5

TABLE V-2. Summary of parking lot toxicity results during the accumulation study. Toxic units are calculated using either the sea urchin fertilization NOEC (TUc) or EC50 (TU). EC50s for the T0 (after cleaning) samples were estimated by graphical interpolation, EC50s for other samples were calculated using probit analysis.

Sample	Time	Use/Maintenance	NOEC (%)	TUc	EC50 (%)	TU
103B	T0	L/U (preclean)	3	33	20.4	4.9
204A	T0	H/U (preclean)	3	33	19.3	5.2
Mean	**T0**	**preclean**	**3**	**33**	**19.8**	**5.0**
101B	T0	L/U (postclean)	25	4	50[a]	2.0
103B	T0	L/U (postclean)	25	4	>50	<2.0
201A	T0	H/M (postclean)	25	4	37[a]	2.7
201C	T0	H/M (postclean)	25	4	46[a]	2.2
204A	T0	H/U (postclean)	25	4	44[a]	2.2
203B	T0	H/U (postclean)	25	4	53[a]	1.9
Mean	**T0**	**postclean**	**25**	**4**	**55.2**	**2.0**
102A	T1	L/U	<12	>8	8.7	11.5
104B	T1	L/U	<12	>8	10.9	9.2
101C	T1	L/M	<12	>8	10.7	9.3
202A	T1	H/U	<3	>33	8.2	12.2
203A	T1	H/U	<3	>33	7.2	13.9
201C	T1	H/M	<3	>33	6.1	16.4
Mean	**T1**		**<8**	**>13**	**8.6**	**12.1**
102B	T2	L/U	3	33	12.0	8.3
103A	T2	L/U	3	33	9.3	10.8
101A	T2	L/M	3	33	11.7	8.5
202B	T2	H/U	12	8	>25	<4
204A	T2	H/U	12	8	19.7	5.1
201A	T2	H/M	3	33	13.5	7.4
Mean	**T2**		**6**	**25**	**19.4**	**7.0**
103B	T3	L/U	3	33	13.5	7.4
104A	T3	L/U	3	33	12.4	8.1
101B	T3	L/M	3	33	11.4	8.8
203B	T3	H/U	6	17	20.5	4.9
204B	T3	H/U	6	17	22.4	4.5
201B	T3	H/M	3	33	23.2	4.3
Mean	**T3**		**4**	**28**	**17.2**	**6.3**

TABLE V-3. Toxicity to sea urchin sperm of parking lot runoff collected at different intensity/duration combinations. Samples representing up to four time intervals were collected at each intensity. The EC50 was calculated by linear interpolation of the fertilization data.

Sample	Intensity (mm/hr)	0-10 minutes EC50 (%)	0-10 minutes TU	10-20 minutes EC50 (%)	10-20 minutes TU	20-40 minutes EC50 (%)	20-40 minutes TU
502R1	6	6.5	15.4	10.5	9.5	27	3.7
505R2	6	8.5	11.8	10.5	9.5	29	3.4
507R3	6	7	14.3	10.5	9.5	28	3.6
Mean	**6**	**7.3**	**13.8**	**10.5**	**9.5**	**28.0**	**3.6**
503R1[a]	13			21[a]	4.8[a]		
504R2[a]	13			21[a]	4.8[a]		
509R3[a]	13			26[a]	3.8[a]		
Mean[a]	**13**			**22.7[a]**	**4.5[a]**		
506R1	25	17	5.9	34	2.9		
508R2	25	26	3.8	57	1.8		
513R3	25	14	7.1	32	3.1		
Mean	**25**	**19.0**	**5.6**	**41.0**	**2.6**		

[a]Samples representing a rainfall interval of 0-20 minutes.

TABLE V-4. Spearman correlation coefficients between sea urchin fertilization toxic units and runoff chemical parameters for all samples analyzed. N = 42 for all analyses.

Constituent	Correlation Coefficient	P value
TSS	0.4175	0.0062
Total PAH	-0.0006	0.9967
Dissolved Al	0.4707	0.0018
Total Al	0.6689	<0.0001
Dissolved Cd	0.4326	0.0044
Total Cd	0.4003	0.0088
Dissolved Cr	0.6932	<0.0001
Total Cr	0.7927	<0.0001
Dissolved Cu	0.4278	0.0049
Total Cu	0.5424	<0.0001
Dissolved Fe	0.3371	0.0293
Total Fe	0.3975	0.0094
Dissolved Pb	0.0280	0.8595
Total Pb	0.2708	0.0824
Dissolved Ni	0.4939	<0.0001
Total Ni	0.6375	<0.0001
Dissolved Zn	0.6293	<0.0001
Total Zn	0.6547	<0.0001

Mercury and silver are not included in the table because the chemistry values were all nondetectable.

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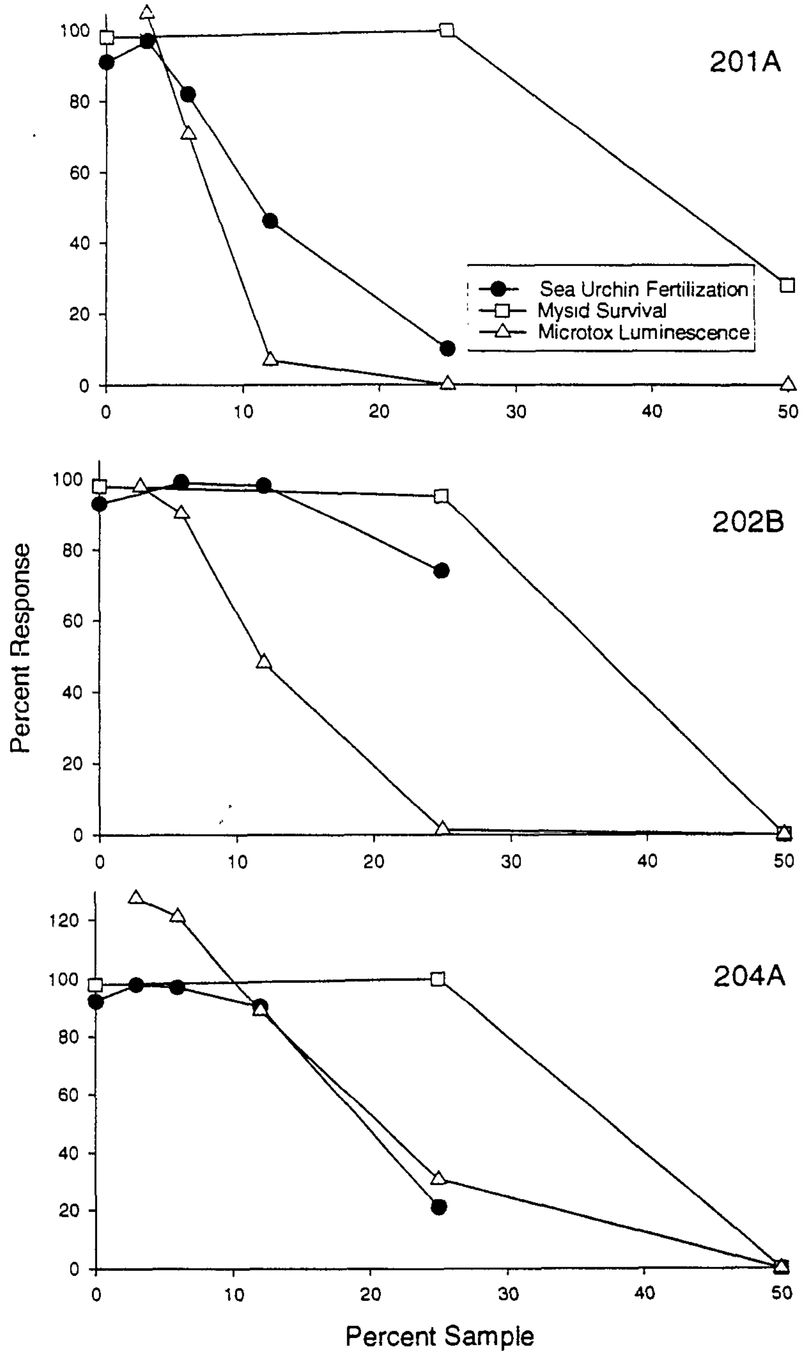

FIGURE V-1. Response of three marine species to runoff samples after 2 months of accumulation. Only data for the chronic version of the Microtox test are shown.

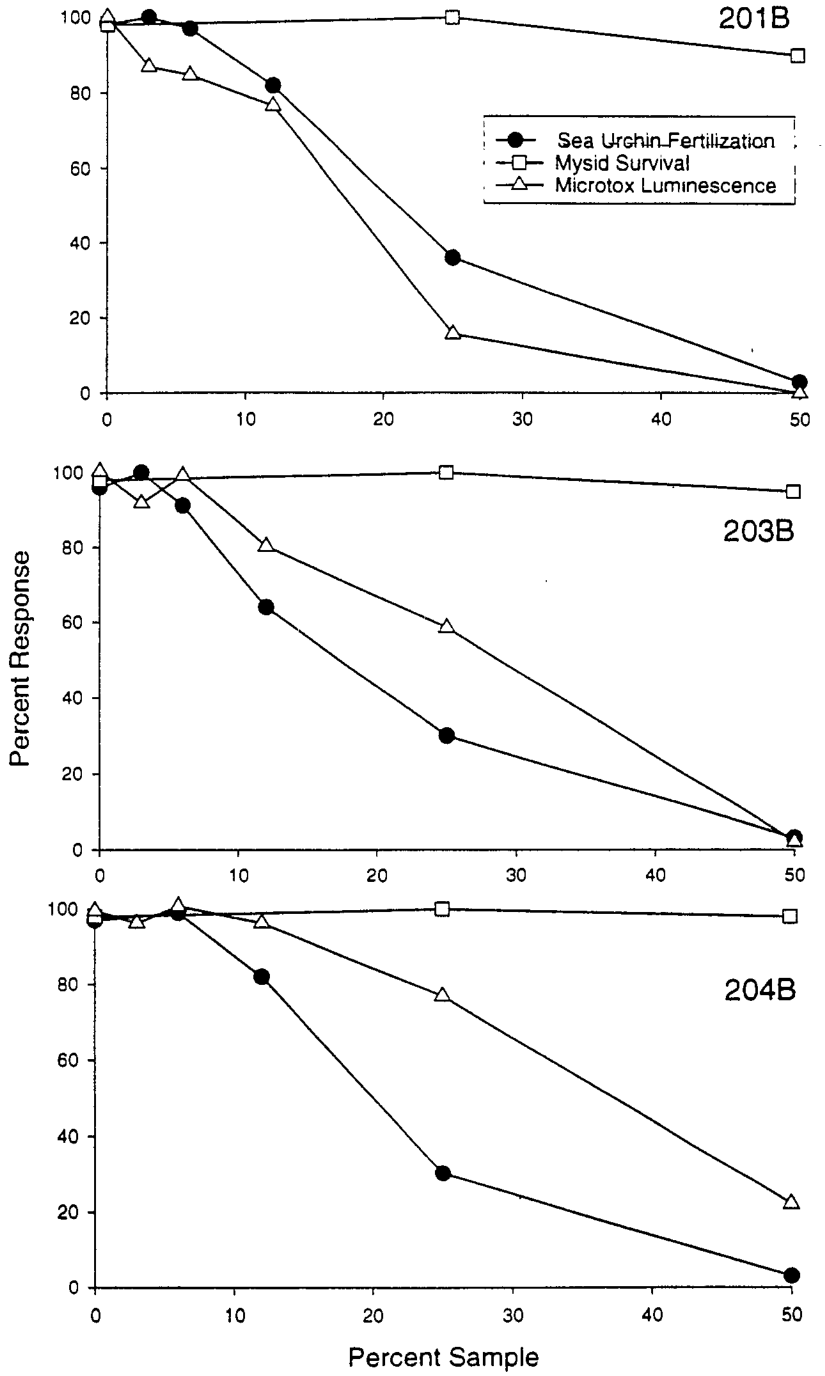

FIGURE V-2. Response of three marine species to runoff samples after 3 months of accumulation. Only data for the chronic version of the Microtox test are shown.

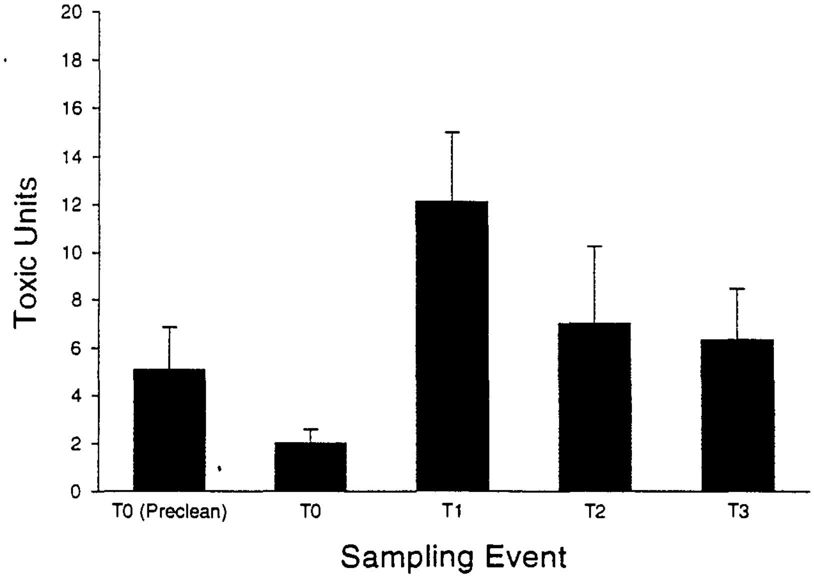

FIGURE V-3. Variation in parking lot runoff toxicity using sea urchin sperm during a 3-month accumulation period (maintenance and use groups combined). Values are the mean + upper 95% confidence interval.

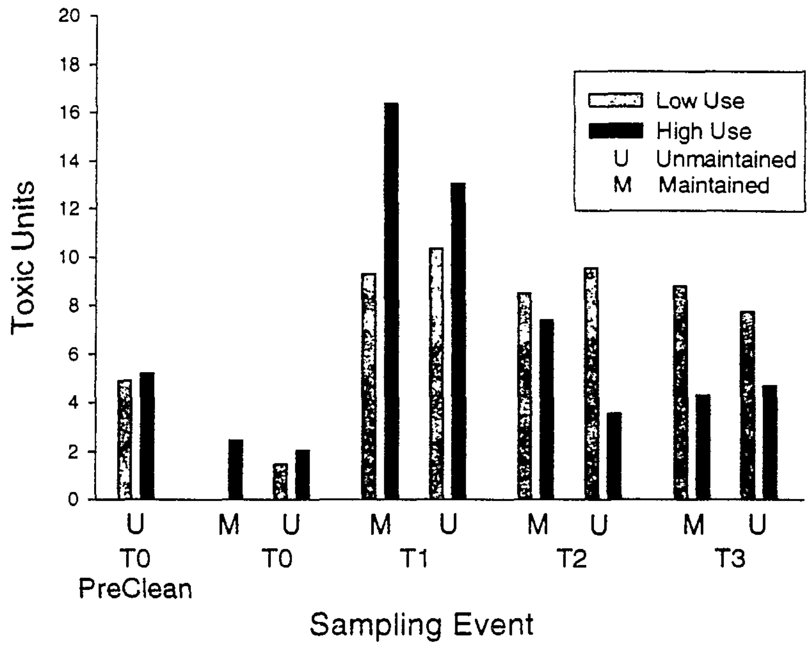

FIGURE V-4. Toxicity of parking lot runoff samples to sea urchin sperm during a three-month accumulation period. Data are the means of two samples except for the maintained sites, where n=1.

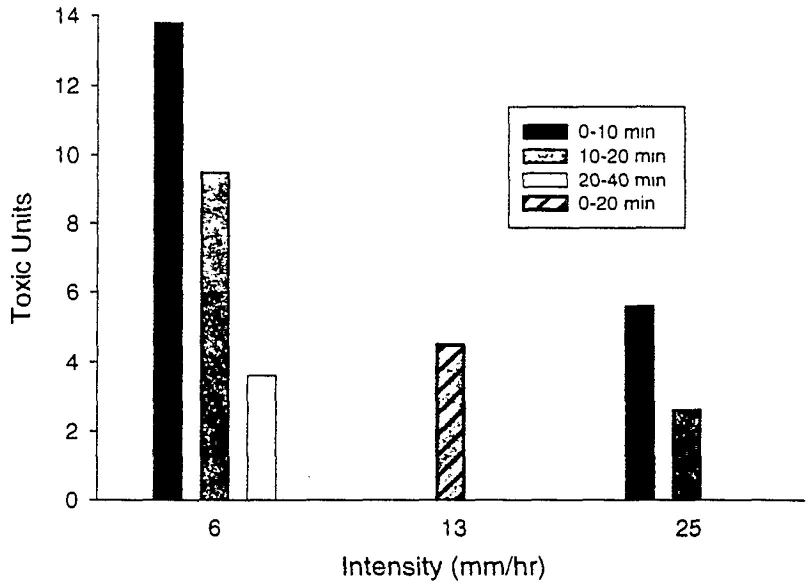

FIGURE V-5. Average toxicity of runoff samples collected at different intensity and duration combinations.

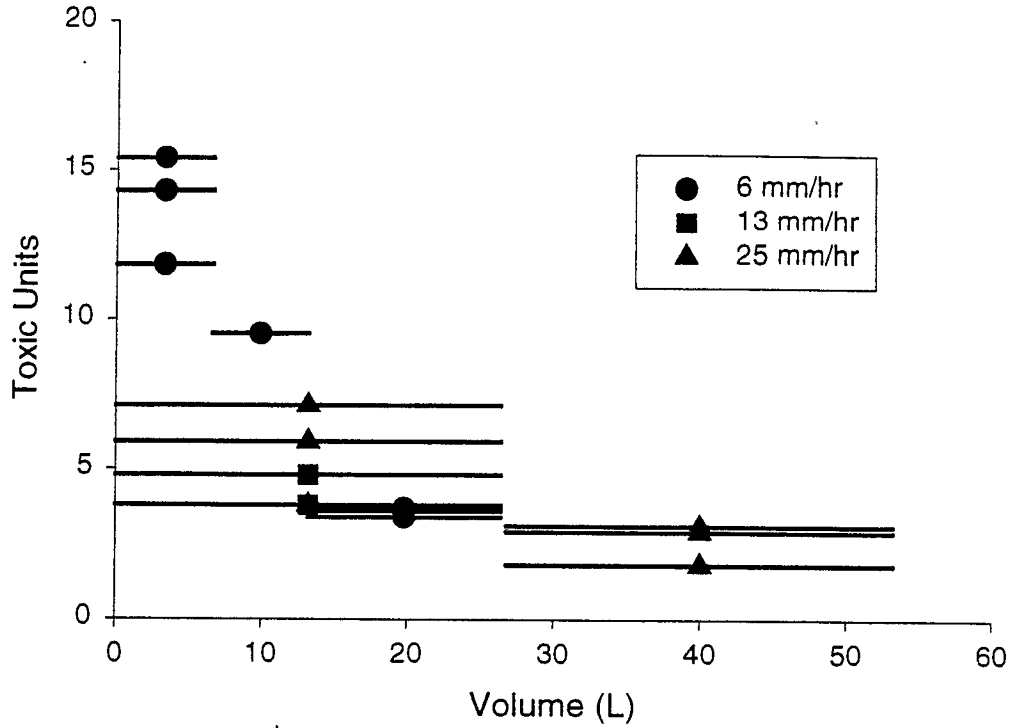

FIGURE V-6. Relationship of toxicity to portion of the rainfall event sampled. The horizontal lines indicate the portion of the runoff flow sampled, with 0 liters representing the start of runoff.

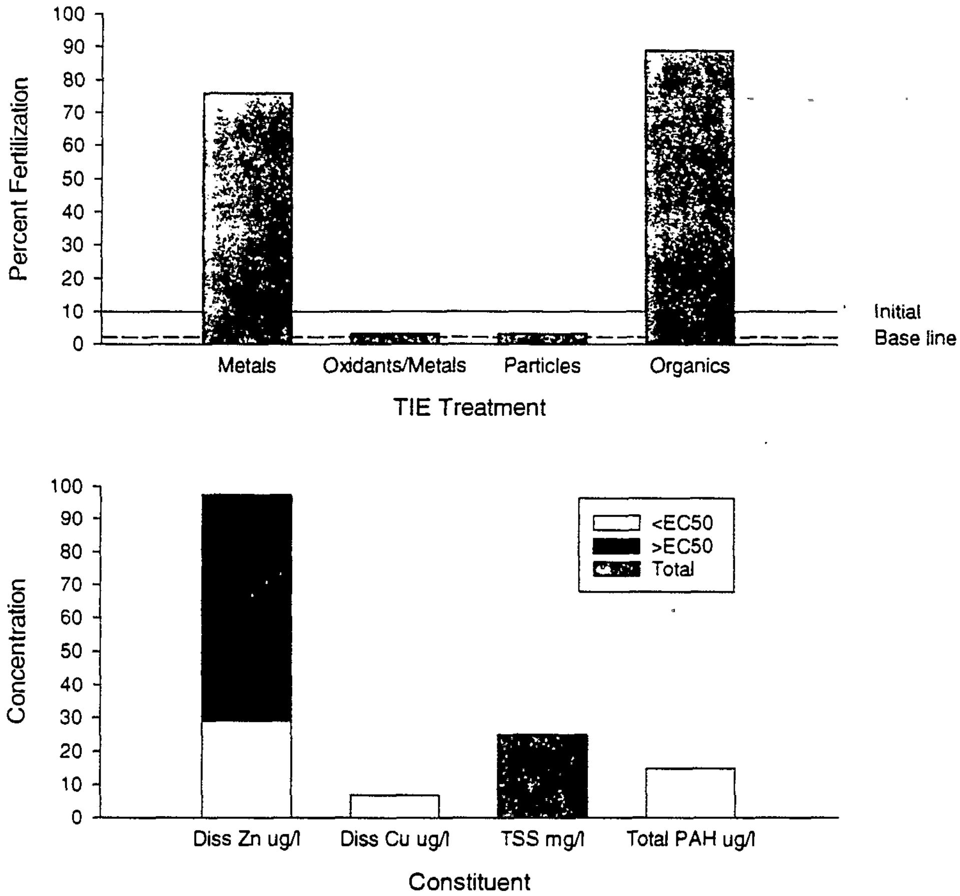

FIGURE V-7. Summary of TIE results for a runoff sample (201A) following 2 months of accumulation. Constituent concentrations shown in the bottom plot have been adjusted for the dilution of the sample (0.25x) used for toxicity testing. The black portion of each bar indicates the portion of the concentration that is greater than the EC50 for the constituent.

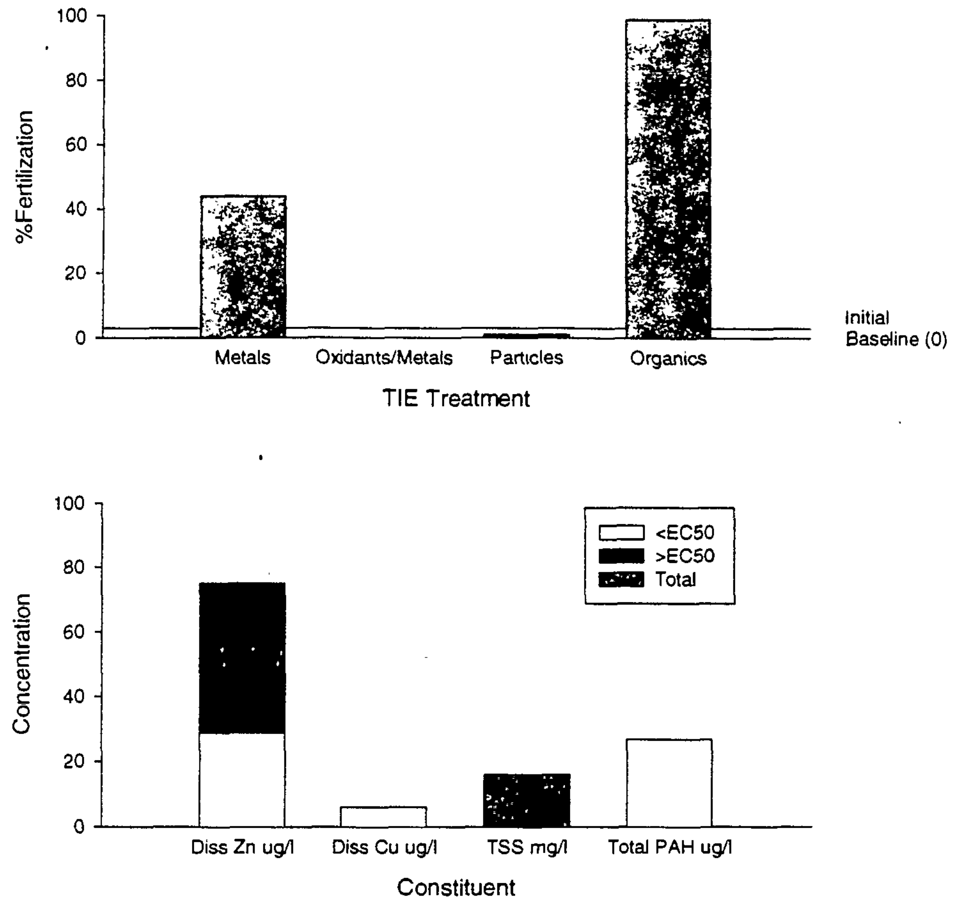

FIGURE V-8. Summary of TIE results for a runoff sample (203B) following 3 months of accumulation. Constituent concentrations shown in the bottom plot have been corrected for the dilution of the sample (0.5x) used for toxicity testing. The black portion of each bar indicates the portion of concentration that is greater than the EC50 for the constituent.

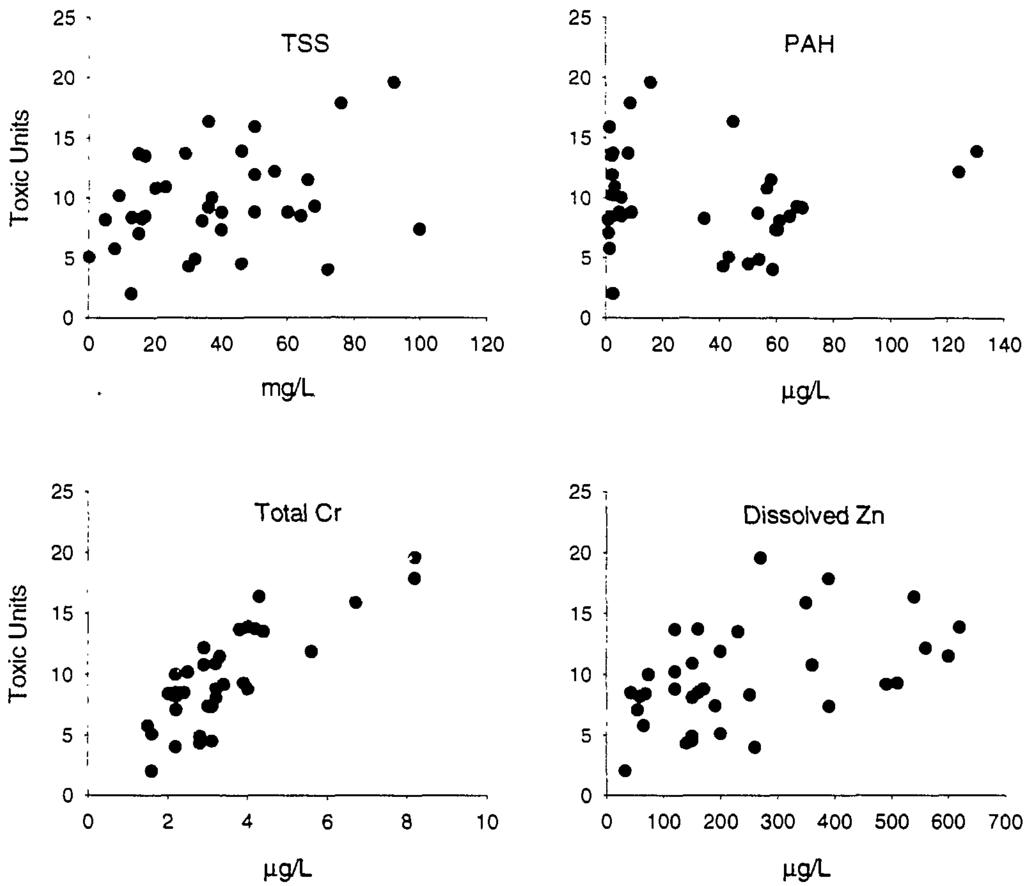

FIGURE V-9. Relationship of toxicity (sea urchin fertilization test) to concentration for selected runoff constituents.

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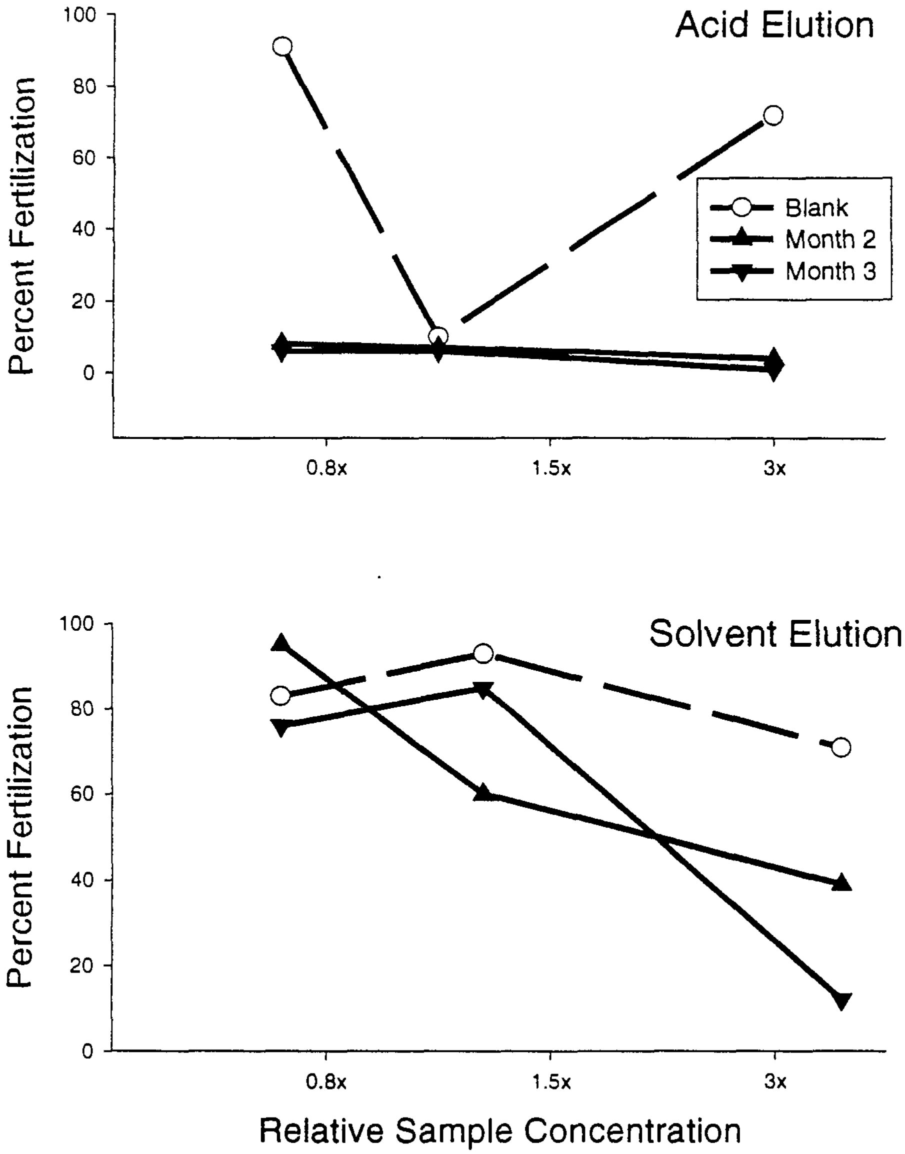

FIGURE V-10. Toxicity of acid or solvent eluates of C-18 column used for TIE. Concentration is expressed relative to the highest concentration tested in the Phase I TIE test.

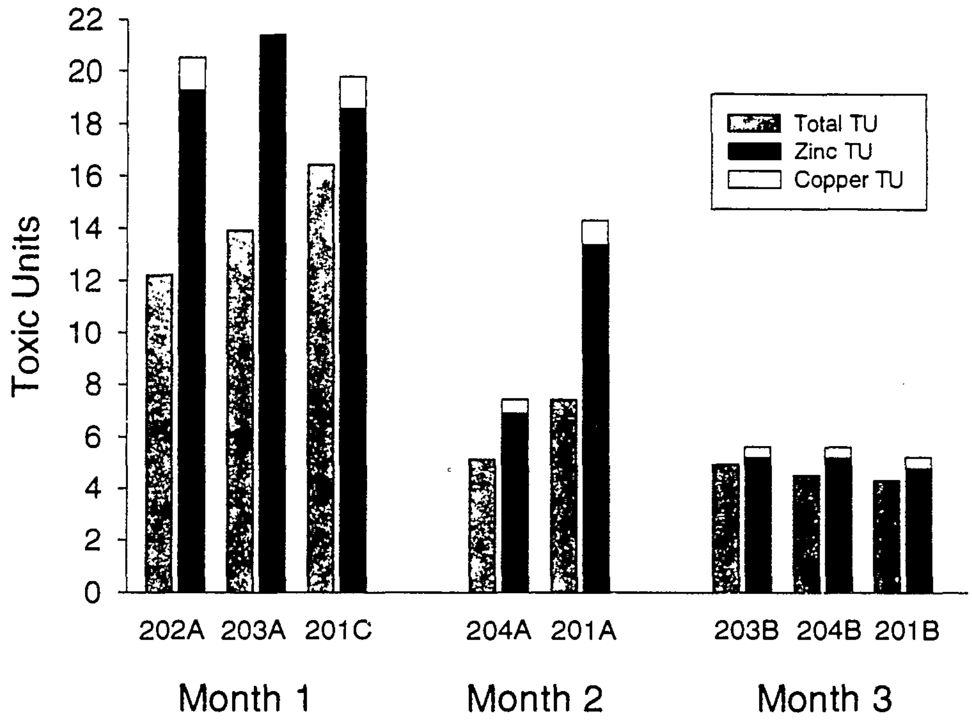

FIGURE V-11. Comparison of measured and calculated toxic units for runoff samples analyzed during the accumulation experiment. Calculated toxic units are based on the concentration of dissolved zinc and copper in the sample.

VI. CONCLUSIONS

- *Accumulation of most constituents occurred within 28 d.*

  Seventeen of 18 constituents had increased concentrations relative to the T0 sampling, ranging from 20-181%, in runoff samples collected after one month of accumulation. Zinc showed the highest accumulation, increasing by nearly a factor of 3 during the antecedent time period. Only total PAH did not increase; concentrations of PAH declined by 20%.

  -- The variability in temporal patterns remains unexplained.

  Constituent concentrations peaked during the first month of accumulation and then decreased in months 2 and 3. Physical factors other than those addressed in this study may play a role in increasing or decreasing the accumulation of constituents on parking lot surfaces including human activities, indirect vehicle deposition, wind, and atmospheric deposition, among others. This study measured time over a period of months; shorter time scales (days to weeks) are needed to explain these types of patterns and interactions.

- *Parking lot usage did not affect the accumulation of runoff constituents.*

  Similar concentrations of TSS, trace metals, and total PAH were observed between parking lots with ≤ 4 cars per hour and parking lots with > 5 cars per hour.

- *Parking lot maintenance did not affect the accumulation of runoff constituents.*

  Parking lots where street sweeping was employed as a maintenance activity had similar runoff concentrations compared to parking lots without street sweeping. Improved street sweeping technology or alternative BMPs will be required to reduce concentrations of contaminants in runoff. Current street sweeping technology may be effective, however, in reducing other types of runoff-transported pollution such as trash or debris.

- *Pressure washing appeared to be partially effective in reducing the accumulation of runoff constituents.*

  Mean constituent concentrations in parking lot runoff were lower after pressure washing compared to mean constituent concentrations in parking lot runoff immediately following pressure washing. Some constituents, in particular zinc, were reduced by as much as 50%.

- *Runoff constituent concentrations were inversely correlated with rainfall duration and intensity. Rainfall duration was more important than intensity during this study.*

  The TSS concentrations varied by one order of magnitude between samples collected at 2 min and samples collected 12 min after the onset of rain, indicating the presence of a first flush. Moreover, more than 75% of the TSS load was washed off in the first 15 min of the simulated storms. The "first-flush" effect was more pronounced during less intense simulated rain events, but the importance of rainfall intensity decreased with longer storm duration.

- *Toxicity was consistently measured in parking lot runoff, but not all species responded similarly to exposure to runoff samples.*

  One hundred percent of simulated runoff samples elicited toxic responses. The sea urchin and marine bacteria were the most sensitive organisms; the mysid was the least sensitive organism. The level of toxicity observed in samples exposed to parking lot runoff was higher than the level observed during the Long Beach wet-weather monitoring program.

- *Toxicity patterns corresponded with constituent accumulation and rainfall intensity/duration patterns.*

  Toxicity in runoff samples increased by a factor of six after one month of accumulation. The magnitude of toxicity between runoff from high-use and low-use parking lots showed no consistent difference. Similarly, the magnitude of toxicity between parking lots with or without street sweeping was similar. A toxicity first-flush effect was also present in runoff samples collected during the first 10 min of a rain event. Runoff samples collected during this time interval were twice as toxic as runoff samples collected from later portions of the simulated storm.

- *Trace metals were an important contributor to toxicity.*

  The TIEs identified trace metals, particularly zinc, as the constituent responsible for toxicity in the purple sea urchin fertilization test. This conclusion was based upon the following findings: (1) complexation of trace metals completely removed toxicity; (2) concentrations of dissolved zinc were sufficient to induce toxic responses; and (3) variations in zinc concentrations among samples were significantly correlated with toxic responses.

VII. RECOMMENDATIONS

- *Parking lot BMPs that focus on initial storm flows will be most effective.*

  A large first-flush effect was observed during this study. Suspended solids concentrations were highest and nearly 75% of the mass emissions occurred in the first 15 min of the simulated rainfall events. Capturing or treating these initial storm flows, particularly at relatively small temporal scales (0-15 min), would likely be most effective at reducing concentrations and loads of runoff constituents.

- *Managers should give priority to reducing dissolved trace metals in runoff treatment programs.*

  Dissolved trace metals, in particular zinc, were identified as the constituents responsible for toxicity to marine organisms such as the purple sea urchin. This finding has been observed in wet-weather discharges from watersheds throughout southern California. Most structural BMPs today do not attempt to ameliorate dissolved constituents in wet-weather runoff.

- *Additional maintenance strategies need to be tested.*

  Parking lot sites that received street sweeping every two weeks showed no difference when compared to parking lot sites that received no street sweeping. However, some moderate decreases in constituent concentrations were observed in runoff samples following pressure washing as a maintenance activity. Additional maintenance strategies, such as, improved street sweepers (i.e. regenerative air sweepers), should be evaluated to assess their effectiveness. Existing maintenance strategies should be retested using additional variable factors (i.e., land uses, constituents, antecedent dry periods, etc.)

- *The accumulation study design needs to be refined.*

  A significant increase in constituent concentrations and toxicity was observed after one month of accumulation. However, most constituent concentrations and some toxicity levels decreased in subsequent months, indicating that secondary factors may influence the accumulation of toxics on parking lot surfaces. Future studies should attempt to account for these factors by measuring wind speed and direction, rainfall, and other variables while decreasing the time interval between sampling events.

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New York SW Management Manual -

Chapter 4: Unified Stormwater Sizing Criteria

4.1 Introduction

This chapter presents a unified approach for sizing SMPs in the State of New York to meet pollutant removal goals, maintain groundwater recharge, reduce channel erosion, prevent overbank flooding, and control extreme floods. For a summary, please consult Table 4.1 below. The remaining sections describe the four sizing criteria in detail and present guidance on how to properly compute and apply the required storage volumes. Justification for the selected sizing criteria can be found in the Technical Support Memorandum submitted to the New York DEC on September 5th, 2000.

Table 4.1. Proposed New York Stormwater Sizing Criteria

Water Quality (WQ_v)	**90% Rule:** $WQ_v = [(P)(R_v)(A)]/12$ $R_v = 0.05+0.009(I)$ I = Impervious Cover (Percent) Minimum Rv = 0.2 P = 90% Rainfall Event Number (See Figure 4.1) A = site area in acres
Channel Protection (Cp_v)	**Default Criterion:** Cp_v = 24 hour extended detention of post-developed 1-year, 24-hour storm event. **Option for Sites Larger than 50 Acres:** Distributed Runoff Control - geomorphic assessment to determine the bankfull channel characteristics and thresholds for channel stability and bedload movement.
Overbank Flood (Q_p)	Control the peak discharge from the 10-year storm to 10-year predevelopment rates.
Extreme Storm (Q_f)	Control the peak discharge from the 100-year storm to 100-year predevelopment rates. Safely pass the 100-year storm event.

Note: The local review authority may waive channel protection, overbank flood, and extreme storm requirements in some instances. Guidance is provided with each of the these stormwater practices

Section 4.2 Water Quality Volume (WQ_v)

The Water Quality Volume (denoted as the WQ_v) is designed to improve water quality sizing to capture and treat 90% of the average annual stormwater runoff volume. The WQ_v is directly related to the amount of impervious cover created at a site. Contour lines of the 90% rainfall event are presented in Figure 4.1.

The following equation can be used to determine the water quality storage volume WQ_v (in acre-feet of storage):

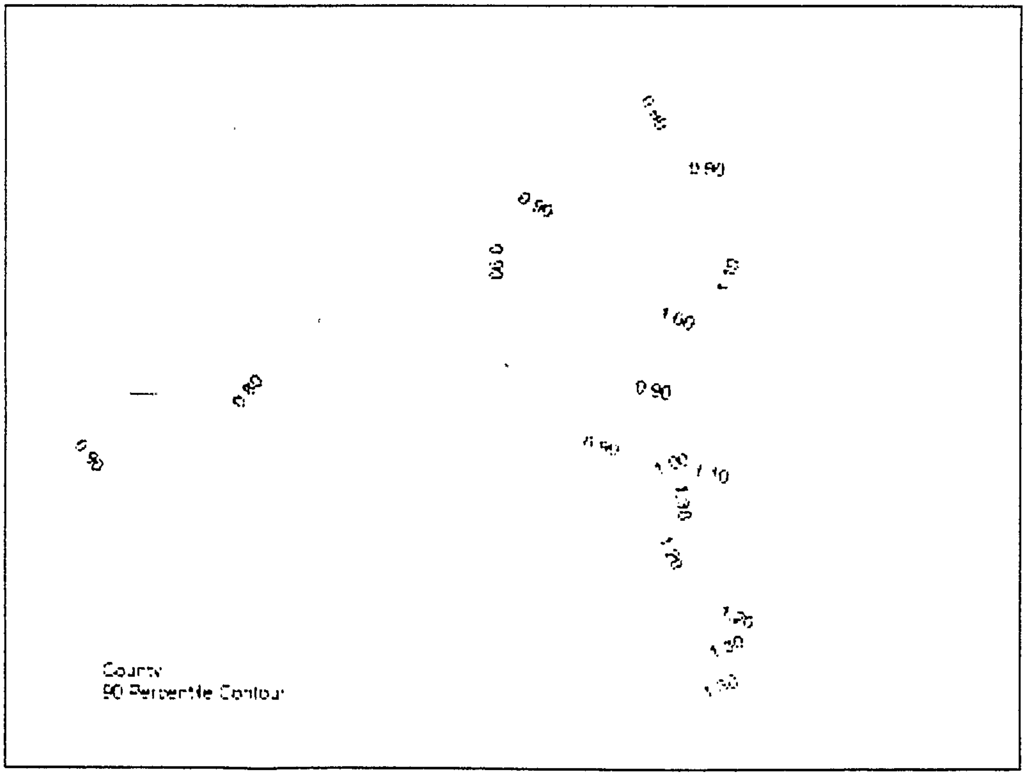
$$WQ_v = \frac{(P)(R_v)(A)}{12}$$

where:

WQ_v	= water quality volume (in acre-feet)
P	= 90% Rainfall Event Number (see Figure 4.1)
R_v	= 0.05 + 0.009(I), where I is percent impervious cover
A	= site area in acres

A minimum WQ_v of 0.2 inches per acre shall be met at residential sites that have less than 17% impervious cover.

Figure 4.1 90% Rainfall in New York State



The water quality criterion presented here assumes that sizing practices using these volumes, and using the practices presented in Table 5.1, using the technical support provided in this manual will by default meet water quality objectives. In some jurisdictions, on-site loading is required to demonstrate removal of specific pollutants. As an aid to these communities, Appendix A of this manual includes a discussion of a method for calculating pollutant export loads from development sites. This method, known as the "Simple Method," provides estimates for stormwater runoff pollutant loads for urban areas using a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. Please consult Appendix A for a more detailed discussion of the Simple Method and its applications for water quality.

Basis For Design for Water Quality

As a basis for design, the following assumptions may be made:

- *Measuring Impervious Cover:* the measured area of a site plan that does not have permanent vegetative or permeable cover shall be considered total impervious cover. Impervious cover is defined as all impermeable surfaces and includes: paved and gravel road surfaces, paved and gravel parking lots, paved driveways, building structures, paved sidewalks, and miscellaneous impermeable structures such as patios, pools, and sheds. Porous or modular block pavement may be considered 50% impervious. Where site size makes direct measurement of impervious cover impractical, the land use/impervious cover relationships presented in Table 4.2 can be used to initially estimate impervious cover.

Table 4.2. Land Use and Impervious Cover (Source: Cappiella and Brown, 2001)

Land Use Category	Mean Impervious Cover
Agriculture	2
Open Urban Land*	9
2 Acre Lot Residential	11
1 Acre Lot Residential	14
1/2 Acre Lot Residential	21
1/4Acre Lot Residential	28
1/8 Acre Lot Residential	33
Townhome Residential	41

Table 4.2. Land Use and Impervious Cover (Source: Cappiella and Brown, 2001)	
Land Use Category	**Mean Impervious Cover**
Multifamily Residential	**44**
Institutional**	**31-38%**
Light Industrial	**50-56%**
Commercial	**70-74%**
* Open urban land includes developed park land, recreation areas, golf courses, and cemeteries. ** Institutional is defined as places of worship, schools, hospitals, government offices, and police and fire stations	

- *Aquatic Resources*: More stringent local regulations may be in place or may be required to protect drinking water reservoirs, lakes, or other sensitive aquatic resources. Consult the local authority to determine the full requirements for these resources.

- *SMP Treatment*: The final WQ_v shall be treated by an acceptable practice from the list presented in this manual. Please consult Chapter 5 for a list of acceptable practices.

- *Determining Peak Discharge for WQ_v Storm*: When designing flow splitters for off-line practices, consult the small storm hydrology method provided in Appendix B.

- *Extended Detention for Water Quality Volume*: The water quality requirement can be met by providing 24 hours of the WQ_v (provided a micropool is specified) extended detention. A local jurisdiction may reduce this requirement to as little as 12 hours in trout waters to prevent stream warming. This storm must be routed separately from the channel protection (Cpv) storm.

- *Off site Areas:* Off site areas shall be assumed to be undeveloped for computing the water quality volume (i.e., treatment is required for only on-site impervious areas).

Section 4.3 Stream Channel Protection Volume Requirements (Cp_v)

Stream Channel Protection Volume Requirements (Cp_v) are designed to protect stream channels from erosion. In New York State this goal is accomplished by providing 24-hour extended detention of the one-year, 24-hour storm event. Trout waters may be exempted from the 24-hour ED requirement, with only 12 hours of extended detention required to meet this criterion.

For developments greater than 50 acres, with impervious cover greater than 25%, it is recommended that a detailed geomorphic assessment be performed to determine the appropriate level of control. Appendix J provides guidance on how to conduct this assessment.

The Cp_v requirement may not apply in certain conditions, including:

- This criterion *is not* required on areas that recharge the entire Cp_v volume.
- The site generates less than one (1) acre of impervious cover.
- The site discharges directly to a fourth order stream or greater, or tidal water.
- A downstream analysis reveals that channel protection is not required (see section 4.6).

A detention pond or underground vault are methods to meet the Cp_v requirement (and subsequent Q_{p10} and Q_f criteria). Schematics of the typical designs are shown in Figures 4.2. and 4.3. Note that, although these practices meet water quantity goals, they are unacceptable for water quality, and need to be coupled with a practice listed in Table 5.1. The Cp_v requirement may also be provided above the water quality (WQ_v) storage in a wet pond or wetland.

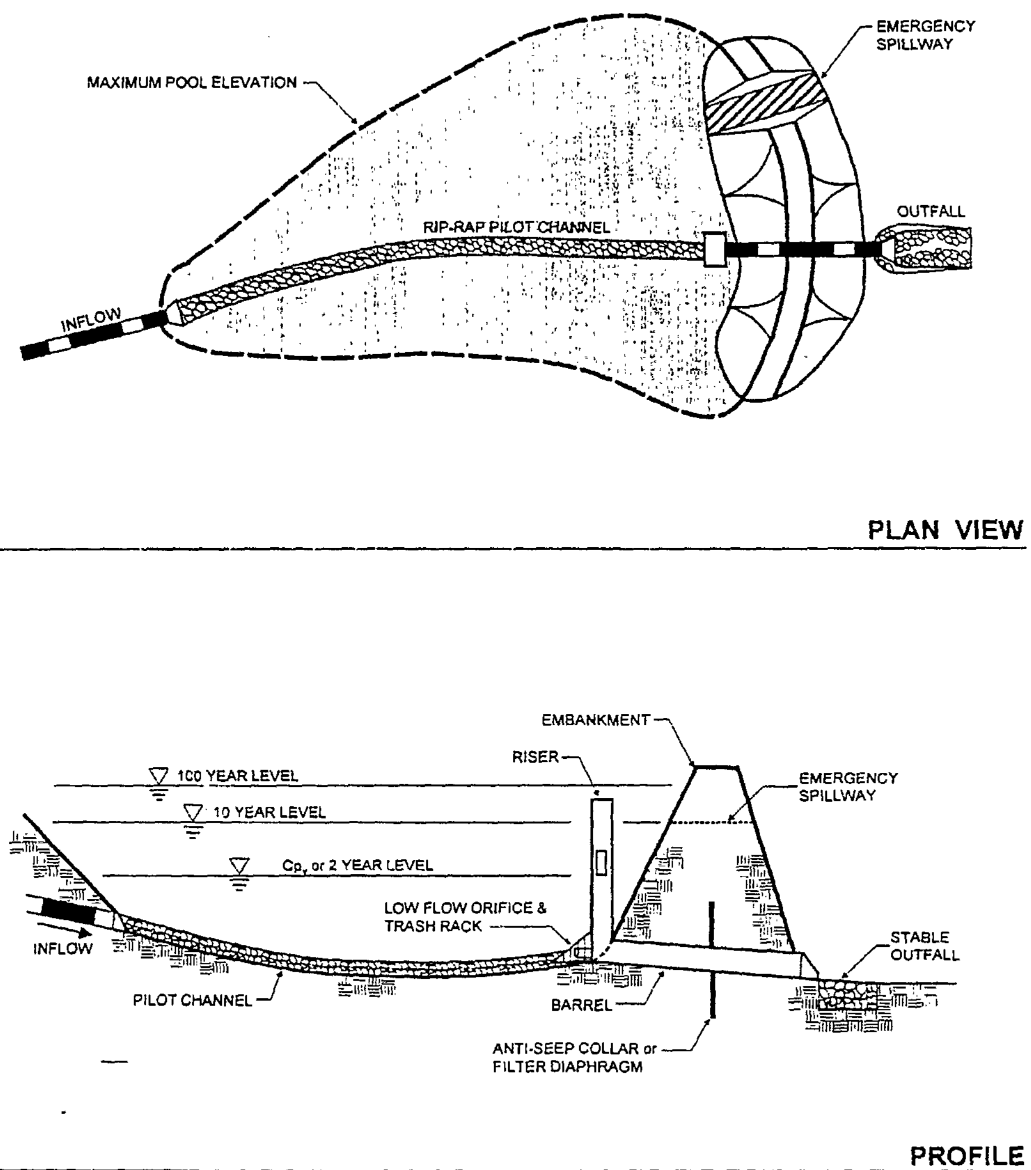
Basis for Determining Channel Protection Storage Volume

The following represent the minimum basis for design:

- The models TR-55 and TR-20 (or approved equivalent) shall be used to determine peak discharge rates.
- Rainfall depths for the one-year, 24 hour storm event are provided in Table 4.3.
- Off-site areas should be modeled as "present condition" for the one year storm event.
- The length of overland flow used in time of concentration (t_c) calculations is limited to no more than 100 feet for post development conditions.

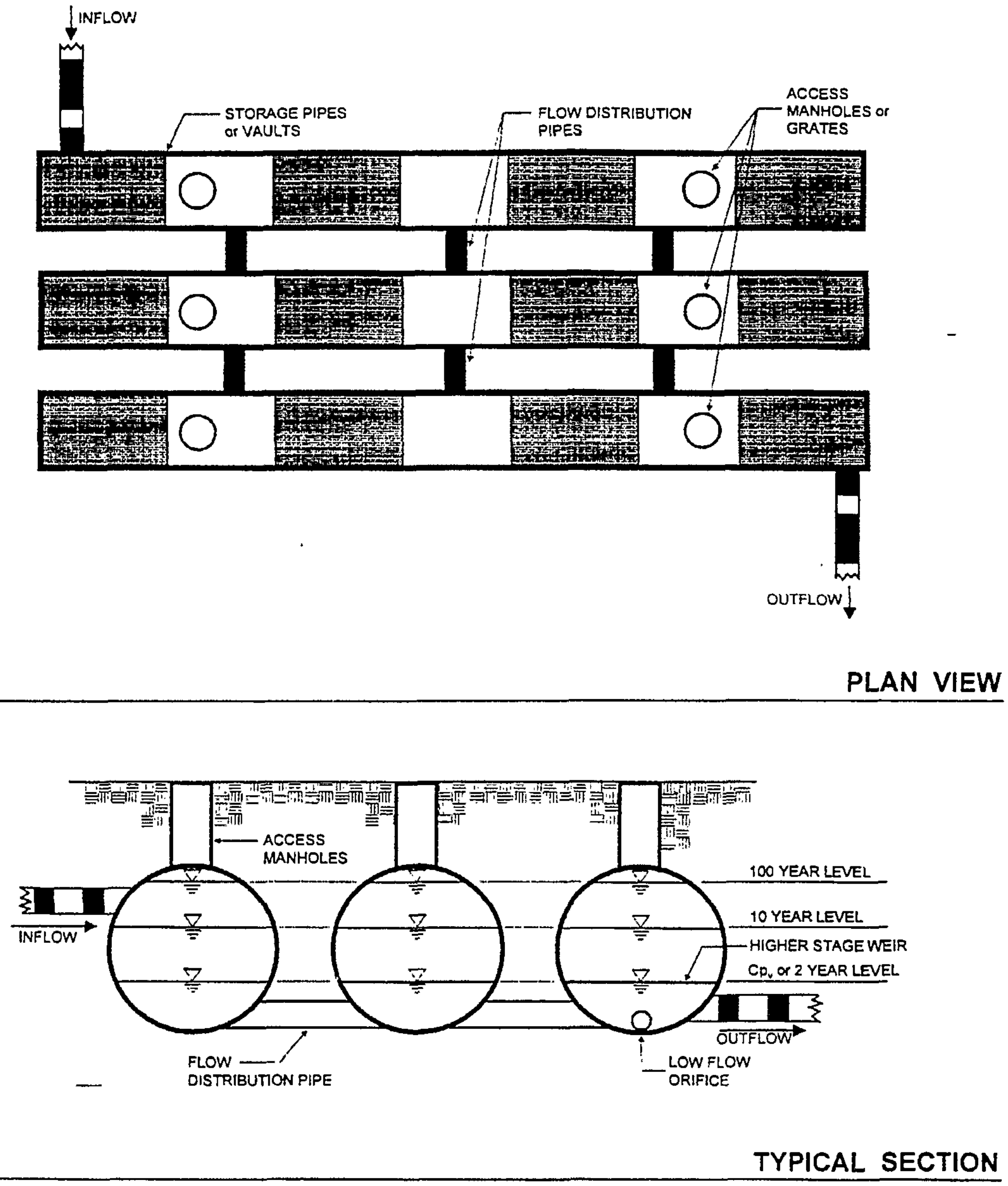
- Cp_v is not required at sites where the resulting diameter of the ED orifice is too small to prevent clogging. (A minimum 3" orifice with a trash rack or 1" if the orifice is protected by an exterior standpipe with slots less than the internal orifice are recommended to prevent clogging. See Figure 3 in Appendix K for design details).
- Extended detention storage provided for the channel protection (Cp_v-ED) does not meet the WQ_v requirement (that is Cp_v-ED and WQ_v-ED should be provided separately).
- The detention time for the one-year storm is defined as the difference in time from the center of mass of the inflow hydrograph and the center of mass of the outflow hydrograph (See Appendix B).

Figure 4.2. Example of a Conventional Stormwater Detention Pond



A typical detention facility provides channel protection control (Cp_v) and overbank control (Q_p) but no water quality control (WQ_v). If this practice is used, WQv must be provided in a separate facility listed on Table 5.1.

Figure 4.3. Example of Stormwater Detention Provided by an Underground Pipe System



An underground pipe system or vaults may be used to provide Cp_v, Q_p and Q_f controls but not WQ_v.

Table 4.3. Design Rainfall Depths

New York County	1 year, 24-Hour Rainfall Depth	2 year, 24-Hour Rainfall Depth	10 year, 24-Hour Rainfall Depth	100 year, 24-hour Rainfall Depth
Albany	2.4	2.9	4.5	7.0
Allegany	2.2	2.6	3.8	5.3
Bronx	2.7	3.5	5.0	7.5
Broome	2.4	2.8	4.2	6.2
Cattaraugus	2.2	2.5	3.7	5.2
Cayuga	2.2	2.5	3.8	5.3
Chautauqua	2.1	2.5	3.6	4.9
Chemung	2.3	2.7	3.9	5.6
Chenango	2.3	2.8	4.0	6.0
Clinton	2.0	2.5	3.5	4.9
Columbia	2.5	3.0	4.7	7.8
Cortland	2.3	2.7	3.9	5.6
Delaware	2.5	2.9	4.5	7.9
Dutchess	2.8	3.5	5.0	8.0
Erie	2.1	2.5	3.6	4.9
Essex	2.1	2.5	3.6	5.1
Franklin	2.0	2.5	3.5	4.8
Fulton	2.3	2.6	3.9	5.5
Genesee	2.1	2.5	3.6	4.9
Greene	3.0	3.0	5.0	8.0
Hamilton	2.2	2.5	3.7	5.4
Herkimer	2.2	2.5	3.7	5.5
Jefferson	2.1	2.5	3.5	4.7
Kings	2.7	3.5	5.0	7.5
Lewis	2.3	2.5	3.6	4.8
Livingston	2.2	2.5	3.7	5.0
Madison	2.3	2.6	3.8	5.5

Table 4.3. Design Rainfall Depths				
New York County	**1 year, 24-Hour Rainfall Depth**	**2 year, 24-Hour Rainfall Depth**	**10 year, 24-Hour Rainfall Depth**	**100 year, 24-hour Rainfall Depth**
Manhattan	2.7	3.5	5.0	7.5
Monroe	2.2	2.5	3.6	4.9
Montgomery	2.4	2.7	3.9	5.7
Nassau	2.7	3.5	5.0	7.5
Niagra	2.1	2.5	3.5	4.8
Oneida	2.3	2.5	3.8	5.4
Onondaga	2.2	2.6	3.8	5.2
Ontario	2.2	2.5	3.7	5.0
Orange	2.9	3.5	5.5	8.0
Orleans	2.1	2.5	3.5	4.8
Oswego	2.2	2.5	3.6	4.9
Otsego	2.4	2.8	4.0	5.9
Putnam	2.7	3.5	5.0	7.5
Queens	2.7	3.5	5.0	7.5
Rensselaer	2.4	2.7	4.3	6.3
Richmond	2.7	3.5	5.0	7.5
Rockland	2.7	3.5	5.0	7.5
Saratoga	2.3	2.6	3.9	5.8
Schenectady	2.4	2.8	4.0	5.8
Schoharie	2.4	2.8	4.5	7.0
Schuyler	2.3	2.6	3.8	5.5
Seneca	2.2	2.5	3.8	5.2
St. Lawrence	2.0	2.5	3.5	4.8
Steuben	2.2	2.6	3.8	5.5
Suffolk	2.7	3.5	5.0	7.5
Sullivan	3.0	3.5	5.0	8.0
Tioga	2.3	2.8	4.0	5.8

Table 4.3. Design Rainfall Depths				
New York County	1 year, 24-Hour Rainfall Depth	2 year, 24-Hour Rainfall Depth	10 year, 24-Hour Rainfall Depth	100 year, 24-hour Rainfall Depth
Tompkins	2.3	2.7	3.9	5.5
Ulster	3.5	4.0	6.0	8.0
Warren	2.2	2.5	3.8	5.4
Washington	2.3	2.6	3.9	5.8
Wayne	2.2	2.5	3.7	4.9
Westchester	2.8	3.5	5.0	7.5
Wyoming	2.2	2.5	3.6	4.9
Yates	2.2	2.5	3.8	5.2

Section 4.4 Overbank Flood Control Criteria (Q_p)

The primary purpose of the overbank flood control sizing criteria is to prevent an increase in the frequency and magnitude of out-of-bank flooding generated by urban development (i.e., flow events that exceed the bankfull capacity of the channel, and therefore must spill over into the floodplain).

Overbank control must reduce 10-year post development runoff levels to 10-year pre-development levels.

The overbank flood control requirement (Q_p) does not apply in certain conditions, including:

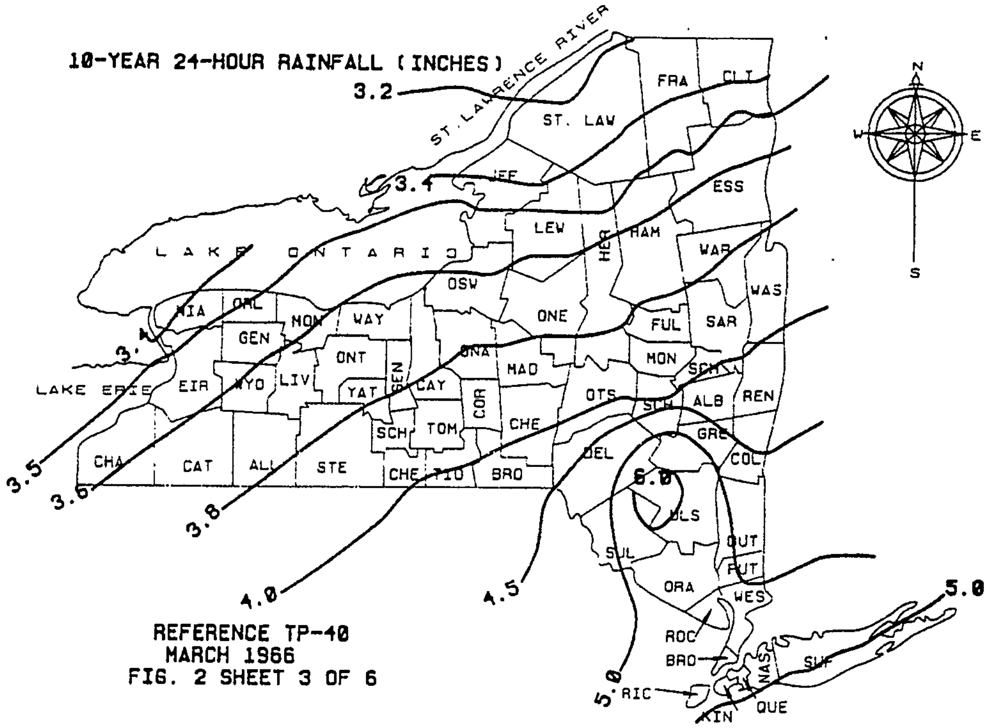
- The site is smaller than five (5) acres
- The site discharges directly tidal waters or fourth order or larger streams
- A downstream analysis reveals that overbank control is not needed (see section 4.7).

Basis for Design of Overbank Flood Control

When addressing the overbank flooding design criteria, the following represent the minimum basis for design:

- The models TR-55 and TR-20 (or approved equivalent) will be used for determining peak discharge rates.
- The standard for characterizing predevelopment land use for non-forested vegetated areas (including agriculture) shall be meadow in good condition.
- Off-site areas should be modeled as "present condition" for the 10-year storm event.
- Table 4.3 indicates the depth of rainfall (24 hour) associated with the 10-year storm event for all counties in the State of New York, and Figure 4.4 provides a graphical representation of this event.
- The length of overland flow used in t_c calculations is limited to no more than 150 feet for predevelopment conditions and 100 feet for post development conditions. On areas of extremely flat terrain, this maximum distance is extended to 250 feet for predevelopment conditions and 150 feet for postdevelopment conditions.

Figure 4.4. 10-Year Design Storm



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Section 4.5 Extreme Flood Control Criteria (Q_f)

The intent of the extreme flood criteria is to (a) prevent the increased risk of flood damage from large storm events, (b) maintain the boundaries of the predevelopment 100-year floodplain, and (c) protect the physical integrity of stormwater management practices

100 Year Control requires storage to attenuate the post development 100-year, 24-hour peak discharge rate (Q_f) to predevelopment rates.

The 100-year storm control requirement can be waived if:

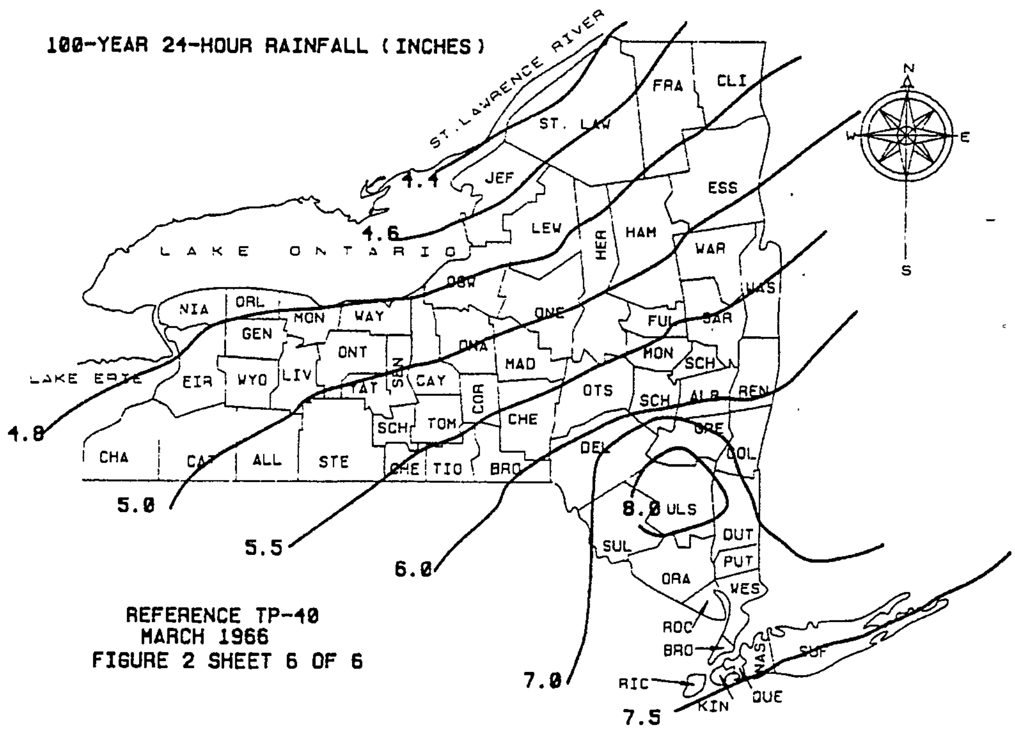
- The outfall discharges directly into tidal waters or fourth order or larger streams
- Development is prohibited within the ultimate 100-year floodplain
- A downstream analysis reveals that 100-year control is not needed (see section 4.7)

Detention structures must provide safe overflow of the 100-year storm event, according to State of New York Dam Construction Specifications and Guidance. For the most recent copy of this document, contact the New York State Department of Environmental Conservation, Dam Safety Division, at (518) 457-0834.

Basis for Design for Extreme Flood Criteria

- Consult with the appropriate review authority to determine the analyses required for the Q_f storm.
- The same hydrologic and hydraulic methods used for overbank flood control shall be used to analyze Q_f.
- Table 4.3 indicates the depth of rainfall (24 hour) associated with the 100-year storm event for all counties in the State of New York, and Figure 4.5 shows a graphical representation.
- For 100-year control, model off-shore areas as "existing," but to safely pass the 100-year flood, use ultimate conditions.

Figure 4.5. 100-Year Design Storm



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4.6 Conveyance Criteria

In addition to the stormwater treatment volumes described above, the manual also provides guidance on safe and non-erosive conveyance to, from, and through stormwater management practices (SMPs). Typically, the targeted storm frequencies for conveyance are the two-year and ten-year events. The two-year event is used to ensure non-erosive flows through roadside swales, overflow channels, pond pilot channels, and over berms within practices. Table 4.3 provides rainfall depths for the two-year, 24-hour storm event, and Figure 4.6 presents the information graphically. The ten-year storm is typically used as a target sizing for outfalls, and as a safe conveyance criterion for open channels practices and overflow channels.

4.7 Downstream Analysis

A community may waive the channel protection, overbank, and extreme flood requirements based on the results of a downstream analysis. In addition, such an analysis is recommended for larger sites (i.e., greater than 50 acres) to size facilities in the context of a larger watershed. This section provides brief guidance for conducting this analysis, including the area of stream to be evaluated and minimum elements to be included in the analysis.

Downstream analysis can be conducted using the 10% rule. That is, the analysis should extend downstream to the point where the site represents 10% of the total drainage area. For example, a 10-acre site would be analyzed to the point downstream with a drainage area of 100 acres.

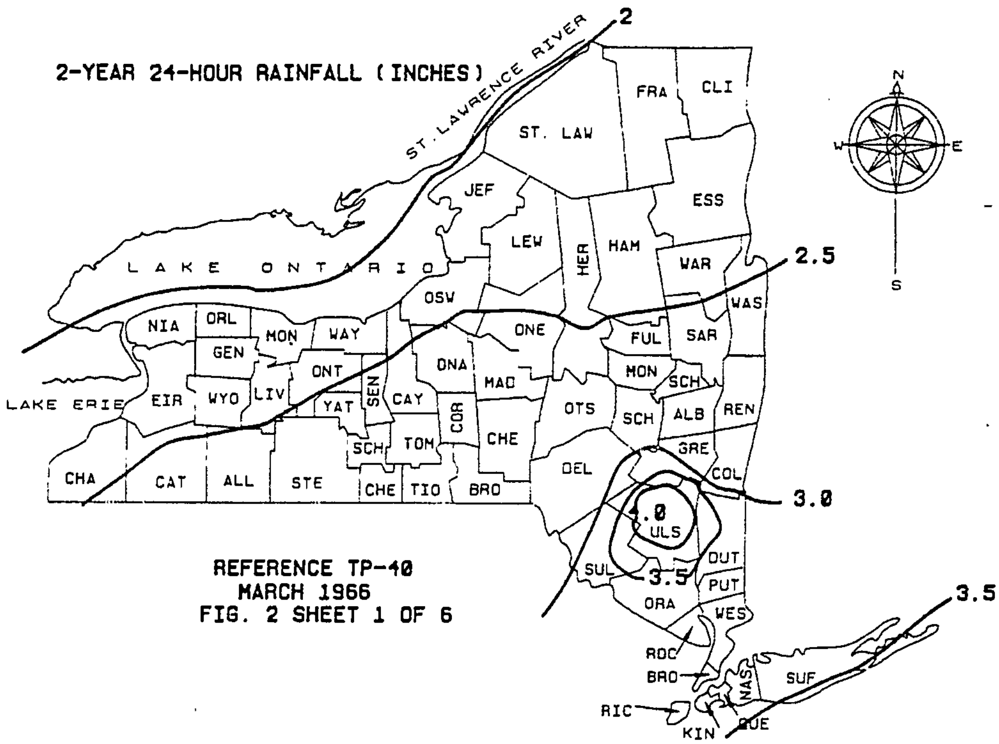
The analysis should include the following:

- Computation of flows and velocities for channel protection, overbank, and flood control storms at the point where the 10% rule is met, as well as all confluences along the downstream channel with first order or higher streams.
- Hydrologic and hydraulic effects of all culverts and/or obstructions within the downstream channel.
- An assessment of water surface elevations to determine if an increase in water surface elevations will impact existing buildings and other structures.

The design, or waiver, at a site level can be approved if the following criteria are met at both:

- Flow rates and velocities increase by less than 5% of the pre-developed condition for all flow conditions analyzed.
- No downstream structures or buildings are impacted.
- The site as designed is not expected to exacerbate downstream channel erosion.

Figure 4.6. 2 - Year Design Storm



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4.8 Stormwater Hotspots

A stormwater hotspot is defined as a land use or activity that generates higher concentrations of hydrocarbons, trace metals or toxicants than are found in typical stormwater runoff, based on monitoring studies. If a site is designated as a hotspot, it has important implications for how stormwater is managed. First and foremost, stormwater runoff from hotspots cannot be allowed to infiltrate into groundwater, where it may contaminate water supplies. Second, a greater level of stormwater treatment is needed at hotspot sites to prevent pollutant washoff after construction. This typically involves preparing and implementing *a stormwater pollution prevention plan* that involves a series of operational practices at the site that reduce the generation of pollutants from a site or prevent contact of rainfall with the pollutants. Table 4.4 provides a list of designated hotspots for the State of New York

Under EPA's stormwater NPDES program, some industrial sites are required to prepare and implement a stormwater pollution prevention plan. A list of industrial categories that are subject to the pollution prevention requirement can be found in the State of New York SPDES. In addition, New York's requirements for preparing and implementing a stormwater pollution prevention plan are also described in the general discharge permit provided in the SPDES. The stormwater pollution prevention plan requirement applies to both existing and new industrial sites.

Table 4.4 Classification of Stormwater Hotspots
The following land uses and activities are deemed *stormwater hotspots:* • Vehicle salvage yards and recycling facilities # • Vehicle fueling stations • Vehicle service and maintenance facilities • Vehicle and equipment cleaning facilities # • Fleet storage areas (bus, truck, etc.) # • Industrial sites (based on SIC codes outlined in the SPDES) • Marinas (service and maintenance) # • Outdoor liquid container storage • Outdoor loading/unloading facilities • Public works storage areas • Facilities that generate or store hazardous materials # • Commercial container nursery • Other land uses and activities as designated by an appropriate review authority
indicates that the land use or activity is required to prepare a stormwater pollution prevention plan under the EPA NPDES stormwater program.

In addition, if a site falls into a "hotspot" category outlined in Table 4.4, a pollution prevention plan may also be required by the appropriate reviewing authority. Golf courses and commercial nurseries may also be required to implement a plan by the appropriate review authority

The following land uses and activities are not normally considered hotspots:

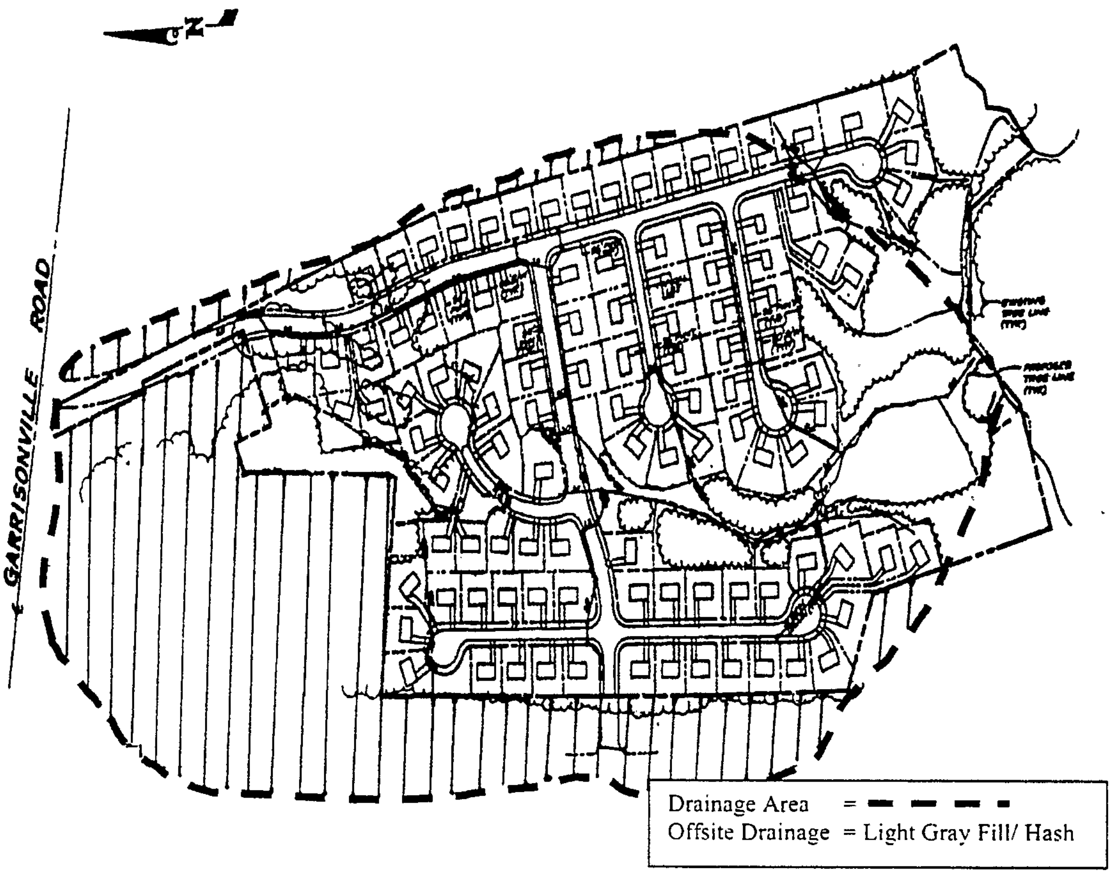
- Residential streets and rural highways
- Residential development
- Institutional development
- Office developments
- Non-industrial rooftops
- Pervious areas, except golf courses and nurseries (which may need an IPM Plan)

While large highways (average daily traffic volume (ADT) greater than 30,000) are not designated as a stormwater hotspot, it is important to ensure that highway stormwater management plans adequately protect groundwater.

4.9 Sizing Example - Stonehill Estates

Following is a sizing example for the hypothetical "Stone Hill Estates," a 45-acre residential develoment in Ithaca, New York (Figure 4.7). The site also drainas approximately 20 acres of off-site drainage, which is currently in a meadow condition. The site is on mostly C soils with some D soils.

Figure 4.7 Stone Hill Site Plan



Base Data
Location: Ithaca, NY
Site Area = 45.1 ac; Offsite Area = 20.0 ac (meadow)
Total Drainage Area (A) = 65.1
Measured Impervious Area=12.0 ac; or I=12.0/45.1=26.6%
Site Soils Types: 78% "C", 22% "D"
Offsite Soil Type: 100% "C"
Zoning: Residential (½ acre lots)

Hydrologic Data

	Pre	Post	Ult.
CN	72	78	82
t_c (hr)	.46	.35	.35

Computation of Preliminary Stormwater Storage Volumes and Peak Discharges

The layout of the Stone Hill subdivision is shown on the previous page.

Step 1. Compute preliminary runoff control volumes from Stormwater Sizing Criteria

Water Quality Volume, WQ_v

- Compute Runoff Coefficient, R_v

$$R_v = 0.05 + (I)(0.009)$$
$$= 0.05 + (26.6)(0.009) = 0.29$$

- Compute WQ_v (Offsite area does not need to be considered when determining the water quality volume)

Use the 90% capture rule with 0.9" of rainfall.

$$WQ_v = (0.9")(R_v)(A)$$
$$= (0.9")(0.29)(45.1\ ac)(1ft/12in)$$
$$= \underline{0.98\ ac\text{-}ft}$$

Establish Hydrologic Input Parameters and Develop Site Hydrology (See Figures 4.8, 4.9, and 4.10)

Condition	**Area**	**CN**	**Tc**
	Ac		*hrs*
Pre-developed	65.1	72	0.46
Post-developed	65.1	78	0.35
Ultimate buildout	65.1	82	0.35

Hydrologic Calculations

Condition	$Q_{1\text{-}yr}$	$Q_{1\text{-}yr}$	$Q_{10\text{-}yr}$	$Q_{100\text{-}yr}$
Runoff	*Inches*	*cfs*	*cfs*	*cfs*
Pre-developed	0.4	19	72	141
Post-developed	0.7	38	112	202
Ultimate buildout	NA	NA	NA	227

PEAK DISCHARGE SUMMARY				
JOB:	STONE HILL			EWB
DRAINAGE AREA NAME:	PRE DEVELOPMENT			21-Jan-97
COVER DESCRIPTION	SOIL NAME	GROUP A,B,C,D?	CN from TABLE 2-2	AREA (In acres)
MEADOW		C	71	20.25 Ac.
MEADOW		D	78	7.95 Ac.
WOOD		C	70	15.09 Ac.
WOOD		D	77	1.81 Ac.
OFF-SITE MEADOW		C	71	20.00 Ac.
			AREA SUBTOTALS:	65.10 Ac.
Time of Concentration 2-Yr 24 Hr Rainfall = 2.7 In	Surface Cover Cross Section	Manning 'n' Wetted Per	Flow Length Avg Velocity	Slope Tt (Hrs)
Sheet Flow	dense grass	'n'=0.24	150 Ft.	3.80% 0.28 Hrs
Shallow Flow	UNPAVED		1300 Ft. 2.65 F.P.S.	2.70% 0.14 Hrs.
Channel Flow Hydraulic Radius =1.26	22.0 SqFt	'n'=0.040 17.5 Ft.	1100 Ft. 7.14 F.P.S.	2.70% 0.04 Hrs.
Total Area in Acres =	65.10 Ac.	Total Sheet	Total Shallow	Total Channel
Weighted CN =	72	Flow=	Flow=	Flow =
Time Of Concentration =	0.46 Hrs.	0.28 Hrs.	0.14 Hrs.	0.04 Hrs.
Pond Factor =	1	RAINFALL TYPE II		
STORM	*Precipitation* (P) inches	*Runoff* (Q)	Qp, PEAK DISCHARGE	TOTAL STORM Volumes
1 Year	2.3 In.	0.4 In.	18.6 CFS	101,195 Cu. Ft.
2 Year	2.7 In.	0.6 In.	30.2 CFS	150,257 Cu. Ft.
10 Year	3.9 In.	1.4 In.	72 CFS	328,570 Cu. Ft.
100 Year	5.5 In.	2.6 In.	141 CFS	611,958 Cu. Ft.

Figure 4.8. Stone Hill Pre-Development Conditions

PEAK DISCHARGE SUMMARY				
JOB:	STONE HILL			EWB
DRAINAGE AREA NAME:	POST DEVELOPMENT			21-Jan-97
COVER DESCRIPTION	SOIL NAME	GROUP A,B,C,D?	CN from TABLE 2-2	AREA (In acres)
MEADOW		C	71	0.16 Ac.
MEADOW		D	78	0.14 Ac.
WOOD		C	70	3.09 Ac.
WOOD		D	77	1.81 Ac.
IMPERVIOUS			98	12.00 Ac.
GRASS		C	74	20.09 Ac.
GRASS		D	80	7.81 Ac.
OFFSITE MEADOW		C	71	20.00 Ac.
		AREA SUBTOTALS:		65.10 Ac.
Time of Concentration 2-Yr 24 Hr Rainfall = 2.7 In	Surface Cover Cross Section	Manning 'n' Wetted Per	Flow Length Avg Velocity	Slope Tt (Hrs)
Sheet Flow	dense grass	'n'=0.24	100 Ft.	3.80% 0.20 Hrs
Shallow Flow (a)	UNPAVED		100 Ft. 1.98 F.P.S.	1.50% 0.01 Hrs.
(b)	PAVED		400 Ft. 2.03 F.P.S.	1.00% 0.05 Hrs.
Channel Flow (a) Hydraulic Radius =0.50	1.6 SqFt	'n'=0.013 3.2 Ft.	1550 Ft. 7.22 F.P.S.	1.00% 0.06 Hrs.
(b) Hydraulic Radius =1.42	12.0 SqFt	'n'=0.030 8.5 Ft.	350 Ft. 13.01 F.P.S.	4.30% 0.01 Hrs.
(c) Hydraulic Radius =1.26	22.0 SqFt	'n'=0.040 8.5 Ft.	300 Ft. 7.89 F.P.S.	3.30% 0.01 Hrs.
Total Area in Acres =	65.10 Ac.	Total Sheet	Total Shallow	Total Channel
Weighted CN =	78	Flow=	Flow=	Flow =
Time Of Concentration =	0.35 Hrs.	0.20 Hrs.	0.07 Hrs.	0.08 Hrs.
Pond Factor =	1	RAINFALL TYPE II		
STORM	*Precipitation* (P) inches	*Runoff* (Q)	Qp, PEAK DISCHARGE	TOTAL STORM Volumes
1 Year	2.3 In.	0.7 In.	37.6 CFS	156,283 Cu. Ft.
2 Year	2.7 In.	0.9 In.	54.0 CFS	217,511 Cu. Ft.
10 Year	3.9 In.	1.8 In.	112 CFS	427,155 Cu. Ft.
100 Year	5.5 In.	3.1 In.	202 CFS	742,265 Cu. Ft.

Figure 4.9. Stone Hill Post-Development Conditions

PEAK DISCHARGE SUMMARY				
JOB:	STONE HILL			EWB
DRAINAGE AREA NAME:	ULTIMATE BUILDOUT			21-Jan-97
COVER DESCRIPTION	SOIL NAME	GROUP A,B,C,D?	CN from TABLE 2-2	AREA (In acres)
MEADOW		C	71	0.16 Ac.
MEADOW		D	78	0.14 Ac.
WOOD		C	70	3.09 Ac.
WOOD		D	77	1.81 Ac.
IMPERVIOUS			98	12.00 Ac.
GRASS		C	74	20.09 Ac.
GRASS		D	80	7.81 Ac.
OFFSITE ULTIMATE				
SF RES (0.25 AC LOTS)		C	83	20.00 Ac.
			AREA SUBTOTALS:	65.10 Ac.
Time of Concentration 2-Yr 24 Hr Rainfall = 2.7 In	Surface Cover Cross Section	Manning 'n' Wetted Per	Flow Length Avg Velocity	Slope Tt (Hrs)
Sheet Flow	dense grass	'n'=0.24	100 Ft.	3.80% 0.20 Hrs
Shallow Flow (a)	UNPAVED		100 Ft. 1.98 F.P.S.	1.50% 0.01 Hrs.
(b)	PAVED		400 Ft. 2.03 F.P.S.	1.00% 0.05 Hrs.
Channel Flow (a) Hydraulic Radius =0.50	1.6 SqFt	'n'=0.013 3.2 Ft.	1550 Ft. 7.22 F.P.S.	1.00% 0.06 Hrs.
(b) Hydraulic Radius =1.42	12.0 SqFt	'n'=0.030 8.5 Ft.	350 Ft. 13.01 F.P.S.	4.30% 0.01 Hrs.
(c) Hydraulic Radius =1.26	22.0 SqFt	'n'=0.040 8.5 Ft.	300 Ft. 7.89 F.P.S.	3.30% 0.01 Hrs.
Total Area in Acres =	65.10 Ac.	Total Sheet	Total Shallow	Total Channel
Weighted CN =	82	Flow=	Flow=	Flow =
Time Of Concentration =	0.35 Hrs.	0.20 Hrs.	0.07 Hrs.	0.08 Hrs.
Pond Factor =	1	RAINFALL TYPE II		
STORM	*Precipitation* (P) inches	*Runoff* (Q)	Qp, PEAK DISCHARGE	TOTAL STORM Volumes
1 Year	2.3 In.	0.9 In.	50.9 CFS	201,772 Cu. Ft.
2 Year	2.7 In.	1.1 In.	70.0 CFS	271,097 Cu. Ft.
10 Year	3.9 In.	2.1 In.	135 CFS	500,458 Cu. Ft.
100 Year	5.5 In.	3.5 In.	227 CFS	834,167 Cu. Ft.

Figure 4.10. Stone Hill Ultimate Buildout Conditions

Compute Stream Channel Protection Volume, (Cp_v)

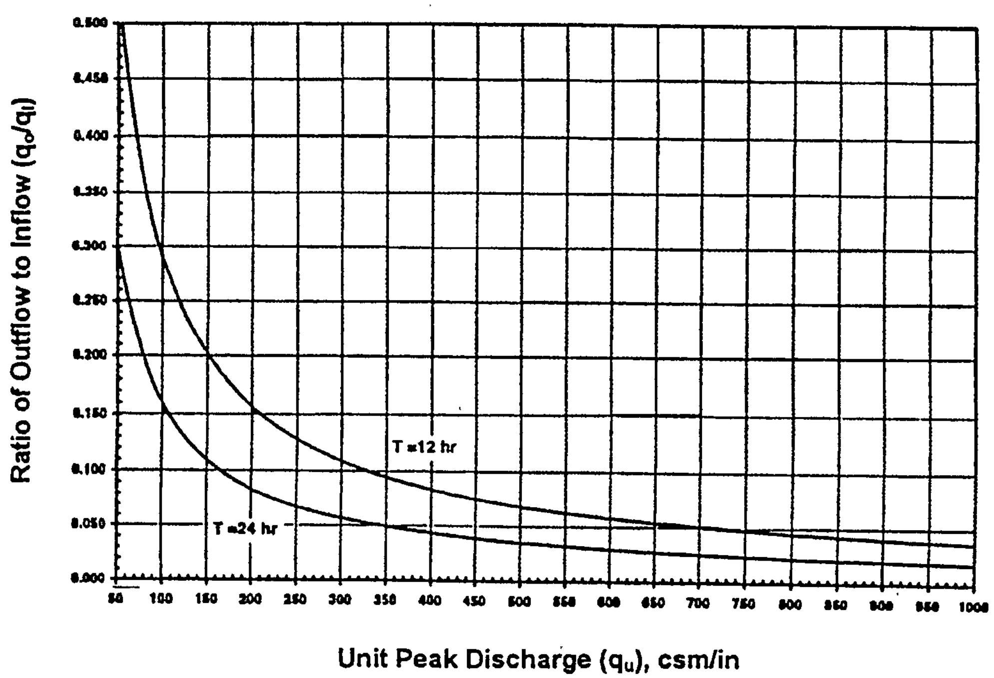
For stream channel protection, provide 24 hours of extended detention (T) for the one-year event.

Utilize SCS approach to Compute Channel Protection Storage Volume

- Initial abstraction (Ia) for CN of 78 is 0.564: [Ia = (200/CN - 2)]
- Ia/P = (0.564)/2.3 inches = 0.245
- T_c = 0.35 hours
- q_u = 570 csm/in (Type II Storm)

Knowing q_u and T (assume 24 hours of extended detention time), find q_o/q_i using Figure 4.11 (MDE, 2000). [Also see methodology in Appendix B]

Figure 4.11. Detention Time vs. Discharge Ratios (Source: MDE, 1998)



- Peak outflow discharge/peak inflow discharge (q_o/q_i) = 0.035
- $Vs/Vr = 0.683 - 1.43(q_o/q_i) + 1.64(q_o/q_i)^2 - 0.804(q_o/q_i)^3$
  - Where Vs equals channel protection storage (Cp_v) and Vr equals the volume of runoff in inches.
  - Vs/Vr = 0.63
  - Therefore, Vs = Cp_v = 0.63(0.7")(1/12)(65.1 ac) = 2.4 ac-ft (104,214 cubic feet)

Define the average ED Release Rate

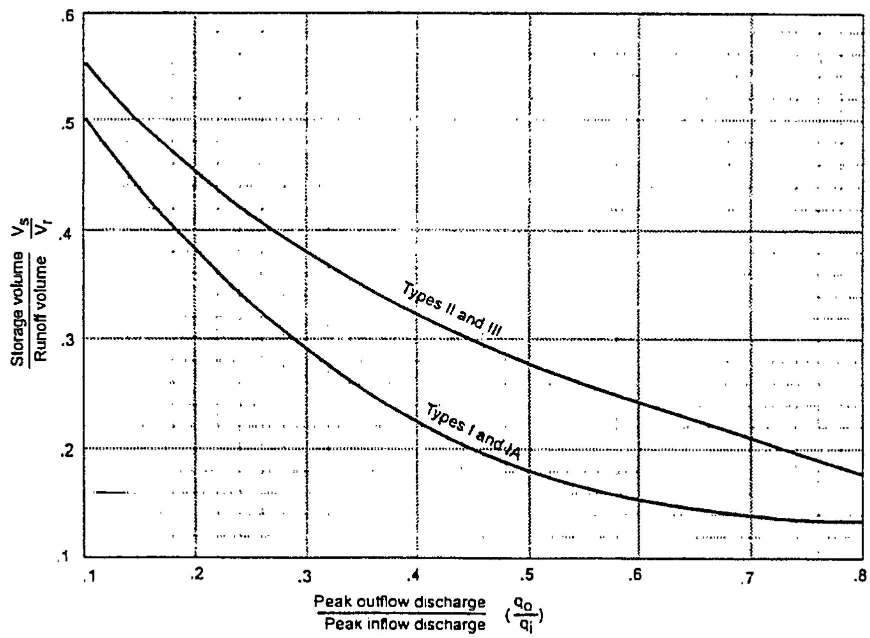
- The above volume, 2.4 ac-ft, is to be released over 24 hours
- (2.4 ac-ft × 43,560 ft^2/ac) / (24 hrs × 3,600 sec/hr) = 1.2 cfs

Compute Overbank Flood Protection Volume, (Qp_{10})

For both the overbank flood protection volume and the extreme flood protection volume, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 4.12).

- For a Q_{in} of of 112 cfs (post-developed), and an allowable Q_{out} of 72 cfs (pre-developed), the value of $(Q_{out})/(Q_{in})$ is 0.64
- Using figure 4.12, and assuming a post-developed curve number of 78, the value of Vs/Vr is 0.23
- Using a runoff volume of 427,155 cubic feet (9.8 acre-feet), the required storage (Vs) is 2.23 acre-feet

Figure 4.12. Approximate Detention Basin Routing for Rainfall Types I, IA, II, and III
Source: TR-55, 1986



While the TR-55 short-cut method reports to incorporate multiple stage structures, experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive with the 10-year storm. So, for preliminary sizing purposes, add 15% to the required volume for the 10-year storm. $Q_{p\text{-}10}$ = 2.23 × 1.15 = 2.56 ac-ft.

Compute Extreme Flood Protection Volume, (Q_f)

Extreme flood protection is calculated using the same methodology as overbank protection.

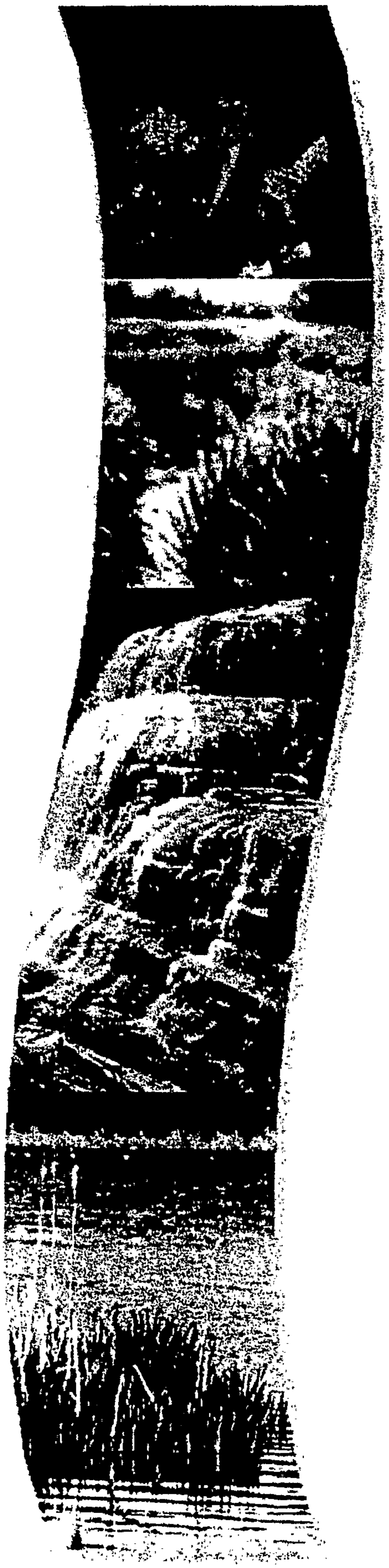
- For a Q_{in} of, and an allowable Q_{out} of, and a runoff volume of the Vs necessary for 100-year control is, under a developed CN of 78. Note that 5.5 inches of rain fall during this event, with approximately 3.1 inches of runoff.
- While the TR-55 short-cut method reports to incorporate multiple stage structures, experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive with the 100-year storm. So, for preliminary sizing purposes add 15% to the required volume for the 100-year storm. $Q_{f\text{-}100} = 3.53 \times 1.15 = 4.06$ ac-ft.

Analyze Safe Passage of 100 Year Design Storm (Qf)

If peak discharge control of the 100-year storm is not required, it is still necessary to provide safe passage for the 100-year event under ultimate buildout conditions (Q_{ult} = 227 cfs).

Table 4.5. Summary of General Storage Requirements for Stone Hill Estates

Symbol	*Category*	Volume Required (ac- ft)	Notes
WQ_v	Water Quality Volume	0.98	
Cp_v	Stream Protection	2.4	Average ED release rate is 1.2 cfs over 24 hours
Q_p	Peak Control	2.5	10-year, in this case
Q_f	Flood Control	4.1	



New York State
Stormwater Management Design Manual

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George E. Pataki, Governor   Erin M. Crotty, Commissioner

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New York SW Management Manual -

4.1 Introduction

This chapter presents a unified approach for sizing SMPs in the State of New York to meet pollutant removal goals, maintain groundwater recharge, reduce channel erosion, prevent overbank flooding, and control extreme floods. For a summary, please consult Table 4.1 below. The remaining sections describe the four sizing criteria in detail and present guidance on how to properly compute and apply the required storage volumes. Justification for the selected sizing criteria can be found in the Technical Support Memorandum submitted to the New York DEC on September 5th, 2000.

Table 4.1. Proposed New York Stormwater Sizing Criteria

Water Quality (WQ_v)	**90% Rule:** $WQ_v = [(P)(R_v)(A)] / 12$ $R_v = 0.05+0.009(I)$ I = Impervious Cover (Percent) Minimum $R_v = 0.2$ P = 90% Rainfall Event Number (See Figure 4.1) A = site area in acres
Channel Protection (Cp_v)	**Default Criterion:** Cp_v = 24 hour extended detention of post-developed 1-year, 24-hour storm event. **Option for Sites Larger than 50 Acres:** Distributed Runoff Control - geomorphic assessment to determine the bankfull channel characteristics and thresholds for channel stability and bedload movement.
Overbank Flood (Q_p)	Control the peak discharge from the 10-year storm to 10-year predevelopment rates.
Extreme Storm (Q_f)	Control the peak discharge from the 100-year storm to 100-year predevelopment rates. Safely pass the 100-year storm event.

Note: The local review authority may waive channel protection, overbank flood, and extreme storm requirements in some instances. Guidance is provided with each of the these stormwater practices

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The water quality criterion presented here assumes that sizing practices using these volumes, and using the practices presented in Table 5.1, using the technical support provided in this manual will by default meet water quality objectives. In some jurisdictions, on-site loading is required to demonstrate removal of specific pollutants. As an aid to these communities, Appendix A of this manual includes a discussion of a method for calculating pollutant export loads from development sites. This method, known as the "Simple Method," provides estimates for stormwater runoff pollutant loads for urban areas using a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. Please consult Appendix A for a more detailed discussion of the Simple Method and its applications for water quality.

Basis For Design for Water Quality

As a basis for design, the following assumptions may be made:

- *Measuring Impervious Cover*: the measured area of a site plan that does not have permanent vegetative or permeable cover shall be considered total impervious cover. Impervious cover is defined as all impermeable surfaces and includes: paved and gravel road surfaces, paved and gravel parking lots, paved driveways, building structures, paved sidewalks, and miscellaneous impermeable structures such as patios, pools, and sheds. Porous or modular block pavement may be considered 50% impervious. Where site size makes direct measurement of impervious cover impractical, the land use impervious cover relationships presented in Table 4.2 can be used to initially estimate impervious cover.

Table 4.2. Land Use and Impervious Cover (Source: Cappiella and Brown, 2001)

Land Use Category	Mean Impervious Cover
Agriculture	2
Open Urban Land*	9
2 Acre Lot Residential	11
1 Acre Lot Residential	14
1/2 Acre Lot Residential	21
1/4Acre Lot Residential	28
1/8 Acre Lot Residential	33
Townhome Residential	41

Section 4.3 Stream Channel Protection Volume Requirements (Cp_v)

Stream Channel Protection Volume Requirements (Cp_v) are designed to protect stream channels from erosion. In New York State this goal is accomplished by providing 24-hour extended detention of the one-year, 24-hour storm event. Trout waters may be exempted from the 24-hour ED requirement, with only 12 hours of extended detention required to meet this criterion.

For developments greater than 50 acres, with impervious cover greater than 25%, it is recommended that a detailed geomorphic assessment be performed to determine the appropriate level of control. Appendix J provides guidance on how to conduct this assessment.

The Cp_v requirement may not apply in certain conditions, including:

- This criterion *is not* required on areas that recharge the entire Cp_v volume.
- The site generates less than one (1) acre of impervious cover.
- The site discharges directly to a fourth order stream or greater, or tidal water.
- A downstream analysis reveals that channel protection is not required (see section 4.6).

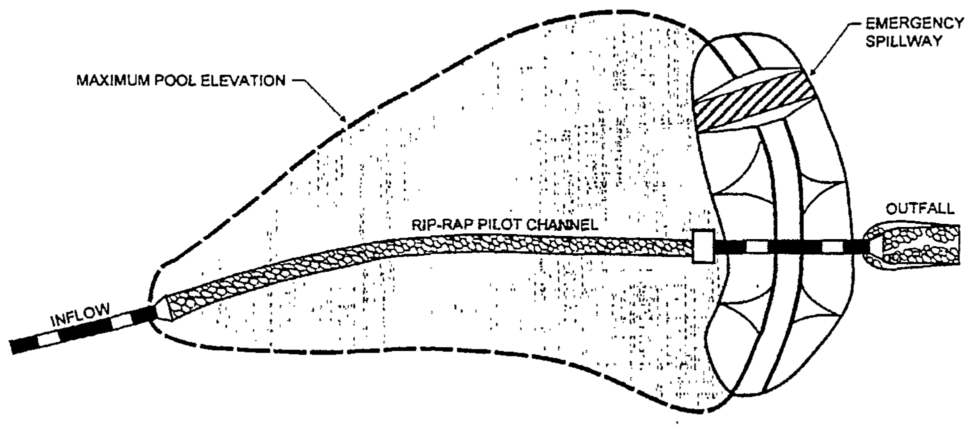
A detention pond or underground vault are methods to meet the Cp_v requirement (and subsequent Q_{p10} and Q_f criteria). Schematics of the typical designs are shown in Figures 4.2. and 4.3. Note that, although these practices meet water quantity goals, they are unacceptable for water quality, and need to be coupled with a practice listed in Table 5.1. The Cp_v requirement may also be provided above the water quality (WQ_v) storage in a wet pond or wetland.

Basis for Determining Channel Protection Storage Volume

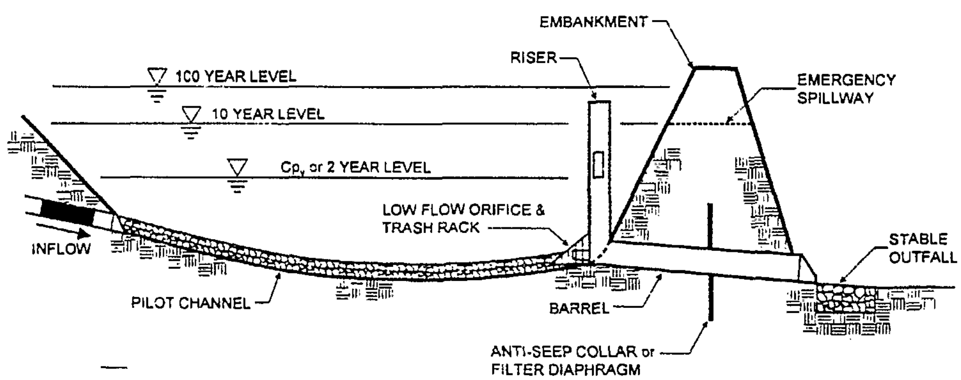
The following represent the minimum basis for design:

- The models TR-55 and TR-20 (or approved equivalent) shall be used to determine peak discharge rates.
- Rainfall depths for the one-year, 24 hour storm event are provided in Table 4.3.
- Off-site areas should be modeled as "present condition" for the one year storm event.
- The length of overland flow used in time of concentration (t_c) calculations is limited to no more than 100 feet for post development conditions.

Figure 4.2. Example of a Conventional Stormwater Detention Pond



PLAN VIEW



PROFILE

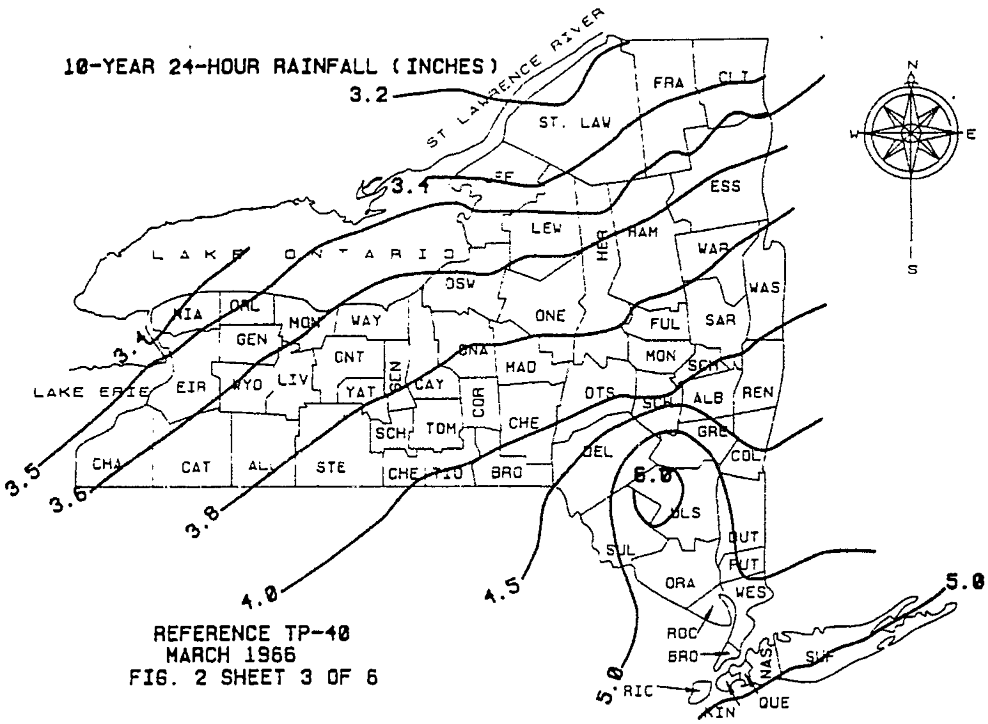
A typical detention facility provides channel protection control (Cp_v) and overbank control (Q_p) but no water quality control (WQ_v). If this practice is used, WQv must be provided in a separate facility listed on Table 5.1.

R0009518

Table 4.3. Design Rainfall Depths				
New York County	1 year, 24-Hour Rainfall Depth	2 year, 24-Hour Rainfall Depth	10 year, 24-Hour Rainfall Depth	100 year, 24-hour Rainfall Depth
Albany	2.4	2.9	4.5	7.0
Allegany	2.2	2.6	3.8	5.3
Bronx	2.7	3.5	5.0	7.5
Broome	2.4	2.8	4.2	6.2
Cattaraugus	2.2	2.5	3.7	5.2
Cayuga	2.2	2.5	3.8	5.3
Chautauqua	2.1	2.5	3.6	4.9
Chemung	2.3	2.7	3.9	5.6
Chenango	2.3	2.8	4.0	6.0
Clinton	2.0	2.5	3.5	4.9
Columbia	2.5	3.0	4.7	7.8
Cortland	2.3	2.7	3.9	5.6
Delaware	2.5	2.9	4.5	7.9
Dutchess	2.8	3.5	5.0	8.0
Erie	2.1	2.5	3.6	4.9
Essex	2.1	2.5	3.6	5.1
Franklin	2.0	2.5	3.5	4.8
Fulton	2.3	2.6	3.9	5.5
Genesee	2.1	2.5	3.6	4.9
Greene	3.0	3.0	5.0	8.0
Hamilton	2.2	2.5	3.7	5.4
Herkimer	2.2	2.5	3.7	5.5
Jefferson	2.1	2.5	3.5	4.7
Kings	2.7	3.5	5.0	7.5
Lewis	2.3	2.5	3.6	4.8
Livingston	2.2	2.5	3.7	5.0
Madison	2.3	2.6	3.8	5.5

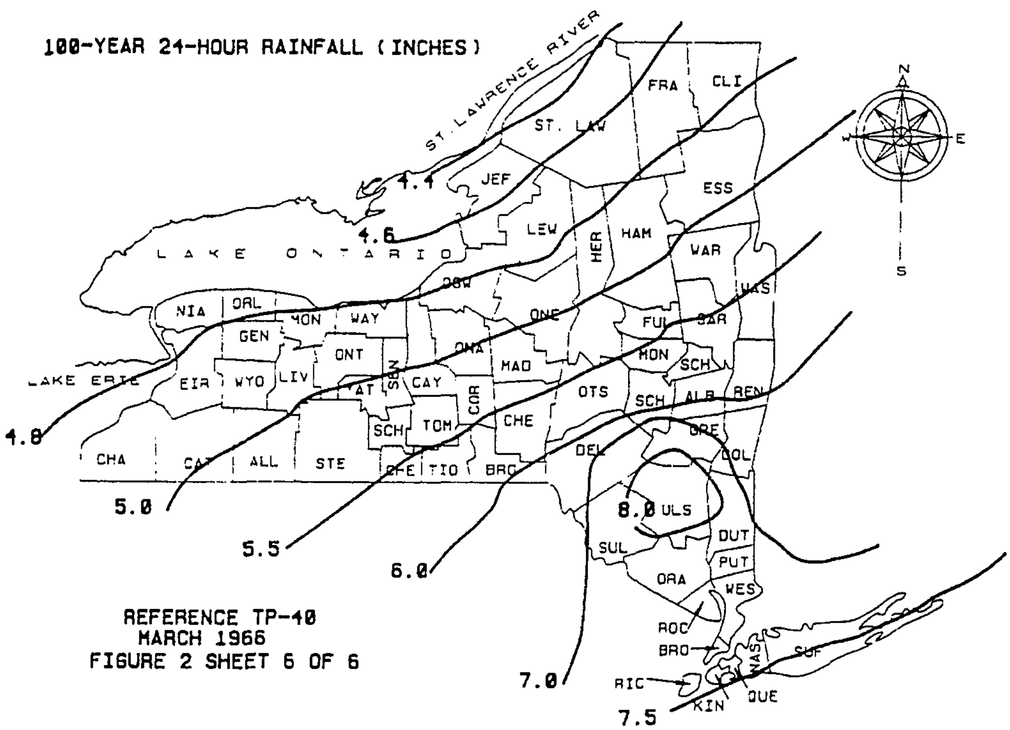
Table 4.3. Design Rainfall Depths				
New York County	**1 year, 24-Hour Rainfall Depth**	**2 year, 24-Hour Rainfall Depth**	**10 year, 24-Hour Rainfall Depth**	**100 year, 24-hour Rainfall Depth**
Tompkins	2.3	2.7	3.9	5.5
Ulster	3.5	4.0	6.0	8.0
Warren	2.2	2.5	3.8	5.4
Washington	2.3	2.6	3.9	5.8
Wayne	2.2	2.5	3.7	4.9
Westchester	2.8	3.5	5.0	7.5
Wyoming	2.2	2.5	3.6	4.9
Yates	2.2	2.5	3.8	5.2

Figure 4.4. 10-Year Design Storm



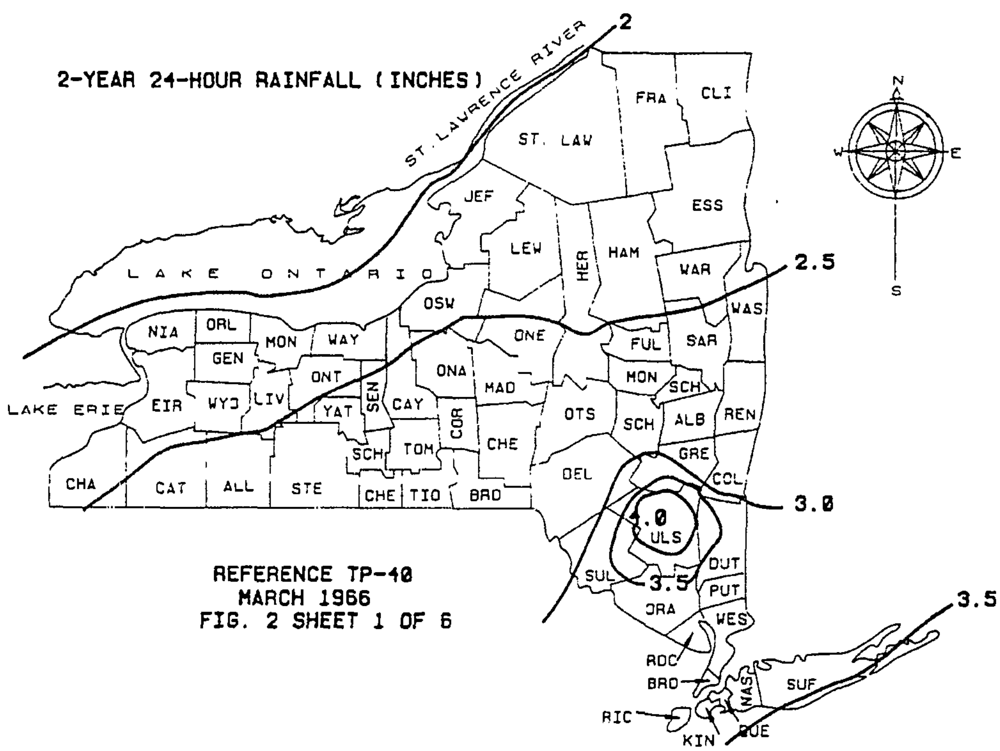
R0009521

Figure 4.5. 100-Year Design Storm



R0009522

Figure 4.6. 2 - Year Design Storm



R0009523

In addition, if a site falls into a "hotspot" category outlined in Table 4.4, a pollution prevention plan may also be required by the appropriate reviewing authority. Golf courses and commercial nurseries may also be required to implement a plan by the appropriate review authority

The following land uses and activities are not normally considered hotspots:

- Residential streets and rural highways
- Residential development
- Institutional development
- Office developments
- Non-industrial rooftops
- Pervious areas, except golf courses and nurseries (which may need an IPM Plan)

While large highways (average daily traffic volume (ADT) greater than 30,000) are not designated as a stormwater hotspot, it is important to ensure that highway stormwater management plans adequately protect groundwater.

4.9 Sizing Example - Stonehill Estates

Following is a sizing example for the hypothetical "Stone Hill Estates," a 45-acre residential develoment in Ithaca, New York (Figure 4.7). The site also drainas approximately 20 acres of off-site drainage, which is currently in a meadow condition. The site is on mostly C soils with some D soils.

Computation of Preliminary Stormwater Storage Volumes and Peak Discharges

The layout of the Stone Hill subdivision is shown on the previous page.

Step 1. Compute preliminary runoff control volumes from Stormwater Sizing Criteria

Water Quality Volume, WQ_v

- Compute Runoff Coefficient, R_v

$$R_v = 0.05 + (I)(0.009)$$
$$= 0.05 + (26.6)(0.009) = 0.29$$

- Compute WQ_v (Offsite area does not need to be considered when determining the water quality volume)

Use the 90% capture rule with 0.9" of rainfall.

$$WQ_v = (0.9")(R_v)(A)$$
$$= (0.9")(0.29)(45.1\ ac)(1ft/12in)$$
$$= \underline{0.98\ ac\text{-}ft}$$

Establish Hydrologic Input Parameters and Develop Site Hydrology (See Figures 4.8, 4.9, and 4.10)

Condition	**Area**	**CN**	**Tc**
	Ac		*hrs*
Pre-developed	65.1	72	0.46
Post-developed	65.1	78	0.35
Ultimate buildout	65.1	82	0.35

Hydrologic Calculations

Condition	$Q_{1\text{-}yr}$	$Q_{1\text{-}yr}$	$Q_{10\text{-}yr}$	$Q_{100\text{-}yr}$
Runoff	*Inches*	*cfs*	*cfs*	*cfs*
Pre-developed	0.4	19	72	141
Post-developed	0.7	38	112	202
Ultimate buildout	NA	NA	NA	227

PEAK DISCHARGE SUMMARY				
JOB:	STONE HILL			EWB
DRAINAGE AREA NAME:	POST DEVELOPMENT			21-Jan-97
COVER DESCRIPTION	SOIL NAME	GROUP A,B,C,D?	CN from TABLE 2-2	AREA (In acres)
MEADOW		C	71	0.16 Ac.
MEADOW		D	78	0.14 Ac.
WOOD		C	70	3.09 Ac.
WOOD		D	77	1.81 Ac.
IMPERVIOUS			98	12.00 Ac.
GRASS		C	74	20.09 Ac.
GRASS		D	80	7.81 Ac.
OFFSITE MEADOW		C	71	20.00 Ac.
			AREA SUBTOTALS:	65.10 Ac.
Time of Concentration 2-yr 24 Hr Rainfall = 2.7 in	Surface Cover Cross Section	Manning 'n' Wetted Per	Flow Length Avg Velocity	Slope Tt (Hrs)
Sheet Flow	dense grass	'n'=0.24	100 Ft.	3.80% 0.20 Hrs
Shallow Flow (a)	UNPAVED		100 Ft. 1.98 F.P.S.	1.50% 0.01 Hrs.
(b)	PAVED		400 Ft. 2.03 F.P.S.	1.00% 0.05 Hrs.
Channel Flow (a) Hydraulic Radius =0.50	1.6 SqFt	'n'=0.013 3.2 Ft.	1550 Ft. 7.22 F.P.S.	1.00% 0.06 Hrs.
(b) Hydraulic Radius =1.42	12.0 SqFt	'n'=0.030 8.5 Ft.	350 Ft. 13.01 F.P.S.	4.30% 0.01 Hrs.
(c) Hydraulic Radius =1.26	22.0 SqFt	'n'=0.040 8.5 Ft.	300 Ft. 7.89 F.P.S.	3.30% 0.01 Hrs.
Total Area in Acres =	65.10 Ac.	Total Sheet	Total Shallow	Total Channel
Weighted CN =	78	Flow=	Flow=	Flow =
Time Of Concentration =	0.35 Hrs.	0.20 Hrs.	0.07 Hrs.	0.08 Hrs.
Pond Factor =	1	RAINFALL TYPE II		
STORM	*Precipitation* (P) inches	*Runoff* (Q)	Qp, PEAK DISCHARGE	TOTAL STORM Volumes
1 Year	2.3 In.	0.7 In.	37.6 CFS	156,283 Cu. Ft.
2 Year	2.7 In.	0.9 In.	54.0 CFS	217,511 Cu. Ft.
10 Year	3.9 In.	1.8 In.	112 CFS	427,155 Cu. Ft.
100 Year	5.5 In.	3.1 In.	202 CFS	742,265 Cu. Ft.

Figure 4.9. Stone Hill Post-Development Conditions

R0009526

Compute Stream Channel Protection Volume. (Cp_v)

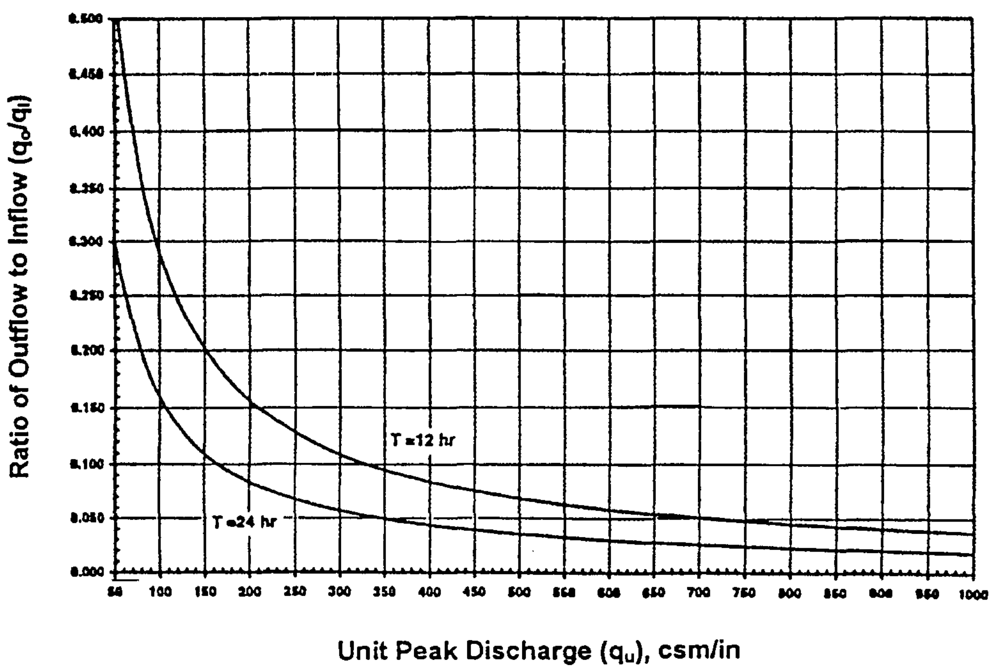
For stream channel protection, provide 24 hours of extended detention (T) for the one-year event.

Utilize SCS approach to Compute Channel Protection Storage Volume

- Initial abstraction (Ia) for CN of 78 is 0.564: [Ia = (200/CN - 2)]
- Ia/P = (0.564)/ 2.3 inches = 0.245
- T_c = 0.35 hours
- q_u = 570 csm/in (Type II Storm)

Knowing q_u and T (assume 24 hours of extended detention time), find q_o/q_i using Figure 4.11 (MDE, 2000). [Also see methodology in Appendix B]

Figure 4.11. Detention Time vs. Discharge Ratios (Source: MDE, 1998)



- Peak outflow discharge/peak inflow discharge (q_o/q_i) = 0.035
- $Vs/Vr = 0.683 - 1.43(q_o/q_i) - 1.64(q_o/q_i)^2 - 0.804(q_o/q_i)^3$
  - Where Vs equals channel protection storage (Cp_v) and Vr equals the volume of runoff in inches.
  - Vs/Vr = 0.63
  - Therefore, Vs = Cp_v = 0.63(0.7")(1/12)(65.1 ac) = 2.4 ac-ft (104,214 cubic feet)

R0009527

Compute Extreme Flood Protection Volume, (Q_f)

Extreme flood protection is calculated using the same methodology as overbank protection.

- For a Q_{in} of, and an allowable Q_{out} of, and a runoff volume of the Vs necessary for 100-year control is, under a developed CN of 78. Note that 5.5 inches of rain fall during this event, with approximately 3.1 inches of runoff.
- While the TR-55 short-cut method reports to incorporate multiple stage structures, experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive with the 100-year storm. So, for preliminary sizing purposes add 15% to the required volume for the 100-year storm. $Q_{f-100} = 3.53 \times 1.15 = 4.06$ ac-ft.

Analyze Safe Passage of 100 Year Design Storm (Qf)

If peak discharge control of the 100-year storm is not required, it is still necessary to provide safe passage for the 100-year event under ultimate buildout conditions ($Q_{ult} = 227$ cfs).

Table 4.5. Summary of General Storage Requirements for Stone Hill Estates

Symbol	*Category*	Volume Required (ac- ft)	Notes
WQ	Water Quality Volume	0.98	
Cp	Stream Protection	2.4	Average ED release rate is 1.2 cfs over 24 hours
Q..	Peak Control	2.5	10-year, in this case
Q.	Flood Control	4.1	

CHAPTER 2

STORMWATER MANAGEMENT and URBAN BMPs

2-1 COMPONENTS OF STORMWATER MANAGEMENT

The goal of storm water management is to mitigate the impact on the hydrologic cycle resulting from changes to the land surface. Urban development has been identified as having a direct impact on the hydrologic cycle by reducing or even eliminating the natural storage capacity of the land. This impact is the result of a decrease in tree cover, loose organic surface soils, and natural depressions, all of which provide natural storage capacity. These natural storage areas are then replaced with impervious and managed pervious surfaces. Impervious cover prevents the percolation of the runoff into the soil, which means that most, if not all of the rainfall is converted to runoff. In addition, managed pervious areas, such as courtyards and lawn areas typically do not provide opportunities for infiltration due to compaction of the surface soil profile and improved drainage conveyances. (The impact of development on the hydrologic cycle is discussed in detail in **Chapter 4; Hydrologic Methods**.) The results of increased stormwater runoff can be classified by its impact on *water quality*, *stream channel erosion*, and *localized flooding*. These components are identified in the Virginia Stormwater Management (SWM) Regulations.

2-1.1 Water Quality

One of the impacts of stormwater runoff is that of the quality of the runoff on the aquatic ecosystem. Various soluble and particulate pollutants are found in stormwater runoff. Studies have shown that the source of these pollutants are atmospheric deposition, urban and agricultural lands, and natural spaces. The focus of this document is on the urban land sources. The impervious surfaces, such as parking lots, roof tops, roads, etc., which are associated with land development serve to accumulate and transport these pollutants to receiving stream channels. It should be noted that pervious areas associated with development, such as golf courses, parks, open space, etc., also contribute pollutants.

The following presents a basic overview of the typical urban pollutants. Additional discussion of urban pollutants associated with certain ultra-urban development environments, referred to as *stormwater hotspots* (Claytor, 1996) is discussed in **Section 2-3: BMP Selection Criteria**.

Nutrients. Concentrations of nutrients, such as nitrogen and phosphorus, found in urban runoff can cause eutrophication of receiving streams, lakes, and rivers, and estuaries. As these nutrients collect in slower moving water bodies, they promote the growth of algae, which in turn blocks sunlight to bottom grasses, and eventually leads to a depletion of available dissolved oxygen (DO). Nutrients in urban runoff have been identified as being a significant contributor to the decline of the Chesapeake Bay. The Virginia Tributary Strategy initiative calls for a 40% reduction in nutrients reaching the Chesapeake Bay by the year 2000.

Suspended solids. All natural drainage channels have a natural sediment bed load which helps maintain a state of equilibrium within the channels of undeveloped watersheds. Increases in the peak rates of flow through the channel or stream system will disrupt the equilibrium by increasing the amount of sediment removed from the channel bed and banks. Suspended solids which result from excessive erosion and scour channel, however, is quite often a very efficient conveyance system and promotes an even faster velocity of flow, which in turn, accelerates the channel erosion process. Once this process has begun, it is very difficult to stop because typical stream channel soils are highly erodible once the protective lining of cobble or vegetation is eroded away.

2-1.3 Flooding

When the rate of stormwater runoff exceeds the capacity of the various manmade or natural conveyance systems, the result is localized flooding. The conveyance system gradually catches up and drains the flood waters as the rainfall subsides. In some cases debris or other materials dislodged by the rising flood waters will clog the drainage system and cause longer periods of flooding. In either case, pockets of standing water which do not drain will remain for periods of time and eventually percolate into the ground or evaporate.

In the pre-developed condition, most stream channels have an adequate floodplain or flood fringe to convey and store the out of bank flows with minimal damage. With urbanization, however, these floodplain areas are often eliminated or developed with improvements. The periodic ponding of water in developed areas often results in damage. Pavement will fail or be undermined, structures will be water damaged, landscaping and other improvements not used to inundation will be damaged.

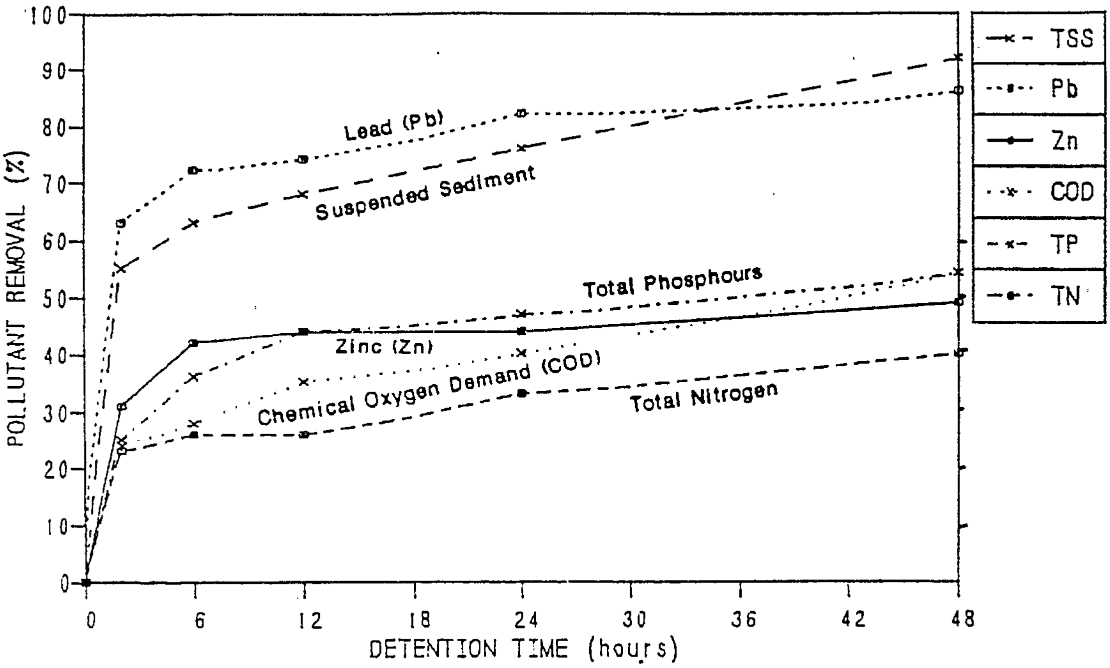
2-1.4 Regional (watershed-wide) Stormwater Plans

The cumulative effect of sedimentation, scouring, increased flooding, lower summer flows, higher water temperature, and pollution contribute to the overall degradation of the stream ecosystem. Many studies have documented the decline of fish diversity in urbanized watersheds. The aquatic insects which are a major food resource for fish are impacted by the increased sediment load, trace metals, nutrients, and flow velocities. Less noticeable impacts to the stream systems are changes in water temperature, oxygen levels, and substrate composition.

A regional or watershed-wide stormwater plan provides the framework needed to evaluate the impacts of changes to the land on water resources. A comprehensive watershed management plan considers all of the impacts of increased stormwater runoff: water quality, channel erosion, and flooding. The plan is the result of studying the environmental features of the watershed to identify those areas that should be protected and preserved. The plan identifies and strategically locates stormwater management measures and design criteria to be utilized to protect the watershed. The plan also aims to utilize and protect ecological processes to lessen the need for structural control methods that require capital costs and maintenance.

FIGURE 2-1

Removal Rate vs. Detention Time for Selected Pollutants



Source: Schueler, Controlling Urban Runoff, 1987

Stormwater filtering or *filtration* is typically limited to BMPs which address water quality. These facilities utilize a filter media, such as sand, peat, grass, compost, or various types of fabrics or other material to strain pollutants out of the stormwater. Since the stormwater must pass through the filter media in order to be treated, these structures are limited to small drainage areas (less than 5 acres) and low flow rates. A drawback to these structures is the overflow or bypass of large flows from high intensity storms. The current sizing criteria for these BMPs is the water quality volume. The Department is currently evaluating the option of designating a flow rate or return frequency intensity for design purposes. In most cases a bypass or diversion structure is needed to allow large flows to bypass the BMP without flushing previously deposited pollutants out of the BMP. Guidance on this issue will be provided in the future.

and filtering of pollutants, as well as decreased export of sediment and attached pollutants via erosion.

Water Quality Volume (WQV)

Ideally, the pollutant removal mechanism should dictate the treatment volume or frequency storm for water quality BMPs. The sizing of BMPs which utilize gravitational settling of pollutants as the removal mechanism can be based on a volume of runoff, while BMPs which utilize filtering should probably be based on a flow rate or frequency. Design criteria provided in **Chapter 3: BMP Minimum Standards**, specifies maximum flow velocities for grass swales and filter strips, as well as the need for a flow splitter or bypass structure for sand filters and other flow through structures.

The Virginia Stormwater Management Regulations require that the *first flush* of runoff be captured and "treated" to remove pollutants. The first flush, or water quality volume (WQV) is generally defined as the first ½" to 1" of runoff from impervious surfaces. Other methods of defining this first flush have been developed. One method in particular, developed by The Center for Watershed Protection, utilizes the Runoff Frequency Spectrum (RFS) for the Washington D.C. area and surrounding Chesapeake Bay watershed. The RFS is based on the fact that 90% of the annual runoff is generated by storms of 1" of rainfall or less. Therefore, the goal of treating at least 90% of the annual runoff results in a treatment volume based on a 1" rainfall. The volume of runoff is determined by multiplying a volumetric runoff coefficient (R_v), based on site imperviousness, by the 1" of rainfall. This method generates a water quality volume of close to 1" for highly impervious sites and gradually decreasing volumes for gradually decreasing levels of imperviousness.

As noted in the Virginia Stormwater Management Regulations, water quality BMPs which are dependent on volume, such as extended detention, constructed stormwater wetlands, and in some cases infiltration, have a required treatment volume of 2.0 x WQV (or 2.0 x 0.5" = 1.0" per impervious acre). This will result in a very similar volume as that based on the RFS method described above. As these methods are studied and BMPs are monitored, the design criteria for determining the WQV may be refined to achieve a greater overall level of treatment.

While the first flush from a storm event is considered to contain the highest concentration of pollutants, there is considerable debate over the intensity of rain needed to wash the pollutants from the urban landscape. Studies have shown that intensity is the critical wash off factor for most storm events, and many people can intuitively comprehend that higher intensity rains leave impervious surfaces cleaner than lower intensity rains. (Adams, 1997). The typical SCS rainfall hyetograph starts with a low rainfall intensity which gradually rises to a peak and then declines. This may indicate that in some cases the designated water quality volume provided in a stormwater basin may fill up with the relatively clean water at the onset of a rain event, consequently allowing the larger flows associated with the high intensity rain and pollutant wash off to pass through the facility.

frequency of every three to six months rather than two years. In addition, for the 2-year storm, the *volume* of runoff has increased to 1.15 watershed inches, more than double the pre-developed volume, which means a significant increase in the *duration* of the peak flow can be expected. Under this scenario, the receiving stream will experience a significant increase in erosive flows.

The solution to designing for stream channel erosion is evolving into a study of stream channel geomorphology. Several studies have indicated that the level of erosion (or bed-material load) is a function of the difference between the flow velocity and the *critical* velocity.(McCuen, 1987). The critical velocity is a function of the type of soil of which the channel bed is composed. The studies indicate that the amount of bed sediment moved is a function of the time duration over which the velocity is greater than the critical velocity. According to McCuen, this explains from a conceptual standpoint why the duration of flow is just as important as the rate of flow. Further, it may explain why detention basins may actually increase the erosion compared to providing no control of the post-developed flows. When no control is provided, the flow tends to exceed the channel capacity and extend out into the floodplain; thus the velocity within the channel banks may not increase significantly even though the peak flow rate does increase significantly.

This should not be interpreted as justification for no control of stormwater runoff. Rather, it highlights the need for a design criteria that replicates the pre-development sediment load transport characteristics of the channel. Several methodologies have been recommended, some of which are very subjective as they are based upon the ability of the designer to analyze and interpret the stream sediment characteristics. This could easily become an expensive and cumbersome methodology, especially in localities that do not experience significant development pressure. The review and approval process could become bogged down in the analysis of field data and trying to verify the channel characteristics, especially when the requirements of the field work may be different for every project.

The Virginia Stormwater Management Regulations address stream channel erosion by requiring compliance with Minimum Standard 19 of the Virginia Erosion and Sediment Control Regulations (4VAC50-30-40.19). This standard requires that **properties downstream from development sites be protected from sediment deposition, erosion, damage due to increases in volume, velocity, and peak flow rate of stormwater runoff.** The specific design criteria specifies that downstream *natural channels* by analyzed for adequacy to convey the developed condition 2-year peak discharge within the channel banks and at a non-erosive velocity. In addition, *man made channels* are analyzed for adequacy to convey the 10-year peak discharge within the channel banks and the 2-year peak discharge at a non-erosive velocity.

When a channel is determined to be not adequate, the use of a stormwater detention BMP sized to discharge the 2-year and 10-year frequency developed-condition peak discharge at the respective pre-developed rates is one of the available options. (Refer to **Chapter 1** for the complete language of Minimum Standard 19.) As we discussed above, this criteria may not be adequate for natural channels due to the increase in the frequency, duration, and volume of the "pre-developed" discharge.

An alternative is to identify a design frequency storm and control the discharge such that it does not exceed

2-3 BMP SELECTION CRITERIA

The following discussion provides a general outline for choosing the appropriate BMPS for a development site. The order of presentation **does not** imply a decision making process that will systematically progress towards an acceptable BMP. On the contrary, any one of the criteria can render a preferred BMP unacceptable. **In some cases**, the designer may be able to accommodate certain limiting feasibility factors by providing an innovative design which addresses or remedies the constraint. **In all cases**, once a BMP is selected, we strongly recommend that the selection, along with the supporting criteria and any compromises or design features, be presented to the various review or permitting agencies to ensure proper evaluation and review. This will help avoid extensive changes to the stormwater management strategy during the review process.

One of the first considerations in selecting a stormwater BMP is the functional goal of the BMP. Previously, we discussed the components of SWM: *stormwater quality, stream channel erosion,* and *flooding*. Any one or combination of these components may be addressed by the local ordinance and will dictate the functional goal of the BMPs. (State agency projects, are required to comply with all three of these regulatory components). In general, stormwater BMPs can be categorized into water *quality* BMPs and water *quantity* (stream channel erosion and flooding) BMPs. **Table 2-2** provides a general categorization of BMPs by functional goal. Note, that some BMPS can be designed to satisfy both quality and quantity goals while others are specifically suited for only one.

The use of some BMPS are limited by site or watershed feasibility factors such as environmental impacts, drainage area or watershed size, and topographic constraints.

Finally, the BMPS designed for water quality control provide varying levels of pollutant removal and are suited for specific development densities. **Table 2-3** presents a generic list of water quality BMPS, their target phosphorus removal efficiency, and appropriate percent impervious cover.

The decision making process of choosing a stormwater BMP must weigh the goals of the proposed facility against the limiting site feasibility factors of the proposed site or BMP location. The limiting *site feasibility* factors include:

1. Topographic and geologic constraints,
2. Contributing drainage area size, and
3. Environmental impacts.
4. Access for maintenance

The possible stormwater management requirements or goals which influence BMP selection include:

1. Multiple Criterion: Stormwater quality, stream channel erosion, flooding, and environmental mitigation,
2. Multiple discharge points,

stormwater to drain out of (or under) the proposed facility.

A thorough geotechnical investigation and report should verify the subsurface conditions for the presence of any of the above features. The scope and requirements of a geotechnical investigation may vary from site to site. Refer to **Minimum Standard 3.10: General Infiltration Practices** for additional information on geotechnical investigations.

d. *Proximity to structures, steep slopes, and water supply wells.* One of the goals of stormwater facilities is to provide recharge of the groundwater. This tends to saturate the adjacent ground during, and for a period of time, after, a storm event. Building foundations, basements, and other structures may be impacted by the wet/dry cycle of the surrounding soils.

Saturating the soils on or adjacent to steep slopes (6 to 10 percent or greater) can cause a failure of the slope and adjacent structures.

The proximity to water supply wells raises concern over the introduction of pollutants into the water supply aquifer. Minimum distances from these features are presented in **Chapter 3: Minimum Standards.**

2. Contributing Drainage Area Size

Some BMPs are restricted based upon the size of the contributing drainage area. The recommended maximum and minimum sizes are considered guidelines and some flexibility should be allowed. The exceptions, however, are the Manufactured BMP Systems (**Minimum Standard 3.15**) The manufacturers design criteria should be adjusted or modified **by the manufacturer only**. The proper operation of these BMPs is dependent on the proper sizing of the structure.

3. Environmental Impacts

It is extremely important for the designer to asses the environmental impacts associated with the site development and the placement of the stormwater BMP. Local, State, and Federal regulations may restrict the disturbance, or encroachment upon any of the following: wetlands, Waters of the United States, stream or wetland buffers, floodplains, conservation easements, and other sensitive resources.

Virginia Water Protection Permit Program: The Virginia Department of Environmental Quality implements the Virginia Water Protection Permit (VWPP) Program. This program regulates all activities in Virginia which result in discharge or dredge or fill material into state waters. This can include wetlands, perennial streams, and other aquatic resources. The VWPP program is in conjunction with the U.S. Corps. of Engineers Federal Permit authorized by the Clear Water Act. Some projects may require one or both permits. The permit typically requires that the developer investigate alternatives to the proposed impacts. If

2. Multiple Discharge Points

The simplest site design includes a stormwater management strategy that consists of one discharge point from the site. Large developments, however, often contain multiple discharge locations as dictated by the topography. Traditionally, this situation has been addressed one of two ways: 1) Provide a Stormwater BMP at each location as required by the size of the contributing drainage area and associated increase in peak discharge, percent imperviousness, etc; or 2) overcompensate at one discharge point in order to allow the other discharge point(s) to go uncontrolled.

Overcompensation of Peak Discharge should be subject to the following conditions:

1. The drainage channels which leave the site must be part of the same stream or tributary network and the confluence should occur at some reasonable distance from the site.

2. The uncontrolled discharge is still subject to the requirements of MS-19, that is the receiving channel is adequate to convey the increased flow.

3. The overall peak rate of discharge leaving the site must not exceed that of the pre-developed condition.

Overcompensation of Water Quality is covered in more detail in the next section which discusses the use of the Performance-based Water Quality Criteria. However, as it applies to multiple discharge points, the following conditions should apply:

1. The drainage channels which leave the site must be part of the same stream or tributary network and the confluence should occur at some reasonable distance from the site.

2. Every effort should be made to provide water quality enhancement through the use of vegetated buffers, open grass/vegetated swales, bioretention, or other low maintenance water quality BMPs.

3. Every effort should be made to minimize the impacts in the uncontrolled drainage area through non-structural means as discussed previously.

4. The overall site water quality compliance must be determined using the performance-based water quality criteria.

Another alternative which may be considered is the control of existing development in lieu of the proposed development. This trade off should be considered only if specific site, watershed, or environmental considerations hinder the successful incorporation of on-site BMPs.

TABLE 2-2

Functional Goal of Stormwater BMPs

Stormwater BMP	Quality	Stream Channel Erosion	Flooding
Vegetated filter strip	• ←+		
Grassed Swale (w/ check dams)	• ←+	• •	
Constructed wetlands	• ←–	• •	
Extended detention	• ←	• ←+	• •
Extended detention enhanced	• ←+	• ←	• •
Bioretention	• ←+		
Retention basin	• ←+	• ←	• •
Sand filter	• ←+		
Infiltration	• ←+		
Infiltration Basin	• ←	• •	• •
Detention		• ←	• ←+
Manufactured BMPs	• ←+		

Legend:
- • ←+ = Primary functional goal
- • ← = Potential secondary functional goal
- • • = Potential secondary functional goal with design modifications or additional storage

NOTE: *Some BMPs, when properly designed, can provide secondary goals. Table 2-2 indicates several water quality BMPs with potential secondary goals. This is not meant to restrict the designer from incorporating design modifications or additional storage as appropriate for the particular site. Care must be taken to ensure that the the design modifications do not diminish the primary goal capabilities of the BMP.*

TABLE 2-4
Classification of Stormwater Hotspots

The following land uses and activities are deemed *stormwater hotspots*
•• vehicle salvage yards and recycling facilities #
•• vehicle fueling stations
•• vehicle service and maintenance facilities
•• vehicle and equipment cleaning facilities #
•• fleet storage areas (bus, truck, etc.) #
•• industrial sites (for SIC codes contact Virginia Dept. Of Environmental Quality)
•• marinas (service and maintenance) #
•• outdoor liquid container storage
•• outdoor loading/unloading facilities
•• public works storage areas
•• facilities that generate or store hazardous materials #
•• commercial container nursery
# indicates that the land use or activity is required to prepare a stormwater pollution prevention plan in accordance with the Virginia Pollution Discharge Elimination System program permit as required by the Virginia Department of Environmental Quality.

Source: Center for Watershed Protection, 1997

2-3.3 *Technology-Based* and *Performance-Based* Water Quality Criteria

The *Technology-based* and *Performance-based* water quality criterion represent a consolidation of the water quality technical criteria of three state agencies charged with the responsibility of monitoring and improving the water resources of the Commonwealth: The Department of Conservation and Recreation (DCR), the Department of Environmental Quality (DEQ), and the Chesapeake Bay Local Assistance Department (CBLAD). The specific responsibilities of these agencies are presented in **Chapter 1**. The stormwater management water quality regulations require compliance by **either** a *performance-based water quality criteria* **or** a *technology-based water quality criteria.*

The *performance-based* water quality criteria states that for land development, the calculated post-development nonpoint source pollutant runoff load shall be compared to the calculated pre-development load based upon the average land cover condition or the existing site condition. This approach requires the designer to calculate the pollutant load to be removed, implement a BMP strategy, and then calculate the performance of that strategy, based on the effectiveness or pollutant removal efficiency of the selected BMP(s), (**Table 2-3**).

3. *Situation 3* consists of land development where the existing percent impervious cover is greater than the average land cover condition.

> Requirement: The pollutant discharge after development shall not exceed (i) the pollutant discharge based on existing conditions less 10% or (ii) the pollutant discharge based on the average land cover condition, whichever is greater.

("...which ever is greater" refers to the calculated pollutant discharge to which the after development pollutant discharge is compared. Additional explanation is provided in the discussion following this section.)

4. *Situation 4* consists of land development where the existing percent impervious cover is served by an existing stormwater management BMP that addresses water quality.

> Requirement: The pollutant discharge after development shall not exceed the existing pollutant discharge based on the existing percent impervious cover while served by the existing BMP. The existing BMP shall be shown to have been designed and constructed in accordance with proper design standards and specifications, and to be in proper functioning condition.

The definition of the average land cover condition is important to the successful implementation of the performance-based water quality criteria. An analysis of the Chesapeake Bay watershed identified the average land cover condition using the following categories: urban land use, forest cover, pasture land, conservation till acreage, and conventional till acreage. Using the pollutant load values from the N.U.R.P. studies, the average land cover condition was then used to establish a baseline existing land use condition pollutant load value of 0.45 lb/ac/yr of phosphorous. Since the Simple Method is based on impervious cover, an equivalent percent impervious cover is needed. 16% impervious cover has been determined to be an equivalent pollutant load source for all of the urban and non-urban land uses which contribute nonpoint source pollution. These values (16% impervious cover and 0.45 lb/ac/yr of phosphorous) represent the average land cover conditions for the Chesapeake Bay watershed. (Keep in mind that these values may be adjusted based on actual land use conditions within the locality or individual watersheds within the locality at the time of DCR or CBLAD program adoption, whichever occurred first.) This allows the designer to calculate, using the Simple Method, the pre-developed pollutant load using average land cover conditions, and the post-developed pollutant load using the project post-developed impervious cover. The difference between the pre- and post-developed pollutant load represents the increase in pollutant load which must then be controlled by an appropriate BMP.

low while allowing for the preservation of high priority open space such as stream buffers and unmanaged open space. However, the clustered development represents a significant source of increased runoff and pollutant load when directly connected to the drainage system. Guidance on mitigating these impacts within the LID strategy can be found in the references provided at the end of this chapter.

If, on the other hand, the development consists of commercial or industrial development and associated infrastructure (parking lots, roads, and other impervious surfaces), located on a sufficiently large parcel such that the total area of impervious cover is less than 16%, and the improvements include a directly connected drainage network, then water quality controls should be provided. This type of development poses a very difficult development situation to regulate using the performance-based water quality criteria since the overall percent impervious cover is low. Initial efforts to define the impervious cover as connected or disconnected led to very awkward and subjective regulatory language. Another option considered revising the definition of *percent impervious* to read "the impervious area divided by the drainage area within the site multiplied by 100." Again, various development situations were presented which led to subjective interpretations of these definitions. The preferred method of dealing with this issue was determined to be clear guidance on the intent of the 16% impervious cover "average land cover condition," and a case by case evaluation of the application of the performance-based water quality criteria.

When improvements on a site are concentrated such that the impervious area is collected and drained to a single receiving channel (connected impervious cover), it is reasonable to expect that the developed condition runoff will have an impact on the receiving system in terms of water quality impairments, regardless of the overall "site" percent imperviousness, and therefore should be considered in the water quality strategy. In such cases, DCR recommends that the percent impervious cover calculation be based on the drainage area being collected by the improved drainage system.

Development Situation 2 describes new development which results in impervious cover greater than the average land cover condition. The selection and location of a BMP to satisfy the pollutant removal requirement is verified using the Simple Method.

Development Situation 3 describes development of a site with existing development already present. This development situation is provided to help create an incentive for development, or "redevelopment" of existing infrastructure as opposed to developing a raw piece of land. Clearly redevelopment contains more challenges with regard to existing utilities, building locations, entrances, drainage systems, etc. The requirement of 10% reduction in calculated pollutant load from the site allows flexibility in siting a BMP at the most advantageous location with regard to existing site restrictions. If the amount of impervious surface does not change significantly, the designer has the choice of several BMPs to achieve the 10% reduction including the Manufactured BMP Systems (**Minimum Standard 3.15**) which can be easily located on an existing storm system.

an imperviousness range of 67 - 100%).

Likewise the development of a low density subdivision in the range of 16 -21% imperviousness would indicate the selection of a vegetated filter strip or grassed swale (or any of the more efficient BMPs). The designer need only verify using the performance-based calculation procedure that the required removal efficiency would dictate a similar selection, thus indicating the equality of the two methodologies.

The difference in the two methodologies is the ability to incorporate a combination of BMPs using the performance-based criteria. Consider the just mentioned office park. If an extended detention-enhanced basin is selected, yet does not capture the runoff from the entire site to the effect that the calculated pollutant removal of the BMP does not satisfy the site or planning area pollutant removal requirement, then an additional BMP or a more efficient BMP must be designed.

Consider, as part of the office park, a two acre parking area along the edge of the office park which does not drain to the extended detention-enhanced facility. The designer may choose to incorporate a grassed swale with check dams to control the two acre drainage area. Since the two acre drainage area is almost entirely impervious, strict application of the technology-based criteria would preclude the use of anything but the most efficient BMPs (sand filter, infiltration, etc.) The performance-based criteria, on the other hand, allows for a total pollutant removal to be calculated to measure the combined effectiveness of the more efficient extended detention-enhanced facility on the majority of the site along with the lower efficiency grassed swale serving the small portion of the site.

The use of sound judgement in the application of multiple BMPs should dictate. If the designer is using the technology approach to control a majority of the site, and proposes a less efficient BMP to control the small area draining in the other direction, the requirement to calculate the total site pollutant removal using the performance-based calculation procedure is at the discretion of the plan approving authority. On the other hand, if a portion of the development site is being left uncontrolled, the plan approving authority may certainly require the performance-based calculation procedure to verify compliance.

Several examples will be provided by DCR as guidance in these types of review decisions.

Asserted problems with on-site facilities:

1. Not as efficient at pollutant removal as larger facilities.

2. More land is disturbed because of need for a number of smaller facilities; an additional 5 to 10 acres will not be available for development out of every 1, 000 acres served by stormwater management facilities.

3. Not well maintained, reducing pollutant removal efficiency.

4. More complicated for localities to maintain a large number of small facilities.

5. Access may be more difficult.

6. Do not typically have maintenance features such as forebays, access roads, and sediment disposal areas. Difficulty in access and maintenance often results in maintenance responsibility being shifted to homeowner's associations, which experience has shown, are not generally capable of coordinating the public works function required to effectively maintain stormwater management facilities. Uncertainty of maintenance puts long- term reliability of the facility in question.

7. Pose a greater public safety hazard.

8. Have more potential to become "eyesores."

9. Can only be sited to address stormwater discharges from future development since they are implemented for individual development projects only.

10. More expensive.

11. May result in a haphazard siting pattern for stormwater management facilities; with only limited control of down stream erosion and flooding.

Asserted benefits of regional facilities:

1. More efficient and ensure the highest possible efficiencies for the entire watershed, rather than one small site.

2. Offer the ability to control temperature of outflow which is not possible with small facilities.

3. Can be strategically located within a watershed and designed for coincident stormwater releases,

a master plan specifying the sites and design criteria, (2) implement a phased construction program so that facilities are in place when new development occurs, and (3) recover pro-rata charges from new development or establish a stormwater utility with which to offset the costs for the regional facilities.

These three components include the following:

A. **Inventory**

1. **Define the watershed boundary.**
2. **Conduct a watershed inventory of natural resource features** (wetlands, floodplains, stream corridors, greenways, rare and endangered species, steep slopes, erodible soils, karst bedrock areas, sensitive habitats, fish and wildlife resources, recreational areas, sources of water supply).
3. **Conduct a stream inventory** (size, order, water and habitat quality, flow regime).
4. **Identify significant environmental features in neighboring watersheds** (large pollution sources, wildlife refuges, sources of water supply).
5. **Identify and quantify existing sources of point and nonpoint source pollution.**
6. **Model the existing hydrology and hydraulics of the watershed** (understand the impact of land use, conveyances, land cover, stormwater management facilities, stream cross sections, roadway crossings, flooding and drainage problems).

B. **Planning**

1. **Define the goals of the watershed management plan** (what is envisioned for the watershed and who is going to lead the implementation efforts).
2. **Identify and quantify future sources of point and nonpoint source pollution.**
3. **Model the future hydrology and hydraulics of the watershed.**
4. **Develop and evaluate alternatives to meet the goals and manage water quality** (point and nonpoint source pollution) **and quantity** (hydrology and hydraulics).
5. **Identify opportunities to restore natural resources.**
6. **Develop the watershed management plan** (include specific recommendations on development and land use evaluation, selection of structural and non-structural BMPs, public education needs, regulatory requirements, and funding).

C. **Implementation**

1. **Identify the stakeholders responsible for developing, implementing and updating the plan to ensure long-term accountability.**
2. **Define the implementation costs** (capital costs and annual administrative, operations and maintenance costs) **and who will pay for the implementation of the watershed management plan** (provide incentives and secure commitments).
3. **Develop a watershed monitoring program.**
4. **Develop an evaluation and revision process for the watershed management plan.**
5. **Establish and implementation schedule.**

The natural resource features to be inventoried would depend on the characteristics of the watershed being studied and could include:

- Wetlands
- Floodplains
- Stream corridors and greenways
- Steep slopes
- Erodible soils
- Karst bedrock areas
- Rare and endangered species
- Sensitive habitats
- Cultural resources
- Fish and wildlife resources
- Recreational areas
- Sources of water supply

Wetlands

Wetlands provide unique habitats for both plants and wildlife, including many threatened and endangered species. As a consequence, wetlands are valued for aesthetic and recreational reasons. Wetlands also provide valuable flood storage, groundwater recharge, and pollutant-filtering functions.

Wetlands are widely scattered throughout Virginia and commonly are encountered on development sites and throughout watersheds. Protecting the natural functions of wetlands is a critical element of the site development process and watershed management planning. For moderate- to high-quality wetlands, which are very difficult to replace, avoidance is recommended. If the watershed contains scattered, small, low-quality wetlands, which are more readily replaced, mitigating the wetlands at a central location may be more appropriate, thereby enhancing wetland functions and reducing a potential constraint to development. Early coordination with resource agencies is recommended.

Floodplains and Stream Corridors

Floodplains and stream corridors include waterways and adjacent riparian lands that may be subject to flooding. Natural waterways provide habitat for fish, aquatic plants, and benthic (bottom dwelling) organisms. Development in waterways may destroy aquatic organisms and introduce large loads of sediment and pollutants into the waterways. Modifying waterways to accommodate development also may destroy the physical features essential to a good habitat, including: stable stream banks and bottom substrates, pools and riffles, meanders, and spawning areas.

Vegetated riparian land adjacent to streams stabilizes the stream bank, filters pollutants from storms and floods, and provides habitats for a variety of amphibians, aquatic birds, and mammals that depend on the proximity to water for their life functions. Development in floodplains and riparian corridors can impair the functions and subject structures to damage from flooding and the meandering of natural streams.

A filter strip or riparian-forested buffer should be preserved or created along the banks of streams, where possible. Furthermore, consideration should be given to establishing setbacks for intensive development is likely. The United States Geological Survey is a good source of information on karst bedrock in Virginia. If an area is prone to sink hole development, site drainage should be planned to minimize the concentration of runoff. This can be accomplished by reducing the hydraulic connectivity of impervious surfaces and by the use of filter strips. Where they are required, channels or ponds should be lined.

Certain BMPs can be used in karst areas to provide infiltration opportunities over a very large area. Examples are filter strips, large bioretention facilities, and permeable pavement. These practices mimic the natural process by which rainfall enters the subsurface. Point sources of infiltration, such infiltration trenches or dry wells should be avoided (CH2M HILL, 1998).

Threatened and Endangered Species

Existing information can be obtained from surveys conducted by the Division of Natural Heritage (DNH) of the Virginia Department of Conservation and Recreation. For portions of the watershed that have not been previously surveyed, DNH's Element List can be compared to plant community information derived from previous investigations in the watershed, as well as from wetlands identification efforts. The inventory should include a list of potential threatened or endangered species.

Cultural Resources

Existing information can be obtained from the Virginia Department of Historic Resources. For potential regional (watershed) BMP sites, background research to characterize the cultural resource potential of the project area can be conducted. This research will provide a historic context for evaluating any cultural resources that might be located in the project area.

Fish and Wildlife Resources

Existing information can be obtained from the Virginia Department of Game and Inland Fisheries. This information will be useful when defining watershed goals and selecting BMPs to protect sensitive areas. In addition, fish can be a good indicator of stream health and can be used during the evaluation of effectiveness of the watershed management plan, as part of a watershed monitoring program.

Recreational Areas and Sources of Water Supply

An inventory of recreational areas and sources of water supply will also facilitate, and in some cases mandate, the goals of the watershed. This information will also be important in the selection of models that will be needed to identify sources of pollution, understand the hydrologic and hydraulic characteristics of the watershed, and evaluate alternatives to meet the watershed goals and manage water quality.

The objectives of the model application for a watershed management plan may range from simple screening of environmental problems that require minimum data input to detailed analysis of water quantity and quality in the watershed. Detailed analysis requires more input data and usually provides information needed for the design of a specific project or for the analysis and solution of specific environmental problems. Detailed analyses are used to represent the watershed processes that affect pollution generation. However, it is not always true that detailed analyses, based on sophisticated models, provide the most accurate representation of the watershed and its environmental problems; it is best to use the least complicated model that will produce the results for appropriate decision making.

Model selection also depends significantly on the data available in the watershed. The precision of the model predictions is affected by dynamic and transient conditions, high spatial variability (mainly related to rainfall variability and land use), and differences in event conditions (such as antecedent moisture conditions, infiltration potential, local pipe or stream conditions, etc.). The data availability and the simulation complexities affect model selection by tempering the decision towards acceptance of a model that is accurate but not as precise as other more sophisticated models.
In addition to data availability issues, monitoring data and watershed responses can be highly variable. Selecting a simpler model, and accepting results that are not as precise as desired but remain accurate, is an appropriate strategy.

6. Model the Existing Hydrology and Hydraulics of the Watershed

The model selection strategy presented in the previous section also applies to hydrologic and hydraulic models.

Hydrologic models provide information on the amount of runoff that will reach the outlet of the watershed and any receiving waters. Hydraulic models estimate water surface elevations and velocities of surface water. These models are also used to characterize the drainage system in the watershed. Groundwater models represent the movement of groundwater.

The focus of the modeling of the existing characteristics of the watershed is to develop baseline information that will be used to evaluate BMP siting and sizing alternatives for meeting the watershed goals and solving drainage and flooding problems. The hydrologic and hydraulic models will also facilitate the understanding of the impact of land use, conveyances, land cover, stormwater management facilities, stream cross sections, roadway crossings, and flooding and drainage problems.

Accurate land use data will ensure accurate modeling results. Developing an updating land use and impervious cover information will facilitate the implementation of the watershed plan.

4. **Develop and Evaluate Alternatives to Meet the Goals and Manage Water Quality and Quantity**

In order to meet the watershed goals and to solve the watershed's problems effectively, the watershed master plan should consider all feasible alternatives. These alternatives will manage water quantity and quality in the watershed. Therefore, the alternatives will address flooding, drainage, erosion, and stormwater pollution problems.

Generally, alternative solutions mitigate **flooding and drainage damages** by providing additional storage of flows, by increasing the conveyance capacity of the drainage and stream system, or by floodproofing structures at risk of flooding. Alternative solutions mitigate **erosion damages** by stabilizing stream banks using non-erosive materials and/or by redefining the meandering pattern and using the channel and floodplain to dissipate the flow energy. Alternative solutions mitigate **stormwater pollution** problems by providing structural and non-structural BMPs.

Alternatives should be evaluated by using the existing and future condition models and the information from the inventory component described in **Section 2-5.1**. A map of the watershed showing the recommended alternatives should be prepared and distributed to all stakeholders.

Each alternative, or combination of alternatives, also could be evaluated according to screening criteria that address technical, practical, environmental, economic, and political feasibility. Alternatives can be investigated in detail when they appeared to have potential to be cost-effective and satisfy all project criteria.

Selecting sites for regional (watershed-level) BMPs or flood/erosion controls involves balancing pollutant removal, runoff attenuation, environmental permitting constraints, and cost issues. The following is a typical sequence of the iterative process to be completed for each of the potential sites:

A. Identify potential regional BMP sites and sites for flood/erosion controls.

B. Field screen the sites taking into account the following:
   - drainage area
   - topography
   - existing development and projected future development
   - access and construction issues
   - wetlands constraints
   - other regulatory constraints
   - land ownership/value issues

C. Use the previously described watershed models to analyze pollutant reduction (phosphorous and total suspended solids management), flood/erosion control, and resource protection.

D. Use the inventory and models to identify performance standards for the selection, design, and location

2. **Define the implementation costs and who will pay for the implementation of the watershed management plan**

Use uniform and consistent procedures to estimate project costs for the alternatives developed to solve the problems in each watershed. The cost should include capital costs and annual administrative, operations and maintenance costs for all the elements of the plan.

Identify the funding sources for implementation of the watershed management plan. Below is a summary of the possible funding sources: .

- General obligation and revenue bonds
- Stormwater utility fees
- Land development fees
- Pro-rata share contributions
- General fund resources
- Loans and grant programs
- Special service districts and watershed improvement districts

3. **Develop a watershed monitoring program**

Develop a monitoring program that enables the stakeholders to objectively measure and track indicators of the watershed management plan's success. The indicators should focus on water quantity and quality issues, programmatic and socioeconomic needs, and physical and hydrologic measures.

Stormwater chemistry is fairly well understood. Therefore, chemical monitoring of stormwater outfalls will not necessarily provide valuable data. On the other hand, physical and biological monitoring and selected long-term stream monitoring stations will provide valuable information to "measure" the successful implementation of the watershed plan. If success is not achieved, the monitoring program will provide the data to make revisions to the plan. The monitoring program also will provide information to re-evaluate the watershed goals and the implementation schedule.

4. **Develop an evaluation and revision process for the watershed management plan**

During the implementation of the watershed management plan, it is likely that at least one of the following problems will occur:

- Monitoring indicates that the wrong problem is being solved.
- Solving one problem unmasks another problem that is more difficult to control.
- The program reaches some program or activity goals but may not be effective enough to reach the water

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Muck deposition influences design and maintenance of stormwater ponds

Pollutant Dynamics of Pond Muck

Historically, most research on stormwater ponds has focused on the movement of pollu
and out of the pond. This is quite understandable, as knowledge about inputs and outputs c
helps to estimate pollutant remov al performance. An impressive amount of input/output n
data has been collected; nearly 65 pond monitoring studies have been conducted in the U.S
Canada.

Most of the monitoring studies have shown that stormwater ponds and wetlands are
effective in trapping pollutants carried in urban stormwater. Much less is known, however
fate of stormwater pollutants once they are trapped in a pond. It is generally assumed that
pollutants eventually settle out to the pond bottom and form a muck layer. [The term muck
used here to distinguish newly-deposited bottom sediments from the older parent so ils tha
original pond bottom.- ed.]

n't get your boots stuck in the muck layer

The muck layer deepens as the pond
Pollutants may remain trapped within the
until the entire layer is excavated during a
clean-out. In most cases the muck is event
dewatered, excavated, and a pplied back tc
surface. Research on bottom sediments in
shallow water systems, however, suggests
muck layer may not be so inert. Figure 1 il
how a given pollutant can follow a numbe
and complex pathways into an d out of the
layer.

Some runoff pollutants are transformed within the muck layer, while others are deco
through chemical and microbial processes involved in sediment diagenesis. Indeed, diagen
a key pathway for decompos ition of organic matter and some nutrients. Alternatively, pol
migrate further below the muck layer and into the original soil profile. In some extreme ca
pollutants can travel into groundwater.

Pollutants
number o

complex
and out of the

Alternatively, pollutants might enter the food chain while in the muck layer, either th uptake by wetland plants or by bottom feeding fish. Under the right conditions, some pollu also be released from t he muck into the water column (where they could exit the pond dur storm).

In this article, we examine the internal dynamics within the muck layer of stormwate based on an extensive review of research studies on the physical, chemical, and biological the muck layer of over 5 0 stormwater ponds and wetlands. While it must be admitted that muck is somewhat lacking in glamour, it can have many important implications for the de operation of stormwater ponds and wetlands. Typical questions include:

- What is the average deposition rate of muck in ponds?
- After how many years of deposition will muck need to be removed?
- Can the deposition rate be used to calculate the size of the sediment forebay for a po
- How tightly are pollutants held in the muck layer?
- Is there any risk that pollutants could be released back into the water column? – or i groundwater supplies? – or enter the aquatic food chain where toxicity might be ma
- If pollutants do remain in the muck layer, should muck be considered hazardous or t
- Can muck be safely applied back on the land surface after it is cleaned out from the are more exotic and expensive methods needed to safely dispose of muck?
- Finally, the depth of accumulated muck generally represents the long term work of a trapping pollutants. Can the characteristics of pond muck allow us to infer anything pollutant removal processes operating in ponds or the land uses that drain to it? Do concentrations "fingerprint" land uses?

To answer these questions, we reviewed bottom sediment chemistry data from 37 we detention basins, and two wetland systems, as reported by 14 different researchers. Althou studies covered a broad geogr aphic range, almost 50% of the sites were located in Florida Mid-Atlantic states. Analysis was restricted to mean dry weight concentrations of the surfa sediments that comprise the muck layer (usually the top 5 centimeters). The stormwater pc in age from 3 to 25 years.

The Nature of Pond Muck

The muck layer can be easily distinguished from the parent soils that comprise the pc original bottom. Distinguishing features include the following:

- **a very "soupy" texture** – 57% moisture, Number of studies reporting (N) = 15;
- **a distinctive grey to black color;**
- **a high organic matter content** – nearly 6% volatile suspended solids on average (N
- **a low density** (about 1.3 gms/cm^3); and
- **poorly-sorted sands and silts dominating the muck layer.**

Figure 1. A field guide to the muck layer

Pond muck represents a long term repository for the pollutants trapped within a stor pond. A pollutant, however, can take many different pathways through the mucklayer as s the diagram above.

(a) Pollutant inflow. Sediment, nutrients, trace metals, and hydrocarbons enter the pond during each storm. The total pollutant load delivered to the pond depends to some degree on land use. Some evidence exists that metal and hydrocarbon loads are significantly greater from watersheds draining roads or industrial areas.

(b) Sediment Deposition. A steady rain of sediment particles, attached pollutants, and algal detritus forms the muck layer over time. Field measurements indicate that the muck layer grows from 0.1 to 1 inch per year, with greater deposition note d near the inlet.

(g) Phosphorus Release. In the s low oxygen levels near the bottor can induce a "burp" of soluble ph ammonia, or methane back into tl column.The potential for this phe greatest in deeper ponds in warm itudes.

(h) Groundwater Migration. Pc tightly bound to the pond muck c downward through sediment pore and ultimately reach the watertab pollutants, such as chloride and n the most mobile and have been r

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(c) Muck Microlayer. The uppermost layer of muck represents the recently deposited sediments and pollutants. Consequently, it is very high in organic matter and constantly worked over by microbes, worms and other organisms.

(d) Downward Migration. Most pollutants are tightly bound to sediment particles and remain fixed within the muck layer. Other pollutants can migrate downward into the subsoil via pore spaces between sediment particles.

(e) Fish Bio-magnification. Bottom feeding fish that dwell in larger ponds, such as carp and catfish, ingest detritus from the muck layer. Not much is known about pollutants accumulating in their tissues over time.

(f) Sediment Diagenesis. Organic matter and nutrients are gradually reduced and decomposed over time in the muck layer through a process known as sediment diagenesis. Diagenesis is a key pollutant removal pathway that combines physical, chemical , and biological processes within the sediment to slowly breakdown organic matter, in the presence or absence of oxygen.

migrate outward from ponds into groundwater at modest levels. M monitoring studies, however, rev any risk of groundwater contamir stormwater pond muck.

(i) Wetland Plant Uptake. The r wetland plants take up both nutri metals from the muck layer and t them upward to tubers, stems, an the end of the growing season, th above-ground plant matter often Some of the nutrients are release the pond, while others settle back muck layer as detritus.

(j) Pollutant Export from thePc Pollutants remaining in the pond' column will often flush out durin storm event. Consequently, any p that were released from the muck into the water column may exit a thereby reducing the long term pc removal performance of the pond

(k) Sediment Clean-outs. The ul removal of stormwater pollutants accomplished when the muck lay excavated from the pond and app on the land. This operation may r conducted every 25 to 50 years, d on whether the pond has a foreba existing data and sediment qualit pond muck does not usually cons toxicity hazard.

Deposition of Muck

Muck essentially represents the bulk of all sediments and pollutants that have been h trapped within a pond (excepting those that are microbially broken down into gaseous forr pollutants that migra te below the pond). Therefore, the long term deposition rate of the m of great interest.

The annual deposition rate can be easily calculated if the age of the pond and the dep muck layer are known. The depth of the muck layer is relatively easy to estimate in the fie unique physical characteristics. Annual muck deposition rates on the order of 0.1 to 1.0 in have been reported for a series of ponds in Florida.[23] These rates compare favorably with sedimentation rates calculated at 0.5 inches/yr[6] and 0.8 inches/yr[19] utilizing different tech

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The deposition rate of muck is not always the same throughout a pond. however. Th rates tend to be observed near the inlets of wet ponds. and to some extent. the outlets of de basins.[9] In a ddition. muck deposition rates increase sharply for ponds that are small in rel contributing watershed areas and for ponds that located directly in streams.[6]

Nutrient Content of Pond Muck

As might be expected, the muck layer is highly enriched with nutrients (Table 1). Ph concentration for the 23 studies reviewed averaged 583 mg/kg (range 110 to 1,936 mg/kg, Nearly all the nitrogen found in pond muck is organic in nature, with a mean concentratior mg/kg (range 219 to 11,200, N=20). Nitrate is present in extremely small quantities, whict indicate that some denitrification is occurring in the sediments, or perhaps merely that l es initially trapped in muck.

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In the entire pond data set, the nitrogen to phosphorus (N:P) ratio of the muck layer a about 5 to 1, whereas the average N:P ratio for incoming stormwater runoff is typically arc This lower N:P ratio is not unexpected. Ponds are generally more effective in trapping pho than nitrogen and the decay rate for nitrogen in the muck layer is generally thought to be m than for phosphorus.

Researchers have expressed concern that phosphorus trapped in the muck layer migh released back into the water column, particularly when oxygen levels are low in the summ number of investigators have observed hypoxic and even anoxic conditions near the muck ponds as shallow as 5 feet deep.[6, 22]

An intriguing suggestion for possible sediment phosphorus release is evident in a hai Florida ponds (Table 1). These ponds had unusually high N:P ratios of the muck layer, oft of 10 to 1. One explana tion for the apparent depletion of phosphorus in the muck layer wc mobilization and release of phosphorus from recurring anoxia over many years.

Still, most of the more Northern ponds, as well as many Southern ones, appear to ret the phosphorus deposited in the muck layer. For example, phosphorus levels in the muck l to 10 times higher th an the soils underlying the pond bottom. Also, muck layer phosphoru not normally show a decrease as ponds grow older.

Trace Metal Content of the Muck Layer

The muck layer of stormwater ponds is heavily enriched with trace metals. This pher consistent with reported performance data (Table 2). Trace metal levels are typically 5 to 3 higher in the muck layer, compared to parent soils. Trace metal levels in the muck layer al consistent pattern and distribution, (zinc > lead >> chromium = nickel = copper > cadmiur

This pattern is nearly identical to their reported concentrations monitored in urban st runoff. It also suggests that rarely monitored (or detected) trace metals, such as chromium, nickel, and possibly cadmium, are actually trapped by stormwater ponds. The muck layers ponds often contain more lead than zinc, whereas in younger ponds the converse is true. T reflect the gradual introduction of lead-free fuels over the last decade, with the consequent in lead loadings delivered to the younger ponds.

Table 1: Characteristics of the muck layer in wet stormwater ponds (mg/kg dry weigh otherwise noted)

Location (Ref.)	Land Use	% Moisture	% Volatile Suspended Solids	Total Kjeldahl Nitrogen	Total Phosphorus	Nitrogen to Phosphorus Ratio	Hyd
FL (23)	Road	63	7.1	5180	510	10:1	
FL (23)	Road	77	10.2	4140	301	14:1	
FL (23)	Road	50	9.7	3110	1116	3:1	
FL (23)	Road	60	6.8	1130	100	11:1	
FL (23)	Road	52	6.5	2290	270	9:1	
FL (23)	Road	62	4.5	1440	370	4:1	
FL (23)	Road	65	4.8	2070	480	4:1	
FL (23)	Road	60	4.3	2110	110	20:1	
FL (23)	Road	76	10.4	11200	420	26:1	
FL (22)	Residential	33	2.4	889	292 #	3:1	
FL (3)	Road	64		2306 *	3863	0.6:1	
FL (11)	Residential		6.4	624	619	1:1	
FL (11)	Residential		1.1	256	389	0.7:1	
FL (11)	Commercial		4.1	5026	1936	3:1	
FL (16)	Road				1100		
VA (10)	Residential		4.3	828	232	4:1	
NZ (13)	Industrial			2471	995	3:1	128[illegible]
NZ (13)	Residential			5681	1053	5:1	208[illegible]
MN (14)	Residential	70	9.5		405		
MN (15)	Residential	32	4.8		606		
MN (3)	Road	51		3271	695	5:1	
CT (3)	Road	32		219	499	0.4:1	
MD (17)	Institutional			11000	917	12:1	474
	MEANS	57	6.0	2931	583	5:1	

* = Total Nitrogen
# = May have been influenced by fuel spill

The trace metal content of the muck layer happens to be directly influenced by the ty use that drains to it (Table 3). Muck layers in stormwater ponds that drain residential areas lightest metal enrichment. Commercial sites were subject to slightly greater enrichment. p for copper. lead. and zinc. Ponds that primarily served roads and highways were highly en metals. presumably due to the influence of automotive loading sources (e .g., cadmium. co nickel, and chromium)

Although the muck layer is highly enriched with metals, it should not be considered an especially toxic or hazardous material.

Although the sample size was small (N=2), industrial catchments had. by far and aw greatest level of trace metal enrichment in the muck layer of any land use. Clearly, further of heavily industrial ca tchments is warranted to confirm if muck enrichment represents a

Most trace metals are very tightly fixed in the muck layer and do not migrate more th inches into the soil profile. Many researchers have examined soil cores to determine the di trace metal concent ration with depth. A consistent pattern is noted. Trace metal levels are maximum at the top of the surface layer, and then decline exponentially with depth. Event reach normal background levels within 12 to 18 inches below the pond. Rep resentative se metal profiles are shown in Figure 2.

Although the muck layer is highly enriched with metals, it should not be considered especially toxic or hazardous material. For example, none of over 400 muck layer samples the 50 ponds sites examined in this study exceeded current EPA's land application criteria (Table 2). In fact, metal levels in the muck layer are usually less than ten times higher than national mean for agricultural soils in the U.S.12 (Table 4).

Of perhaps greater interest is whether soluble metals can easily leach from the muck they could exert a biological or groundwater impact. The capacity for metals to leach from is measured by EPA's Toxicity Characteristics Leaching Procedure (TCLP). The TCLP tes variant, has been applied by four different investigators to pond muck 2, 11, 22, 23 with m same result usually less than 5% of the bulk metal concentration is suscepti ble to leaching

In general, cadmium and zinc exhibited the greatest potential for leaching (usually le 10%) while copper and lead showed little or no leaching potential. Moreover, leachate con seldom exceeded the mea n metal concentrations reported for urban stormwater runoff.

Table 2: Trace metal content in the muck layer of 50 stormwater ponds and wetlands (r weight)

BMP	Location	(Ref.)	Land Use	Cadmium	Copper	Lead	Zinc	Nickel	C
WP	FL	(22)	Residential	4.8	13	38.2	35.7	10.8	4.ε
WP13	VA	(2)	Mix	3.2		45.3			25
WP	VA	(10)	Residential	0.8	17.2	48	78	12.2	
WP	NZ	(13)	Industrial		173	578	3171		
WP	NZ	(13)	Commercial		18.2	48.9	146		
WP9	FL	(23)	Road	15	28	374	161	52	61
WP	MD	(17)	Institutional	12	130	202	904		12
WP	MN	(14)	Residential			32.9			
WP	MN	(15)	Residential			17.0			
WP	OR	(4)	Institutional		60.2				
WP	CT	(3)	Road	0.4	19	39	53		13
WP	FL	(3)	Road	ND	13	125	105		31
WP	MN	(3)	Road	ND	57	139	261		51
WP	FL	(16)	Road	6	49	620	250		20
WP	FL	(11)	Residential	1.5	7	11	6	3	6
WP	FL	(11)	Residential	0.6	2	12	11	4	12
WP	FL	(11)	Commercial	2.7	6	42	103	6	11
SM	MN	(14)	Residential			82			
SM	MN	(15)	Residential			56			
DPSM	MD	(9)	Industrial	12	140	400	1098		
EDP	MD	(9)	Residential	0.4	8	223	45		
DP	VA	(9)	Commercial	1.7	30	748	202		
DP8	VA	(2)	Residential	3.0		50		30	
EPA land application criteria				380	3300	1600	8600	990	31

KEY: WP = Wet pond; SM = Shallow marsh; DPSM = Detention basin with shallow ma
Detention basin; EPA = Maximum metal limits for land application

Table 3 The effect of land use on trace metal concentrations in the muck layer (m

Land Use	No. of Sites	Cadmium	Copper	Lead	Zinc	Nickel	Cl
Residential	18	2	9.4	44	35	831	
Commercial	5	2	18	214	150	6	22
Road	13	11	30	330	163	52	51
Industrial	2		157	489.	2135		-

Hydrocarbon Content in Muck

One aspect of the muck layer that has yet to be well explored is the potential for hyd and PAH contamination. The limited data on hydrocarbon levels in the muck layer (Table cause for some concern, particularly at an Auckland, New Zealand industrial site. Gavens that the concentration of total PAH and aliphatic hydrocarbons in the muck layer of a 120 London basin were 3 and 10 times greater, respectively, than the basal sediments. Only lin biodegradation of the hydrocarbons trapped in the muck appeared to have occurred in the l recent years. Yousef[24] on the other hand, reports that hydrocarbons were rarely detected i of Florida ponds.

Aquatic Community

A soupy substrate, high pollutant load, and perio oxygen level render the muck layer a rather poor habit aquatic life. Macroinvertebrate sampling conducted by and Galli[5] indicate that the muck layer community ha diversity and characteristics of high pollution stress. Cl and tubificid worms comprised over 90% of all organi in a Florida pond muck layer, and dipteran midge larva constituted 95% of all organisms collected in the muck Maryland pond. While the diversity of the community low, the benthic population can become very dense at of the year. This is not surprising, given that extensive population that uses the highly organic muck layer as food source.

Sand filter ##

Table 4: Comparative metals concentration in BMP sediments (mg kg) dry weig

BMP	No. of Observations	Cadmium	Copper	Lead	Zinc	Nickel	Chr
Wet pond	38	6.4	24.5	160	299	38	36
Detention Basin	11	4	9	161	448		30
Grassed swale	8	1.9	27	420	202	13	30
Oil grit separator	13	14	210	320	504		284
Oil grit separator #	4	36	788	1198	6785		350
Sand filter	1	1.3	43	81	182	30	30
1	4.6	71	71	418	49	52	
Agricultural soils[12]	3000	0.28	30	12	56	24	
Resid. yards[21]	9	0.1	5	13	9		

= Oil Grit Separator, serving gas stations ## = Sand filter with sedimentatio

Comparison of Pond Muck to Sediments Trapped in Other BMPs

How does pond muck compare to the sediments trapped in other best management p: Table 4 shows that the metal content of the muck layer of wet ponds and stormwater wetla similar to concentrations see n in the soils of "dry" detention basins. The metal content of | and grassed swale soils are also quite similar in most respects, although swale soils tend tc twice as much phosphorus and lead as their pond counterparts. Sediments trapp ed within bed and sedimentation chamber of sand filters also appear to be generally comparable to p although only one sand filter has been sampled to date.[20]

The one best management practice that sharply departs from this pattern is the oil gri (OGS). The metal content of trapped sediment within OGSs is 5 to 20 times higher than ot particularly if the OG S drains a gas station.[17] Hydrocarbon and priority pollutant levels ir sediments are also much higher.

This condition reflects the fact that OGSs often exclusively serve hydrocarbon hotsp designed to trap lighter fractions of oil.[18] It is doubtful that metal and hydrocarbon levels i muck coul d approach the level seen in OGSs, since they typically drain larger watersheds the influence of an individual hydrocarbon hotspot.

Implications for Pond Design and Maintenance

An understanding of the dynamics of the pond muck layer has many implications for and maintenance of stormwater ponds.

Pond Clean-out Frequency

Based on observed muck deposition rates..stormwater ponds should require sedimen on a 15 to 25 year cycle.[19, 23] For example, using a 0.5 inch/year muck deposition rate, an that the muck consolidates over time as it deepens, up to 15 to 25% of pond depth can be l 25 year period. The loss of capacity would be faster if construction occurs in the contributi watershed over this time period.

Most ponds are now designed with a forebay to capture sediments. A common foreb criteria is that it constitutes at least 10% of the total pool volume. Based on a 0.5 inch yr m deposition rate, and the *u ntested* assumption that a forebay traps 50% of all muck deposit pond, the forebay could lose 25 percent of its capacity within 5 to 7 years. At the same tim sediment removal frequency for the main pool might be extended to about 50 yea rs. These calculations assume that turbulence in the forebay does not cause muck to be resuspended exported to the main pool. To meet this critical assumption, the forebay must be reasonabl 6 feet) and have exit velocities no greater than 1 foot/ second at the maximum design inflo

The Proper Disposal of Muck

All of the available evidence strongly argues that pond muck does not constitute a ha toxic material. Thus it can be safely land-applied with appropriate techniques to contain ar as it dewaters. The hi gh organic matter and nutrient content of pond muck might even ma as a soil amendment. Chemical testing of pond muck prior to land application is probably for most residential and commercial sites, given the consistent pattern in the distribution o reviewed in this paper.

Greater care should probably be exercised when disposing of pond muck from indust and perhaps some heavily travelled highways. Although only a few industrial sites have be to date, the data suggests these sites may pose a risk. In addition, there is a much greater cl pollutant spills, leaks, or illegal discharges occurring in a pond over the 20 or 25 year time between clean-outs. It would seem prudent, therefore, to require prior test ing at selected i and roadway ponds to reduce this risk.

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Further Research into the Muck Layer

While our emerging understanding about the muck layer is probably sufficient to ma reasonably good management decisions regarding clean-outs and disposal, further researct layer dynamics is needed in several are as.

- Ponds need to be sampled to verify the deposition rate of muck over a broader range geographic and regional conditions. Based on this data a predictive model of muck c rates could be developed to help practitioners who design and maintain ponds.
- Much more data needs to be collected concerning the accumulation of hydrocarbons in the muck layer, particularly in ponds draining roads and industrial sites. Further te muck layer for these compounds would give managers greater c onfidence about the method for muck disposal, as well as providing inferences about how well stormwat can trap these key pollutants.

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- The significance of muck layer phosphorus release as a factor in reducing the long t pollutant removal performance of a stormwater pond remain an open question. Perh insitu measurements of phosphorus flux in a stormwater pond, such as th ose used f years in estuarine studies, could help resolve this issue.
- So far, few researches have explored the possible risk of pollutant biomagnification layer, either by wetland plant uptake or by bottom feeding fish. A systematic sampli to define pollutant levels in plant and animal tissue in a large population of stormwa and wetlands would help assess the nature of this risk. Such a survey would also prc guidance to designers on the issue of whether efforts should be made to attract wildl systems.

Special thanks to Dr. Yousef A. Yousef of the University of Central Florida for his co this article.

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Stormwater Management Manual

September 2000

Revision #1

Environmental Services
City of Portland
CLEAN RIVER WORKS

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Chapter 9.0

STORMWATER POLLUTION CONTROLS FOR HIGHER-RISK CATEGORIES

Chapter 9.0
STORMWATER POLLUTION CONTROLS FOR HIGHER-RISK CATEGORIES

Summary of Chapter 9.0

This chapter presents stormwater pollution controls (SPCs) required for higher-risk site uses and characteristics that generate, or have the potential to generate, specific pollutants of concern.

9.1 INTRODUCTION AND APPLICABILITY

Some site characteristics and uses may generate pollutants that are not addressed solely through implementation of the pollution reduction measures identified in Chapters 4.0 and 5.0. This chapter presents stormwater pollution controls (SPCs) for controlling those pollutants at their source.

Stormwater Discharge benchmarks for pollutants exist in NPDES Industrial Stormwater General Permits issued by the State of Oregon for facilities with industrial activities that are exposed to rainfall and stormwater runoff. The state also has water quality standards listed in Oregon Administrative Rules Division 340 for discharges to surface waters. In addition, City Code 17.39 lists prohibited discharges to the City's storm sewer. The City has utilized these standards and benchmarks in the development of the listed Stormwater Pollution Control BMP's so that discharges to the City's storm sewer system achieve these criteria.

Section 9.1.1, below, describes the site uses and characteristics subject to the requirements of this chapter. Sections 9.2 through 9.12 then provide detailed information about the required SPCs.

These SPCs apply to <u>all new development and redevelopment</u> (Management Levels 1, 2, 3) with the defined uses or characteristics. *(See Chapter 1.0, Section 1.5, for definitions of management levels.)* The SPCs are also applicable to <u>tenant improvements</u> that result in any of the defined site uses or characteristics. With tenant improvements, only those areas of a structure that are being disturbed under the permit are required to make the structural changes identified in the SPCs.

The requirements of this chapter are in addition to the applicable pollution reduction requirements of Chapters 4.0 and 5.0.

If any of the SPC requirements apply to the development site, applicants shall submit **Form SPC** (located at the end of this chapter) as part of their submittal package. (*See Chapter 3.0 for complete submittal requirements.*) Development subject to the requirements of Section 9.5 shall also submit **Form HAZ** (located at the end of this chapter) separately to the Bureau of Water Works.

NOTE: Unless there is an existing plan to the contrary, it is assumed that combined sewers will become separated storm sewers that will discharge to the river through the implementation of the City's Combined Sewer Overflow Plan. Therefore, requirements placed on projects with the site characteristics and uses found in this chapter shall meet the water quality requirements appropriate for separated storm sewer areas even though currently, the site is discharging to a combined storm sewer.

Applicants may propose alternatives to the SPCs identified in this chapter if they believe such alternatives would work better on the site (*see Section 9.1.3*). In this case, the applicant shall complete Part B of Form SPC. Proposal of an alternative SPC or alternative design element will require an additional review process and may delay issuance of related building permits.

Note: Developments citing special circumstances (*see Chapter 1.0, Section 1.7*) are not exempt from the SPC requirements of this chapter.

9.1.1 Site Uses and Characteristics

Projects with the following site uses and characteristics are subject to the requirements of this chapter.

- **Fuel Dispensing Facilities (*Section 9.2*):** Places where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above-ground fuel tanks, fuel pumps, and the surrounding pad). Applies to large-sized gas stations as well as single-pump fueling operations.

- **Above-Ground Storage of Liquid Materials (*Section 9.3*):** Places where there is any exterior storage (either permanent of temporary) of liquid chemicals, food products, waste oils, solvents, or petroleum products in above-ground containers, in quantities of 50 gallons or more.

- **Solid Waste Storage Areas, Containers, and Trash Compactors (*Section 9.4*):** Places with facilities that store solid waste (both food and non-food waste) outdoors in one or more solid waste storage areas. Single-family residential sites are exempt.

- **Storage, Use, and Transportation of Hazardous/Toxic Materials in Designated Groundwater Resource Protection Areas (*Section 9.5*):** Storage, use, and transportation areas for substances that are toxic, carcinogenic, or halogenated solvents. Materials are also mobile and exceed specified threshold quantities, as defined in Section 9.5.

Note: Section 9.5 applies to sites within the following designated groundwater resource protection areas: Columbia South Shore Plan District, Cascade Station/ Portland International Center Plan Districts, and Powell Valley Groundwater Resource Protection Area. The requirements of Section 9.5 apply to any development or other activity that requires a building permit. Refer to Section 9.5 for more information.

- **Exterior Storage of Bulk Materials (*Section 9.6*):** Places that stockpile erodable materials outside.

- **Material Transfer Areas/Loading Docks (*Section 9.7*):** Areas designed to accommodate a truck/trailer being backed up to or into them, and used specifically to receive or distribute materials to/from trucks/trailers. Includes loading/ unloading facilities with docks, and large bay doors without docks.

- **Vehicle and Equipment Traffic Areas, Parking, and Storage (*Section 9.8*):** Parking lots, retail store parking lots, fleet vehicle lots and yards, equipment sale and rental lots, and access roads with defined high-use or high-risk conditions. Single-family and duplex residential sites are exempt.

- **Covered Vehicle Parking Areas (*Section 9.9*):** Covered vehicle parking areas, as defined in Section 9.9. Single-family and duplex residential sites are exempt.

- **Equipment and/or Vehicle Washing Facilities** (*Section 9.10*): Designated equipment and/or vehicle washing or steam cleaning areas. Single-family and duplex residential sites are exempt.

- **Interior Floor Drains** (*Section 9.11*): Buildings and facilities that have interior floor drains. Single-family residential and duplex residential sites are exempt.

- **Stormwater Disposal from Development on Recycled Land** (*Section 9.12*): Land that currently or previously has had pollutants detected in the soil or groundwater at concentrations that exceed risk-based cleanup levels or state/federal cleanup standards for the pollutant(s) of concern.

Note: Definitions of terms used in Sections 9.2 through 9.12 are provided on page 9-65.

9.1.2 Goals and Objectives for Stormwater Pollution Controls

Development of the specific SPC requirements was based on the following goals and objectives:

1) Prevent stormwater pollution by eliminating pathways that may introduce pollutants into stormwater.

2) Protect soil, groundwater, and surface water by capturing acute releases and reducing chronic contamination of the environment.

3) Segregate stormwater and wastewater flows to minimize additions to the sanitary and combined sewer systems.

4) Drain wastewater discharges and areas with the potential for relatively consistent wastewater discharges (such as vehicle washing facilities) to the sanitary or combined sewer system.

5) Drain areas that have the potential for acute releases or accidental spills, and are not expected to regularly receive flow or require water use (such as covered fuel islands or covered containment areas), to an approved method of containment.

6) Contain spills on-site.

7) Emphasize structural controls over operational procedures. Structural controls are not operator dependent and are considered to provide more permanent and

reliable pollution control. Any proposals for operation-based SPCs need to describe the long-term viability of the maintenance program.

8) Provide permanent structural solutions to address the range of potential impacts resulting from multiple site uses and tenant turnover.

9.1.3 Performance Approach

The design professional may propose alternative designs to achieve the intent of the SPC requirements presented in this chapter. Alternative SPCs designed using the performance-based approach shall satisfy the following:

1) If a stormwater management facility described in Chapter 5.0 is used to control pollutants generated by specific site uses, the designer shall comply with applicable sizing and design requirements in Chapter 5.0.

2) The designer shall fulfill all applicable requirements of Chapters 7.0 and 8.0. The designer shall also address overflow, safety, and access requirements similar to the requirements for facilities described in Chapter 5.0.

Applicants who want to use the performance approach shall fill out Part B of Form SPC (located at the end of this chapter) and include it in their submittal package. This form shall be used to request alternatives or major modifications to the SPCs required under this chapter. It shall also be used when SPCs already exist on the site that differ from the requirements, or when implementation of the required SPC(s) is not the best or preferred solution.

9.1.4 Approval of SPCs

The following process will be used after Form SPC is submitted:

1) The Bureau of Environmental Services (BES) Industrial Source Control Division will review the request and the proposed plan.

2) BES will notify the applicant if there is a denial, including any deficiencies and needed corrections. When additional information is needed or corrections need to be addressed, the notification is referred to as a "check-sheet." Notification of approval is part of the overall plan review process.

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3) The applicant may resubmit the request and plan after making the requested revisions.

4) Applicants who are not satisfied with a decision can challenge the decision through the appeals process outlined in Chapter 2.0.

9.1.5 Multiple SPC Requirements

Applicants are required to address all of the site characteristics and uses listed in Sections 9.2 through 9.12. For example, if a development includes both a fuel dispensing area and a vehicle washing facility, the SPCs in both Sections 9.2 and 9.10 will apply. A separate Form SPC is required for each applicable use or characteristic.

9.1.6 Operations and Maintenance Requirements

Chapter 8.0 describes operations and maintenance (O&M) requirements, including preparation of an O&M plan, for stormwater management facilities and facility elements. Applicants are required to include all O&M activities related to SPCs in the overall site O&M plan. An O&M template is provided at the end of Chapter 8.0.

Applicants shall review Chapter 8.0 to determine the O&M requirements relevant to the SPCs in this chapter. Chapter 8.0 may not, however, specifically address all of the structural or nonstructural stormwater controls implemented as a result of SPC requirements. It is the applicant's responsibility to determine all appropriate O&M provisions for the proposed SPCs and include them in the O&M plan.

9.1.7 Signage Requirements

Informational signage is required for some site uses and activities that have the potential to contaminate stormwater. Signage addresses good housekeeping rules and provides emergency response measures in case of an accidental spill.

All signage shall conform to the requirements described in the following box. Additional signage requirements for specific activities are noted in 9.2, 9.3, 9.5, and 9.7.

Signs shall be located and plainly visible from all activity areas. More than one sign may be needed to accommodate larger activity areas. Signs shall also be water resistant. They shall include the following information:

- Safety precautions
- Immediate spill response procedures—for example: "Turn the valve located at..." or "Use absorbent materials"
- Emergency contact(s) and telephone number(s)—for example: "Call 911" and "City of Portland (BES) Spill Response Number 503-823-7180"

Signs may need to be in more than one language if required to effectively communicate with employees and delivery personnel.

A complete copy of spill response and any loading/unloading procedures shall be mounted within 20 feet of the loading/unloading area. Any applicable spill response supplies need to be clearly marked and located where the signage is posted. More than one spill response kit may be necessary to accommodate larger activity areas.

9.1.8 Additional Requirements

Conformance with this chapter's requirements does not relieve the applicant of other applicable local, state, or federal regulatory or permit requirements. This chapter is intended to complement any additional requirements, and is not expected to conflict with, exclude, or replace those requirements. In case of a conflict, the most stringent local, state, or federal regulations shall apply. Any conflict shall be resolved by a City review representative in consultation with appropriate agencies. The applicant may appeal the decision through the appeals process outlined in Chapter 2.0.

Some of the more common requirements that may apply are summarized below.

SPILL RESPONSE SUPPLIES

The City requires spill response supplies, such as absorbent material and protective clothing, to be available at the tank storage area. Employees shall be familiar with the site's operations and maintenance plan and/or proper spill cleanup procedures.

STORMWATER AND WASTEWATER DISCHARGE PERMITS

Some facilities may be required to obtain an NPDES stormwater permit before discharging to the City's separated storm sewer system or to waters of the state. Applicants may also be required to obtain an industrial wastewater permit for discharges to the sanitary sewer system. Facilities subject to these requirements are generally commercial or industrial facilities. Typical discharges include process wastewaters, cooling water, or other discharges generated by some of the SPCs in this chapter that drain to a City sewer system (storm, sanitary, or combined). (*See Appendix 9-A: Sanitary Sewer Discharge Limits.*)

An evaluation will be done during the building permit review process to determine if an industrial discharge permit is required. If a permit is required, the application process will be independent of the building permit review/issuance process.

OTHER LOCAL, STATE, AND FEDERAL REGULATIONS

The requirements presented in this chapter do not exclude or replace the requirements of other applicable codes or regulations, such as the hazardous substances storage requirements of articles 79 and 80 of the Oregon State Fire Code; the spill prevention control and containment (SPCC) regulations of 40 CFR 112 (EPA); the Resource Conservation and Recovery Act (RCRA); or any other applicable local, state, or federal regulations or permit requirements.

The Oregon Department of Environmental Quality has identified drywells and/or sumps as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. Since the UIC Program states that these types of wells have a direct impact on groundwater, stormwater pollution controls will apply. More information about the UIC program can be found on DEQ's web site at: Http://waterquality.deq.state.or.us/wq/groundwa/uichome.htm

Additional City of Portland and Oregon Department of Environmental Quality (DEQ) permit requirements may apply. Contact BES's Industrial Source Control Division at 503-823-7122 for additional information about stormwater or wastewater discharges to City-owned sanitary, stormwater, or combined sewer systems.

9.2 FUEL DISPENSING FACILITIES

9.2.1 Applicability

The requirements in this section apply to all development where vehicles or equipment are refueled on the premises—whether a large-sized gas station or a single-pump maintenance yard. They do not apply to propane tanks.

A fuel dispensing facility is defined as the area where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above-ground fuel tanks, fuel pumps, and the surrounding pad).

Applicants subject to these requirements shall prepare a **Form SPC** located at the end of this chapter) that fulfills the requirements of Section 9.2.3, below, and include it in their submittal package.

> NOTE: Mobile fueling operations require authorization by BES's Industrial Stormwater Permitting Section and may have specific SPC requirements not identified in this chapter. These types of operations are typically used for construction activities or other limited-duration projects.

9.2.2 Issue

Fuel dispensing facilities are a potential source of chronic loading and acute releases of pollutants to the environment. Stormwater runoff from fuel dispensing facilities may contain oil and grease, toxic hydrocarbons, heavy metals, and other pollutants.

9.2.3 Requirements

The following SPCs are required for fuel dispensing operations, unless an equivalent alternative is requested on Form SPC and approved by BES.

1) COVER

The fuel dispensing area shall be covered with a permanent canopy, roof, or awning so precipitation cannot come in contact with the fueling area. Precipitation shall be directed from the cover to a stormwater disposal system that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling area it is to cover.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling area it is to cover.

This SPC should be implemented in conjunction with prevention of stormwater run-on into the covered area.

2) PAVEMENT

A paved fueling pad shall be placed under and around the fueling activity. The pad shall be sized to adequately cover the activity area, including placement of the vehicle or piece of equipment to be fueled.

Gasoline and other materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks.

3) DRAINAGE

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains. This will prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, an approved on-site industrial wastewater treatment facility, or other approved on-site temporary storage facility or containment device/structure.

> **Note:** An on-site temporary storage facility or containment device/structure shall be used only as a last resort and only for temporary storage of the wastewater or contaminated stormwater (*see Appendix 9-B*).
>
> If a water pollution control facility permit (WPCF) is required by DEQ and results in changes to the facility, Source control must be given copies of these changes.

4) SIGNAGE

Signage shall be provided at the fuel dispensing area and shall be plainly visible from all fueling activity areas (*see section 9.1.7).*

The following language shall be added to the building plan set, as a general note on the site and/or utility plan:

> "Signage will be provided at the fuel dispensing area that is plainly visible and water resistant, and includes the following information:
>
> - Safety precautions
> - Immediate spill response procedures
> - Emergency contacts and telephone numbers"

5) SEDIMENTATION MANHOLE

A sedimentation manhole shall be installed on the discharge line of the fueling pad (before the domestic waste line tie-in). The manhole shall be located on property. For more information about sedimentation manholes, refer to the City's *Standard Construction Specifications Book,* detail 4-11.

The requirement for a sedimentation manhole prior to sanitary discharge is to help achieve local discharge limitations applicable to the City's sanitary sewer. (See *Appendix 9-A* for more information about sanitary sewer discharge limits.)

Design Retrofit of Sedimentation Manhole: The outlet of the manhole will need to be revised to reflect a tee installation, with a removable watertight cap for cleaning. The tee must extend downward approximately 18 inches. This feature is to help capture oils and greases.

6) SHUT-OFF VALVE

A shut-off valve shall be installed downstream of the sedimentation manhole, before the domestic waste line tie-in. The shut-off valve must be located on property. For more information about shut-off valves and associated valve boxes, contact the City's Commercial Plumbing Department at 503-823-7302.

This requirement is to comply with City Code, Chapter 17.34.090, requiring spills that occur within the activity area to be effectively contained for appropriate clean-up and disposal. (The emergency contacts and responders identified on the required signage shall determine the appropriate clean-up and disposal of a spill.)

7) ADDITIONAL REQUIREMENTS

Please carefully review the following additional requirements. These requirements are not applicable to all development projects. If they do apply, however, and are not addressed in the project design, revisions will be required. This could delay issuance of related building permits.

A) **Above-ground fuel tanks** are subject to additional requirements (*see Section 9.3*).

B) **Additional oil controls** may be required for vehicle traffic, parking, and storage areas if the facility is defined as a higher-use or higher-risk site (*see Section 9.8*).

C) **Bulk fuel terminals** require an additional review process to determine regulatory authority and requirements.

8) EXCEPTIONS

A) The requirement to cover the fuel dispensing area can be waived if the fuel dispensing area is generally used to service oversized equipment (e.g., cranes) that cannot maneuver under a roof or canopy.

City Code (Chapter 17.32.080 and 17.32.090) prohibits stormwater from being discharged to a City separated sanitary sewer, with limited exceptions allowed by the Chief Engineer. If approval is granted and a cover is not installed because of oversized equipment, Chapter 17.36 of the City Code allows the City of Portland to bill a facility for the disposal of stormwater into the City separated sanitary sewer. Charges are determined by either calculated volumes (based on the average annual rainfall and the square footage of impervious area drained) or by meter readings from a City-approved discharge meter.

A written **stormwater volume charge request** will be required as part of the approval process for this exception. The written request shall document the property owner's acknowledgement of the City's right to charge the facility sanitary sewer rates for the volume of stormwater discharged to the sanitary sewer system. The application shall be signed by the property owner and notarized.

B) Propane tanks are exempt from requirements #1 through 5 in 7.2.3. Traffic protection crash posts shall be placed at a maximum spacing of 5 feet on all sides of the AST where traffic patterns may exist and a containment wall is not present.

9.3 ABOVE-GROUND STORAGE OF LIQUID MATERIALS

9.3.1 Applicability

The requirements in this section apply to all development where there is any exterior storage of liquid chemicals, food products, waste oils, solvents, or petroleum products in above-ground containers, in quantities of 50 gallons or more. This includes permanent storage and temporary storage areas.

The requirements do not apply to underground storage tanks or to businesses permitted by the Oregon Department of Environmental Quality (DEQ) to treat, store, or dispose of regulated substances or wastes.

Double-walled tanks may be exempt from complying with the requirements of this SPC, depending on the loading and unloading procedures used for the tank.

Note: Storage of reactive, ignitable, or flammable liquids shall comply with the Uniform Fire Code as adopted by the State of Oregon. See #6 under "Additional Requirements," below.

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter) that fulfills the requirements of Section 9.3.3, below, and include it in their submittal package.

9.3.2 Issue

Stationary containers that store liquid materials have the potential to introduce toxic compounds, solvents, oil, grease, heavy metals, abnormal pH, nutrients, and bacteria to stormwater. In addition, spills may occur during liquid transfer operations or tank failure.

9.3.3 Requirements

1) CONTAINMENT

Liquid materials shall be stored and contained in such a manner that if the container(s) is ruptured, the contents will not discharge, flow, or be washed into a receiving system.

Double-walled containers are generally exempt from these spill containment measures. Exposed dispensing hoses or other fixtures may require some form of containment; this will be determined during the SPC application review process.

2) COVER

Storage containers (other than tanks) shall be completely covered so precipitation cannot come in contact with them. Precipitation shall be directed from the cover to a stormwater disposal system that meets all applicable code requirements.

Liquid storage tanks are not required to be covered with a canopy or roof. However, all taps, couplings, pumps, and other potential drip, spill, and leak-prone spots (during liquid transfer operations, and when making and breaking connections) shall be completely covered with rain shields. Drip pans shall be placed under the rain shields. Any materials collected in the drip pans and any soiled absorbent materials shall be reused, recycled, or appropriately disposed of. Disposal locations and dates shall be recorded as part of the facility's operations and maintenance log, as identified under the requirements of Chapter 8.0 of this manual.

3) PAVEMENT

A paved storage area is required unless otherwise approved by BES's Industrial Source Control Division staff. The paved area shall be sized to adequately cover the area intended for storage.

Gasoline and other materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks.

When an exception to the requirement is allowed, the stored material shall still need to be raised off the ground by pallets or similar methods, with provisions for spill control. The applicant shall clearly identify this alternative method in Form SPC, Sections B and C.

4) DRAINAGE

All paved storage areas shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater run-on to a storage area.

Covered storage areas with containment: Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the containment area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, approved on-site industrial wastewater treatment system, or other approved on-site temporary storage facility or containment device/structure.

Uncovered storage areas with containment: Water will accumulate in uncovered storage areas during and after rain. Any *contaminated* water cannot simply be drained from the area. It must be collected, inspected, and possibly tested before proper disposal can be determined. Frequent draining may be required during the wet season, which may prove costly. Some type of monitoring may also be needed to determine the characteristics and level of contamination of the stormwater.

In uncovered storage areas, a valve shall be installed in the storage area so excess stormwater can be drained out of the activity area and directed either to the storm drainage facilities (*if clean*) or into the City sanitary sewer, an on-site industrial wastwater treatment system, or other approved on-site temporary storage facility or containment device/structure (*if contaminated*). Except when excess stormwater is being discharged, the valve shall always be kept closed so any spills within the activity area can be effectively contained.

Note: An on-site temporary storage facility or containment device/structure shall be used only as a last resort and only for temporary storage of the wastewater or contaminated stormwater (*see Appendix 9-B*).

All discharges to the sanitary sewer shall be considered batch discharges and shall require approval and pretreatment prior to discharge. Pretreatment requirements will be set as part of the discharge approval process, based on the types and quantities of material to be discharged. A discharge evaluation shall be performed before connection to a sanitary sewer. Testing may be required to establish characteristics of the wastewater or contaminated stormwater and to verify that local discharge limits are not exceeded. For batch discharge applications, call BES's Source Control Division at 503-823-5320.

5) SIGNAGE

Signage shall be provided at the fuel dispensing area and shall be plainly visible from all fueling activity areas (*see section 9.1.7).*

The following language shall be added to the building plan set, as a general note on the site and/or utility plan:

> "Signage will be provided at the fuel dispensing area that is plainly visible and water resistant, and include the following information:
>
> - Safety precautions
> - Immediate spill response procedures
> - Emergency contacts and telephone numbers"

Signage shall be provided at the storage area, in accordance with the requirements of Section 9.1.7.

6) ADDITIONAL REQUIREMENTS

Please carefully review the following additional requirements. These requirements are not applicable to all development projects. If they do apply, however, and are not addressed in the project design, revisions will be required. This could delay issuance of related building permits.

A) **A shut-off valve** may be required for the covered storage area if the applicant elects to install drainage facilities to an approved City sanitary sewer. BES will make this determination based on the type of material stored and the proposed system receiving the discharge.

This requirement is to comply with City Code, Chapter 17.34.090, requiring spills that occur within the activity area to be effectively contained for appropriate clean-up and disposal. (The emergency contacts and responders identified on the required signage shall determine the appropriate clean-up and disposal of a spill.)

B) **Storage of hazardous materials** that are toxic, carcinogenic, or halogenated solvents (located in designated groundwater resource protection areas) are subject to additional requirements, as identified in Section 9.5: Storage, Use, and Transportation of Hazardous Materials in Designated Groundwater Resource Protection Areas.

C) **Storage of reactive, ignitable, or flammable liquids** shall comply with the Uniform Fire Code as adopted by the State of Oregon. SPCs presented in this section are intended to complement, not conflict with, current fire code requirements. None of these requirements shall exclude or supersede any other requirements in this manual, other City permit requirements, or state and federal laws pertaining to water quality. Contact the Portland Fire Bureau (503-823-7366) and/or BES's Industrial Source Control Division (503-823-7122) for further information and requirements.

9.4 SOLID WASTE STORAGE AREAS, CONTAINERS, AND TRASH COMPACTORS

9.4.1 Applicability

The requirements in this section apply to all development with facilities that store solid wastes (both food and non-food wastes) outdoors in one or more solid waste storage areas. A solid waste storage area is a place where solid waste containers are collectively stored. Solid waste containers include trash compactors, dumpsters, and garbage cans (including those used to contain recyclable materials).

Single family homes are exempt from these requirements. Multi-family residential sites are not exempt.

Applicants subject to these requirements shall prepare **Form SPC** located at the end of this chapter) that fulfills the requirements of Section 9.4.3, below, and include it in their submittal package.

9.4.2 Issue

Pollutants may be introduced into stormwater if the stormwater mixes with solid waste or with fluids leaking from waste containers. Stormwater run-off from food waste storage areas may be contaminated with oils, greases, nutrients, and suspended solids if waste containers are leaking, not covered, or are too small to contain the amount of waster generated. Improper storage of non-food wastes can allow toxic compounds such as, oil, grease, heavy metals, , nutrients, and suspended solids to contaminate stormwater run-off.

9.4.3 Requirements

1) COVER

Dumpsters and Garbage Cans Used to Store Non-Food Solid Waste

Non-food solid wastes include refuse typically generated by a household or business. These areas are not required to have a structured cover, but shall be covered with a lid. Only leak-proof containers shall be used.

Dumpsters and Garbage Cans Used to Store Food Wastes and Materials other than Solid Waste

Food waste refuse, as discussed here, is typically generated by restaurants and other food industry businesses. Food waste includes foods not consumed by customers and excess or spoiled food.

Dumpsters and garbage cans used to store food wastes and materials other than solid wastes (such as fertilizers, chemicals, oil, and waste oil) shall be covered with a permanent canopy or roof to prevent stormwater contact and minimize the quantity of stormwater entering the waste storage area. The area beneath the cover shall be hydraulically isolated from other portions of the site through grading, berms, or drains.

Trash Compactors without A Hard-Piped Connection to the Sanitary Sewer

Trash compactors without a hard-piped connection to the sanitary sewer shall be covered with a canopy or roof to prevent stormwater contact and minimize the quantity of stormwater entering the waste storage area. The area beneath the cover shall be hydraulically isolated from other portions of the site through grading, berms, or drains. Drainage from the area beneath the cover shall be directed to a sanitary sewer or other approved on-site containment structure.

Trash Compactors with A Hard-Piped Connection to the Sanitary Sewer

Trash compactors with a hard-piped connection to the sanitary sewer shall be kept closed except when loading material and are not required to have a permanent cover or canopy.

2) PAVEMENT

The area beneath the cover shall be paved with asphalt or concrete and meet all applicable City of Portland Building Code requirements. A paved waste storage area is required for waste storage areas with a structural cover or using a trash compactor, as identified above. The area beneath the cover shall be hydraulically isolated through grading, berms, or drains.

3) DRAINAGE

Drainage beneath any covered area shall be hydraulically isolated through berming, grading, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, an approved on-site industrial wastewater treatment facility, or other approved on-site temporary storage device and/or containment structure. Stormwater drainage from the cover shall be directed to an approved stormwater system that meets all applicable City of Portland Building Code requirements.

Note: An on-site temporary storage facility or containment device/structure shall be used only as a last resort and only for temporary storage of the wastewater or contaminated stormwater (*see Appendix 9-B*).

OPERATION AND MAINTENANCE REQUIREMENTS

4) WASHING

If the solid waste storage area and/or solid waste containers are washed, the wastewater shall be directed to a sanitary sewer or contained and disposed of by a licensed contractor. This wastewater shall not be allowed to enter a stormwater system.

5) INSPECTION

Solid waste containers shall be inspected by a trained facility employee at least once a month to verify that fluids have not leaked. Inspection records shall be retained as part of the facility's operations and maintenance records.

6) DRY SWEEPING

The solid waste storage area shall be dry-swept and cleaned every two months (or more often as needed) by the property owner, operator, or their contractor or designee.

9.5 STORAGE, USE, AND TRANSPORTATION OF HAZARDOUS/ TOXIC MATERIALS IN DESIGNATED GROUNDWATER RESOURCE PROTECTION AREAS[1]

9.5.1 Applicability

The requirements of this section apply to development that:

- Requires a building permit, AND
- Has either **interior or exterior** hazardous/toxic materials storage, use, or transportation areas, AND
- Is located within any of the following groundwater resource protection areas (see **Exhibit 9-1** and **Exhibit 9-2**):
  - Columbia South Shore (COSS) Plan District
  - Cascade Station/Portland International Center (CS/PIC) Plan Districts
  - Powell Valley Groundwater Resource Protection Area (PVRPA)

The groundwater resources in the COSS, CS/PIC and PVRPA provide the primary and back-up water supply for the City of Portland and much of the metropolitan area. Developments in these areas are subject to stringent management requirements in order to protect groundwater and drinking water resources.[2]

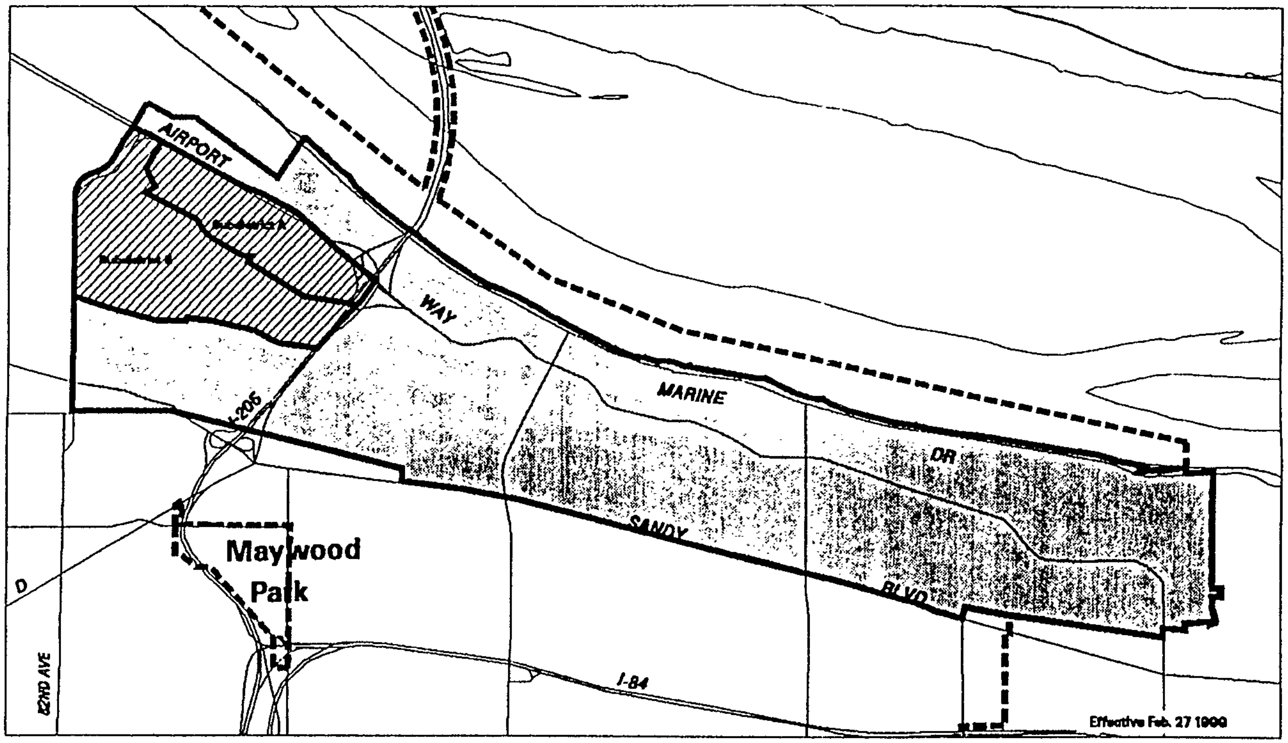
Hazardous materials[3] are considered to be materials that are classified as, or have constituents with, one or more of the following characteristics:

[1] The City of Portland Bureau of Water Works, Groundwater Resource Protection Program, is responsible for implementing the requirements of Section 9.5.

[2] Section 9.5 supersedes the Draft *COSS Hazardous Materials Containment Handbook* that previously provided guidance regarding hazardous materials containment within groundwater resource areas. That is why the requirements of section 9.5 may also apply to all developments requiring building permits within the COSS, CS/PIC and PVRPA, even if no new impervious area is created.

[3] This section does not use the Resource Conservation and Recovery Act (RCRA) definition of "hazardous." For purposes of this section, "hazardous material" is intended to include hazardous, toxic, and other harmful substances. Refer to "Definition of Terms" at the end of this chapter for further clarification.

EXHIBIT 9-1



NORTH

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Scale in Feet

Plan District/
Subdistrict Boundaries

City Boundary

CascadeStation / Portland International Center and Columbia South Shore Plan Districts

CascadeStation/Portland International Center

Columbia South Shore

Bureau of Planning • City of Portland, Oregon

LEGEND

DELINEATION ZONES

- 2-Year Time-of-Travel Capture Zone
- 5-Year Time-of-Travel Capture Zone
- 10-Year Time-of-Travel Capture Zone with 25° Deflection and Drinking Water Protection Area Boundary

TRANSPORTATION ROUTE TYPES

- Primary Arterial
- Secondary Arterial
- Minor Arterial
- Minor Street

LAND USE DESIGNATIONS

- Open Space
- Industrial
- Neighborhood Commercial
- General Commercial
- Residential

JURISDICTIONAL BOUNDARIES

- City of Portland
- City of Gresham
- Powell Valley Road Water District
- Multnomah County

POTENTIAL SOURCE LOCATIONS

1. McMillan, R. (Heating Oil Tank)
2. Cortez, R. (Heating Oil Tank)
3. Queirolo, J. (Heating Oil Tank)
4. Boland, J. (Heating Oil Tank)
5. Moyer Properties (Car Wash)
6. Rick's RV Repair
7. CLM Auto Repair
8. Siebert's Auto Body
9. Fetser Property
10. Belco Manufacturing Co.
11. Leathers Oil #36
12. Meadowland Dairy
13. Jin's Cleaners
14. Koetjes Spray Service
15. Chevron
16. Best Cleaners
17. Kraais Automotive
18. Small Engine Repair
19. Pilgrams Cleaners
20. Highland Cleaners

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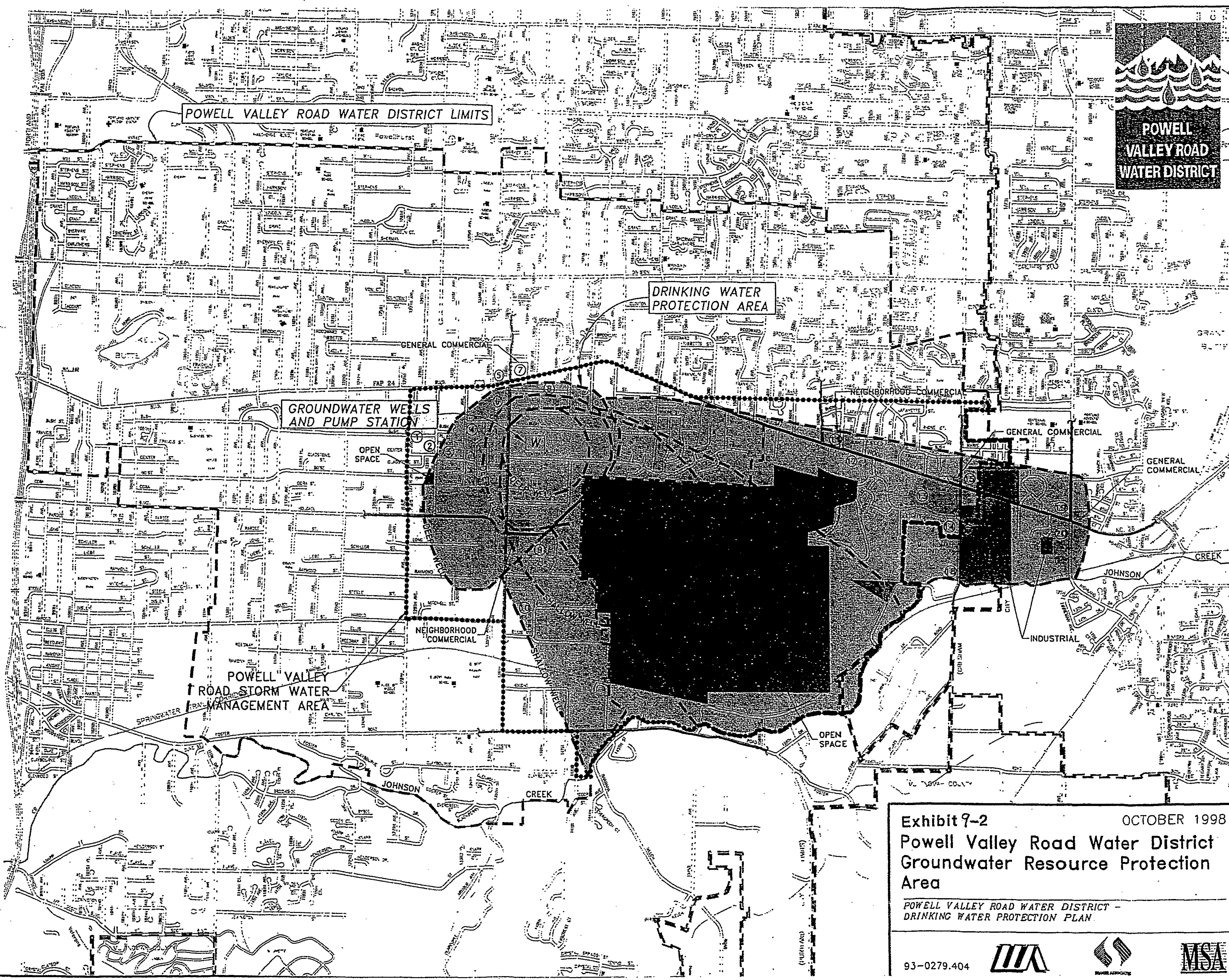

Exhibit 9-2 OCTOBER 1998

Powell Valley Road Water District Groundwater Resource Protection Area

POWELL VALLEY ROAD WATER DISTRICT – DRINKING WATER PROTECTION PLAN

93-0279.404

MSA

R0009599

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- Carcinogenic
- Toxic
- Halogenated solvents

If the site use(s) potentially meet the above criteria, the applicant shall complete a hazardous materials inventory, as identified in 9.5.3 (Step 1). Based on the results of the inventory and subsequent guidance in 9.5.3, the applicant may have no further requirements under this section if:

a) The materials are not mobile, as defined in 9.5.3.
b) The quantity stored/transported does not exceed specified threshold quantities defined in 9.5.3.

LIQUID MATERIALS STORED IN ABOVE-GROUND TANKS

Liquid materials stored in above-ground storage tanks may be subject to the requirements in this section. Applicants who use, transport, or store liquid materials in above-ground storage tanks that may be hazardous, toxic, or a halogenated solvent (within the designated groundwater resource protection areas) shall perform the inventory in Section 9.5.3. If results of the inventory indicate the applicant has materials regulated by Section 9.5 in quantities that exceed threshold amounts, the requirements of Section 9.5 shall supersede the requirements of Section 9.3.

9.5.2 Issue

Stormwater runoff may gather many pollutants when it contacts exposed bulk or chemical materials. Stormwater runoff and spills from some materials storage, use, or transportation areas have the potential to contribute chemical, physical, and biological pollutants to receiving systems, including toxic substances, organic compounds, oil and grease, heavy metals, bacteria, nutrients, and suspended solids. These substances can enter the groundwater or surface water through acute releases or chronic loading. Potential pollutants can vary extensively in type and severity, depending on the characteristics of the material being stored.

9.5.3 Requirements

Section 9.5.3 identifies the requirements for the storage, use, and transportation of hazardous/toxic materials. **Exhibit 9-3** summarizes the steps the applicant shall perform.

Exhibit 9-3
SUMMARY OF APPLICANT REQUIREMENTS

STEP 1: Applicant completes a hazardous materials inventory.

STEP 2: Applicant uses the inventory to determine risk classification, based on chemical mobility and threshold quantities. This step involves the following procedures:

A) Determine chemical mobility.
B) Evaluate carcinogens, toxics, and halogenated solvent characteristics.
C) Determine threshold quantities.
D) Determine site risk classification.

If materials are defined as mobile and exceed threshold quantities, the applicant shall proceed to Step 3. **If materials are not mobile and/or do not exceed threshold quantities, the applicant does not need to proceed further.**

> *Note: The applicant may seek technical assistance to evaluate the risk classification. Contact the Portland Bureau of Water Works (503-823-7577) to obtain technical assistance after the materials inventory has been completed.*

STEP 3: Applicant determines required management measures. This step involves the following procedures, as relevant:

A) Identify functional areas: hazardous material containment zones (HMCs), site transportation routes, and loading/unloading facilities.
B) Prepare a hazardous materials containment plan and provide signage.
C) Implement interior containment requirements.
D) Implement exterior containment requirements.
E) Implement transportation route requirements.

Section 9.5.3 identifies the applicant's required submittal forms relevant to these steps.

Following receipt of the applicant's submittal, the City will review the inventory, proposed HMCs, transportation zones, loading/unloading facilities, and containment plan and make a final determination on site risk classification and the proposed management measures.

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STEP 1: HAZARDOUS MATERIALS INVENTORY

If the proposed site use(s) fall under the applicability criteria defined in section 9.5.1, the applicant shall complete a hazardous materials inventory. **Form HAZ: Hazardous Materials Inventory** and instructions are provided at the end of this chapter.

STEP 2: RISK CLASSIFICATION

The applicant shall use the completed Form HAZ to evaluate the risks associated with using and storing hazardous materials on the site. The risk classification procedure involves four components, as identified under A through D, below.

Note: The applicant may seek technical assistance to evaluate the risk classification. Contact Portland Bureau of Water Works (503-823-7577) to obtain technical assistance after Form HAZ (Step 1) has been completed.

A) Determine Chemical Mobility

Note: Some of this information may be obtained from the product Material Safety Data Sheet (MSDS). Applicants should check with the product manufacturer or supplier if they do not have an MSDS or are unsure if the product is required to have one.

A mobile chemical is defined as a substance that has one or both of the following characteristics:

- Is a solid with measurable solubility in water (see MSDS).
- Is in liquid state at ambient temperature.

➔ If a used, stored, or transported material has one or both of these characteristics, it is considered to be mobile, and the applicant shall continue to B), below. **If the material does not have either of the characteristics listed above**, it is not mobile for purposes of this evaluation. The material is considered to be a low risk, and **no further action is required under Section 9.5.**

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B) **Evaluate Carcinogens, Toxics, and Halogenated Solvent Characteristics**

Threshold quantities apply to the following materials if they have been classified as mobile:

1) Carcinogens
2) Highly and moderately toxic materials
3) Halogenated solvents

Definitions for these materials are provided below.

1) ***Carcinogens***

The City of Portland uses the National Toxicology Program list of nationally recognized carcinogens (NTP list) to identify chemicals that are confirmed or suspected carcinogens. The lists of suspected and known carcinogens can be found on the NTP website:

http://ntp-server.niehs.nih.gov/Main_pages/NTP_8RoC_pg.html.

If the material in question is included on this list, the City considers the material a confirmed carcinogen for purposes of this evaluation.

Carcinogenic mixtures (products that contain any confirmed carcinogen) shall be considered carcinogenic.

2) ***Toxic Materials***

The City of Portland uses the oral ingestion lethal dose for 50 percent of the experimental population (LD-50) value to classify the level of toxicity associated with a particular substance. The LD-50 can be determined from the following sources (presented in the order in which they should be consulted):

- The product MSDS sheet.
- The product manufacturer.
- The hazardous material list presented in **Appendix 9-C**.
- A City representative. Contact Portland Bureau of Water Works, 503-823-7577, for assistance.

Chemical mixtures (products that contain multiple chemical constituents) shall be evaluated using the most toxic constituent (lowest LD-50 value) present above 10 percent of the total mixture.

Definitions for materials and mixtures are:

Highly toxic:	Any material with a LD-50 under 500 mg/kg
Moderately toxic:	Any material with a LD-50 between 500 mg/kg and 5000 mg/kg

3) ***Halogenated Solvents***

A list of halogenated solvents is provided in **Appendix 9-D.** Any material included on that list shall be evaluated.

➔ If the stored or transported materials have any of the defined characteristics, the applicant shall continue to C), below, to determine threshold quantities. **If the materials do not have any of the defined characteristics, no further action is required under Section 9.5.**

C) Determine Threshold Quantities

The threshold quantities listed in **Exhibit 9-4** apply to carcinogens, toxic materials, halogenated solvents, and combinations of these categories.

Facilities that use, store or transport multiple categories of materials (carcinogenics, toxics, halogenated solvents), each in quantities of 10 gallons, or 50 pounds, or greater, shall add quantities of materials within each category. If the total quantity within each category does not exceed the quantity thresholds for that individual category (carcinogen, highly toxic, moderately toxic, or halogenated solvents), the total quantities in all categories shall be added together to determine the overall total for the site.

> Example: One site has the following materials present: 25 gallons of confirmed carcinogens, 15 gallons of highly toxic materials, and 140 gallons of moderately toxic materials. None of the quantities exceeds the threshold amounts for an individual category, so the site threshold would be determined based on the sum total of all the categories, or 180 gallons.

Sites where two or more categories of material are used, but do not exceed the threshold amounts for individual categories (confirmed carcinogens, highly toxic, moderately toxic, or halogenated solvents), are called multiple-chemical sites.

Exhibit 9-4
APPLICABLE THRESHOLD QUANTITIES

Category	Definition	Threshold Quantity
Carcinogen	Included on NTP list	40 gallons or 300 lbs
Highly toxic	LD-50 under 500 mg/kg	40 gallons or 300 lbs
Moderately toxic	LD-50 between 500 mg/kg and 5000 mg/kg	160 gallons or 1200 lbs
Halogenated solvents	See Appendix 9-D for chemical listing	10 gallons or 100 lbs
Multiple-chemical sites	Sum of all individual categories if none of the categories exceeds thresholds	180 gallons or 1200 lbs

➔ If the quantity of stored, used, or transported materials exceeds any threshold quantity for individual or multiple-chemical sites, the applicant shall continue to D), below, to determine site risk classification. **If the stored or transported materials do not exceed these thresholds, no further action is required under Section 9.5.**

D) Determine Site Risk Classification

Sites are classified as Class 1 or Class 2, based on the total quantity of the most dangerous materials present on the entire site at one time. Class 1 sites pose a higher risk and Class 2 sites pose a lesser risk. A site's classification will determine the degree to which containment facilities are required to keep any material spills or leaks from reaching groundwater or surface water.

Containment facilities may also be classified individually within a site. For example, a site that exceeds the threshold quantities for both highly toxic and moderately toxic materials would be classified as a Class 1 site. Based on site design, function, and chemical compatibility, the materials could be stored together or separately within the site. If the materials are stored together, the more stringent containment requirements (Class 1) would apply. (When compatible materials with different classifications are stored together, the more stringent classification applies.) Individual containment requirements would apply, however, if all the highly toxic materials (Class 1) were stored in one area and all the moderately toxic materials (Class 2) were stored in another.

Sites where two or more categories of material are used, but do not exceed the threshold amounts for specific site categories (confirmed carcinogens, highly toxic, moderately toxic, halogenated solvents), shall be regulated as multiple-chemical sites.

Exhibit 9-5 shows how the site and any individual containments should be classified, based on the category of material and the threshold quantity.

Exhibit 9-5
RISK CLASSIFICATIONS

Category	Threshold Quantity	Classification
Carcinogen	40 gallons or 300 lbs	Class 1
Highly toxic	40 gallons or 300 lbs	Class 1
Halogenated solvents	10 gallons or 100 lbs	Class 1
Moderately toxic	160 gallons or 1200 lbs	Class 2
Multiple chemicals	180 gallons or 1200 lbs	Class 2

STEP 3: REQUIRED MANAGEMENT MEASURES

This step specifies the management measures required for Class 1 and Class 2 storage, use, and transportation areas. The requirements are summarized in **Exhibit 9-6** and described in more detail following the exhibit.

Development projects required to implement management measures shall complete **Form SPC,** located at the end of this chapter, and include it in their submittal package.

Exhibit 9-6
REQUIRED MANAGEMENT MEASURES

Management Measure	Class 1	Class 2
A) Identify functional areas: hazardous material containment zones (HMCs), loading/unloading areas, and transportation routes.	X	X
B) Prepare a hazardous materials containment plan and install signs.	X	X
C) Implement interior containment requirements.	X	X
D) Implement exterior containment requirements.	X	X
E) Implement transportation route requirements.	X	

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A) Identify Functional Areas: Hazardous Material Containment Zones (HMCs), Loading/Unloading Areas, and Transportation Routes

The applicant shall identify all HMCs, loading/unloading areas, and transportation routes (see following definitions) that will occur on the proposed development site. These different areas can be thought of as "functional areas" that are associated with certain kinds of activities/functions. The intent is to identify the types of activities that occur at a site, and group chemical storage, use, and transportation/transfer areas in a manner that will satisfy functional needs and facilitate site safety, yet minimize containment areas and associated requirements. All functional areas shall be designated on Form SPC (Parts D and E), located at the end of this chapter.

Hazardous materials containment zones (HMCs) are areas where a specific individual activity takes place and where chemical quantities at that location are expected to exceed the thresholds identified in this section. HMCs are typically subject to permanent structural containment requirements and shall be physically or hydraulically separated from the surroundings. HMCs may include (but are not be limited to) storage and/or process areas, transportation routes, work areas, and loading/unloading facilities.

If the total quantity of material stored in a specific location (such as a maintenance area or within a piece of machinery) does not exceed 25 percent of the quantity threshold for the material, containment is not required in that area.

Loading/unloading areas are any areas that: 1) are designed (size, width, etc.) to accommodate a truck/trailer being backed up to or into them, and 2) are expected to be used specifically to receive or distribute materials to/from trucks or trailers.

Transportation routes are any paths used to transport materials regulated in section 9.5 onto, off of, or within a site.

Functional areas collectively identify the HMCs, loading/unloading areas, work areas using hazardous materials, and transportation routes on a site. The applicant shall separately evaluate the risk and classify each functional area.

B) Prepare a Hazardous Materials Containment Plan and Provide Signage

Form SPC, Part E (located at the end of this chapter) provides the form and instructions for preparing a hazardous materials containment plan.

The hazardous materials containment plan shall include the management requirements specified in C), D), and E), below, as appropriate. These shall include secondary containment of hazardous materials, spill prevention/detention measures for loading/unloading areas and transportation corridors.

Signage shall be provided for all designated HMCs, in accordance with the requirements of Section 9.1.7.

C) Implement Interior Requirements

These interior requirements address activities conducted inside a building. All interior HMCs that exceed the appropriate threshold quantities shown in Exhibit 9-4 shall implement the following requirements:

1) Provide secondary containment. Secondary containment can be achieved through flooring, paving, liners, walls, curbs, gutters, berms, drains, piping, valves, self-contained sumps, vaults, double-walled tanks, or other commercially available secondary containment devices.

2) Use impervious materials. All secondary containment devices shall be constructed of impervious materials. Impervious surfaces may consist of concrete, asphalt, pavement, synthetic liners, or any other material having a permeability of less than 1×10^{-6} cm/sec. Testing may be required.

   The applicant may also use the following mix specifications to achieve presumed compliance with impervious requirements:

   - For concrete, a water: cement ratio of less than 0.6 and a maximum size of aggregate of less than 3 inches shall be used.

   - For asphalt, the air voids shall be less than 10 percent.

3) Seal all joints and cracks with a bonded epoxy or similar material.

D) Implement Exterior Containment Requirements

The following requirements apply to all designated HMC zones.

1) Cover the materials.

   All HMCs shall be covered to prevent rainfall from entering the area. Exterior areas may be constructed with or without sidewalls.

a) Structures with sidewalls:

Exterior HMCs constructed with sidewalls may include sheds manufactured specifically for materials storage and spill containment purposes. The structure shall meet the requirements for impervious surfaces and spill containment capacity stated in this section.

b) Structures without sidewalls:

Exterior HMCs may also be covered with a pole building, awning, or other permanent cover. The cover for an exterior materials storage area shall have a minimum overhang of 3 feet on each side for covers 10 feet high or less. The cover shall have a minimum overhang of 5 feet on each side for covers more than 10 feet high. The overhang shall be measured relative to the berm beneath the cover.

2) Store materials on an impervious surface. All designated HMC zones shall be underlain by impervious surfaces over the entire area of the zone. Impervious surfaces are defined above under C) Implement Interior Requirements.

3) Berm the perimeter of all HMC zones without sidewalls. All materials shall be stored within the berm and under a cover, or inside a building.

4) Direct drainage from the paved area beneath the cover to an approved on-site containment structure. The area beneath the canopy or roof shall be reverse-graded or bermed to hydrologically isolate the area from other portions of the facility and minimize the amount of stormwater runoff accumulating beneath the cover. The approved containment structure shall also contain material spills inside the bermed area.

5) Provide spill containment for 110 percent of the largest volume of any single container being stored within the containment, or 10 percent of the total volume of material being stored, whichever is greater. Some interior or completely enclosed materials storage areas shall also provide containment volume for 20 minutes of fire flow. (See the Uniform Fire Code for further definition of this requirement.)

E) Implement Transportation Route Requirements

A transportation route is defined as any route used to transport materials regulated under Section 9.5 onto, off of, or within a site. This includes driveways, parking areas, and all other passageways used to transport regulated materials onto, off of, or within a site.

1) Provide spill containment.[4] All containment facilities shall provide a minimum capacity adequate to capture 150 gallons. This containment volume may be provided by treatment facilities, oversized piping, or a combination. Spill control containment volume shall be incorporated into stormwater quality/quantity systems using either of the following:

   - A spill control separator or multi-chambered oil/water treatment device may be used to satisfy the requirements for both the transportation corridors and paved surfaces/parking areas. Oil/water treatment devices used for spill containment purposes shall be equipped with a shut-off mechanism immediately downstream. The valve shall be well marked and in good working order, and employees shall be trained in spill response procedures.

   - Spill containment that will be integrated into the site stormwater quality/quantity systems shall be constructed with a quick-closing valve and lined forebay that precede the stormwater facility. The forebay and piping system shall be designed to capture 150 gallons. In addition, a valve or other shut-off device shall be placed between the forebay and the treatment facility to isolate any spilled materials. The valve shall be well marked and placed in a location that can be accessed easily and safely in an emergency situation and shall be in good working order. Employees shall be trained in spill response procedures.

2) Use pavement, curb, and gutter materials constructed of impervious materials. Impervious surfaces are defined above under C) Implement Interior Requirements.

3) Seal all joints and cracks with a bonded epoxy or similar material.

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[4] Stormwater drainage shall also meet the requirements in Section 9.8 for parking area/paved surfaces. Those requirements specify that stormwater drainage shall be treated for oil and grease prior to disposal.

9.6 EXTERIOR STORAGE OF BULK MATERIALS

9.6.1 Applicability

The requirements in this section apply to developments that stockpile erodable materials outside. This includes, but is not limited to, the following general categories:

- Pesticides/fertilizers
- Food items and wastes
- Scrap and recycling materials and/or yards.
- Soil, sand, and other materials that increase total suspended solids (TSS) in stormwater (including contaminated soil)
- Raw by-product materials, waste or final product.

Materials with any of the following characteristics are exempt from the requirements of this section:

- Have no measurable solubility or mobility in water and no hazardous, toxic, or flammable properties, or

- Exist in a gaseous form at ambient temperature, or

- Are containerized in a manner that prevents contact with stormwater (excluding pesticides and fertilizers)

Exhibit 9-7 lists some common bulk materials. The list is separated into materials that typically require SPCs and those that are not expected to affect water quality and therefore do not generally require SPCs.

This section does not regulate construction sites subject to the City's *Erosion Control Manual* and City Code, Title 10.

Applicants subject to the requirements in 9.6 shall prepare **Form SPC** located at the end of this chapter) that fulfills the requirements of Section 9.6.3, below, and include it in their submittal package.

Exhibit 9-7
BULK MATERIAL CATEGORIES

Bulk Materials with SPC Requirements	Bulk Materials without SPC requirements
Recycling materials	Washed gravel/rock
Scrap or salvage goods	Finished lumber
Metal	Rubber and plastic products (hoses, gaskets, pipe, etc.)
Sawdust/barkchips	Clean concrete products (blocks, pipe, etc.)
Storage and processing of food items	Glass products (new, non-recycled)
Chalk/gypsum products	Inert products
Sand/dirt/soil (including contaminated soil piles)	
Feedstock/grain	
Material by-products	
Asphalt	
Fertilizer/compost	
Pesticides	
Unwashed gravel/rock	
Lime/lye/soda ash	
Animal/human wastes	

9.6.2 Issue

Exterior storage of non-containerized bulk materials has the potential to contribute a variety of pollutants to stormwater, depending on the material being stored. Impacts generally associated with bulk materials storage include oil and grease, heavy metals, toxic or organic compounds, biochemical oxygen demand (BOD), suspended solids, bacteria, nutrients, metals, pH, and temperature.

The primary problem with most of these types of pollutants is that they are soluble, which means they cannot easily be filtered out of stormwater runoff or out of contaminated water that seeps into the soil.

9.6.3 Requirements

The following SPCs are required unless an equivalent alternative measure has been requested on Form SPC and approved by BES's Industrial Source Control Division.

1) COVER

Bulk materials shall be covered with a canopy or roof to prevent stormwater contact and minimize the quantity of precipitation entering the storage area. Precipitation shall be directed from the cover to a stormwater disposal system that meets all applicable code requirements.

2) PAVEMENT

A paved storage area is required beneath the structural cover.

Gasoline and other materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks that could contribute to soil contamination.

3) DRAINAGE

The paved area beneath the structural cover shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities <u>are not required</u> for the containment area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, approved on-site industrial stormwater treatment system, or other approved on-site temporary storage facility or containment device/structure.

Note: An on-site temporary storage facility or containment device/structure shall be used only as a last resort and only for temporary storage of the wastewater or contaminated stormwater. (*See Appendix 9-B.*)

4) ADDITIONAL REQUIREMENTS

Please carefully review the following additional requirements. These requirements are not applicable to all development projects. If they do apply, however, and are not addressed in the project design, revisions will be required. This could delay issuance of related building permits.

A) **Storage of pesticides and fertilizers** may need to comply with specific regulations outlined by the Oregon Department of Environmental Quality (DEQ). Applicants should contact DEQ for additional information.

B) **A sampling manhole** or other suitable stormwater monitoring access point may be required to monitor stormwater runoff from the storage area. This may apply to certain types of storage activities and materials or if an alternative SPC is proposed. This requirement is to comply with City Code, Chapter 17.39.080, to ensure appropriate stormwater disposal, BES Source Control staff will review for applicability of this requirement.

C) **Signage** shall be provided at the storage area if hazardous materials or other materials of concern are stored. Signage shall be located so it is plainly visible from all storage activity areas. More than one sign may be needed to accommodate large storage areas.

The following language shall be added to the building plan set, as a general note on the site and/or utility plan:

"Signage will be provided at the storage area that is plainly visible and water resistant, and include the following information:

- Safety precautions
- Immediate spill response procedures
- Emergency contacts and telephone numbers"

D) **A shut-off valve** may be required for the structurally covered storage area if the applicant elects to install drainage facilities to an approved City sanitary sewer. BES will make this determination based on the type of material stored and the proposed system receiving the discharge.

This requirement is to comply with City Code, Chapter 17.34.090, requiring spills that occur within the activity area to be effectively contained for appropriate clean-up and disposal. (The emergency contacts and responders identified on the required signage shall determine the appropriate clean-up and disposal of a spill.)

E) **Storage of hazardous materials** that are toxic, carcinogenic, or halogenated solvents (located in designated groundwater protection areas) are subject to additional requirements, as identified in Section 9.5: Storage, Use, and Transportation of Hazardous/Toxic Materials in Designated Groundwater Resource Protection Areas.

9.7 MATERIAL TRANSFER AREAS/LOADING DOCKS

9.7.1 Applicability

The requirements in this section apply to all development with a material transfer area.

Two construction techniques are generally associated with material transfer areas: 1) loading/unloading facilities with docks, and 2) large bay doors without docks. The requirements apply to all material transfer areas, including loading/unloading docks, bay doors, and any other building access point(s) with the following characteristics:

- The area is designed (size, width, etc.) to accommodate a truck/trailer being backed up to or into it, <u>and</u>

- The area is expected to be used specifically to receive or distribute materials to/from trucks or trailers.

The requirements may not apply to areas that are used only for mid-sized to small-sized passenger vehicles and that are restricted (by lease agreements or other regulatory requirements) to storing, transporting or using materials that are:

- Typically used by a household, or

- Classified as domestic use, such as a primary educational facility (elementary, middle, or high school); a building used for temporary storage (a lease agreement will need to be provided); a church, etc.

For assistance in making this determination, contact BES's Industrial Source Control Division at 503-823-7122.

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter that fulfills the requirements of Section 9.7.3, below. include it in their submittal package

9.7.2 Issue

Stormwater runoff may pick up many pollutants when it comes into contact with transfer areas through acute and chronic releases of materials in these areas. These may include oils and greases, toxic hydrocarbons, chemicals, heavy metals, and a variety of other substances that can degrade water quality. Releases or contact with materials of concern are generally expected to occur during material transfer activities in the area surrounding the truck or trailer end.

9.7.3 Requirements

1) COVER

New Buildings with Loading Docks

Loading docks shall be covered with a canopy, roof, or other permanent overhang that shall extend a minimum of 10 feet over the trailer or truck end. The cover shall minimize the volume of precipitation discharged to the City sanitary sewer, on-site industrial wastewater treatment system, or other approved on-site temporary storage facility or containment device/structure. Precipitation shall be directed from the cover to a stormwater disposal system that meets all applicable code requirements.

Existing Buildings with Loading Dock Improvements

Loading docks shall be covered with a canopy, roof, or other permanent overhang that shall extend a minimum of 4 feet over the trailer or truck end.

(Note: As part of an existing building's improvements, 10-foot overhangs make it difficult to meet Fire Code regulations.)

Bay Doors and Other Interior Transfer Areas

All transfer of materials shall be conducted with the truck or trailer end backed into the building a minimum of 5 feet (see additional requirements below). A cover is not required for these areas.

2) PAVEMENT

A paved area shall be placed underneath and around the loading and unloading activities. This will reduce the potential for soil contamination with potential impacts on groundwater and will help control any acute or chronic release of materials present in these areas.

Some materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks.

3) DRAINAGE

Loading Docks

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, approved on-site industrial wastewater treatment facility, or other approved on-site temporary storage facility or containment device/structure.

Note: An on-site temporary storage facility or containment device/structure shall be used only as a last resort and only for temporary storage of the wastewater or contaminated stormwater (*see Appendix 9-B*).

Bay Doors and Other Interior Transfer Areas

Bay doors and other interior transfer areas shall be designed so stormwater run-on does not enter the building. This can be accomplished by grading or drains.

Because interior material transfer areas are not expected to accumulate precipitation, installation of floor drains is not required or recommended. It is preferable to handle these areas with a dry-mop or absorbent material such as cat liter. If interior floor drains are installed, they shall be plumbed to an approved City sanitary sewer or approved on-site industrial wastewater treatment facility.

4) SIGNAGE

The following requirements apply to all material transfer areas/loading docks.

Signage shall be provided and shall be plainly visible from all material transfer activity areas (*see section 9.1.7*). More than one sign may be needed to accommodate large transfer areas.

The following language shall be added to the building plan set, as a general note on the site and/or utility plan:

> "Signage will be provided at the material transfer area that is plainly visible and water resistant, and will include the following information:
> - Safety precautions
> - Immediate spill response procedures
> - Emergency contacts and telephone numbers"

5) ADDITIONAL REQUIREMENTS

Please carefully review the following additional requirements. These requirements are not applicable to all development projects. If they do apply, however, and are not addressed in the project design, revisions will be required. This could delay issuance of related building permits.

A) **Bay doors and other interior transfer areas** shall provide a 10-foot "no obstruction zone" beyond the entrance. This will allow the transfer of materials to occur with the truck or trailer end placed at least 5 feet inside the building, with an additional staging area of 5 feet beyond that.

B) A **shut-off valve** may be required for discharges to an approved City sanitary sewer. BES will make this determination based on the type of material being transferred and the proposed system receiving the discharge.

This requirement is to comply with City Code, Chapter 17.34.090, requiring spills that occur within the activity area to be effectively contained for appropriate clean-up and disposal. (The emergency contacts and responders identified on the required signage shall determine the appropriate clean-up and disposal of a spill.)

C) **Transport and handling of hazardous materials** that are toxic, carcinogenic, or halogenated solvents (located in designated groundwater protection areas) are subject to are subject to additional requirements, as identified in Section 9.5: Storage, Use, and Transportation of Hazardous/Toxic Materials in Designated Groundwater Resource Protection Areas.

D) **Appropriate spill response training** shall be provided to all employees. The operations and maintenance agreement shall include information about the spill response training plan. The City requires spill response supplies, such as absorbent material, to be stored at the transfer area.

6) EXCEPTIONS

A) **Cover:** The requirement to cover the loading dock area will be waived under either of the following conditions:

- A retractable curtain is installed that automatically extends out from the building and over the back end of the truck or trailer during material transfer activities. This curtain then retracts back into the building when not in use. A detail of the curtain shall be submitted with the building plans at the time of building permit application. The detail will be reviewed to ensure that there is no possibility for spills to be discharged to stormwater.

- The loading dock is an improvement to an existing building, and the property owner agrees to pay the City for stormwater discharges to the sanitary sewer system (if drainage from the uncovered loading dock discharges to the City's sanitary sewer).

  City Code (Chapter 17.32.080 and 17.32.090) prohibits stormwater from being discharged to a City separated sanitary sewer, with limited exceptions allowed by the Chief Engineer. If an exception is approved and a cover is not installed, Chapter 17.36 of the City Code allows the City of Portland to bill a facility for the disposal of stormwater into the City separated sanitary sewer. Charges are determined by either calculated volumes (based on the average annual rainfall and the square footage of impervious area drained) or by meter readings from a City-approved discharge meter.

  A written **stormwater volume charge request** shall be submitted as part of the approval process for this exception. The request shall document the property owner's acknowledgement of the City's right to charge the facility sanitary sewer rates for the volume of stormwater discharged to the sanitary sewer system. The application shall be signed by the property owner and notarized.

B) **Drainage:** The requirement for the drainage from the hydraulically isolated area of the loading dock to be directed to an approved City sanitary sewer, approved on-site industrial wastewater treatment facility, or other approved on-site temporary storage facility or containment device/structure will be waived under any of the following conditions:

- A dock leveler is used where the transfer activities occur, and has been retrofitted with a 4" – 6"metal plate across the front to provide spill containment and capture any contaminated stormwater within the leveling well. A detail of the leveler shall be submitted with the building plans at the time of building permit application. Any fluids collected should be batch discharged.

- The loading dock is an improvement to an existing building; the sanitary sewer service is not easily accessible; and the tenant is not handling materials of concern.

If any of these three conditions applies, an operations and maintenance agreement is required, stating the property owner will be responsible for ensuring the tenants do not handle materials of concern and is accountable for discharges from the activity area to the storm sewer system. BES's Industrial Source Control Division (503-823-7122) can provide preferred language that will satisfy this requirement.

9.8 VEHICLE AND EQUIPMENT TRAFFIC AREAS, PARKING, AND STORAGE

9.8.1 Applicability

The requirements of this section apply to all types of parking lots (commercial, public, and private), retail store parking lots, fleet vehicle lots and yards (including rental car lots and car dealerships), equipment sale and rental lots, and access roads with any of the following **higher-use** or **higher-risk** conditions:

- A commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area.
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more vehicles or equipment (trucks, buses, heavy equipment, etc.).
- A commercial or industrial area identified for the specific use and traffic from vehicles or equipment that are over 10 tons gross weight (trucks, trains, heavy equipment, etc.).
- A commercial or industrial site subject to the storage of wrecked or impounded vehicles.
- Sites with a high likelihood of oil and grease releases (e.g., vehicle repair, vehicle sales, vehicle parts sales, vehicle fueling services).

<u>The requirements of this section do not apply to single-family and duplex residential sites.</u>

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter. Form SPC shall be included in the submittal package.

Notes:

The traffic threshold focuses on vehicle turnover per square foot of building area (trip generation) rather than ADT alone. This is because oil leakage is greatest when engines are idling or cooling. In general, all-day parking areas are not intended to be captured by these thresholds. The petroleum storage and transfer stipulation is intended to address regular transfer operations such as service stations, not occasional filling of heating oil tanks. Traffic thresholds are researched and compiled by the Institute of Transportation Engineers (ITE).

Parking lots that do not have the above higher-use or higher-risk conditions must use required landscaping within the project area for stormwater (*See Chapter 1.0, Section 1.6.*)

9.8.2 Issue

Stormwater runoff from higher-use or higher-risk sites can contain toxic materials and other organic compounds, oil and grease, heavy metals, nutrients, and suspended solids. Pollutants of concern are primarily generated by vehicle washing and maintenance activities, road oils, and vehicle drips/leaks. These pollutant loads may not be adequately addressed when no water quality facility is required or when volumes exceed the capacity of any required facilities. In such cases, additional pollution reduction facilities or activities may be required. BES will identify additional pollutant prevention or removal needs during SPC application review.

9.8.3 Requirements

1) PAVEMENT

Because of the potential for soil and groundwater contamination, all high-use or high-risk sites shall be paved.

Gasoline and other materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks.

2) DRAINAGE

Drainage from these areas shall be directed to a stormwater disposal system that meets all water quality requirements of this manual and any other applicable codes.

> The Oregon Department of Environmental Quality has identified drywells and/or sumps as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. Since the UIC Program states that these types of wells have a direct impact on groundwater, stormwater pollution controls will apply. More information about the UIC program can be found on DEQ's web site at:
> Http://waterquality.deq.state.or.us/wq/groundwa/uichome.htm

3) OIL CONTROL

City code prohibits the discharge of stormwater with a visible sheen to the City's storm sewer system The following oil control options are designed to capture and detain oil and associated pollutants.

Oil/Water Separators

Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. The two types of oil/water separators used for stormwater treatment are the baffle type or API (American Petroleum Institute) oil/water separator and the coalescing plate oil/water separator.

- **Baffle oil/water separators** use vaults that have multiple cells separated by baffles extending down from the top of the vault. The baffles block oil flow out of the vault. Baffles are also commonly installed at the bottom of the vault to trap solids and sludge that accumulate over time. In many situations, simple floating or more sophisticated mechanical oil skimmers are installed to remove the oil once it has separated from the water.

- **Coalescing plate separators** are manufactured units consisting of a baffled vault containing several inclined corrugated plates stacked and bundled together. The plates are equally spaced and are made of a variety of materials, most commonly fiberglass and polypropylene. Efficient separation results because the plates reduce the vertical distance oil droplets must rise in order to separate from the stormwater. Once they reach the plate, oil droplets form a film on the plate surface. The film builds up over time until it becomes thick enough to migrate upward under the influence of gravity along the inclined plate. When the film reaches the edge of the plate, oil is released as large droplets that rise rapidly to the surface, where the oil accumulates until the unit is maintained. Because the plate pack significantly increases treatment effectiveness, coalescing plate separators can achieve a specified treatment level with a smaller vault size than a simple baffle separator.

Design Criteria and Requirements for Oil/Water Separators when Not Discharged to a Sanitary Sewer: Research has shown that baffle oil/water separators are not as effective for stormwater management as those with coalescing plate separators and cannot be guaranteed to meet the City's prohibited discharge requirements. For this reason, the sizing of oil/water separators with baffles reflects a factor of safety to ensure that they meet the benchmarks. The following design criteria are established to treat the first flush of a storm event, not the complete storm.

- Characteristics of the runoff shall be assumed to be:
  - Specific gravity (SG) of oil is .9
  - Temperature of stormwater runoff is 50°F to 60°F
  - Oil droplet size is 50 microns.

- Baffled separators shall be able to handle a water quality (WQ) design flow equal to two-thirds of a 2- year storm event, in a 24-hour period.

- Coalescing plate separators shall have a WQ design flow equal to one-third of a 2-year storm event, in a 24-hour period.

- Flow calculation shall be based on the impervious area before mitigation has been credited; however, the roof area shall be excluded from the total.

- Oil/water separators shall be installed off-line, bypassing flows greater than the WQ design flow.

- The separator shall precede other water quality treatment facilities when open surface approaches (e.g. swales, infiltration basins) are used. When other types of treatment facilities are used (e.g., manufactured subsurface facilities), the separator may be downstream of those treatment facilities. The separator may be positioned either upstream or downstream of detention facilities, since there are both advantages and disadvantages with either placement.

- If the oil/water separator is discharging to an open-surface water quality facility, the flows shall not exceed three feet per second, per water quality requirements as identified in Chapter 5.0.

- To maintain efficiencies and reduce size, all roof drainage shall enter the stormwater system downstream of the oil/water separator.

- Any pumping devices shall be installed downstream of the separator to prevent oil emulsification in stormwater.

- Engineered calculations shall be required, using the Santa Barbara Unit Hydrograph (SBUH), to verify appropriate sizing of the oil/water separator.

Note: Additional design considerations are required for a baffled oil/water separator is installed. Design requirements are twice the standard water quality requirement for other water quality facilities in this manual, and flow management will need to be engineered. A possible solution may be a flow splitter upstream of the separator and another flow splitter downstream of the separator (but upstream of the water quality facility design).

Design Criteria and Requirements for Oil/Water Separators Discharged to a Sanitary Sewer: Since the discharge limits for the sanitary sewer are not as restrictive as the storm sewers, the design criteria are not as complicated:

- The characteristics of the runoff shall be assumed to be the same as stated above.

- Baffled separators shall retain maximum flows of a system for 45 minutes.

- Coalescing plate separators shall retain maximum flows of a system for 15 minutes.

- Engineered calculations shall be required to verify appropriate sizing of the oil/water separator.

Note: For high-use or high-risk sites located within a larger commercial center, only the impervious surface associated with the high-use or high-risk portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the high-use or high-risk business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.

Linear Sand Filters

Linear sand filters have proven effective in meeting standard water quality requirements (*see Chapter 4.0*). Because design criteria are still being established to ensure these facilities can also effectively control oil and grease, their proposed use will require an additional review process for approval. This may delay issuance of related building permits. For more information on the use of linear sand filters to remove oil and grease, contact BES's Industrial Source Control Division at 503-823-7122.

Other Options

There may be other acceptable oil controls not listed above. In many cases landscaping alternatives may be equally or more effective. Applicants may propose an oil control option that would be as effective as those listed. However, proposal of a new oil control will require an additional review process for approval, which may delay issuance of related building permits.

5) ADDITIONAL REQUIREMENTS

Please carefully review the following additional requirements. These requirements are not applicable to all development projects. If they do apply, however, and are not addressed in the project design, revisions will be required. This could delay issuance of related building permits.

Hazardous materials that are toxic, carcinogenic, or halogenated solvents (located in designated groundwater protection areas) are subject to additional requirements, as identified in Section 9.5: Storage, Use, and Transportation of Hazardous/Toxic Materials in Designated Groundwater Resource Protection Areas.

9.9 COVERED VEHICLE PARKING AREAS

9.9.1 Applicability

The requirements in this section apply to all development with a covered vehicle parking area, except single-family and duplex residential sites. Existing parking structures are not required to retrofit unless the structure is being redeveloped. New parking structures are required to meet these requirements.

Applicants subject to these requirements shall prepare **Form SPC**, located at the end of this chapter, fulfills the requirements of Section 9.9.3. Form SPC shall be included in the submittal package.

9.9.2 Issue

Run-off from covered vehicle parking areas can be contaminated with toxic substances, organic compounds, oil and grease, heavy metals, and suspended solids.

9.9.3 Requirements

1) DRAINAGE

Top Floor Drainage of a Multi-Level Parking Structure

Stormwater runoff from the top floor shall be directed to a stormwater disposal system that meets all water quality requirements of this manual and any other applicable codes.

Lower Floor Drainage of a Multi-Level Parking Structure

Significant amounts of precipitation are not expected to accumulate in covered vehicle parking areas, and drainage facilities are not required for the lower floors. If the applicant elects to install drainage facilities, the drainage from the lower floors shall be directed to an approved City sanitary sewer.

Adjacent, Uncovered Portions of the Site

The surrounding uncovered portions of the site shall be designed so stormwater run-on does not enter the covered parking areas. This can be accomplished through grading or drains.

9.10 EQUIPMENT AND/OR VEHICLE WASHING FACILITIES

9.10.1 Applicability

The requirements in this section apply to all development with a designated equipment and/or vehicle washing or steam cleaning area. The types of vehicles may include, but are not limited to, highway maintenance trucks, taxicabs, buses, rental cars, new and used automobiles on lots, government and company cars, construction equipment, fork lifts, golf carts, riding lawn mowers, and similar large vehicles. Single-family and duplex residential sites are exempt.

Development that is intended for the storage of 10 or more fleet vehicles shall include a designated vehicle washing area. An exception is granted if the applicant can show evidence that vehicles are routinely washed in an approved location.

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter, that fulfills the requirements of Section 9.10.3. Form SPC should be included in the submittal package.

9.10.2 Issue

Wastewater from equipment and/or vehicle washing may contain toxic substances, organic compounds, oil and grease, nutrients, heavy metals, and suspended solids.

9.10.3 Requirements

1) COVER

The washing area shall be covered with a permanent canopy or roof so precipitation cannot come in contact with the washing area. Precipitation shall be directed from the cover to a stormwater disposal system that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing area it is to cover.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing area it is to cover.

2) PAVEMENT

A designated paved wash area shall be placed underneath and around permanent washing areas. This area shall be hydraulically isolated through grading, berms, or drains. Sizing of the paved area shall adequately cover the activity area, including the placement of the vehicle or piece of equipment to be cleaned.

Some materials can react with asphalt pavement, causing the release of toxic oils from the pavement. It is therefore preferable to pave the area with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant shall be applied to the pavement surface. Whichever paving material is used, the paved surface shall be properly maintained to prevent gaps and cracks.

3) DRAINAGE

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer, approved on-site industrial wastewater treatment facility, or other approved on-site wash recycling system (process treatment system).

4) OIL CONTROLS

Any vehicle and equipment washing activity that cleans large commercial vehicles (vans, trucks, buses, etc), or more than 10 mid to small sized vehicles, and all equipment washing will be reviewed for needed oil control

EXCEPTIONS

If a washing facility is generally used to service oversized equipment that cannot maneuver under a roof or canopy (cranes, etc.) an exception to the roof or canopy requirement will be granted.

A request for the exception will need to be submitted to BES Source Control Division of BES. This request should document the property owner's acknowledgement of the City's right to charge the facility sanitary sewer rates for the volume of stormwater discharged to the sanitary sewer. Charges will be based on either calculated volumes from the area being drained to the sanitary sewer times the annual average rainfall OR by meter readings from a City approved discharge meter. The document should be titled "**Stormwater Volume Application** "and must be signed and notarized by the property owner(s).

9.11 INTERIOR FLOOR DRAINS

9.11.1 Applicability

The requirements in this section apply to all development with buildings and facilities that have interior floor drains, except single-family and duplex residential sites.

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter, that fulfills the requirements of Section 9.11.3. Form SPC should be included in the submittal package.

9.11.2 Issue

A variety of wastewaters generated by floor washing, accidental spills, and other activities may be present near interior floor drains. Directing the drainage from interior floor drains to a City sanitary treatment facility or other approved on-site temporary storage facility or containment structure provides proper wastewater treatment or spill containment.

9.11.3 Requirements

1) DRAINAGE

Drainage entering interior floor drains is prohibited from discharge into a stormwater system. All drainage from floor drains within buildings shall be directed to a City sanitary treatment facility or other approved on-site temporary storage facility or containment structure.

Prohibited Uses

Interior floor drains are prohibited in all areas designated for manufacture, storage, or processing of materials required to have a permit under the Uniform Fire Code (UFC) or regulated by the Resource Conservation and Recovery Act (RCRA) or Toxic Substances Control Act (TSCA). If chemical use or chemical waste generation may occur at a site, the user should consult these listed regulations or policies for further information.

All wastewater that will/may be discharged to interior floor drains shall be evaluated before discharge. Certain types of discharges may require a permit and/or pretreatment before discharge to a City of Portland sanitary sewer. Contact BES's Industrial Source Control Division (503-823-7122) for a discharge evaluation and additional information.

9.12 STORMWATER DISPOSAL FROM DEVELOPMENT ON RECYCLED LAND

9.12.1 Applicability

The requirements in this section apply to all development on recycled land. Recycled lands, commonly referred to as "brownfields," are lands that currently or previously have had pollutants detected in soil or groundwater at concentrations that exceed risk-based cleanup levels or state/federal cleanup standards for the pollutant(s) of concern.

Applicants subject to the requirements of this section shall prepare **Form SPC,** located at the end of this chapter, that fulfills the requirements of Section 9.12.3,, and include it in the submittal package.

9.12.2 Issue

Contaminated soils or groundwater can cause long-term impacts is in two ways:

- Stormwater runoff that comes into contact with contaminated soils or groundwater can carry some of those contaminants along with suspended solids into receiving waters.
- Contaminants can be transported by discharges from footings or foundation drains.

9.12.3 Requirements

Because the pollutants, media, and site conditions are unique to each parcel of land, stormwater management practices for development on recycled land shall be reviewed on a case-by-case basis. If assistance is needed prior to submittal, call BES's Source Control Division at 503-823-7122 to schedule an evaluation. The City of Portland will coordinate with the owner/developer and the Oregon Department of Environmental Quality (DEQ) to arrive at an acceptable stormwater management plan. General requirements are included here to assist the applicant in planning.

1) COVER

All contaminated soils shall be covered to prevent stormwater from coming into contact with them. Contaminated soils that are stockpiled shall also be covered, and a berm shall be used to prevent stormwater run-on and run-off.

Contaminated groundwater shall be stored in an above-ground containment structure for appropriate pretreatment before disposal.

2) PAVEMENT

Pavement is not required beneath stored contaminated materials. However, an impervious layer shall be placed beneath the materials so they do not contaminate uncontaminated areas if they leach.

3) DRAINAGE

All drainage shall be evaluated for contamination prior to disposal. No infiltration will be allowed without pretreatment to ensure that soils and groundwater are not further transported or spread to other areas.

Note: All proposed discharges are required to go through a batch discharge process, as identified in *Appendix 9-B*: Temporary Storage Facilities and Containment Devices/Structures.

4) LABORATORY ANALYSIS REPORTS

Laboratory analysis reports are required to identify the characteristics and levels of contamination in groundwater and stormwater run-off. An additional review process will be applied to these reports to determine regulatory authority and requirements. This may delay issuance of related building permits.

5) PRETREATMENT OR DISPOSAL

Pretreatment or disposal must follow specific regulations outlined by DEQ and any other local pretreatment requirements identified by City Code.

NOTE: A Letter of Authorization of a No Further Action (NFA) Report from DEQ will be required by the City of Portland and may delay issuance of related building permits if not included with submittal.

DEFINITION OF TERMS

Above-ground storage tank (AST): A stationary container, vessel, or other permanent holding device designated for the storage and/or distribution of a liquid product.

Approved on-site containment structure: A structure that satisfies the definition of a dead-end sump and has been accepted by BES. This could include berms, walls, or other new technological devices or materials that temporarily hold and store spilled liquid.

Approved receiving system: Any system approved by BES to receive stormwater runoff or other discharges. Receiving systems include, but are not limited to, groundwater; on-site, off-site, or public stormwater, sanitary, or combined sewers; and waters of the state.

Approved stormwater system: Any system approved by BES to provide conveyance and quality and/or quantity management of stormwater or other discharges. Stormwater systems include, but are not limited to, on-site, off-site, or public stormwater systems.

Batch discharge: The controlled discharge of a discrete, contained volume of water or wastewater.

Bulk fuel terminal: Any area whose primary function is dedicated to the storage and distribution of fuel to distributors such as gas stations.

Bulk materials: Non-containerized materials.

Containerized: The storage of any product, by-product, or waste that is completely held or included on all sides, within a discrete volume or area.

Containment: The temporary storage of potentially contaminated stormwater or process wastewater when a City sanitary sewer is not available for appropriate disposal.

Driveway: The area that provides vehicular access to a site. A driveway is the same width as a curb cut, excluding any aprons or extensions of the curb cut. A driveway begins at the property line and extends into the site. Driveway does not include parking, maneuvering, or circulation areas in parking areas.

Exterior materials storage area: Any exterior materials storage location that is not completely enclosed by a roof and sidewalls.

Hazardous material: Any material or combination of materials that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or that may pose a present or potential hazard to human health, safety, or welfare, or to animal or aquatic life or the environment when improperly used, stored, transported or disposed of, or otherwise managed. For purposes of chemical regulation by this manual, moderate to high toxicity and confirmed human carcinogenicity are the criteria used to identify hazardous substances. (Note: This manual does not use the Resource Conservation and Recovery Act (RCRA) definition of hazardous. For the purpose of this manual, hazardous material is intended to include hazardous, toxic, and other harmful substances.)

Hazardous material containment zone (HMC zone): An area where a specific individual activity involving use of a hazardous material takes place, and where chemical quantities at that location are expected to exceed defined thresholds. HMCs may include (but are not limited to) storage and/or process areas, transportation routes, work areas, and loading/unloading facilities.

High-use or high-risk sites: As used in Section 9.8, high-use or high-risk sites include any one of the following:

- A commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area.
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more vehicles or equipment (trucks, buses, heavy equipment, etc.).
- A commercial or industrial area identified for the specific use and traffic from vehicles or equipment that are over 10 tons gross weight (trucks, trains, heavy equipment, etc.).
- A commercial or industrial site subject to the storage of wrecked or impounded vehicles.
- Sites with a high likelihood of oil and grease releases (e.g., vehicle repair, vehicle sales, vehicle parts sales, vehicle fueling services).

LD-50 : The lethal dose of a substance that is expected to kill approximately 50 percent of experimental animals through oral ingestion. (Refer to product Material Safety Data Sheet.)

Local dispensing location: An area within 15 feet of an above-ground storage tank (AST) and used to dispense fuel directly from the AST, typically through a flexible hose.

Multi-level parking structure: Any parking facility with greater than one contiguous level of parking.

Parking area: All the area devoted to the standing, maneuvering, and circulation of motor vehicles. Parking areas do not include driveways or areas devoted exclusively to non-passenger loading.

Receiving System: Any system that receives stormwater runoff. Receiving systems include, but are not limited to groundwater; on-site, off-site, or public surface water facilities; and waters of the state.

Roadway: Any paved surface used to carry traffic (trucks/vehicles, forklifts, farm machinery, and any other large machinery).

Transportation route: Any path routinely used to transport materials regulated in Section 9.5 onto, off of, or within a site. Transportation routes shall be constructed with impervious surfaces and shall provide spill containment.

Form SPC	Stormwater Pollution Control Plan for:
Use this form to describe: • Proposed SPC measures in conformance with the requirements of this manual • Proposed alternatives to the SPC requirements of this manual • SPC requirements specific to Section 9.5 (Hazardous/ Toxic Materials)	______________________________ (Identify section and site use/characteristic—for example, 9.2: Fuel Dispensing Facilities) *Note: A separate form shall be filled out for each type of use/characteristic.*

Please answer each question as briefly as possible, while still conveying relevant information. Use additional pages if necessary.

GENERAL INFORMATION (to be completed for all SPCs)

Date: ________________ Applicant's Name: ______________________________

Facility Name: ______________________ Owner/Operator Name: ____________________

Facility Address: ____

Business Mailing Address: ____

Phone No.: ________________ Type of business/facility: ________________________

Describe the site activity(ies) the SPC(s) apply to:

Describe the SPC(s) required by Chapter 9.0 of the manual:

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Form SPC (page 2)

PART A **(Complete if proposing approved SPC measures in conformance with the requirements of this manual.)**

Describe how the SPC(s) will be implemented on the site. Include all required and any non-required management practices.

PART B **(Complete if proposing alternatives to the SPC requirements of this manual.)**

Describe why the SPC requirements in the manual will not work on the site or are not desirable:

Describe the proposed alternative SPC(s):

Explain why the alternative(s) will work: (*use additional sheets or manufacturer information as necessary*)

Form SPC (page 3)

PART C **(Complete for both approved SPCs described in Part A and alternative SPCs described in Part B.**

Describe any constraints or limitations of the approved or alternative SPC(s)--e.g., application or seasonal limitations, environmental constraints:

Attach a figure or site plan with the location of the approved or alternative SPC(s). Identify any other attachments (e.g., vendor information).

Other comments:

TO BE COMPLETED BY CITY:

Approved   Approved with Conditions   Denied

Date:____________ Signature: ________________ Title: ____________

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Form SPC (page 4)

Complete Parts D, E, and F only for SPC requirements specific to Section 9.5 (Hazardous/Toxic Materials)

PART D: SITE PLAN

Include the following information on the site plan (see **Form SITE** in Chapter 3.0) that is submitted as part of the development's overall submittal package:

- Property boundaries
- Identification of functional areas on the site (HMCs, loading/ unloading areas, transportation routes). Include the total number of each and their uses.
- Stormwater and other drainage facilities/patterns
- Treatment facilities, if applicable
- Wells
- Surface water features
- Underground and above-ground storage tanks

Form SPC (page 5)

Complete Parts D, E, and F only for SPC requirements specific to Section 9.5 (Hazardous/Toxic Materials)

PART E: CONTAINMENT PLAN

Describe/illustrate the containment system(s) proposed for the site and how they would function to prevent spills from entering groundwater, surface water and/or the City's storm sewer system. List all structures or measures that will be implemented to contain hazardous materials and prevent contamination. Attach sketches and/or cross-sections/schematics of materials/equipment as necessary to adequately describe the containment concept. The containment plan shall contain the following information. A separate plan or sheet shall be prepared for each functional area.

- Area the containment plan applies to (e.g., functional area, such as HMC, loading/unloading area, transportation route)
- Location on site
- Activities/use
- Hazardous materials inventory of the chemicals, products, or wastes that will be used, stored, generated, transported, or otherwise present on the site/functional area *(can be obtained from Form HAZ)*
- Maximum amount of materials present
- Maximum containment volume
- Containment measures (per manual requirements in Section 9.5)
- Receiving system for stormwater runoff

Operation and maintenance measures (non-structural measures to be used in conjunction with structural containment facilities to minimize the potential of spills and contaminated runoff entering groundwater, surface water, and/or the City's storm sewer system). *Note: These O&M measures shall be incorporated into the site-wide O&M plan, as required by Chpt. 9.0.*

Form SPC (page 6)

Complete Parts D, E, and F only for SPC requirements specific to Section 9.5 (Hazardous/Toxic Materials)

PART F: AUTHORIZED SIGNATURE & EMERGENCY CONTACTS

Do you wish to have any of the information submitted in this application be confidential?
[ ] Yes [ ] No
If yes, please stamp confidential on those pages which you would like the City to evaluate as being confidential information.

1) Designated signatory authority of the facility:
(Attach the following information for each authorized representative.)

Name: ______________________
Title: ______________________
City: ______________State: ________ Zip: ________
Phone No.: ______________________

2) Designated facility contacts

Primary Contact: ______________________
Title: ______________________
Phone No.: ______________________

Secondary Contact: ______________________
Title: ______________________
Phone No.: ______________________

3) Emergency contacts (provide two):

Name: ______________________
Title: ______________________
Phone No.: ______________________

Name: ______________________
Title: ______________________
Phone No.: ______________________

Form SPC (page 7)

Complete Parts D, E, and F only for SPC requirements specific to Section 9.5 (Hazardous/Toxic Materials)

PART F: (continued)

Authorized Representative Statement:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: ____

Title: ____

Signature: ____

Date: ____________________

For City Use Only:
Certified Mail No.:
Date Received:
Date Approved:
File No.:

Form HAZ

HAZARDOUS MATERIALS INVENTORY

SURVEY OF HAZARDOUS MATERIALS FOR ON-SITE CONTAINMENT PLAN REVIEW

If the development proposal is located within the Columbia South Shore Plan District or Cascade Station/Portland International Center Plan Districts (see Exhibit 9-1) or the Powell Valley Groundwater Resource Protection Area (see Exhibit 9-2), the Water Bureau needs to know what hazardous materials currently exist or are proposed for the **entire site, both exterior and interior.** Please complete this survey form and return it to the Bureau of Water Works, 1001 SW Fifth Avenue, Suite 450, Portland, OR 97204. For questions, call the Water Bureau at 503-823-7577, or fax to 503-823-7269.

1) **Project or Business Name:** 2) **OPDR Permit No.:**

3) **Street Address or Legal Description of Property:**

4) **Description of Business::**

5) **Business SIC Code(s):**

6) **Is any use of cleaners, paints, solvents, fuels or petroleum products currently on the site or planned in the future?**

YES __ NO __ If YES, please complete the inventory listing sheet on page 3.

7) **Will any chemicals, products or wastes containing hazardous ingredients or constituents be used, stored, generated, or otherwise be present on the site for which Material Safety Data Sheets are required?**

YES __ NO __ If YES, please complete the inventory listing sheet on page 3.

Form HAZ (page 2)

8) **Are any wells present on this site?**

YES __ NO __ UNKNOWN __ If YES, please complete the following:

Well No.	*Status*	*Use*	*Casing Diam.*	*Depth*	*Screened Interval*

9) **Are any underground or above-ground liquid storage tanks currently on the site or planned in the future?**

YES __ NO __ UNKNOWN __ If YES, please fill in the following:

Type of Tank	Number	Size	Contents	Current or planned?

10) **Please describe any future use of this site that is different from the above.**

I certify that the statements made above are complete and true to the best of my knowledge. I understand that a separate containment plan review is required for new uses, remodeling and expansions, changes in the types and quantities of hazardous materials, and changes in the location or method of transport, handling or storage of these materials.

Applicant Name	Applicant Signature	Date	Phone No.
Responsible Company Official Title	Responsible Company Official Signature	Date	Phone No.

Form HAZ (page 3)

INVENTORY LISTING SHEET

Please list all liquids, chemicals, products, wastes containing hazardous ingredients or constituents for which Material Safety Data Sheets are required by 29 CFR 1910.1200 or OAR 437 Division 155 that will be used, stored, generated or otherwise present on this site. Attach copies of Material Safety Data Sheets for all listed chemicals/products or make them available to City staff upon request.

Chemical/ Product Name/ Waste Stream Description	Use/Origin (1)	CASRN (2)	Max. Qty. (3, 4)	Avg. Usage (5)	Container Type and Size	Frequency & Amount of Delivery/ Disposal

(1) Indicate what the substance is used for and/or how the waste stream is generated.
(2) CASRN = Chemical Abstracts Service Registry Number (if applicable; look for the CASRN on the MSDS)
(3) Quantities for solids shall be expressed in pounds and quantities for liquids expressed in gallons.
(4) Maximum quantity is defined as the largest amount potentially present on-site at any one time.
(5) Indicate whether average usage is on a monthly or yearly basis.

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Form HAZ (page 4)

MATERIALS CONTAINMENT / MITIGATION MEASURES SHEET

Please describe any hazardous materials containment and/or mitigation measures proposed for this site.

INSTRUCTIONS FOR FORM HAZ

The following instructions describe how to complete Form HAZ. Form HAZ is required in addition to other state or local requirements pertaining to hazardous substances, such as the requirements for an Oregon State Fire Marshal Hazardous Substance survey or an Industrial Wastewater and/or Stormwater Discharge Permit. **In cases where an applicant has completed other forms that ask for the same information, a copy of the other application may be attached to Form HAZ and a note should be made on Form HAZ.**

General Information (Questions 1 - 5): Provide the name, address and a brief description of the business/project. List the business's primary and secondary (if applicable) Standard Industrial Classification (SIC) code(s), if known. Also provide the permit number from the Office of Planning and Design Review (OPDR).

Hazardous Substances Inventory (Questions 6, 7, and Inventory Listing Sheet): Check yes if any of the listed items will be used. For Question 7, check yes if there will be any substances used, stored, or handled on the site for which a Material Safety Data Sheet (MSDS) is required. (Use of the MSDS criterion is meant to simplify inventory completion. Every employer is required by OSHA to have a complete set of MSDSs on file).

If use of any of these substances is planned, complete the inventory listing sheet. Provide the requested information for each substance to be used during either the construction or operation of the facility (except those listed later in these instructions as exempt).

Consider the following types of materials when preparing the inventory:

- Process Materials - All chemicals used in the plant processes, including feedstock materials, solvents, fuels, liquids in process equipment, cleaners, and lubricants.
- Waste Materials - All liquid, potentially liquid, or water soluble by-products and waste generated on, transported through, stored, on, or handled within the site.
- Products/By-Products - Any products of the facility that may be toxic or hazardous if released into the soil or water.

INSTRUCTIONS FOR FORM HAZ (page 2)

- Stored Materials - All hazardous substances that might be stored or transferred within the site.

- Energy Source Materials - These are distinguished from process materials in that they are often handled, stored, and used outside.

- Construction Materials - Any hazardous substance used during construction, e.g., soil sterilants, herbicides, wood preservatives, paints, thinners, or solvents.

Exemptions

Certain materials are exempt from the inventory reporting. (The amounts given are maximum amounts present on the site at any time.) However, you will need to provide an estimate of the aggregate amount of these supplies.

- Janitorial Supplies - Janitorial and cleaning supplies less than 100 pounds net weight (or 15 gallons net volume), in aggregate. These supplies shall be packaged for consumer use in containers of five gallons or less or having a net weight less than 30 pounds per container. This does not include cleaners or solvents used for cleaning machinery or motor vehicle and machine parts.

- Office Supplies - Office and stationary supplies less than 100 pounds net weight, in aggregate. These supplies shall be packaged for consumer use in containers sized less than five (5) gallons in size or thirty (30) pounds net weight.

- Fluids within Motor Vehicles - Any quantity of fuels, lubricants, fluids and any other hazardous substances contained within on-site vehicles (whether employee, visitor or fleet) or construction equipment for the purposes of vehicle operation. This exemption does not apply to hazardous substances considered to be freight or cargo.

If you are uncertain about whether to include a substance in the inventory, you should list it. If a substance could be present, it should be listed. Keep in mind that listing hazardous substances does not automatically mean that hazardous substance containment will be required. However, if developing a list of hazardous substances is not feasible, the site may be assigned a Class 1 designation by default, and containment facilities appropriate for a high-risk facility may be required.

INSTRUCTIONS FOR FORM HAZ (page 3)

If a hazardous substance is not included in the initial inventory and the site is not constructed for its use, it cannot be used on the site if it triggers a higher containment requirement(s) that is not satisfied by existing containment structures on the site. Because the listing of hazardous substances potentially present on-site may limit future industrial use of the site, the inventory should be comprehensive in order to maintain site marketing options.

Copies of the MSDS sheets for the listed products or materials shall accompany the completed inventory form or be available for review by City staff upon request. Be sure the MSDSs are current, particularly since chemical manufacturers are continually reformulating and producing safer, less hazardous alternatives for many chemicals.

Wells (Question 8): List any existing wells on the site, including water supply wells, monitoring wells, piezometers, cathodic protection wells, oil and gas wells, and geothermal wells. Old, inactive, or improperly constructed wells can potentially provide access for contaminated spills or runoff to enter groundwater.

Provide the well number (if known), well status (i.e. active or inactive), type of use (domestic supply, irrigation, etc.), and construction details. Include casing diameter, depth and screened interval(s). Attach a copy of the well log (if available) to the completed inventory.

Underground or Above-ground Storage Tanks (Questions 13 and 14): Indicate whether there are any existing or proposed underground or above-ground liquid storage tanks, including septic tanks and heating oil tanks. If there are, list the tank type (steel, fiberglass, concrete, etc.), number of tanks, tank size, and tank contents (if empty, what it used to hold), and show the approximate tank locations on the site plan.

Appendix 9-A
SANITARY SEWER DISCHARGE LIMITS

All commercial and industrial users of the City sewer system are to be aware that it is unlawful to discharge industrial waste into the City sewer system in excess of the limitations established in City Code, Section 17.34.030 and 17.34.040, and the Industrial Source Control Division Administrative Rules (below).

CITY CODE, CHAPTER 17.34.010 – DECLARATION OF POLICY

It is the policy of the City of Portland to provide and manage sewer facilities that are adequate for the transportation, treatment, and disposal of wastewater from within the City and to operate the sewer system in such a manner which protects public health and the environment. In carrying out this policy, the objectives of City Code, Chapter 17.34, are:

- To prevent pollutants from entering the sewer system which will interfere with its normal operation or contaminate the resulting sludge
- To prevent the introduction of pollutants into the sewer system which will not be adequately treated and will pass through into the environment
- To improve the opportunity for recycling and reclamation of wastewater and sludge
- To insure protection of worker safety and health
- To insure that all industrial users comply with applicable federal, state and local laws and regulations governing wastewater discharges and that sanctions for failure to comply are imposed

It is the intent of the City to provide needed sewer service to all users while meeting the outlined objectives. Chapter 17.34 provides the structure under which the service will be provided for industrial wastewater so the system is protected and can continue to provide efficiently for the wastewater treatment needs of the City.

CITY CODE, CHAPTER 17.34 – ADMINISTRATIVE RULES (LOCAL LIMITS)

Pollutants/Parameters	Concentration Limit (Daily Maximum in mg/l or ppm)
METALS	
Arsenic, (T)	0.2
Cadmium, (T)	0.7
Chromium, (T)	5.0
Copper, (T)	3.7
Lead, (T)	0.7
Mercury, (T)	0.010
Molybdenum, (T)	1.4
Nickel, (T)	2.8
Selenium, (T)	0.6
Silver, (T)	0.4
Zinc, (T)	3.7
NON-METALS	
Cyanide	1.2
Fats, Oils, and Grease (non-polar)	110.0
Sulfide (D)	4.0
ORGANICS	
Acrylonitrile	1.0
Chlorodane	0.03
Chlorobenzene	0.20
Chloroform	0.20
1,2 Dichloroethane	0.5
2,4 Dinitrotoluene	0.13
Nitrobenzene	2.0
Pentachlorophenol	0.04
Trichloroethylene	0.20

T= Total
D= Dissolved

Appendix 9-B
FACILITIES AND CONTAINMENT DEVICES/STRUCTURES FOR TEMPORARY STORAGE

An on-site storage facility or containment device/structure shall only be used as a last resort and only for temporary storage of the wastewater or contaminated stormwater.

TEMPORARY STORAGE FACILITIES

If it is not possible to discharge to a City sanitary sewer or approved on-site industrial wastewater or stormwater treatment facility, an alternative temporary storage facility may be allowed for storing the collection of wastewater or contaminated stormwater on a temporary basis.

If the site activity produces large amounts of stormwater runoff, temporary storage will not be very effective because the stray contaminants will overflow the storage facility or pond in the activity area before collection and disposal are possible.

Temporary storage facilities are not intended for hazardous materials containment. Refer to "Containment Devices/Structures," below, for guidance in dealing with hazardous materials containment.

> **Note:** For the purpose of disposal classification, contaminated stormwater from a commercial or industrial site is considered "industrial (non-domestic) wastewater."

- Oversized catch basins, holding tanks, and underground vaults may be used. Alternative storage facilities may be proposed. Additional code requirements may apply; applicants should check with local fire and building code requirements and authorities.

- The storage facility shall be installed underneath or near the collection drains installed for the regulated area(s).

- Sizing of a storage facility is difficult and will be reviewed on a case-by-case basis. This will require an additional review process for approval, which may delay issuance of related building permits.

- The contents of the storage facility shall be pumped out or drained before the facility is full. This requirement can make this type of facility costly, especially during the wet season.

CONTAINMENT DEVICES/STRUCTURES

Containment devices/structures are an effective means for preventing stormwater run-on to a contaminated activity area and for containing spills within the activity area. Spill containment shall be designed so the spilled material/product will not discharge, flow, or be washed into the storm drainage system, surface waters, or groundwater.

- Containment may be achieved with concrete curbing, a berm, a tub such as a plastic wading pool, or some other dike material, depending on the activity, its size, and resources available. Additional code requirements may apply; applicants should check with local fire and building code requirements and authorities.

- If a curb, berm, or dike is used to prevent stormwater run-on to a covered activity area and the activity area is paved or otherwise impermeable, the device shall be placed under the covering so precipitation will not pond inside it. (In some cases, run-on can be prevented by placing containment materials on up-slope sides of the activity areas.)

- A containment device/structure for accidental spills shall have enough capacity to capture a minimum of 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

- If a containment area does not have a cover, water will accumulate in the area during and after a rain event. Depending on the circumstances, an outflow pipe may be allowed, with a valve to allow collected stormwater to be drained out of the activity area and directed to either:

  - the storm drainage system (*if clean*).
  - the sanitary sewer, industrial wastewater or stormwater treatment facility, or hauled off by a licensed provider (*if contaminated*).

  Unless authorized draining activities are occurring, this valve shall always be kept closed to contain any spills that occur within the activity area.

- If containment, rather than covering, is used for stockpiles of material, a dike, berm, or filter shall be placed on at least three sides of every stockpile to act as a barrier or filter to runoff. In some cases, the dike or filter can be made of hay bales, silt fencing, filter fabric, concrete curbing, ecology blocks, or similarly effective materials. Timbers treated with creosote or other preservatives shall not be used because they can leach contaminants into run-off.

- For small items, the simplest containment device is a tub or wading pool. A rubber or plastic children's wading pool may be sufficient for some activities that do not require a lot of space, such as storing remodeling and painting materials. These small containment areas shall also be covered with a tarp or other cover.

- Commercial products are available that are a combination containment box/elevated pedestal. These devices prevent stormwater run-on by elevating containers of liquids (such as drums) off the ground and collecting spills and drips inside the pedestal box.

- In areas where accidental spills may occur, the City requires spill response supplies (such as absorbent material and protective clothing) to be available at the storage area. Employees shall be familiar with the site's proper spill clean-up procedures.

- Spill containment of hazardous materials is more complex then standard containment methods, and depends on the hazardous materials being contained. Sizing requirements are the same as stated above, but the type of containment used will require an additional review process for approval, which may delay issuance of related building permits.

CAUTION: Neglect and poor maintenance can render containment devices/structures useless. Maintenance of containment devices/structures is essential for them to work as intended.

DISPOSAL

Proper disposal of collected wastewater or contaminated stormwater is required. One of two methods can be used.

Licensed Disposal Contractor

Several commercial services are available for pumping out storage facilities or containment devices/structures. These service providers can be found in the telephone directory's yellow pages under the headings "Sewer Contractors" and "Tank Cleaning."

Note: Septic system pump-out and hauling contractors shall not be used for disposing wastewater other than domestic sewage. They are not allowed to haul industrial wastewaters.

Disposal costs vary considerably, depending on the types of materials, quantities, methods of collection and transport, and whether the wastes are mixed. The contractor's rate will generally reflect the costs of testing and/or treating waste materials (if necessary) and subsequent disposal.

It is important to keep different types of wastes separated, so the disposal contractor can take them to the appropriate place(s) without causing inadvertent contamination problems elsewhere. If the wastewater generator is using appropriate SPCs and collecting contaminated wastewater for proper disposal, these efforts will compromised if the disposal contractor subsequently disposes the contaminated wastewater as domestic sewage. It is essential to be familiar with disposal alternatives and the different types of contractors for each disposal option.

Wastewater disposal is the generator's responsibility. The generator should check a company's references before allowing it to handle waste. All wastewater collected by the company should be delivered to an authorized site. Copies of all transactions should be maintained, since this information is required as part of the facility's operations and maintenance log, as identified in Chapter 8.0: Operations and Maintenance Requirements.

Batch Discharge to a City Sewer

The City's batch discharge process can be used if a City sanitary or storm sewer is available on the property. All batch discharge applications will go through an evaluation process and will approval before a discharge to the City sewer system is allowed.

Requests for batch discharges to the sanitary sewer system and to the storm sewer system have separate processes and requirements. Testing may be required to establish characteristics of the wastewater or contaminated stormwater and to verify that local discharge limits are not exceeded. For batch discharge applications, call BES's Industrial Source Control Division at 503-823-7122.

Appendix 9-C
HAZARDOUS MATERIALS LIST

DNAPL Site Evaluation

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Table A-1. Selected data on DNAPL chemicals (refer to explanation in Appendix A).

DNAPL	Synonym	CAS #	Empirical Formula	Formula Weight (g)	Ref.	Specific Density (g/cc)	Ref.	Absolute Viscosity (cp)	Ref.
Aniline	Benzenamine	62-53-3	C6H7N	93.13	b	1.022	b	4.40	c
o-Anisidine	2-Methoxybenzenamine	90-04-0	C7H9NO	123.15	b	1.092	b		
Benzyl alcohol	Benzenemethanol	100-51-6	C7H8O	108.14	a	1.045	a	7.76	d(15)
Benzyl chloride	Chloromethylbenzene	100-44-7	C7H7Cl	126.59	a	1.100	a		
Bis(2-chloroethyl)ether	Bis(-chloroethyl)ether	111-44-4	C4H8Cl2O	143.01	b	1.220	b	2.14	c(25)
Bis(2-chloroisopropyl)ether	Bis(-chloroisopropyl)ether	108-60-1	C6H12Cl2O	171.07	a	1.103	a		
Bromobenzene	Phenyl bromide	108-86-1	C6H5BR	157.01	b	1.495	b	0.99	c(30)
Bromochloromethane	Chlorobromomethane	74-97-5	CH2BrCl	129.39	b	1.934	b	0.57	h
Bromodichloromethane	Dichlorobromomethane	75-27-4	CHBrCl2	163.83	a	1.980	a	1.71	c
Bromoethane	Ethyl bromide	74-96-4	C2H5Br	108.97	b	1.460	b	0.418	d(15)
Bromoform	Tribromomethane	75-25-2	CHBr3	252.73	a	2.890	a	2.02	c
Butyl benzyl phthalate	Benzyl butyl phthalate	85-68-7	C19H20O4	312.37	a	1.120	a		
Carbon disulfide	Carbon bisulfide	75-15-0	CS2	76.13	a	1.263	a	0.37	c
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl4	153.82	a	1.594	a	0.97	c
Chlorobenzene	Benzene chloride	108-90-7	C6H5Cl	112.56	a	1.106	a	0.80	c
2-Chloroethyl vinyl ether	(2-Chloroethoxy)ethene	110-75-8	C4H7ClO	106.55	a	1.048	a		
Chloroform	Trichloromethane	67-66-3	CHCl3	119.38	a	1.483	a	0.58	c
1-Chloro-1-nitropropane	Chloronitropropane	600-25-9	C3H6ClNO2	123.54	b	1.209	b		
2-Chlorophenol	o-Chlorophenol	95-57-8	C6H5ClO	128.56	a	1.263	a	2.25	c(45)
4-Chlorophenyl phenyl ether	p-Chlorodiphenyl ether	7005-72-3	C12H9ClO	204.66	a	1.203	a		
Chloropicrin	Trichloronitromethane	76-06-2	CCl3NO2	164.38	b	1.656	b		
m-Chlorotoluene		108-41-8	C6H4CH3Cl	126.59	f	1.072	f	0.75	h(38)
o-Chlorotoluene	2-Chloro-1-methylbenzene	95-45-8	C6H4CH3Cl	126.58	f	1.082	f	0.75	h(38)
p-Chlorotoluene		106-43-4	C6H4CH3Cl	126.59	f	1.066	f(25)		
Dibromochloromethane	Chlorodibromomethane	124-48-1	CHBr2Cl	208.28	a	2.451	a		
1,2-Dibromo-3-chloropropane	DPCP	96-12-8	C3H5Br2Cl	236.36	b	2.050	b		
Dibromodifluoromethane	Freon 12-B2	75-61-6	CBr2F2	209.82	b	2.297	b		
Dibutyl phthalate	Dibutyl-n-phthalate; DBP	84-74-2	C16H22O4	278.35	a	1.046	a	20.30	c
1,2-Dichlorobenzene	o-Dichlorobenzene	95-50-1	C6H4Cl2	147.00	a	1.305	a	1.32	c(25)
1,3-Dichlorobenzene	m-Dichlorobenzene	541-73-1	C6H4Cl2	147.00	a	1.288	a	1.04	c(25)
1,1-Dichloroethane	1,1-DCA	75-34-3	C2H4Cl2	98.96	a	1.176	a	0.44	c
1,2-Dichloroethane	Ethylene dichloride; 1,2-DCA	107-06-2	C2H4Cl2	98.96	a	1.235	a	0.80	c
1,1-Dichloroethene	Vinylidene chloride; 1,1-DCE	75-35-4	C2H2Cl2	96.94	a	1.218	a	0.36	c
trans-1,2-Dichloroethene	trans-1,2-DCE	156-60-5	C2H2Cl2	96.94	a	1.257	a	0.40	c
1,2-Dichloropropane	Propylene dichloride	78-87-5	C3H6Cl2	112.99	a	1.560	a	0.86	c
cis-1,3-Dichloropropene	cis-1,3-Dichloropropylene	10061-01-5	C3H4Cl2	110.97	a	1.224	a		
trans-1,3-Dichloropropene	trans-1,3-Dichloropropylene	10061-02-6	C3H4Cl2	110.97	a	1.182	a		
Dichlorvos	No-Pest Strip	62-73-7	C4H7Cl2O4P	220.98	b	1.415	b(25)		
Diethyl phthalate	DEP	84-66-2	C12H14O4	222.24	a	1.118	a	35.00	c
Dimethyl phthalate	DMP	131-11-3	C10H10O4	194.19	a	1.191	a	17.20	c(25)

Table A-1. Selected data on DNAPL chemicals (refer to explanation in Appendix A).

DNAPL	Synonym	CAS #	Empirical Formula	Formula Weight (g)	Ref.	Specific Density (g/cc)	Ref.	Absolute Viscosity (cp)	Ref.
Ethylene dibromide	1,2-Dibromoethane; EDB	106-93-4	C2H4Br2	187.86	b	2.179	b	1.72	c
Hexachlorobutadiene	HCBD	87-68-3	C4Cl6	260.76	a	1.554	a	2.45	c(38)
Hexachlorocyclopentadiene	HCCPD	77-47-4	C5Cl6	272.77	a	1.702	a		
Iodomethane	Methyl iodide	74-88-4	CH3I	141.94	b	2.279	b	0.52	d(15)
1-Iodopropane	Propyl iodide	107-08-4	C3H7I	169.99	b	1.749	b	0.84	d(15)
Malathion		121-75-5	C10H19O6PS2	330.36	b	1.230	b(25)		
Methylene chloride	Dichloromethane	75-09-2	CH2Cl2	84.93	a	1.327	a	0.43	c
Nitrobenzene	Nitrobenzol	98-95-3	C6H5NO2	123.11	a	1.204	a	2.01	c
Nitroethane	UN 2842	79-24-3	C2H5NO2	75.07	b	1.045	b(25)	0.66	d(25)
1-Nitropropane	UN 2608	108-03-2	C3H7NO2	89.09	b	1.008	b(24)	0.80	d(25)
2-Nitrotoluene	1-Methyl-2-nitrobenzene	88-72-2	C7H7NO2	137.14	b	1.163	b	2.37	d
3-Nitrotoluene	1-Methyl-3-nitrobenzene	99-08-1	C7H7NO2	137.14	b	1.157	b		
Parathion		56-38-2	C10H14NO5PS	291.27	b	1.260	b		
PCB-1016	Aroclor 1016	12674-11-2	varies	257.90	a	1.330	a(25)	19.3	g(38)
PCB-1221	Aroclor 1221	11104-28-2	varies	192.00	a	1:180	a(25)	4.8	g(38)
PCB-1232	Aroclor 1232	11141-16-5	varies	221.00	a	1.240	a(25)	8.2	g(38)
PCB-1242	Aroclor 1242	53469-21-9	varies	261.00	a	1.392	a(15)	24	g(38)
PCB-1248	Aroclor 1248	12672-29-6	varies	288.00	a	1.410	a(25)	65	g(38)
PCB-1254	Aroclor 1254	11097-69-1	varies	327.00	a	1.505	a(15)	700	g(38)
Pentachloroethane	Ethane pentachloride	76-01-7	C2HCl5	202.28	b	1.680	b	2.75	d(15)
1,1,2,2-Tetrabromoethane	Acetylene tetrabromide	79-27-6	C2H2Br4	345.65	b	2.875	b	9.79	d
1,1,2,2-Tetrachloroethane	Acetylene tetrachloride	79-34-5	C2H2Cl4	167.85	a	1.595	a	1.75	c
Tetrachloroethene	Perchloroethylene; PCE	127-18-4	C2Cl4	165.83	a	1.623	a	0.89	c
Thiophene	Thiacyclopentadiene	110-02-1	C4H4S	84.14	b	1.065	b	0.65	d
1,2,4-Trichlorobenzene	1,2,4-TCB	120-82-1	C6H3Cl3	181.45	a	1.454	a	1.42	c
1,1,1-Trichloroethane	Methyl chloroform; 1,1,1-TCA	71-55-6	C2H3Cl3	133.40	a	1.339	a	1.20	c
1,1,2-Trichloroethane	1,1,2-TCA	79-00-5	C2H3Cl3	133.40	a	1.440	a	0.12	c
Trichloroethene	TCE	79-01-6	C2HCl3	131.39	a	1.464	a	0.57	c
1,1,2-Trichlorofluoromethane	Freon 11	75-69-4	CCl3F	137.37	a	1.487	a	0.42	c(25)
1,2,3-Trichloropropane	Allyl trichloride	96-18-4	C3H5Cl3	147.43	b	1.3889	b		
1,1,2-Trichlorotrifluoroethane	Freon 113	76-13-1	C2Cl3F3	187.38	b	1.564	b		
Tri-o-cresyl phosphate	o-Cresyl phosphate	78-30-8	C21H21O4P	368.37	b	1.955	b	80.00	d
Water	Ice	7732-18-5	H2O	18.02		1.000		1.00	

Table A-1. (continued)

DNAPL	Boiling Point (deg.C)	Ref.	Melting Point (deg.C)	Ref.	Aqueous Solubility (mg/L)	Ref.	Vapor Pressure (mm Hg)	Ref.	Henry's Law Constant (atm-m3/mol)	Ref.
Aniline	184	b	-6	b	3.50E+04	b	3.00E-01	b	1.36E-01	b
o-Anisidine	224	b	6	b	1.30E+04	b	<0.1	b	1.25E-06	b
Benzyl alcohol	205	a	-15	a	3.50E+04	a	<1	a		a
Benzyl chloride	179	a	-39	a	4.93E+02	a	9.00E-01	a	3.04E-04	a
Bis(2-chloroethyl)ether	179	b	-47	b	1.02E+04	b	7.10E-01	b	1.30E-05	b
Bis(2-chloroisopropyl)ether	187	a	-20	aax	1.70E+03	a	8.50E-01	a	1.10E-04	a
Bromobenzene	156	b	-31	b	5.00E+02	b	3.30E+00	b	2.40E-03	b
Bromochloromethane	68	b	-87	b	1.67E+04	b(25)	1.41E+00	b(25)	1.44E-03	b
Bromodichloromethane	90	a	-57	a	4.50E+03	a(0)	5.00E+01	a	2.12E-04	a
Bromoethane	38	b	-119	b	9.14E+03	b	3.75E+02	b	7.56E-03	b
Bromoform	149	a	8	a	3.01E+03	a	4.00E+00	a	5.32E-04	a
Butyl benzyl phthalate	370	a	-35	a	2.82E+00	a	8.60E-06	a	1.30E-06	a
Carbon disulfide	46	a	-112	a	2.10E+03	a	2.98E+02	a	1.33E-02	a
Carbon tetrachloride	77	a	-23	a	8.00E+02	a	9.00E+01	a	3.02E-02	a
Chlorobenzene	132	a	-46	a	5.00E+02	a	9.00E+00	a	4.45E-03	a
2-Chloroethyl vinyl ether	108	a	-70	a	1.50E+04	a	2.68E+01	a	2.50E-04	a
Chloroform	62	a	-63	a	8.00E+03	a	1.60E+02	a	3.20E-03	a
1-Chloro-1-nitropropane	142	b	<25	b	6.00E+00	b	5.80E+00	b(25)	1.57E-01	b
2-Chlorophenol	175	a	9	a	2.85E+04	a	1.42E+00	a(25)	8.28E-06	a
4-Chlorophenyl phenyl ether	284	a	-8	a	3.30E+00	a(25)	2.70E-03	a(25)	2.20E-04	a
Chloropicrin	112	b	-64	b	2.00E+03	b	2.00E+01	b	8.40E-02	b
m-Chlorotoluene	160	f	-48	f	4.80E+01	e	4.60E+00	e	1.60E-02	e
o-Chlorotoluene	159	f	-34	f	7.20E+01	e	2.70E+00	f	6.25E-03	e
p-Chlorotoluene	162	f	7	f	4.40E+01	e	4.50E+00	e	1.70E-02	e
Dibromochloromethane	117	a	-22	a	4.00E+03	a	7.60E+01	a	9.90E-04	a
1,2-Dibromo-3-chloropropane	196	b	6	b	1.00E+03	b	8.00E-01	b	2.49E-04	b
Dibromodifluoromethane	23	b	-141	b			6.88E+02	b		
Dibutyl phthalate	335	a	-35	a	1.01E+01	a	1.40E-05	a(25)	6.30E-05	a
1,2-Dichlorobenzene	180	a	-17	a	1.00E+02	a	1.00E+00	a	1.90E-03	a
1,3-Dichlorobenzene	173	a	-25	a	1.11E+02	a	2.30E+00	a(25)	3.60E-03	a
1,1-Dichloroethane	56	a	-97	a	5.50E+03	a	1.82E+02	a	4.30E-03	a
1,2-Dichloroethane	83	a	-35	a	8.69E+03	a	6.40E+01	a	9.10E-04	a
1,1-Dichloroethene	37	a	-122	a	4.00E+02	a	4.95E+02	a	2.10E-02	a
trans-1,2-Dichloroethene	47	a	-50	a	6.00E+02	a	2.65E+02	a	3.84E-01	a
1,2-Dichloropropane	96	a	-100	a	2.70E+03	a	4.20E+01	a	2.30E-03	a
cis-1,3-Dichloropropene	104	a	-84	a	2.70E+03	a	2.50E+01	a	1.30E-03	a
trans-1,3-Dichloropropene	112	a	-84	a	2.80E+03	a	2.50E+01	a	1.30E-03	a
Dichlorvos					1.00E+04	b	1.20E-02	b	5.00E-03	b
Diethyl phthalate	298	a	-40	a	9.28E+02	a	1.65E-03	a(25)	8.46E-07	a
Dimethyl phthalate	283	a	0	a	4.29E+03	a	1.65E-03	a(25)	4.20E-07	a

(continued)

...ure (...Hg)	Ref.	Henry's Law Constant (atm-m3/mol)
:-01	b	1.36E-01
.1	b	1.25E-06
1	a	
:-01	a	3.04E-04
:-01	b	1.30E-05
:-01	a	1.10E-04
:+00	b	2.40E-03
:+00	b(25)	1.44E-03
:+01	a	2.12E-04
:+02	b	7.56E-03
:+00	a	5.32E-04
E-06	a	1.30E-06
:+02	a	1.33E-02
:+01	a	3.02E-02
:+00	a	4.45E-03
:+01	a	2.50E-04
E+02	a	3.20E-03
E+00	b(25)	1.57E-01
E+00	a(25)	8.28E-06
)E-03	a(25)	2.20E-04
	b	8.40E-02
E+00	e	1.60E-02
E+00	f	6.25E-03
E+00	e	1.70E-02
E+01	a	9.90E-04
)E-01	b	2.49E-04
E+02	b	
)E-05	a(25)	6.30E-05
E+00	a	1.90E-03
)E+00	a(25)	3.60E-03
E+02	a	4.30E-03
)E+01	a	9.10E-04
5E+02	a	2.10E-02
5E+02	a	3.84E-01
)E+01	a	2.30E-03
)E+01	a	1.30E-03
)E+01	a	1.30E-03
0E-02	b	5.00E-03
5E-03	a(25)	8.46E-07
5E-03	a(25)	4.20E-07

R... NAPL	Boiling Point (deg.C)	Ref.	Melting Point (deg.C)	Ref.	Aqueous Solubility (mg/L)	Ref.	Vapor Pressure (mm Hg)	Ref.	Henry's Law Constant (atm-m3/mol)	Ref.
...omide	131	b	10	b	4.32E+03	b	1.10E+01	b	7.06E-04	b
...adiene	215	a	-21	a	2.55E+00	a	1.50E-01	a	2.60E-02	a
...lopentadiene	237	a	-9	a	1.10E+00	a(22)	8.10E-02	a(25)	1.60E-02	a
	42.4	b	-66	b	1.40E+04	b	3.75E+02	b	5.48E-03	b
	102	b	-101	b	1.06E+03	b(23)	4.00E+01	b(24)	9.09E-03	b
			2.9	b	1.45E+02	b	1.25E-06	b	4.89E-09	b
...oride	40	a	-95	a	2.00E+04	a	3.49E+02	a	2.00E-03	a
	211	a	6	a	1.90E+03	a	1.50E-01	a	2.45E-05	a
	115	b	-50	b	4.50E+04	b	1.56E+01	b	4.66E-05	b
...e	130	b	-108	b	1.40E+04	b	7.50E+00	b	8.68E-05	b
	222	b	-3	b	6.00E+02	b	1.50E-01	b	4.51E-05	b
	233	b	16	b	5.00E+02	b	1.50E-01	b	5.41E-05	b
	375	b	6	b	1.20E+01	b	4.00E-04	b	8.56E-08	b
	325	a			2.30E-01	a	4.00E-04	a(25)		
	275	a	1	a	5.90E-01	a(24)	6.70E-03	a(25)	3.24E-04	a
	290	a	-35	a	1.45E+00	a(25)	4.60E-03	a(25)	4.64E+00	a
	325	a	-19	a	2.00E-01	a	1.00E-03	a	5.60E-04	a
	340	a	-7	a	5.00E-02	a	4.94E-04	a(25)	3.50E-03	a
	365	a	10	a	5.00E-02	a	6.00E-05	a	2.70E-03	a
...ane	159	b	-22	b	5.00E+02	b	3.40E+00	b	2.45E-03	b
...moethane	239	b	0	b	7.00E+02	b	1.00E-01	b	5.40E-05	b
...oroethane	146	a	-36	a	2.90E+03	a	5.00E+00	a	3.80E-04	a
...ne	121	a	-19	a	1.50E+02	a	1.40E+01	a	1.53E-02	a
	84	b	-30	b	3.60E+03	b(18)	6.00E+01	b	2.93E-03	b
...enzene	210	a	17	a	1.90E+01	a(22)	4.00E-01	a(25)	2.32E-03	a
...thane	74	a	-30	a	1.36E+03	a	1.00E+02	a	1.80E-02	a
...thane	114	a	-37	a	4.50E+03	a	1.90E+01	a	7.40E-04	a
	87	a	-73	a	1.10E+03	a	5.78E+01	a	9.10E-03	a
...uoromethane	24	a	-111	a	1.10E+03	a	6.87E+02	a	1.10E-01	a
...ropane	142	b	-15	b			2.00E+00	b	3.18E-04	b
...ifluoroethane	48	b	-35	b	2.00E+02	b	2.84E+02	b	3.33E-01	b
...phate	410	b	-25	b	3.00E-01	b				
	100		0				1.75E+01			

Table A-1. (continued)

DNAPL	Log Koc (mL/g)	Ref.	Log Kow	Ref.	Vapor Density (g/L)	Ref.	Relative Vapor Density	Interfacial Liquid Tension (dyn/cm)	Ref.	Surface Tension (dyn/cm)	Ref.
Aniline	1.41	b	0.90	b	3.81	b	1.001	5.8		42.9	c
o-Anisidine			0.95	b	5.03	b					
Benzyl alcohol	1.98	a	1.10	a	4.42	a					
Benzyl chloride	2.28	a	2.30	a	5.17	a	1.004				
Bis(2-chloroethyl)ether	1.15	b	1.58	b	5.84	b	1.004			37.9	c
Bis(2-chloroisopropyl)ether	1.79	a	2.58	a	6.99	a	1.006				
Bromobenzene	2.33	b	3.01	b	6.42	b	1.019	39.8	j	35.8	c
Bromochloromethane	1.43	b	1.41	b	5.29	b	1.006			33.3	h
Bromodichloromethane	1.79	a	1.88	a	6.70	a	1.309				
Bromoethane	2.67	b	1.57	b	4.05	b	2.377			24.5	h
Bromoform	2.45	a	2.30	a	10.33	a	1.041			45.5	c
Butyl benzyl phthalate	2.32	a	4.78	a	12.76	a	1.000				
Carbon disulfide	2.47	a	1.84	a	3.11	a	1.646	48.4	j	32.3	c
Carbon tetrachloride	2.64	a	2.83	a	6.29	a	1.515	45.0	j	27.0	c
Chlorobenzene	1.68	a	2.84	a	4.60	a	1.035	37.4	j	33.2	c
2-Chloroethyl vinyl ether	0.82	a	1.28	a	4.36	a	1.095				
Chloroform	1.64	a	1.95	a	4.88	a	1.664	32.8	j	27.2	c
1-Chloro-1-nitropropane	3.34	b	4.25	b	5.05	b	1.025				
2-Chlorophenol	2.56	a	2.16	a	5.25	a	1.006			40.3	c
4-Chlorophenyl phenyl ether	3.60	a	4.08	a	8.36	a	1.000				
Chloropicrin	0.82	b	1.03	b	6.72	b	1.124				
m-Chlorotoluene	3.08	e	3.28	e			1.021			32.8	c
o-Chlorotoluene	3.20	e	3.42	f			1.012			32.9	h(25)
p-Chlorotoluene	3.08	e	3.3	e			1.020			34.6	h(25)
Dibromochloromethane	1.92	a	2.08	a	8.51	a	1.624				
1,2-Dibromo-3-chloropropane	2.11	b	2.63	b	9.66	b	1.008				
Dibromodifluoromethane					8.58	b	6.701				
Dibutyl phthalate	3.14	a	4.57	a	11.38	a	1.000			33.4	c
1,2-Dichlorobenzene	2.27	a	3.40	a	6.01	a	1.005	40.0	c	37.0	c
1,3-Dichlorobenzene	2.23	a	3.38	a	6.01	a	1.012			33.2	c
1,1-Dichloroethane	1.48	a	1.78	a	4.04	a	1.585			24.8	c
1,2-Dichloroethane	1.15	a	1.48	a	4.04	a	1.206	30.0	c(30)	32.2	c
1,1-Dichloroethene	1.81	a	2.13	a	3.96	a	2.545	37.0	c(23)	24.0	c(15)
trans-1,2-Dichloroethene	1.77	a	2.09	a	3.96	a	1.827	30.0	c	25.0	c
1,2-Dichloropropane	1.71	a	2.28	a	4.62	a	1.162			28.7	c
cis-1,3-Dichloropropene	1.68	a	1.41	a	4.54	a	1.094	23.8	c(27)	31.2	c
trans-1,3-Dichloropropene	1.68	a	1.41	a	4.54	a	1.094				
Dichlorvos	9.57	b	1.40	b	9.03	b	1.000				
Diethyl phthalate	1.84	a	2.35	a	9.08	a	1.000			37.5	c
Dimethyl phthalate	1.63	a	1.61	a	7.94	a	1.000				

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Table A-1. (continued)

DNAPL	Log Koc (mL/g)	Ref.	Log Kow	Ref.	Vapor Density (g/L)	Ref.	Relative Vapor Density	Interfacial Liquid Tension (dyn/cm)	Ref.	Surface Tension (dyn/cm)	Ref.
Ethylene dibromide	1.64	b	1.76	b	7.68	b	1.080	36.5	e	38.7	c
Hexachlorobutadiene	3.67	a	4.78	a	10.66	a	1.002				
Hexachlorocyclopentadiene	3.63	a	5.04	a	11.15	a	1.001			37.5	e
Iodomethane	1.36	b	1.69	b	5.80	b	2.943			31.0	e
1-Iodopropane	2.16	b	2.49	b	6.95	b	1.259				
Malathion	2.46	b	2.89	b	13.50	b	1.000				
Methylene chloride	0.94	a	1.30	a	3.47	a	1.897	28.3	j	27.9	c
Nitrobenzene	2.01	a	1.95	a	5.03	a	1.001	25.7	j	43.0	c
Nitroethane			0.18	b	3.07	b	1.033				
1-Nitropropane			0.87	b	3.64	b	1.021				
2-Nitrotoluene			2.30	b	5.61	b	1.001				
3-Nitrotoluene			2.42	b	5.61	b	1.001				
Parathion	3.07	b	3.81	b	11.91	b	1.000				
PCB-1016	4.70	a	5.88	a			1.000				
PCB-1221	2.44	a	2.80	a			1.000				
PCB-1232	2.83	a	3.20	a	9.03	a	1.000				
PCB-1242	3.71	a	4.11	a	10.67	a	1.000				
PCB-1248	5.64	a	6.11	a			1.000				
PCB-1254	5.61	a	6.47	a	13.36	a	1.000				
Pentachloroethane	3.28	b	2.89	b	8.27	b	1.027			34.7	e
1,1,2,2-Tetrabromoethane	2.45	b	2.91	b	14.13	b	1.001				
1,1,2,2-Tetrachloroethane	2.07	a	2.56	a	6.86	a	1.032			36.0	c
Tetrachloroethene	2.42	a	2.60	a	6.78	a	1.088	44.4	e(25)	31.3	c
Thiophene	1.73	b	1.81	b	3.44	b	1.152				
1,2,4-Trichlorobenzene	3.98	a	4.02	a	7.42	a	1.003			39.1	c
1,1,1-Trichloroethane	2.18	a	2.47	a	5.45	a	1.479	45.0	e	25.4	c
1,1,2-Trichloroethane	1.75	a	2.18	a	5.45	a	1.091			34.0	c
Trichloroethene	2.10	a	2.53	a	5.37	a	1.272	34.5	e(24)	29.3	c
1,1,2-Trichlorofluoromethane	2.20	a	2.53	a	5.85	a	4.415			19.0	c
1,2,3-Trichloropropane							1.011				
1,1,2-Trichlorotrifluoroethane	2.59	b	2.57	b	7.66	b	3.062				
Tri-o-cresyl phosphate	3.37	b	5.11	b	15.06	b					

Table A-1. (continued)

DNAPL	Air Diffusion Coefficient (sq.cm./sec)	Ref.	Water Diffusion Coefficient (sq.cm/sec)	Ref.	Estimated Half-life in Soil (days)	Estimated Half-life in Groundwater (days)	RCRA or NJ Action Level Water (mg/L)	RCRA or N Action Level Soil (mg/kg)
Ethylene dibromide					28-180	20-120	4E-07	8E-03
Hexachlorobutadiene					28-180	56-360	4E-03	9E+01
Hexachlorocyclopentadiene					7-28	7-56	2E-01	6E+02
Iodomethane					7-28	14-56		
1-Iodopropane								
Malathion					3-7	8-103	2E-01 NJ	
Methylene chloride	1.02E-01	i	1.1E-06	c	7-28	14-56	5E-03	9E+01
Nitrobenzene	7.20E-02	h	7.6E-06	c	12-197	2-394	2E-02	4E+01
Nitroethane								
1-Nitropropane					28-180	56-360		
2-Nitrotoluene								
3-Nitrotoluene								
Parathion							2E-01	5E+02
PCB-1016							5E-06 *	9E-02 *
PCB-1221							5E-06 *	9E-02 *
PCB-1232							5E-06 *	9E-02 *
PCB-1242							5E-06 *	9E-02
PCB-1248							5E-06 *	9E-02
PCB-1254							5E-06 *	9E-02
Pentachloroethane								
1,1,2,2-Tetrabromoethane								
1,1,2,2-Tetrachloroethane					0.45-45	0.45-45	2E-03	4E+01
Tetrachloroethene	7.40E-02	i	7.5E-06	c	180-360	360-720	7E-04	1E+01
Thiophene								
1,2,4-Trichlorobenzene					28-180	56-360	7E-01	2E+03
1,1,1-Trichloroethane	7.96E-02	i	8E-06	h	140-273	140-546	3E+00	7E+03
1,1,2-Trichloroethane	7.90E-02	h	8E-06	h	136-360	136-720	6E-03	1E+02
Trichloroethene	8.11E-02	i	8.3E-06	c	180-360	321-1653	5E-03	6E+01
1,1,2-Trichlorofluoromethane					180-360	360-720	1E+01	2E+04
1,2,3-Trichloropropane					180-360	360-720	2E-01	5E+02
1,1,2-Trichlorotrifluoroethane					180-360	360-720		
Tri-o-cresyl phosphate								

Table A-1. (continued)

DNAPL	Air Diffusion Coefficient (sq.cm./sec)	Ref.	Water Diffusion Coefficient (sq.cm/sec)	Ref.	Estimated Half-life in Soil (days)	Estimated Half-life in Groundwater (days)	RCRA or NJ Action Level Water (mg/L)	RCRA or NJ Action Level Soil (mg/kg)
Aniline	7.50E-02	c(30)					6E-03	1E+02
o-Anisidine					28-180	56-360		
Benzyl alcohol							2E+00 NJ	
Benzyl chloride					0.62-12	0.62-12		
Bis(2-chloroethyl)ether					28-180	56-360	3E-03	5E+01
Bis(2-chloroisopropyl)ether					18-180	36-360	3E-01 NJ	
Bromobenzene								
Bromochloromethane								
Bromodichloromethane							3E-05	5E-01
Bromoethane								
Bromoform					28-180	56-360	7E-01	2E+03
Butyl benzyl phthalate					1-7	2-180	7E+00	2E+04
Carbon disulfide	8.92E-02	h	1.1E-05	h			4E+00	8E+03
Carbon tetrachloride	7.97E-02	i			180-360	7-360	3E-04	5E+00
Chlorobenzene	7.50E-02	c(30)	7.9E-06	h	68-150	136-300	7E-01	2E+03
2-Chloroethyl vinyl ether								
Chloroform	9.90E-02	i	9.1E-06	h	28-180	56-1800	6E-03	1E+02
1-Chloro-1-nitropropane								
2-Chlorophenol							2E-01	4E+02
4-Chlorophenyl phenyl ether								
Chloropicrin								
m-Chlorotoluene								
o-Chlorotoluene								
p-Chlorotoluene								
Dibromochloromethane					28-180	14-180	1E-02 NJ	
1,2-Dibromo-3-chloropropane					28-180	56-360	2E-06 NJ	
Dibromodifluoromethane								
Dibutyl phthalate	4.20E-02	c(25)	4.1E-05	c	2-23	2-23	4E+00	8E+03
1,2-Dichlorobenzene					28-180	56-360	6E-01 NJ	
1,3-Dichlorobenzene					28-180	56-360	6E-01 NJ	
1,1-Dichloroethane	8.90E-02	i			32-154	64-154	7E-02 NJ	
1,2-Dichloroethane	8.90E-02	i			100-180	100-360	5E-03	8E+00
1,1-Dichloroethene	9.11E-02	i	9.5E-06	h	28-180	56-132	7E-03	1E+01
trans-1,2-Dichloroethene	9.11E-02	i	9.5E-06	c			1E-01 NJ	
1,2-Dichloropropane					167-1289	334-2592	5E-04 NJ	
cis-1,3-Dichloropropene					5-11	5-11	1E-02	2E+01
trans-1,3-Dichloropropene					5-11	5-11	1E-02	2E+01
Dichlorvos								
Diethyl phthalate					3-56	6-112	3E+01	6E+04
Dimethyl phthalate					1-7	2-14	7E+00 NJ	

Table A-1. (continued)

DNAPL	Flash Point (deg.C)	Ref.	LEL (%)	Ref.	UEL (%)	Ref.	ACGIH TWA (ppm)	ACGIH STEL (ppm)	NIOSH IDLH (ppm)	Odor Low Threshold (ppm)	Odor High Threshold (ppm)
Aniline	70	b	1.3	b	11	b	Ca 2 (7.6)		Ca 100	5.25E-05	92
o-Anisidine	30	b(oc)					Ca 0.1 (0.50)		Ca 9.8		
Benzyl alcohol	93	a									
Benzyl chloride	60	b	1.1	b			Ca 1 (5.2)		10	4.54E-02	0.3
Bis(2-chloroethyl)ether	55	a									
Bis(2-chloroisopropyl)ether	85	a									
Bromobenzene	51	b									
Bromochloromethane	NC	b					200 (1060)		5000	3.17E+02	317
Bromodichloromethane											
Bromoethane	<-20	b	6.7	b	11.3	b	200 (891)	250 (1110)	3500	2.00E+02	- 200
Bromoform	NC	a					0.5 (5.2)			5.13E+02	513
Butyl benzyl phthalate	110	a									
Carbon disulfide	-30	a	1.3	a	50	a	10 (31)		500	7.80E-03	7
Carbon tetrachloride	NC	a					Ca 5 (31)		Ca 300	9.54E+00	238
Chlorobenzene	28	a	1.3	a	7.1	a	75 (345)		2400	2.13E-01	61
2-Chloroethyl vinyl ether	16	a									
Chloroform	NC	a					Ca 10 (49)		Ca 1000	5.12E+01	205
1-Chloro-1-nitropropane	62	b					2 (10)		2000		
2-Chlorophenol	64	a								3.59E-03	1
4-Chlorophenyl phenyl ether											
Chloropicrin	detonates	b					0.1 (0.67)		4	8.12E-01	1
m-Chlorotoluene											
o-Chlorotoluene											
p-Chlorotoluene											
Dibromochloromethane	NC	a									
1,2-Dibromo-3-chloropropane	77	b(oc)							Ca	9.98E-03	0
Dibromodifluoromethane	NC	b									
Dibutyl phthalate	157	a	0.5	a	2.5	a	(5)		803		
1,2-Dichlorobenzene	66	a	2.2	a	9.2	a	50 (301) C		1000	2.00E+00	50
1,3-Dichlorobenzene	63	a	2	a	9.2	a					
1,1-Dichloroethane	-6	a	5.6	a	16	a	200 (810)	250 (1010)	4000	1.10E+02	200
1,2-Dichloroethane	13	a	6.2	a	16	a	Ca 10 (4)		Ca 1000	5.93E+00	109
1,1-Dichloroethene	-15	a	6.5	a	15.5	a	Ca 5 (20)	Ca 20 (79)		5.04E+02	1009
trans-1,2-Dichloroethene	2	a	9.7	a	12.8	a	200 (793)		4000	8.47E-02	498
1,2-Dichloropropane	15.6	a	3.4	a	14.5	a	Ca 75 (347)	Ca 110 (508)	2000 ca	2.52E-01	131
cis-1,3-Dichloropropene	35	a	5.3	a	14.5	a	Ca 1 (4.5)				
trans-1,3-Dichloropropene	5.3	a	5.3	a	14.5	a	Ca 1 (4.5)				
Dichlorvos	NC	b					0.1 (0.90)		21		
Diethyl phthalate	140	a	0.7	a			(5)				
Dimethyl phthalate	146	a	1.2	a			(5)		1152		

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Table A-1. (continued)

DNAPL	Flash Point (deg.C)	Ref.	LEL (%)	Ref.	UEL (%)	Ref.	ACGIH TWA (ppm)	ACGIH STEL (ppm)	NIOSH IDLH (ppm)	Odor Low Threshold (ppm)	Odor High Threshold (ppm)
Ethylene dibromide	NC	b					Ca		400 ca	1.00E+01	10
Hexachlorobutadiene	NC	a					Ca 0.02 (0.21)			1.13E+00	1
Hexachlorocyclopentadiene	NC	a					0.01 (0.11)			1.34E-01	0
Iodomethane	NC	b					Ca 2 (12)		800 ca		
1-Iodopropane											
Malathion	NC	b					(10)		364	9.99E-01	1
Methylene chloride	NC	c					Ca 50 (174)		5000 ca	1.55E+02	622
Nitrobenzene	88	a	1.8	a			1 (5)		200	4.67E-03	2
Nitroethane	28	b	3.4	b			100 (307)		1000	2.02E+02	202
1-Nitropropane	34	b	2.2	b			25 (91)		2300	2.96E+02	296
2-Nitrotoluene	106	b	2.2	b					200		
3-Nitrotoluene	101	b	1.6	b					200		
Parathion	NC	b					(0.1)		1.6	4.00E-02	0
PCB-1016	NC	a									
PCB-1221	141	a									
PCB-1232	152	a									
PCB-1242	176	a							Ca 0.9		
PCB-1248	193	a									
PCB-1254	222	a							Ca 0.3		
Pentachloroethane											
1,1,2,2-Tetrabromoethane	NC	a					1 (14)				
1,1,2,2-Tetrachloroethane	NC	a					Ca 1 (6.9)			3.06E+00	5
Tetrachloroethene	NC	a	NA		NA		Ca 50 (339)	Ca 200 (1357)	Ca 500	4.65E+00	69
Thiophene	-1.1	a									
1,2,4-Trichlorobenzene	105	a	2.5	a	6.6	a	5 (37) C			3.23E+00	3
1,1,1-Trichloroethane	NC	c					350 (1910)	450 (2460)	1000	9.95E+01	696
1,1,2-Trichloroethane	NC	c					Ca 10 (65)		Ca 500		
Trichloroethene	32.2	a	8	a	10.5	a	Ca 50 (269)	Ca 200 (1070)		2.10E-01	402
1,1,2-Trichlorofluoromethane	NC	a					1000 (5620) C		10000	4.98E+00	208
1,2,3-Trichloropropane	73.3	b	3.2	b	12.6	b	10 (60)		Ca 1000		
1,1,2-Trichlorotrifluoroethane	NC	b					1000 (7670)	1250 (9590)	4500	4.46E+01	134
Tri-o-cresyl phosphate	225	b					(0.1)		2.6		

Appendix 9-D
HALOGENATED SOLVENT LIST

Appendix 9D (Page 1 of 10)
Halogenated Solvents/Chemicals of Concern
BUREAU OF WATER WORKS
PORTLAND, OREGON

Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Acenaphthene	83-32-9	1,2-Dihydroacenaphthylene, 1,8-Ethylenenaphthalene, PERI, Acenaphthylene.	NA	2 ppm[17]	NA	3	NA	[illegible]
Acetic Acid	64-19-7	Glacial acetic acid, ethanoic acid, vinegar acid.	NA	128 ppm[4]	NA	3	Miscible	[illegible]
Acetone	67-64-1	2-Propanone, Dimethyl ketone, Pyroacetic ether, Beta-ketopropane.	NA	NA	NA	2	Miscible	[illegible]
Acrolein	107-02-8	Acrylic aldehyde, Acyaldehyde, Propenal, 2-Propenal, Acraldehyde, Allyaldehyde.	Aqualin, Aqaulin biocide, Aqualin-slimicide.	0.32 ppm[4]	NA	3	40%	0.84
Acrylonitrile	107-13-1	Cyanoethylene, Propenitrile, An, Vinyl cyanide.	Fumigrain, Ventox	0[5]	R	3	7%	0.81
Alachlor	15972-60-8	NA	Lasso, Alanex.	0[5]	R	2	NA	NA
Aldicarb	116-06-3	Aldecarb; 2-Methyl-2-(methylthio)-propionaldehyde o-(methylcarbamoyl)-oxime; Methylcarbamic acid o-((2-methyl-2-(methylthio)propylidene)-amino derivative; Carbanolate; 2-Methl-2-(methylthio)propanal o-[(methylamino)carbonyl]oxime.	UC 21149, Temik, ENT-27093, WHO OMS-771, NCI-C08640.	.01 ppm	NA	3	NA	NA
Aldrin	309-00-2	Adrine; HHDN; Aldocit, Compound 118, Ent 15,949, Kortofin, NCI-C00044, SD 2794, Tatuzinho, Tipula.	Octalene, Aldrex, Aldrosol, Drinox, Aldrite.	5 ppm[14]	NA	3	0.003%	1.60
Dieldrin	60-57-1	Compound-497; ENT 16225; Heod; Exo-dieldrin; Aldrin epoxide; Dildrin.	Octalox, Alvit, Quintox, Diedrex, Dieldrite, Panaram D-31, Illoxal, Dielmoth, Dorytox, Insectlack, Kombi-Alberta, Moth Snub D, Red Shield, SD 3417, Termitox.	5 ppm[14]	NA	3	0.02%	1.75
Aluminum	74-299-05	NA	NA	.05 ppm[6]	NA	3	NA	NA
Ammonia	7664-41-7	Anhydrous ammonia.	NA	.05 ppm[4]	NA	3	34%	NA
Aniline	62-53-3	Aminobenzene, Phenylamine, Aniline oil, Benzenamine, Aminophen, Kyanol, Blue Oil, Arylamine.	NA	5 ppm[4]	NA	3	4%	1.02
Anthracene	120-12-7	Paranaphthalene, Green oil, Tetra Olive NZG, Anthracen, Anthracin.	NA	10 ppm[17]	NA	3	NA	NA
Antimony	7440-36-0	Stibium.	NA	.003 ppm[14]	NA	3	Insoluble	6.69
Arsenic	7440-38-2	NA	NA	0[4]	K	3	Insoluble	5.73
Asbestos	1332-21-4	Chrysotile, Amosite, Crocidolite, Tremolite, Anthophylite, Actinolite, Calcium magnesium salt, Silicic acid, Blue asbestos, Mysorite, Brown asbestos, Calidiria RG Ferroanthophyllite, Cassiar AK, Avibest C, 7-45 Asbestos, Serpentine, Amianthus, White asbestos.	Ascarite.	0[5]	K	3	Insoluble	NA
Atrazine	1912-24-9	6-Chloro-N-ethyl-N-(1-methylethyl)-1,3,5-triazine-2,4-diamine; 2-Chloro-4-ethylamino-6-isopropylamino-s-triazine.	Gesaprim, Primatol, Aatrex, Atranex, Primatol A, Atred, Crisazine, Vectal SC.	.0770 mg/day[7]	NA	3	NA	NA
Benomyl	17804-35-2	NA	Benlate, Tersan, Arbotrine.	NA	NA	3	NA	NA
Benzene	71-43-2	Benzol, Cyclohexatriene, Coal tar naphtha, Phenyl hydride, Phene, Polystream, Pyrobenzol, Benzole.	NA	0[5]	K	3	0.07%	0.88
Benzo(a)anthracene	--	1,2-Benzanthracene, 2,3-Benzphenanthrene, Tetraphene, Benzanthrene, Naphthanthracene, Benzo(b)phenanthrene, 2,3-benzophenanthrene, 1,2-benz(a)anthracene, 1,2-benzanthrene, 1,2-benzanthracene, benzanthracene, BA, B(A)A.	NA	0[5]	R	3	NA	NA

Notes appear on page 10 of 10.

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Benzo(a)pyrene	50-32-8	3,4-Benzpyrene, 3,4-Benzopyrene, BAP, 1,2-Benzpyrene, Benzo(del) chrysene, 3,4-Benzo(a)pyrene, Benz(alpha)pyrene, B(A)P, BP, 3,4-BP.	NA	0[5]	R	3	NA	NA
Benzo(b)fluoranthene	--	2,3-Benzofluoranthene, Benz(e)acephenanthrylene, 3,4-Benzo-fluoranthene, B(B)F, Benzo(k)fluoranthene	NA	0[5]	R	3	NA	NA
Beryllium	7440-41-7	Glucinium, glucinum.	NA	NA	NA	3	Insoluble	1 85
Bromacil	314-40-9	5-Bromo-6-methyl-3-(1-methylpropyl)-2,4(1H, 3H)-pyrimidinedione; 5-Bromo-3-sec-butyl-6-methyluracil.	duPont herbicide 976, Hyvar, Hyvar X, Uragon, Urox B, Urox HX, Krovar II, Borea, Hyvar X-L.	0[5]	R	D	NA	NA
Bromoform	75-25-2	Tribromomethane, Methyl tribromide, Methylene tribromide, Formyl tribromide.	NA	5,000 ppm[14]	NA	3	0 1%	2 89
1,3-Butadiene	106-99-0	NA	NA	0[5]	R	3	Insoluble	0 65
Cadmium	7440-43-9	NA	NA	0[5]	R	3	Insoluble	8 65
Carbaryl	63-25-2	NA	Sevin, Carbamine, Denapon, Dicarbam, Hexavin, Karbaspray, Nac, Ravyon, Septene, Tercyl, Tricarnam, Atoxan.	.1 ppm	NA	3	0.01%	1 23
Carbofuran	1563-66-2	2,3-Dihydro-2,2-dimethyl-7-benzofuranyl ester of methyl-carbamic acid; 2,3-Dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate; NIA 10242; Niagaral 242; ENT 27164; 2,2-dimethyl-7-coumaranyl n-methylcarbamate; Methylcarbamate.	Furadan, Curaterr, Yaltox, Niagara 10242, OMS 864, BAY 70143.	.005 ppm	NA	3	NA	NA
Carbon Tetrachloride	56-23-5	Tetrachloromethane, Methane tetrachloride, Perchloromethane, Carbon chloride, Carbona, Carbon tet, Tetrachlorocarbon, CCL ENT 4705.	Necatorina, Nectorine, Benzinoform, Halon 104, Fasciolin, Flukoids, Freon 10, Tetrafinol, Tetraform, Tetrasol, Univerm, Vermoestricid.	0[5]	R	3	0.05%	1 59
Chlordane	57-74-9	Toxichlor; Octra-Klor; 1068.	Ortho-Klor(Chevron), Velsicol-1068(Velsicol), Dow-Klor(Dow), Belt, CD68, Chlordan, Gamma Chlordan, Chlorindan,Chlor Kil, Chlorodane, Corodant, ENT 9932, ENT 25552-X, Kypchlor, M140, M410, Corodane, Dowchlor, HCS3260, Niran, Oktaterr, Topichlor, Topichlor 20, Kipchlor, Topiclor, Octaclor, SD5532, Synklor, Tat Chlor 4.	60 ppm[14]	NA	3	Insoluble	1 56
Heptachlor	76-44-8	NA	Velsicol-104, Heptamul, E3314, Heptagran, Drinox, ENT 15152, H, H-34, Rhodiachlor, AAHEPTA, Agroceres, GPKH, NCI-COO180.	.00006 ppm	NA	3	Insoluble	1.66
Chlorine	7782-50-5	NA	NA	250 ppm[9]	NA	3	0.7%	NA
Chlorobenzene	108-90-7	Monochlorobenzene, Chlorobenzol, Phenyl chloride, Benzene chloride.	NA	NA	NA	2	0.05%	1 11
Chloroform	67-66-3	Trichloromethane, Formyl trichloride, Methane trichloride, Methenyl trichloride, Methyl trichloride, NCI-CO2686, Trichloroform.	Freon 20, R20.	22 ppm[4]	NA	3	0.5%	1 48
Chrysene	218-01-9	1,2-Benzphenanthrene; Benz(a)phenanthrene; 1,2,5,6-dibenzo-naphthalene.	NA	.00001 ppm[17]	NA	3	NA	NA
Clorpyrifos	2921-88-2	NA	Dursban, Lorsban, Killmaster, ENT 27311.	NA	NA	3	NA	NA
Chromium and Related Compounds	7440-47-3	NA	NA	0[5]	K	3	Insoluble	7.14
Copper Sulphate	7758-98-7	NA	Bluestone, Blue vitriol, Komeen, Koplex, Blue copperas, Triangle.	.001 ppm[10]	NA	3	NA	NA

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Cresol	1319-77-3	NA	NA	.001 ppm[4]	NA	3	2%	1.03
Cyanide and Related Compounds	57-12-5	NA	NA	.2 ppm[4]	NA	3	58%	[illegible]
2,4-D	94-75-7	2,4-D acid; Hedonal; 2,4-Dichlorophenoxy acetic acid.	Weed-B-Gone; Super-D-Weedone, Herbical, Miracle, Lawn Keep.	.002 ppm[4]	NA	3	0.05%	1.57
DDT	50-29-3	P,P'-dichlorodiphenyltrichloroethane, Chlorophenothane, Dicophane, Pentachlorin, Gesarol, Chlorophenothane, ENT 1506, Persistospray, Santobane.	Neocid, P,P-DDT, Anofex, Neocoid, Zerdane, Dinocide, Gespon, Gesarex, Guespon, Guesarol, Pentech, Arkotine, Gyron, Ixodex, Neocidol, DND, GNB, GNB-A, Gesarol.	0[5]	R	NA	Insoluble	[illegible]
Diazinon	333-41-5	O,O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl)phosphorothioate.	Diazajet, Diazide, Diazitol, Diazol, Dicid, Exodin, Flytrol, Galesan, Kayazinon, Dimpylat, Dizinon, Dyzol, D-Z-N, Diazinon 14G, Geigy Spectracide, Lawn and Garden Insect Control, Basudin, Bazudin, Ciazinon, Ducutox, Cassitox, Dazzel, Dianon, Diater, Diater-fos, Necidol, Nucidol, R-Fos.	.1 ppm[4]	NA	3	NA	NA
1,2,5,6-Dibenzanthracene	53-70-3	Dibenz(a,h)anthracene; DB(A,H)A,; DBA; Dibenzo(a,h)anthracene; 1,2,7,8-Dibenzanthracene.	NA	0[5]	R	3	NA	NA
Dibromochloromethane	124-48-1	NA	NA	18 ppm[4]	NA	2	NA	NA
Dicamba	1918-00-9	3,6-Dichloro-o-anisic acid;2-Methoxy-3,6-dichlorobenzoic acid; 3,6-Dichloro-o-anisic; 3,6-Dichloro-2-methoxybenzoic acid; 3,6-Dichloro-2-methoxybenzoic acid; 3,6-Dichloro-2-methoxy-benzoic acid.	Velsicol compound "R", Velsicol 58-CS-11, Dianat, Dianate, Banlen, Mondak, Banes, Banex, Banvel D, Mediben.	.2 ppm[11]	NA	2	NA	NA
1,2-Dichlorobenzene	95-50-1	O-dichlorobenzene, Orthodichlorobenzene, Dichlorobenzol, DCB, O-dichlorobenzol, ODB, ODCB, Orthodichlorobenzol.	Dowtherm E, Chloroben, Cloroben, Dizene.	.6 ppm[12]	NA	3	0.01%	[illegible]
1-3-Dichlorobenzene	541-73-1	M-dichlorobenzene. and 1,4-Dichlorobenzene, P-dichlorobenzene; PDCB; PDB; Paradichlorobenzene; Parazene; Paradichlorobenzol; P-dichlorobenzol.	Dichlorocide, Paracide, Paradow, Paramoth, Santochlor.	.6 ppm[12]	NA	3	0.008%	1.25
Dichlorodifluoromethane	75-71-8	Difluorodichloromethane	Fluorocarbon 12, Freon-12, Genetrum-12, Frigen 12, Arcton 6, Halon, Freon F-12, Isceon 122, Ledan 12, Propellant 12, Refrigerant 12, Halon 122, Isotron 2, F12, FC12, Algofrene Type 2, Electro-CF 12, Freon F-12, Isceon 122, Ledan 12, Propellant 12, Refrigerant 12, Veon 12	2.8 ppm[4]	NA	1	0.03%	NA
1,2-Dichloroethylene	540-59-0	Acetylene dichloride; Alpha, beta-dichloroethylene; SYM-1,2-dichloroethylene; 1,2-Dichloro-(9Cl)ethene; Dioform; 1,2-Dichloroethene.	NA	.1 ppm[12]	NA	3	0.4%	1.27
Dichloroethyl Ether	111-44-4	Bis-(2-chloroethyl) ether, 2,2-Dichloroethyl ether, Bis(beta-chloroethyl) ether, Dichlorodiethyl ether, Di-(2-chloroethyl)ether, 1-Chloro-2-(beta-chloroethoxy)ethane, Dichloroether, DCEE, Chlorex, Clorex, BCEE, Dichloroethyl oxide, Sym-dichloroethyl ether.	ENT 4,504.	1.5 ppm[4]	NA	3	1%	1.22
Dichloropropene	542-75-6	Dichloro-(9Cl)1--propene; Allyene dichloride; (Van)dichloride; (S)dichloride; N.O.S. Dichloropropene; Dichloropropylene; N.O.S. Dichloropropylene; 1,3-Dichloropropene.	NA	0[5]	R	3	NA	NA

Notes appear on page 10 of 10.

R0009680

Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
1,2,4-Dimethylphenol	105-67-9	2,4-Xylenol; 1-Hydroxy-2,4-dimethylbenzene; 4-Hydroxy-1,3 -dimethyl-benzene; 2,4-DMP; M-xylenol; M-4-xylenol; Asym-o-xylenol.	NA	.4 ppm[4]	NA	3	NA	NA
Dimethyl Phthalate	131-11-3	DMP; Dimethyl 1,2-benzedinicarboxylate; 1,2-Benzenedicarboxylic acid; Dimethyl ester; Dimethyl ester phthalic acid; Methyl phthalate; Dimethyl-benzene-o-dicarboylate.	Avolin, ENT 262, Fermine, Solvanom, Mipax, NTM, Palatinol M, Solvarone.	313 ppm	NA	2	0.4%	1.19
2,4-Dinitrotoluene	25321-14-6	DNT; 1-Methyl-2,4-(9CI)benzene; 2,4-Dinitro(8CI)toluene; O,P-Dinitro-toluene; NCI-CO1865; 1-Methyl-2,4-dinitrobenzene; 2,4-Dinitro-1-methyl-benzene; 2,4-Dinitro-1-methylbenzene; 2,4-Dinitrotoluol; 2,4-DNT.	NA	100 ppm[14]	NA	3	Insoluble	1.32
2,6-Dinitrotoluene	606-20-2	2,6-DNT; 2-Methyl-1,3-dinitro-(9CI)benzene.	NA	100 ppm[14]	NA	3	Insoluble	1.32
Dioctyl Phthalate	117-81-7	Bis-(2-ethylhexyl)phthalate; Dioctyl ester o-benzenedicarboxylic acid; Diethyl hexyl phthalate; Dioctyl o-benzenedicarboxylate; Octyl phthalate; Di-n-octyl phthalate.	Celluflex DOP, Polycizer 162, PX-138.	.0003 ppm[13]	NA	3	Insoluble	0.99
Dioxane	123-91-1	1,4-Dioxane; Diethylene dioxide; Diethylene ether; Dioxan; P-Dioxane; Diethylene oxide.	NA	0[5]	R	3	Miscible	1.03
Dioxin	1746-01-6	2,3,7,8-tetrachlorodibenzo-p-dioxin; P-dioxin; Hexachlorodibenzo-p-dioxin; TCDD; 2,3,7,8-Tetrachlorodibenzo-(9CI)dibenzo[b,e][1,4]dioxin; TCDBD; 2,3,7,8-Tetrachlorodibenzo-1,4-dioxin.	NA	.0006 ppm[14]	NA	3	NA	NA
Disulfoton	298-04-4	Phosphorodithoic acid; O-O-diethyl S-[2(ethylio)ethyl] dithiophosphate; O-O-diethyl S-[2-(Ethlio)ethyl]ester; O,O-diethyl S-[2-(Ethlio)ethyl] phophorodithioate.	Ethyliometon B, Di-Syston, Frumin Al, Solvirex, M74, Bayer 19639, Dithiodemeton, Dithiosystox, Frumin G, Thiodemeton, Frumin, Glebofos, Vuagt 1964, Disipton, ENT 23437, Ethyl Thiometon, Vuagt 1-4.	.004 ppm[10]	NA	3	NA	NA
Diuron	330-54-1	NA	DCMV, DMV, Krovar II (27%), Karmex (80%), Marmer, Dichlorfenidim, Urox, Vonduron, Dynex, Unidon, Cekiruon, Di-on, Dailon, Diurox, Diater, Diurol, Drexel Diruon 4L.	.07 ppm[10]	NA	3	NA	NA
Endosulfan	115-29-7	NA	OMS 570, HOE 2671, BIO 5462, Thiodan, Malix, SD 4314, Chlorothepin, Endosulpham, Beosit, Cyclodan, Kop-thiodan, Tiovel, Thiorex, Nia 5462, Thifor, Thiosulfan, Tionel, Thimul Thiofur,Thiomul, Benzoepin, FMC 5462, Crisulfan, Endocel, Endosol, Hildan, Thioulfan.	.074 ppm[4]	NA	3	NA	NA
Ethion	563-12-2	O,O,O,O-tetraethyl S,S-methylene diphosphorodithioate; Diethion; Ethyl methylene phosphorodithioate; Bis(S-(diethoxyphosphinothioyl)mercapto) methane; S,S-dimethanedithioate O,O-diethyl phosphorodithioate; 0,0,0,0-tetraethyl S,S-methylenebis(dithiophosphate; Tetraethyl S,S-methylene bis(phosphorothiolothionate); O,O,O,O-Tetraethyl S,S-methylene di(phosphorodithioate).	Niagara 1240, Rodocide, Hylemax, Rodocid, Fosfatox E, Phosphotox E, Hylemox, RP 8167, ENT 24,105, Nialate, Vegfru Fosmite, Nia 12 40, AC 3422, Bladan, Embathio, Ethodan, FMC-1240, Fosfono 50 Itopaz, Kwit, Soprathion.	NA	NA	3	NA	NA
Ethylbenzene	100-41-4	Phenylethane, EB.	NA	2 ppm[4]	NA	2	0.01%	0.87

Notes appear on page 10 of 10.

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Ethylene Dibromide	106-93-4	EDB; 1,2-Dibromoethane; Ethylene bromide; Dibromoethane; S-dibromoethane; Alpha,beta-dibromoethane; Glycol dibromide; Sym-dibromomethane.	Bromofume, Dowfume 40, Dowfume EDB, Dowfume MC-2, Dowfume(W8), Dowfume (W85), E-D-Bee, ENT 15,349, Dowfume(W10), Dowfume(W15), Dowfume(W40), Fumo-gas, Iscobrome D, Kopfume, Pestmaster, Pestmaster EDB-85, Soilbrom-85, Soilfume, Unifume.	0[5]	R	3	0.4%	[illegible]
Ethylene Dichloride	107-06-2	Ethylene chloride; S-dichloroethane; Alpha, beta-dichloride; Ethane dichloride; Dichloro-1,2-ethane; Ethylidene chloride; 1,2-Dichloroethane; EDC; glycol dichloride.	Brocide, Destruxol borer sol, Di-chlor-mulsion, Dutch liquid, ENT 1,656, NCI-COO511, Borer sol, Dowfume.	0[5]	R	3	0.9%	1.24
Ethylene Oxide	75-21-8	Anprolene, Dihydrooxirene, EO, ETO, Oxane, Oxacyclopropane, Oxidoethane, Alpha,beta-oxidoethane, Oxiran, Oxirane, Dimethylene oxide, 1,2-epoxy ethane.	ETOX.	0[5]	R	3	Miscible	0.82
Fenvalerate	51630-58-1	NA	Ectrin, Pydrin, Sumicidin, Blockade, Tribute, Evercide.	NA	NA	3	NA	NA
Fluoranthene	206-44-0	Benzo(k,j)fluorene; Idryl; 1,2-(1,8-naphthalene)benzene; 1,2-Benzacenaphthene.	NA	1 ppm[17]	NA	3	NA	NA
Fluorides	16984-48-8	NA	NA	4 ppm[14]	NA	3	0.04%	2.78
Fluorotrichloromethane	75-69-4	Trichlorofluoromethane, Trichloromonofluoromethane.	Fluorocarbon 11, Freon, Freon-11, Arcton-9, Frigen-11, Genetron, Genetron 11, Isotron, Isotron 11, Racon, Ucon, Ucon Fluorocarbon 11, Ucon Refrigerant 11, Algofrene Type 1, F-11, Electro-CF-11, Eskimon 11, FC-11, Isceon 131, Isotron 11, Ledon 11.	NA	NA	3	0.1%	1.47
Formaldehyde	50-00-0	Methanal, Oxymethane, Methylin oxide, Methyl aldehyde, Oxymethylene, Formic aldehyde, Formalin.	BFV, Fannoform, Formalith, Formal, Fyde, Ivalon, Karsan, Lysoform, Morbbicid, Paraform, Super Lysoform.	0[5]	R	3	Miscible	1.08-1.10
Gasoline	8006-61-9	Petrol.	NA	NA	NA	3	NA	NA
Hexachlorobenzene	118-74-1	HCB; Granox; Perchlorobenzene; Pentachlorophenyl chloride.	Amatin, Anticaries, Bunt-cure, Bunt-no-more, Co-op Hexa, Granox NM, Julin's Carbon Chloride, No Bunt, No Bunt 40, No Bunt 80, No Bunt Liquid, Sanocide, Snieciotox; Ortho HCB 4 Flowable Seed Protectant: 40% HCB; Ortho Wheat Seed Protectant: HCB: 40%, Captan 40%; Ortho Wheat Seed Protectant Flowable: HCB 18%, Captan 18%; impurity in production of Dacthal, Mirex, Simazine, Atrazine, Propazine, Pentachloronitrobenzene.	0[5]	R	3	NA	NA
Hexachlorobutadiene	87-68-3	HCBD; Hexachloro-1,3-butadiene; Perchlorobutadiene; 1,1,2,3,4,4-hexachloro-1,3-butadiene; C-46.	NA	NA	NA	3	NA	NA
Hexachlorocylohexane	608-73-1	BHC, Benzene hexachloride, Hexachlor, Hexachloran, HCCH, HCH, TBH.	Benzex, FBHC, Kotol, Submar, Hilbeech, Hexafor, Hexablanc, Hexamul, Hexapurdre, Ambocide, Gyben, Hexdow, Isaton, Trives T.	0[5]	R	3	NA	NA

Notes appear on page 10 of 10.

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Hexane	110-54-3	Hexyl Hydride, N-hexane.	NA	1 ppm	NA	3	0.002%	0.66
Hydrochloric Acid	7647-01-0	Hydrogen chloride, Hydrochloride, Muriatic acid, Spirits of salt.	NA	NA	NA	3	NA	NA
Hydrogen Fluoride	7664-39-3	Anhydrofluoric acid (the gas).	NA	1.2 ppm[4]	NA	3	Miscible	1.00
Indeno(1,2,3-cd)pyrene	193-39-5	2,3-O-phenylenepyrene; IP.	NA	0[5]	R	3	NA	NA
Isophorone	78-59-1	3,5,5-Trimethyl-2-cyclohexen-1-one.	NA	0[5]	R	3	1.0%	0.92
Kerosene	8008-20-6	Fuel Oil, Jet fuel, Range Oil, Coal oil.	NA	NA	NA	3	NA	NA
Lead	7439-92-1	Plumbum (Latin name)	NA	.005 ppm[12]	NA	NA	Insoluble	11.34
Lindane	58-89-9	Gamma hexachlorocyclohexane, DBH, HCCH, HCH, Gamma benzene-hexachloride, Gamma-1,2,3,4,5,6-hexachlorocyclohexane.	666, Bensahex, Gammaexane, Chemhex, Aparasin, Streunex, Tri-6, Lorexane, Kwell, Jacutin, Gamoxol, Hexdon, Celanex, Chloresene, Devoran, Dol Granule, Aplidal, Bentox 10, Exagama, Gallogama, Gamaphex, Inexit, Lindagrain, Denkagranox, Lindalo, Lindamul, Lindapoudre, Lindaterra, Novigam.	0[5]	R	3	0.001%	1.85
Malathion	121-75-5	NA	Phosphothion, Mercapthion, Carbofos, EPN, American-Cyanimide-4049, Insecticide-4049, Malathon, Calmathion, Detmol Ma 96%, Carbophos, Cythion, Cyanamid, MLT, Karbofos, Carbetox, Carbethoxy malathion, Chemathion, Compound 4049, Zithiol, Siptox I, SF 60, Sadophos, Sadofos, Oleophosphothion, Malphos, Malatox, Malatol, Malathion LV Concentrate, Malakill, ENT 17034, Formal, Emmatos Extra, Malaspray, Malagran, Kopthion, Fosfothion, Malaphos, Fyfanon, Kypfos, Malamar, Ethiolacar, Malaman 50, Malacide, Fog 3, Malathion E 50, Malafor, Moscdarda.	.1 ppm[4]	NA	NA	0.02%	1.21
MCPA	94-74-6	[(4-Chloro-o-tolyl)oxy] acetic acid; (4-Chloro-2-methylphenoxy) acetic acid; Metaxon; MCP; 2-Methyl-4-chlorophenoxyacetic acid; SCPA.	Agroxone, Agritox, Cornox M, Methoxoice, Chiptox, Rhomene, Rhonox, Agroxohe, Mephanaic.	.1 ppm[4]	NA	NA	NA	NA
Mercury	7439-97-6	NA	NA	.002 ppm[12]	NA	NA	Insoluble	13.6
Methyl Bromide	74-83-9	Bromomethane, Brom-o-gas, Bromosol, Brozone, MEBR, Monobromo-methane.	Zytox, Profume, Retox, Embafume, Dowfume MC-33, Dowfume-MC2, Celfume, Metafume, Isobrone, Pestmaster, Terro-gas 100, M-B-C Fumigant	1.39 ppm[4]	NA	3	NA	1.68
Methylchloroform	71-55-6	1,1,1-Trichloroethane, TCE, Alpha-trichloroethane, Ethylidene chloride, Chlorotene, Baltana, Genklene.	Chlorothene Nu, Aerothene TT.	.2 ppm[12]	NA	3	0.4%	1.34
Methylene Chloride	75-09-2	Dichloromethane, Methylene bichloride, Methylene dichloride, Methane dichloride, NCI-C50102, Aerothene MM, Freon 30, Narkotil, Solaesthin, Solmethine.	NA	0[5]	R	3	2.0%	1.33
Methyl Ethyl Ketone	78-93-3	2-Butanone, MEK, Ethyl methyl ketone, Butanone, Methyl acetone.	NA	NA	NA	NA	28%	0.81
Methyl Isobutyl Ketone	108-10-1	4-Methyl 2-pentanone, Hexone, MIK, 2-Methyl-4-pentanone, Isopropylacetone, Isobutyl methyl ketone, MIBK.	NA	NA	NA	3	2%	0.80
Naphthalene	91-20-3	Naphthalin, Maphthene, Tar camphor, Naphthaline, Moth flakes, Albocarbon, Dezodorator, White tar.	NA	NA	NA	3	0.003%	1.15

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Notes appear on page 10 of 10.

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcinogenicity[2]	Toxicity[3]	Solubility	Specific Gravity
N-Butyl Phthalate	84-74-2	Dibutyl ester phthalic acid; Di-n-butyl phthalate; Dibutyl phthalate; Dibutyl ester 1,2-benzenedicarboxylic acid.	PX 104, Celluflex DPB, Elaol, Palatinol C, Polycizer DBP, Staflex DBP, Witicizer 300, Hexaplas M/B, Genoplast B, Unimcll DB, DBP.	34 ppm[15]	NA	3	0.5%	[illegible]
Nickel	7490-02-0	NA	NA	0[5]	R	3	Insoluble	8.90
Nitric Acid	7697-37-2	NA	NA	10 ppm[4]	NA	3	Miscible	[illegible]
Nitrobenzene	98-95-3	Oil of Mirbane, Essence of Mirbane, Nitrobenzol.	NA	NA	NA	3	0.2%	1.20
Nitrogen Oxide (Nitrates)	10024-97-2	Nitrous oxide; Dinitrogen monoxide, Hyponitrous acid anhydride.	NA	10 ppm[14]	NA	2	NA	NA
O-Nitrophenol	88-75-5	2-Nitrophenol, Mononitrophenol, 2-Hydroxynitrobenzene.	Atonik, Ortho-nitrophenol, ONP	.001 ppm[4]	NA	3	NA	NA
P-Nitrophenol	100-02-7	4-Nitrophenol, Mononitrophenol, 4-Hydroxynitrobenzene.	PNP, Para-nitrophenol.	.001 ppm[4]	NA	3	NA	NA
N-nitrosodimethylamine	62-75-9	Dimethylnitrosamine, N,n-dimethylnitrosamine, DMN, DMNA.	NA	0[5]	R	3	Soluble	1.0
N-nitrosodi-n-propylamine	621-64-7	Other nitrosamines: N-nitroso-n-propyl-1-propanomine, N-nitro-sodipropylamine, N-nitroso-dipropylamine, Dipropylnitrosamine, Nitrosodipropylamine, N-N-dipropylnitrosamine, DPNA, NDPA, DPN, Di-N-Propylnitrosamine.	NA	0[5]	R	3	NA	NA
Parathion	56-38-2	O,O-diethyl-o,p-nitrophenyl phosphorothioate; Diethyl-p-nitrophenyl monothiophosphate; Diethyl p-nitrophenyl thiophosphate; O,O-diethyl-o-(4-nitrophenyl)phosphorothioate; Diethyl 4-nitrophenyl thionophosphate; O,O-diethyl-o-(p-nitrophenyl)thionophosphate; O,O-diethyl-o-(4-nitrophenyl)thiophosphate; Diethylparathion; O,O-diethyl o-(p-nitrophenyl)ester of phosphorothioic acid; O-ester P-nitrophenol with O,O-diethyl phosphorothioate; Ethyl parathion.	Corothion, Drexel parathion 8E, Fosferno 50, Soprathion, Alkron, DNTP, DPP, Niran Penphos, Phoskil, Thiophos, Vapophor, Genithion, Bladan, Folidol, Thiophos, ENT 15,108.	.1 ppm[4]	NA	3	0.001%	1.27
PCBs	1336-36-3	Polychlorinated biphenyls: Arochlor 1242 (CAS 53469-21-9), Arochlor 1254 (CAS 11091-69-1), 1221 (CAS 11104-28-2), 1232 (CAS 11141--16-5), 1248 (CAS 12672-29-6), 1260 (CAS 11096-82-5), 1016 (CAS 12674-11-2).	Aroclor, Dykanol, Noflamol, Chlorentol, Inerteen, Pyranol, Therminol, Chlorophen, Chlorextol, Clophen, Fenclor, Kanachlor, Kanechlor, Montar, Pyralene, Santotherm, Santotherm FR, Sovol, Therminol FR.	0[5]	R	3	NA	NA
Pentachlorophenol	87-86-5	PCP, Penta, Penchlorol.	Santophen-20, Dowicide-G, Dowicide-7, Dowicide EC-7, Monsanto Penta, Santobrite.	.01 ppm[4]	NA	3	0.001%	1.98
Petroleum	8002-05-9	Crude oil, of which the major fractions are: benzine (not benzene), lubricating oils, paraffin wax, asphalt, diesel fuel, and kerosene.	NA	NA	NA	3	Insoluble	0.63-0.66
Phenanthrene	85-01-8	NA	NA	NA	NA	3	NA	NA
Phenol	108-95-2	Carbolic acid, Phenylic acid, Hydroxybenzene, Phenyl hydroxide, Oxybenzene, Phenic acid, Phenyl hydrate, Monohydroxybenzene.	NA	NA	NA	3	9%	1.06
Phorate	298-02-2	NA	Thimet, Timet.	.0007 ppm[16]	NA	3	NA	NA
Phosphorus	7723-14-0	NA	NA	NA	NA	3	0.0003%	1.82
Prometryn	1610-18-0	2-Methoxy-4,6-bis(isopropylamino)-s-triazine; Methoxy propazine.	Prometone, Pramitol, Prometon, Primatol 25E.	2 ppm[10]	NA	NA	NA	NA
Pronamide	23950-58-5	NA	Propyzamide, Kerb.	2.6 ppm[10]	NA	NA	NA	NA
Propylene Dichloride	78-87-5	Dichloropropane; 1,2-Dichloropropane; DCP; Alpha,beta-dichloropropane; Alpha,beta-propylene dichloride; Propylene chloride; ENT 15,406; NCI-C55141; it also occurs in mixtures of 1,3-Dichloropropane; Isothiocyanotomethane; Trichloronitromethane; and Ethylene dibromide.	Propylene dichloride is mixed in compounds with these tradenames: D-D soil fumigant, Dowfume NC, Vidden D, EP-201, Nemex, Vorlex, D-D Pilfume, Terr-o-cide, Terr-o-gas, Dorlone, New Fieldfume.	NA	NA	NA	0.3%	1.16

Notes appear on page 10 of 10.

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Pyrene	129-00-0	NA	NA	1 ppm[17]	NA	3	NA	NA
Selenium	7782-49-2	Red selenium.	NA	.01 ppm[4]	NA	NA	Insoluble	4.28
Simazine	122-34-9	DCT; Primatol-S; Princep Cet; (G27692): Simanex; 2-Chloro-4,6-bis (ethylamino)-s-triazine; 2,4-Bis(ethylamino)-6-chloro-s-triazine; Simazin.	Gesatop, Primatol, Aquazine, Princep, Gasatop, Simadex.	.175 ppm[10]	NA	3	NA	NA
Sodium Hydroxide	1310-73-2	Caustic soda, Soda lye, Lye, Sodium hydrate.	NA	24 ppm[13]	NA	3	NA	NA
Styrene	100-42-5	Styrol, Styrolene, Cinnemene, Dinnamol, Phenylethylene, Vinylbenzene.	NA	NA	NA	3	Slight	0.91
Sulfur	7704-34-9	NA	NA	250 ppm[14]	NA	3	NA	NA
Sulfuric Acid	7664-93-9	Dithionic acid, Brown oil, Oil of vitriol, Vitriol, Oleum (fuming sulfuric acid), Vitriol brown oil, Dripping acid, Bov., Battery acid, Chamber acid, Fertilizer acid.	NA	250 ppm[4]	NA	3	Miscible	1.86
Systox	8065-48-3	Demeton; Demox; E 1059; Mercaptophos; Bayer-8169; Systemox; Demeton-O; Demeton-S; O,O-diethyl-o-(2-(ethylthio)ethyl)-phosphorothionate; O,O-diethyl-o-ethylmercaptoethylthiophosphate; O,O-diethyl-s-(2-ethylthio)ethyl)phosphorothiolate; O,O-diethyl-s-ethylmercaptoethyl-thiophosphate.	NA	.1 ppm[4]	NA	NA	NA	NA
Tebuthiuron	34014-18-1	N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N-dimethylurea.	Tebulon, Spike, Grassland.	2.45 ppm[10]	NA	3	NA	NA
Tetrachloroethane	79-34-5	S-tetrachloroethane, Cellon, Bonoform, 1,1-Dichloro-2,2-dichloroethane, Acetylene tetrachloride, 1,1,2,2-Tetrachloroethane.	NA	.0018 ppm[4]	NA	3	0.3%	1.59
Tetrachloroethylene	127-18-4	Tetrachloroethene, PCE, Carbon bichloride, Carbon dichloride, Ethylene tetrachloride, Per, Perc, Perchlor, Perchloroethylene, Perchlorethylene, Perk, Tetrachlorethylene, 1,1,2,2-Tetrachloroethylene.	Ankilostin, Antisal 1, DEE-Solv, Didakene, Dow-per, Ent 1860, Fedal-Un, Nema, Perclene, Percosolv, Perklone, Persec, Tetlen, Tetracap, Tetraleno, Tetravec, Tetraguer, Tetropil, Perawin, Tetralex, Dowclene EC.	0[5]	R	3	0.02%	1.62
Toluene	108-88-3	VOC, Toluol, Methylbenzene, Methacide phenylmethane.	NA	2 ppm[4]	NA	3	0.05%	0.87
Toluene-2,4-Diisocyanate	584-84-9	2,4-Diisocyanato-1-methyl-(9CI)benzene; 4-Methyl-m-phenylene ester (8CI)isocyanic acid; 2,4-Diisocyanatotoluene; Toluylene 2,4-diisocyanate; Tolylene 2,4-diisocyanate; TDI; 2,4-Diisocyanato-1-methylbenzene; 2,4-Tolylene diisocyanate; 2,4-TDI; 4-Methyl-m-phenylene diisocyanate; 4-Methyl-m-phenylene isocyanate.	Desmodur T80, Hylene T, Mondur TDS, TDS-80, Rubinate TDI 80/20, Mondur TD-80, Voranate T-80, Nacconate, TDI, Hylene TM.	0[5]	R	3	Insoluble	1.22
Toxaphene	8001-35-2	Octachlorocamphene, Compound-3956, Alltox, Geniphene, Toxakil, Toxadust, Phenacide, Penphene, Chlorinated camphene.	Phenatox.	0[5]	R	3	NA	NA
Trimethyltin Hydroxide	56-24-6	NA	NA	NA	NA	3	NA	NA
1,2,4-Trichlorobenzene	120-82-1	Unsym-trichlorobenzene, Asym-trichlorobenzene.	NA	NA	NA	3	NA	NA
1,1,2-Trichloroethane	79-00-5	Vinyl trichloride; Ethane trichloride; Beta-trichloroethane; 1,2,2-Trichloroethane.	Beta-T.	0[5]	R	3	0.4%	1.44

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Compound	CAS Number	Synonyms	Trade Name	EPA Drinking Water Criteria	Carcino-genicity[2]	Toxicity[3]	Solubility	Specific Gravity
Trichloroethylene	79-01-6	TCE; Trichloroethene; Ethinyltrichloride; Acetylene trichloride; 1-Chloro-2,2-dichloroethylene; 1,1-Dichloro-2-chloroethylene; Ethylene trichloride; 1,1,2-Trichloroethylene; 1,2,2-Trichloroethylene; TCS; TRI; Trichlorethene.	Tri-clene, Trielene, Trilene, Trichloran, Trichloren, Algylen, Trimar, Triline, Trethylen, Trethylene, Westrosol, Chlorylen, Gemalgene, Germalgene, Benzinol, Blacosolv, Blancosolv, Cecolene, Circosolv, Crawhaspol, Dow-tri, Dukerom, Fleck-flip, Flock-flip, Lanadin, Lethurin, Nialk, Perm-a-chlor, Perm-trial, Triasol, Trielin, Triklone, Triol, Vestrol, Vitran, Anamenth, Chlorilen, Chlorylea, Chorylen, Densinfluat, Fluate, Narcogen, Narkogen, Narkosoid, Petzinol, Philex, Threthylen, Threthylene, Triad, Trial, Triclene, Trilen, Tri-plus, Tri-plus M, NCI-C04546.	.005 ppm[15]	NA	3	0.1%	[illegible]
2,4,6-Trichlorophenol	88-06-2	TCP; Sym-trichlorophenol; NCI-C02904; 2,4,6-Trichloro-(8Cl9Cl)phenol; 1,3,5-Trichlorophenol; 2,4,6-T; Dowicide 2S; Omal; Phenachlor.	NA	0[5]	R	3	NA	NA
Triclopyr	93-72-1	NA	Garlon 3a.	.01 ppm[4]	NA	3	NA	NA
Trifluralin	1582-09-8	NA	Treflan.	105 ppm[10]	NA	3	NA	NA
Vinyl Chloride	75-01-4	Chloroethylene, Chloroethene, VCL, Vinyl C monomer, VCM, Monochloroethylene.	NA	0[5]	K	3	0.1%	NA
Vinylidene Chloride	75-35-4	1,1-DCE; 1,1-Dichloroethylene; Dichloroethene; 1,1-Dichloroethane; Asdichloroethylene; Unsym-dichloroethylene.	NA	NA	NA	3	0.6%	1.18
Xylene	1330-20-7	Dimethylbenzene, Xylol, 1,3-Dimethylbenzene, 1,2-Dimethylbenzene, 1,4-Dimethylbenzene.	NA	2 ppm[4]	NA	3	Insoluble	0.88
Zinc Phosphide	1314-84-7	Trizinc diphosphide, Wuelmaustod arviteol.	Phosvin, Delusal, Wuelmaus-koeder.	5 ppm[4]	NA	3	NA	NA

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Notes:

[1]Derive from "Chemicals of Special Concern in Washington State", Ellen Atkinson, Washington Department of Ecology, July 1992.

[2]Where available, carcinogenicity is categorized according to the National Toxicology Program's "Eighth Annual Report on Carcinogens", as follows:

K = Known to be a human carcinogen

R = Reasonably anticipated to be a human carcinogen

NA = Not Available

[3]Where available, toxicity is rated according to the following scale:

1: Low - LD50 of 4,000 to 40,000 mg/kg

2: Meduim - LD50 of 400 to 4,000 mg/kg

3: High - LD50 of less than 400 mg/kg

D: Insufficient data to determine rating

[4]EPA recommended drinking water limit.

[5]Recommended drinking water limit of 0 due to potential carcinogenic affects.

[6]SMCL = secondary maximum contaminant level.

[7]TNMR =

[8]Lifetime Health Advisory.

[9]EPA maximum contaminant level (MCL) 250 mg/l.

[10]DWEL = drinking water exposure limit.

[11]Lifetime Health Advisory.

[12]Proposed MCL.

[13]Chronic aquatic toxicity limit.

[14]Washington ground water criteria.

[15]EPA proposed drinking water limit.

[16]No-observable-adverse-effect-level (NOAEL) in drinking water.

[17]Ground water reference concentration provided in Appendix I, Environmental Cleanup Manual, Oregon DEQ, June 1994.

NA = not available

ppm = parts per million

ppb = parts per billion

mg/l = milligrams per liter

µg/l = micrograms per liter

"--" =

INNOVATIVE URBAN WET-WEATHER FLOW MANAGEMENT SYSTEMS

Chapter 4

Source Characterization

Robert Pitt

The Source Concept

Urban runoff is comprised of many separate source area flow components that are combined within the drainage area and at the outfall before entering the receiving water. Considering the combined outfall conditions alone may be adequate when evaluating the long term, area-wide effects of many separate outfall discharges to a receiving water. However, if better predictions of outfall characteristics (or the effects of source area controls) are needed, then the separate source area components must be characterized. The discharge at the outfall is made up of a mixture of contributions from different source areas. The "mix" depends on the characteristics of the drainage area and the specific rain event. The effectiveness of source area controls is, therefore, highly site and storm specific.

Various urban source areas all contribute different quantities of runoff and pollutants, depending on their characteristics. Impervious source areas may contribute most of the runoff during small rain events. Examples of these source areas include paved parking lots, streets, driveways, roofs, and sidewalks. Pervious source areas become important contributors for larger rain events. These pervious source areas include gardens, lawns, bare ground, unpaved parking areas and driveways, and undeveloped areas. The relative importance of the individual sources is a function of their areas, their pollutant washoff potentials, and the rain characteristics.

The washoff of debris and soil during a rain is dependent on the energy of the rain and the properties of the material. Pollutants are also removed from source areas by winds, litter pickup, or other cleanup activities. The runoff and pollutants from the source areas flow directly into the drainage system, onto impervious areas that are directly connected to the drainage system, or onto pervious areas that will attenuate some of the flows and pollutants, before they discharge to the drainage system.

Sources of pollutants on paved areas include on-site particulate storage that cannot be removed by usual processes such as rain, wind, and street cleaning. Atmospheric deposition, deposition from activities on these paved surfaces (e.g., auto traffic, material storage) and the erosion of material from upland areas that directly discharge flows onto these areas, are the major sources of pollutants to the paved areas. Pervious areas contribute pollutants mainly through erosion processes where the rain energy dislodges soil from between vegetation. The runoff from these source areas enters the storm drainage system where sedimentation in catchbasins or in the sewerage may affect their ultimate discharge to the outfall. In-stream physical, biological, and chemical processes affect the pollutants after they are discharged to the ultimate receiving water.

Knowing when the different source areas become "active" (when runoff initiates from the area, carrying pollutants to the drainage system) is critical. If pervious source areas are not contributing runoff or pollutants, then the prediction of urban runoff quality is greatly simplified. The mechanisms of washoff and delivery yields of runoff and pollutants from paved areas are much better known than from pervious urban areas (Novotny and Chesters 1981). In many cases, pervious areas are not active except during rain events greater than at least five or ten mm. For smaller rain depths, almost all of the runoff and pollutants originate from impervious surfaces (Pitt 1987). However, in many urban areas, pervious areas may contribute the majority of the runoff, and some pollutants, when rain depths are greater than about 20 mm. The actual importance of the different source areas is highly dependent on the specific land use and rainfall patterns. Obviously, in areas having relatively low-density development, especially where moderate and large sized rains occur frequently (such as in the Southeast), pervious areas typically dominate outfall discharges. In contrast, in areas having significant paved areas, especially where most rains are relatively small (such as in the arid west), the impervious areas dominate outfall discharges. The effectiveness of different source controls is, therefore, quite different for different land uses and climatic patterns.

If the number of events exceeding a water quality objective are important, then the small rain events are of most concern. Stormwater runoff typically exceeds some water quality standards for practically every rain event (especially for bacteria and some heavy metals). In the upper midwest, the median rain depth is about six mm, while in the southeast, the median rain depth is about twice this depth. For these small rain depths and for most urban land uses, directly connected paved areas usually contribute most of the runoff and pollutants. However, if annual mass discharges are more important (e.g. for long-term effects), then the moderate rains are more important. Rains from about 10 to 50 mm produce most of the annual runoff volume in many areas of the U.S. Runoff from both impervious and pervious areas can be very important for these rains. The largest rains (greater than 100 mm) are relatively rare and do not contribute significant amounts of runoff pollutants during normal years, but are very important for drainage design. The specific source areas that are most important (and controllable) for these different conditions vary widely.

This chapter describes sources of urban runoff flows and pollutants based on many studies as found in the literature. This chapter also reports on the specific source area sampling activities conducted as part of this research funded by the USEPA for use in this report.

Sources and Characteristics of Urban Runoff Pollutants

Years of study reveal that the vast majority of stormwater toxicants and much of the conventional pollutants are associated with automobile use and maintenance activities and that these pollutants are strongly associated with the particulates suspended in the stormwater (the non-filterable components or suspended solids). Reducing or modifying automobile use to reduce the use of these compounds, has been difficult with the notable exception of the phasing out of leaded gasoline. Current activities, concentrated in the San Francisco, CA area, focus on encouraging brake pad manufacturers to reduce the use of copper.

The effectiveness of most stormwater control practices is, therefore, dependent on their ability to remove these particles from the water, or possibly from intermediate accumulating locations (such as streets or other surfaces) and not through source reduction. The removal of these particles from stormwater is dependent on various characteristics of these particles, especially their size and settling rates. Some source area controls (most notably street cleaning) affect the particles before they are washed-off and transported by the runoff, while others remove the particles from the flowing water. This discussion, therefore summarizes the accumulation and washoff of these particulates and the particle size distribution of the suspended solids in stormwater runoff to better understand the effectiveness of source area control practices.

Table 4-1 shows that most of the organic compounds found in stormwater are associated with various human-related activities, especially automobile and pesticide use, or are associated with plastics (Verschueren 1983). Heavy metals found in stormwater also mostly originate from automobile use activities, including gasoline combustion, brake lining, fluids (e.g., brake fluid, transmission oil, anti-freeze, grease), undercoatings, and tire wear (Durum 1974, Koeppe 1977, Rubin 1976, Shaheen 1975, Solomon and Natusch 1977, and Wilbur and Hunter 1980). Auto repair, pavement wear, and deicing compound use also contribute heavy metals to stormwater (Field et al. 1973 and Shaheen 1975). Shaheen (1975) found that eroding area soils are the major source of the particulates in stormwater. The eroding area soil particles, and the particles associated with road surface wear, become contaminated with exhaust emissions and runoff containing the polluting compounds. Most of these compounds become tightly bound to these particles and are then transported through the urban area and drainage system, or removed from the stormwater, with the particulates. Stormwater concentrations of zinc, fluoranthene, 1,3-dichlorobenzene, and pyrene are unique in that substantial fractions of these compounds remain in the water and are less associated with the particulates.

All areas are affected by atmospheric deposition, while other sources of pollutants are specific to the activities conducted on the areas. As examples, the ground surfaces of unpaved equipment or material storage areas can become contaminated by spills and debris, while undeveloped land remaining relatively unspoiled by activities can still contribute runoff solids, organics, and nutrients, if eroded. Atmospheric deposition, deposition from activities on paved surfaces, and the erosion of material from upland unconnected areas are the major sources of pollutants in urban areas.

Table 4-1. Uses and sources for organic compounds found in stormwater (Verschueren 1983).

COMPOUND	EXAMPLE USE SOURCE
Phenol	gasoline, exhaust
N-Nitroso-di-n-propylamine	contaminant of herbicide Treflan
Hexachloroethane	plasticizer in cellulose esters, minor use in rubber and insecticide
Nitrobenzene	solvent, rubber, lubricants
2,4-Dimethylphenol	asphalt, fuel, plastics, pesticides
Hexachlorobutadiene	rubber and polymer solvent, transformer and hydraulic oil
4-Chloro-3-methylphenol	germicide, preservative for glues, gums, inks, textile, and leather
Pentachlorophenol	insecticide, algaecide, herbicide, and fungicide mfg., wood preservative
Fluoranthene	gasoline, motor and lubricating oil, wood preservative
Pyrene	gasoline, asphalt, wood preservative, motor oil
Di-n-octylphthalate	general use of plastics

Many studies have examined different sources of urban runoff pollutants. These references were reviewed as part of this study and the results are summarized in this section. These significant pollutants have been shown to have a potential for creating various receiving water impact problems, as described in Appendix D (???) of this report. Most of these potential problem pollutants typically have significant concentration increases in the urban feeder creeks and sediments, as compared to areas not affected by urban runoff.

The important sources of these pollutants are related to various uses and processes. Automobile related potential sources usually affect road dust and dirt quality more than other particulate components of the runoff system. The road dust and dirt quality is affected by vehicle fluid drips and spills (e.g., gasoline, oils) and vehicle exhaust, along with various vehicle wear, local soil erosion, and pavement wear products. Urban landscaping practices potentially affecting urban runoff include vegetation litter, fertilizer and pesticides. Miscellaneous sources of urban runoff pollutants include firework debris, wildlife and domestic pet wastes and possibly industrial and sanitary wastewaters. Wet and dry atmospheric contributions both affect runoff quality. Pesticide use in an urban area can contribute significant quantities of various toxic materials to urban runoff. Many manufacturing and industrial activities, including the combustion of fuels, also affect urban runoff quality.

Natural weathering and erosion products of rocks contribute the majority of the hardness and iron in urban runoff pollutants. Road dust and associated automobile use activities (gasoline exhaust products) historically contributed most of the lead in urban runoff. However, the decrease of lead in gasoline has resulted in current stormwater lead concentrations being about one tenth of the levels found in stormwater in the early 1970s (Bannerman et al. 1993). In certain situations, paint chipping can also be a major source of lead in urban areas. Road dust, contaminated by tire wear products and zinc plated metal erosion material, contributes most of the zinc to urban runoff. Urban landscaping activities can be a major source of cadmium (Phillips and Russo 1978). Electroplating and ore processing activities can also contribute chromium and cadmium.

Many pollutant sources are specific to a particular area and on-going activities. For example, iron oxides are associated with welding operations and strontium, used in the production of flares and fireworks, would probably be found on the streets in greater quantities around holidays, or at the scenes of traffic accidents. The relative contribution of each of these potential urban runoff sources, is, therefore, highly variable, depending upon specific site conditions and seasons.

Specific information is presented in the following subsections concerning the qualities of various rocks and soils, urban and rural dustfall, and precipitation. This information is presented to assist in the interpretation of the source area runoff samples collected as part of this project.

Chemical Quality of Rocks and Soils

The abundance of common elements in the lithosphere (the earth's crust) is shown in Table 4-2 (Lindsay l979). Almost half of the lithosphere is oxygen and about 25% are silica. Approximately eight percent is aluminum and five percent is iron. Elements comprising between two percent and four percent of the lithosphere include calcium, sodium, potassium and magnesium. Because of the great abundance of these materials in the lithosphere, urban runoff transports only a relatively small portion of these elements to receiving waters, compared to natural processes. Iron and aluminum can both cause detrimental effects in receiving waters if in their dissolved forms. A reduction of the pH substantially increases the abundance of dissolved metals.

Table 4-2. Common elements in the Lithosphere (Lindsay 1979).

Abundance Rank	Element	Concentration in Lithosphere (mg/kg)
1	O	465,000
2	Si	276,000
3	Al	81,000
4	Fe	51,000
5	Ca	36,000
6	Na	28,000
7	K	26,000
8	Mg	21,000
9	P	1,200
10	C	950
11	Mn	900
12	F	625
13	S	600
14	Cl	500
15	Ba	430
16	Rb	280
17	Zr	220
18	Cr	200
19	Sr	150
20	V	150
21	Ni	100

Table 4-3, also from Lindsay (1979), shows the rankings for common elements in soils. These rankings are quite similar to the values shown previously for the lithosphere. Natural soils can contribute pollutants to urban runoff through local erosion. Again, iron and aluminum are very high on this list and receiving water concentrations of these metals are not expected to be significantly affected by urban activities alone.

Table 4-3. Common elements in soils (Lindsay 1979).

Abundance Rank	Element	Typical Minimum (mg/kg)	Typical Maximum (mg/kg)	Typical Average (mg/kg)
1	O	- -	- -	490,000
2	Si	230,000	350,000	320,000
3	Al	10,000	300,000	71,000
4	Fe	7,000	550,000	38,000
5	C	- -	- -	20,000
6	Ca	7,000	500,000	13,700
7	K	400	30,000	8,300
8	Na	750	7,500	6,300
9	Mg	600	6,000	5,000
10	Ti	1,000	10,000	4,000
11	N	200	4,000	1,400
12	S	30	10,000	700
13	Mn	20	3,000	600
14	P	200	5,000	600
15	Ba	100	3,000	430
16	Zr	60	2,000	300
17	F	10	4,000	200
18	Sr	50	1,000	200
19	Cl	20	900	100
20	Cr	1	1,000	100
21	V	20	500	100

The values shown on these tables are expected to vary substantially, depending upon the specific mineral types. Arsenic is mainly concentrated in iron and manganese oxides, shales, clays, sedimentary rocks and phosphorites. Mercury is concentrated mostly in sulfide ores, shales and clays. Lead is fairly uniformly distributed, but can be concentrated in clayey sediments and sulfide deposits. Cadmium can also be concentrated in shales, clays and phosphorites (Durum 1974).

Street Dust and Dirt Pollutant Sources

Characteristics

Most of the street surface dust and dirt materials (by weight) are local soil erosion products, while some materials are contributed by motor vehicle emissions and wear (Shaheen 1975). Minor contributions are made by erosion of street surfaces in good condition. The specific makeup of street surface contaminants is a function of many conditions and varies widely (Pitt 1979).

Automobile tire wear is a major source of zinc in urban runoff and is mostly deposited on street surfaces and nearby adjacent areas. About half of the airborne particulates lost due to tire wear settle out on the street and the majority of the remaining particulates settle within about six meters of the roadway. Exhaust particulates, fluid losses, drips, spills and mechanical wear products can all contribute lead to street dirt. Many heavy metals are important pollutants associated with automobile activity. Most of these automobile pollutants affect parking lots and street surfaces. However, some of the automobile related materials also affect areas adjacent to the streets. This occurs through the wind transport mechanism after being resuspended from the road surface by traffic-induced turbulence.

Automobile exhaust particulates contribute many important heavy metals to street surface particulates and to urban runoff and receiving waters. The most notable of these heavy metals has been lead. However, since the late 1980s, the concentrations of lead in stormwater has decreased substantially (by about ten times) compared to early 1970 observations. This decrease, of course, is associated with significantly decreased consumption of leaded gasoline.

Solomon and Natusch (1977) studied automobile exhaust particulates in conjunction with a comprehensive study of lead in the Champaign-Urbana, IL area. They found that the exhaust particulates existed in two distinct morphological forms. The smallest particulates were almost perfectly spherical, having diameters in the range of 0.1 to 0.5 μm. These small particles consisted almost entirely of PbBrCl (lead, bromine, chlorine) at the time of emission. Because the particles are small, they are expected to remain airborne for considerable distances and can be captured in the lungs when inhaled. The researchers concluded that the small particles are formed by condensation of PbBrCl vapor onto small nucleating centers, which are probably introduced into the engine with the filtered engine air.

Solomon and Natusch (1977) found that the second major form of automobile exhaust particulates were rather large, being roughly 10 to 20 μm in diameter. These particles typically had irregular shapes and somewhat smooth surfaces. The elemental compositions of these irregular particles were found to be quite variable, being predominantly iron, calcium, lead, chlorine and bromine. They found that individual particles did contain aluminum, zinc, sulfur, phosphorus and some carbon, chromium, potassium, sodium, nickel and thallium. Many of these elements (bromine, carbon, chlorine, chromium, potassium, sodium, nickel, phosphorus, lead, sulfur, and thallium) are most likely condensed, or adsorbed, onto the surfaces of these larger particles during passage through the exhaust system. They believed that these large particles originate in the engine or exhaust system because of their very high iron content. They found that 50 to 70 percent of the emitted lead was associated with these large particles, which would be deposited within a few meters of the emission point onto the roadway, because of their aerodynamic properties.

Solomon and Natusch (1977) also examined urban particulates near roadways and homes in urban areas. They found that lead concentrations in soils were higher near roads and houses. This indicated the capability of road dust and peeling house paint to contaminate nearby soils. The lead content of the soils ranged from 130 to about 1,200 mg/kg. Koeppe (1977), during another element of the Champaign-Urbana lead study, found that lead was tightly bound to various soil components. However, the lead did not remain in one location, but it was transported both downward in the soil profile and to adjacent areas through both natural and man-assisted processes.

Street Dirt Accumulation

The washoff of street dirt and the effectiveness of street cleaning as a stormwater control practice are highly dependent on the available street dirt loading. Street dirt loadings are the result of deposition and removal rates, plus "permanent storage." The permanent storage component is a function of street texture and condition and is the quantity of street dust and dirt that cannot be removed naturally or by street cleaning equipment. It is literally trapped in the texture, or cracks, of the street. The street dirt loading at any time is this initial permanent loading plus the accumulation amount corresponding to the exposure period, minus the re-suspended material removal by wind and traffic-induced turbulence. Removal of street dirt can occur naturally by winds and rain, or by human activity (e.g., by the turbulence of traffic or by street cleaning equipment). Very little removal occurs by any process when the street dirt loadings are small, but wind removal may be very large with larger loadings, especially for smooth streets (Pitt 1979).

Figure 4-1 shows very different street dirt loadings for two San Jose, CA residential study areas (Pitt 1979). The accumulation and deposition rates (and therefore the amounts lost to air) are quite similar, but the initial loading values (the permanent storage values) are very different. The loading differences were almost solely caused by the different street textures.

Table 4-4 summarizes many accumulation rate measurements obtained from throughout North America. In the earliest studies (APWA 1969; Sartor and Boyd 1972; and Shaheen 1975), the initial street dirt loading values after a major rain or street cleaning were assumed to be zero. Calculated accumulation rates for rough streets were, therefore, very large. Later tests measured the initial loading values close to the end of major rains and street cleaning and found that they could be very high, depending on the street texture. When these starting loadings were considered, the calculated accumulation rates were, therefore, much lower. The early, uncorrected, Sartor and Boyd accumulation rates that ignored the initial loading values were almost ten times the correct values shown on this table. Unfortunately, most urban stormwater models used these very high early accumulation rates as default values.

The most important factors affecting the initial loading and maximum loading values shown on Table 4-4 were found to be street texture and street condition. When data from many locations are studied, it is apparent that smooth streets have substantially less loadings at any accumulation period compared to rough streets for the same land use. Very long accumulation periods relative to the rain frequency resultant in high street dirt loadings. During these conditions, the wind losses of street dirt (as fugitive dust) may approximate the deposition rate, resulting in relatively constant street dirt loadings. At Bellevue, WA, typical interevent rain periods average about three days. Relatively constant street dirt loadings were observed in Bellevue because the frequent rains kept the loadings low and very close to the initial storage value, with little observed increase in dirt accumulation over time (Pitt 1985). In Castro Valley, CA, the rain interevent periods were much longer (ranging from about 20 to 100 days) and steady loadings were only observed after about 30 days when the loadings became very high and fugitive dust losses caused by the winds and traffic turbulence moderated the loadings (Pitt and Shawley 1982).

An example of the type of research conducted to obtain the values shown in Table 4-4 was conducted by Pitt and McLean (1986) in Toronto. They measured street dirt accumulation rates and the effects of street cleaning as part of a comprehensive stormwater research project. An industrial street with heavy traffic and a residential street with light traffic were monitored about twice a week for three months. At the beginning of this period, intensive street cleaning (one pass per day for each of three consecutive days) was conducted to obtain reasonably clean streets. Street dirt loadings were then monitored every few days to measure the accumulation rates of street dirt. Street dirt sampling procedures developed by Pitt (1979) were applied. Powerful industrial vacuums (two units, each having two HP, combined with a "Y" connector, and using a six inch wide solid aluminum head) were used to clean many separate subsample strips across the roads which were then combined for physical and chemical analyses.

In Toronto, the street dirt particulate loadings were quite high before the initial intensive street cleaning period and were reduced to their lowest observed levels immediately after the last street cleaning. After street cleaning, the loadings on the industrial street increased much faster than for the residential street. Right after intensive cleaning, the street dirt particle sizes were also similar for the two land uses. However, the loadings of larger particles on the industrial street increased at a much faster rate than on the residential street, indicating more erosion or tracking materials being deposited onto the industrial street. The residential street dirt measurements did not indicate that any material was lost to the atmosphere as fugitive dust, probably because of the low street dirt accumulation rate and the short periods of time between rains. The street dirt loadings never had the opportunity to reach the high loading values needed before they could be blown from the streets by winds or by traffic-induced turbulence. The industrial street, in contrast, had a much greater street dirt accumulation rate and reached the critical loading values needed for fugitive losses in the relatively short periods between the rains.

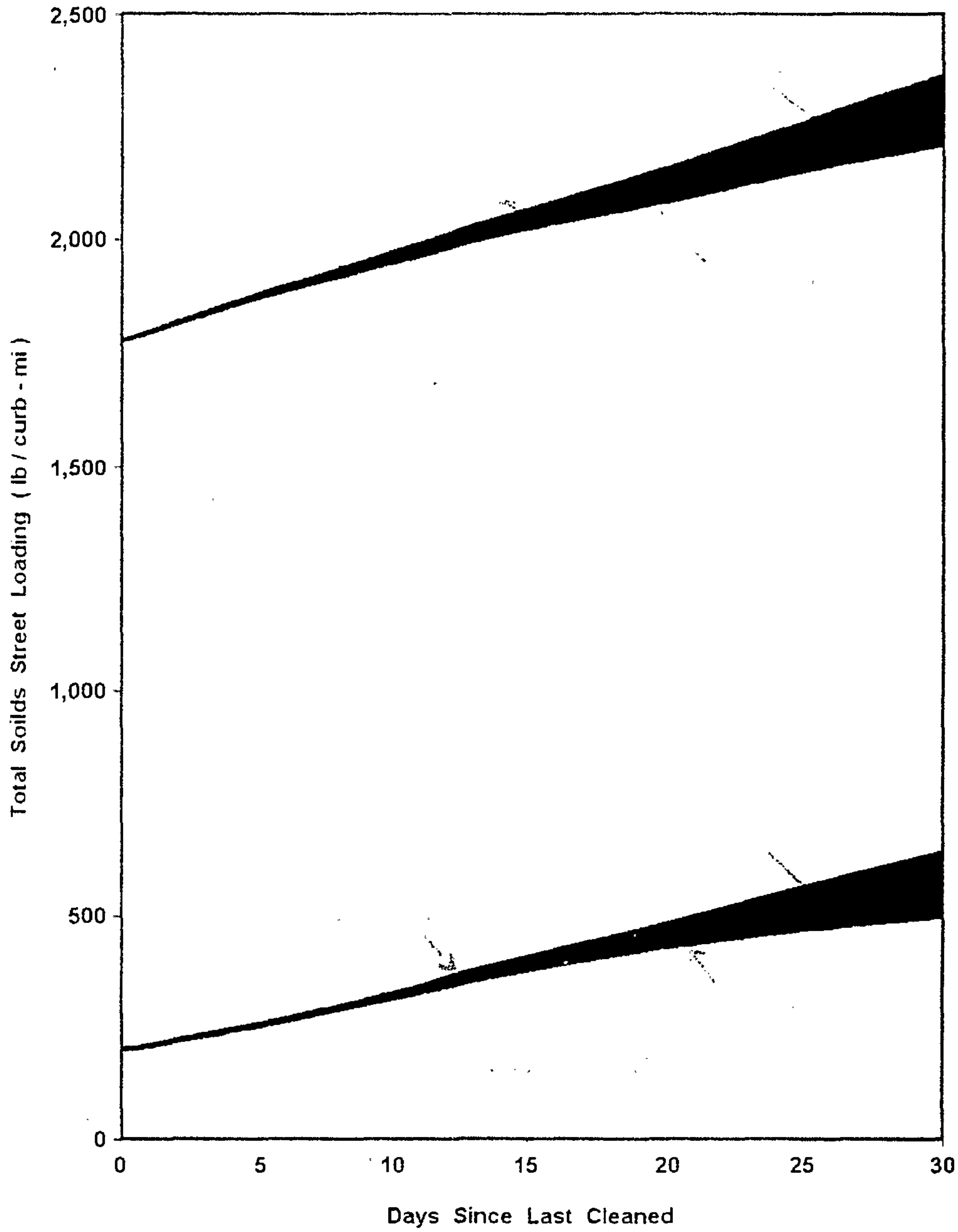

Figure 4-1. Deposition and accumulation of street dirt (Pitt 1979).

Table 4-4. Street dirt loadings and deposition rates.

	Initial Loading Value (grams/curb-meter)	Daily Deposition Rate (grams/curb-meter-day)	Maximum Observed Loading (grams/curb-meter)	Days to Observed Maximum Loading	Reference
Smooth and Intermediate Textured Streets					
Reno/Sparks, NV – good condition	80	1	85	5	Pitt and Sutherland 1982
Reno/Sparks, NV – good with smooth gutters (windy)	250	7	400	30	Pitt and Sutherland 1982
San Jose, CA – good condition	35	4	>140	>50	Pitt 1979
U S. nationwide – residential streets, good condition	1[illegible]0	6	140	5	Sartor and Boyd 1972 (corrected)
U.S. nationwide – commercial street, good condition	85	4	140	5	Sartor and Boyd 1972 (corrected)
Reno/Sparks, NV – moderate to poor condition	200	2	200	5	Pitt and Sutherland 1982
Reno/Sparks, NV – new residential area (construction)	710	17	910	15	Pitt and Sutherland 1982
Reno/Sparks, NV – poor condition, with lipped gutters	370	15	630	35	Pitt and Sutherland 1982
San Jose, CA -- fair to poor condition	80	4	230	70	Pitt 1979
Castro Valley, CA -- moderate condition	85	10	290	70	Pitt and Shawley 1982
Ottawa, Ontario -- moderate condition	40	20	Na	Na	Pitt 1983
Toronto, Ontario – moderate condition, residential	40	32	100	>10	Pit and McLean 1986
Toronto, Ontario – moderate condition, industrial	60	40	351	>10	Pit and McLean 1986
Bellevue, WA – dry period, moderate condition	140	6	>230	20	Pitt 1984
Bellevue, WA – heavy traffic	60	1	110	30	Pitt 1984
Bellevue, WA – other residential sites	70	3	140	30	Pitt 1984
Average:	150	9	>270	>25	
Range:	35 - 710	1 - 40	85 – 910	5 - 70	
Rough and Very Rough Textured Streets					
San Jose, CA – oil and screens overlay	510	6	>710	>50	Pitt 1979
Ottawa, Ontario – very rough	310	20	Na	Na	Pitt 1983
Reno/Sparks, NV	630	10	860	35	Pitt and Sutherland 1982
Reno/Sparks, NV – windy	540	34	>1,400	>40	Pitt and Sutherland 1982
San Jose, CA – poor condition	220	6	430.	30	Pitt 1979
Ottawa, Ontario – rough	200	20	Na	Na	Pitt 1983
U.S. nationwide – industrial streets (poor condition)	190	10	370	10	Sartor and Boyd 1972 (corrected)
Average:	370	15	>750	>30	
Range:	190 - 630	6 - 34	370 - >1,400	10 - >50	

Washoff of Street Dirt

The Yalin equation relates the sediment carrying capacity to runoff flow rate (Yalin 1963). Yalin stated that sediment motion begins when the lift force of flow exceeds a critical lift force. Once a particle is lifted, the drag force of the flow moves it downstream until the weight of the particle forces it back down. The Yalin equation is used to predict particle transport, for specific particle sizes, on a weight per unit flow width basis. It is used for fully turbulent channel flow conditions, typical of shallow overland flow in urban areas. The receding limb (tail) of a hydrograph may have laminar flow conditions, and the suspended sediment carried in the previously turbulent flows would settle out. The predicted constant Yalin sediment load would therefore only occur during periods of rain, and, the sediment load would decrease, due to sedimentation, after the rain stops.

The critical particle bedload tractive force, the tractive force at which the particle begins to move, can be obtained from the Shields' diagram. However, Shen (1981) warned that the Shields' diagram alone cannot be used to predict "self-cleaning" velocities, because it gives only a lower limit below which deposition will occur. It defines the boundary between bed movement and stationary bed conditions. The Shields' diagram does not consider the particulate supply rate in relationship to the particulate transport rate. Reduced particulate transport occurs if the sediment supply rate is less than the transport rate. The Yalin equation by itself is, therefore, not sensitive to particulate supply; it only predicts the carrying capacity of flowing waters.

Besides the particulate supply rate, the Yalin equation is also very sensitive to local flow parameters (specifically gutter flow depth). Therefore, a hydraulic model that can accurately predict sheetflow across impervious surfaces and gutter flow is needed. Sutherland and McCuen (1978) statistically analyzed a modified form of the Yalin equation, in conjunction with a hydraulic model for different gutter flow conditions. Except for the largest particle sizes, the effect of rain intensity on particle washoff was found to be negligible.

The Yalin equation is based on classical sediment transport equations and requires some assumptions concerning the micro-scale aspects of gutter flows and street dirt distributions. The Yalin equation, as typically used in urban stormwater evaluations, assumes that all particles lie within the gutter and no significant washoff occurs by sheetflows traveling across the street towards the gutter. The early measurements of across-the-street dirt distributions made by Sartor and Boyd (1972) indicated that about 90 percent of the street dirt was within about 30 cm of the curb face (typically within the gutter area). These measurements, however, were made in areas of no parking (near fire hydrants because of the need for water for the sampling procedures that were used) and the traffic turbulence was capable of blowing most of the street dirt against the curb barrier (or over the curb onto adjacent sidewalks or landscaped areas) (Shaheen 1975).

In later tests, Pitt (1979) and Pitt and Sutherland (1982) examined street dirt distributions across the street in many additional situations. They found distributions similar to Sartor and Boyd's observations only on smooth streets, with moderate to heavy traffic, and with no on-street parking. In many cases, most of the street dirt was actually in the driving lanes, trapped by the texture of rough streets. If extensive on-street parking was common, much of the street dirt was found on the outside edge of the parking lanes, where much of the resuspended (in air) street dirt blew against the parked cars and settled to the pavement.

Another process that may result in washoff less than predicted by Yalin is bed armoring (Sutherland et al. 1982). As the smaller particulates are removed, the surface is covered by predominantly larger particulates which are not effectively washed-off by rain. Eventually, these larger particulates hinder the washoff of the trapped, underlying, smaller particulates. Debris on the street, especially leaves, can also effectively armor the particulates, reducing the washoff of particulates to very low levels (Singer and Blackard 1978).

Observations of particulate washoff during controlled tests using actual streets and natural street dirt and debris are affected by street dirt distributions and armoring. The earliest controlled street dirt washoff experiments were conducted by Sartor and Boyd (1972) during the summer of 1970 in Bakersfield, CA. Their data were used in many stormwater models (including SWMM, Huber and Heaney 1981; STORM, COE 1975; and HSPF, Donigian and Crawford 1976) to estimate the percentage of the available particulates on the streets that would wash off during rains of different magnitudes. Sartor and Boyd used a rain simulator having many nozzles and a drop height of 1.5 to two meters in street test areas of about five by ten meters. Tests were conducted on concrete, new asphalt, and old asphalt, using simulated rain intensities of about five and 20 mm/hr. They collected and analyzed runoff samples every 15 minutes for about two hours for each test. Sartor and Boyd fitted their data to an exponential curve, assuming that the rate of particle removal of a given size is proportional to the street dirt loading and the constant rain intensity:

$$dN/dt = krN$$

where: dN/dt = the change in street dirt loading per unit time
k = proportionality constant (1/hr)
r = rain intensity (in/hr)
N = street dirt loading (lb/curb-mile)

This equation, upon integration, becomes:

$$N = N_0 e^{-krt}$$

where: N = residual street dirt load (after the rain)
N_o = initial street dirt load
t = rain duration (hr)

Street dirt washoff is, therefore, equal to N_o minus N. The variable combination rt, or rain intensity (in/hr) times rain duration (t), is equal to total rain depth (R), in inches. This equation then further reduces to:

$$N = N_o e^{-kR}$$

Therefore, this equation is only sensitive to the total depth of the rain that has fallen since the beginning of the rain, and not rain intensity. Because of decreasing particulate supplies, the exponential washoff curve also predicts decreasing concentrations of particulates with time since the start of a constant rain (Alley 1980 and 1981).

The proportionality constant, k, was found by Sartor and Boyd to be slightly dependent on street texture and condition, but was independent of rain intensity and particle size. The value of this constant is usually taken as 0.18/mm, assuming that 90 percent of the particulates will be washed from a paved surface in one hour during a 13 mm/hr rain. However, Alley (1981) fitted this model to watershed outfall runoff data and found that the constant varied for different storms and pollutants for a single study area. Novotny (as part of Bannerman et al. 1983) also examined "before" and "after" rain event street particulate loading data from the Milwaukee Nationwide Urban Runoff Program (NURP) project and found almost a three-fold difference between the constant value of k for fine (<45 μm) and medium sized particles (100 to 250 μm). The calculated values were 0.026/mm for the fine particles and 0.01/mm for the medium sized particles, both much less than the "accepted" value of 0.18/mm. Jewell et al. (1980) also found large variations in outfall "fitted" constant values for different rains compared to the typical default value. Either the assumption of the high removal of particulates during the 13 mm/hr storm was incorrect or/and the equation cannot be fitted to outfall data (most likely, as this would require that all the particulates are originating from homogeneous paved surfaces during all storm conditions).

This washoff equation has been used in many stormwater models, along with an expression for an availability factor. An availability factor is needed, because N_o is only the portion of the total street load available for washoff. This availability factor (the fraction of the total street dirt loading available for washoff) is generally used as 1.0 for all rain intensities greater than about 18 mm/hr and reduces to about 0.10 for rains of one mm/hr.

The Bellevue, WA urban runoff project (Pitt 1985) included about 50 pairs of street dirt loading observations close to the beginnings and ends of rains. These "before" and "after" loading values were compared to determine significant differences in loadings that may have been caused by the rains. The observations were affected by rains falling directly on the streets, along with flows and particulates originating from non-street areas. The net loading differences were, therefore, affected by street dirt washoff (by direct rains on the street surfaces and by gutter flows augmented by "upstream" area runoff) and by erosion products that originated from non-street areas that may have settled out in the gutters. When all the data were considered together, the net loading difference was about 10 to 13 g/curb-m removed. This amounted to a street dirt load reduction of about 15 percent, which was much less than predicted using either of the two previously described washoff models. Very large reductions in street dirt loadings during rains were observed in Bellevue for the smallest particles, but the largest particles actually increased in loadings (due to deposited erosion materials originating from off-street areas). The particles were not source limited, but armor shielding may have been important. Most of the particulates in the runoff were in the fine particle sizes (<63 µm). Very few particles greater than 1000 µm were found in the washoff water. Care must be taken to not confuse street dirt particle size distributions with stormwater runoff particle size distributions. The stormwater particle size distributions are much more biased towards the smaller sizes, as described later.

Suspended solids washoff predictions for Bellevue conditions were made using the Sutherland and McCuen modification of the Yalin equation and the Sartor and Boyd equation. Three particle size groups (<63, 250-500, and 2000-6350 µm), and three rains, having depths of 5, 10, and 20 mm and 3-hr durations, were considered. The gutter lengths for the Bellevue test areas averaged about 80 m, with gutter slopes of about 4.5%. Typical total initial street dirt loadings for the three particle sizes were: 9 g/curb-m for <63 µm, 18 g/curb-m for 250-500 µm, and 9 g/curb-m for 2000-6350 µm. The actual Bellevue net loading removals during the storms were about 45% for the smallest particle size group, 17% for the middle particle size group, and minus six percent (six percent loading increase) for the largest particle size group. The predicted removals were 90 to 100% using the Sutherland and McCuen method, 61 to 98% using the Sartor and Boyd equation, and 8 to 37% using the availability factor with the Sartor and Boyd equation. The ranges given reflect the different rain volumes and intensities only. There were no large predicted differences in removal percentages as a function of particle size. The availability factor with the Sartor and Boyd equation resulted in the closest predicted values, but the great differences in washoff as a function of particle size was not predicted.

The Bellevue street dirt washoff observations included effects of additional runoff water and particulates originating from non-street areas. The additional flows should have produced more gutter particulate washoff, but upland erosion materials may also have settled in the gutters (as noted for the large particles). However, across-the-street particulate loading measurements indicated that much of the street dirt was in the street lanes, not in the gutters, before and after rains. This particulate distribution reduces the importance of these extra flows and particulates from upland areas. The increased loadings of the largest particles after rains were obviously caused by upland erosion, but the magnitude of the settled amounts was quite small compared to the total street dirt loadings.

In order to clarify street dirt washoff, Pitt (1987) conducted numerous controlled washoff tests on city streets in Toronto. These tests were arranged as an overlapping series of 2^3 factorial tests, and were analyzed using standard factorial test procedures described by Box et al. (1978). The experimental factors examined included: rain intensity, street texture, and street dirt loading. The differences between available and total street dirt loads were also related to the experimental factors. The samples were analyzed for total solids (total residue), dissolved solids (filterable residue: <0.45 μm), and SS (particulate residue: >0.45 μm). Runoff samples were also filtered through 0.45 μm filters and the filters were microscopically analyzed (using low power polarized light microscopes to differentiate between inorganic and organic debris) to determine particulate size distributions from about 1 to 500 μm. The runoff flow quantities were also carefully monitored to determine the magnitude of initial and total rain water losses on impervious surfaces.

The total solids concentrations varied from about 25 to 3000 mg/l, with an obvious decrease in concentrations with increasing rain depths during these constant rain intensity tests. No concentrations greater than 500 mg/l occurred after about two mm of rain. All concentrations after about 10 mm of rain were less than 100 mg/l. Total solids concentrations were independent of the test conditions. A wide range in runoff concentrations was also observed for SS, with concentrations ranging from about 1 to 3000 mg/l. Again, a decreasing trend of concentrations was seen with increasing rain depths, but the data scatter was larger because of the experimental factors. The dissolved solids (<0.45 μm) concentrations ranged from about 20 to 900 mg/l, comprising a surprisingly large percentage of the total solids loadings. For small rain depths, dissolved solids comprised up to 90 percent of the total solids. After 10 mm of rain depth, the filterable residue concentrations were all less than about 50 mg/l.

Manual particle size analyses were also conducted on the suspended solids washoff samples, using a microscope with a calibrated recticle. Figures 4-2 and 4-3 are examples of particle size distributions for two tests. These plots show the percentage of the particles that were less than various sizes, by measured particle volume (assumed to be similar to weight). The plots also indicate median particle sizes of about 10 to 50 μm, depending on when the sample was obtained during the washoff tests. All of the distributions showed surprisingly similar trends of particle sizes with elapsed rain depth. The median size for the sample obtained at about one mm of rain was much greater than for the samples taken after more rain. The median particle sizes of material remaining on the streets after the washoff tests were also much larger than for most of the runoff samples, but were quite close to the initial samples' median particle sizes. The washoff water at the very beginning of the test rains, therefore, contained many more larger particles than during later portions of the rains. Also, a substantial amount of larger particles remained on the streets after the test rains. Most street runoff waters during test rains in the 5 to 15 mm depth category had median suspended solids particle sizes of about 10 to 50 μm. However, dissolved solids (less than 0.45 μm) made up most of the total solids washoff for elapsed rain depths greater than about five mm.

These particle size distributions indicate that the smaller particles were much more important than indicated during previous tests. As an example, the Sartor and Boyd (1972) washoff tests (rain intensities of 50 mm/h for two hour durations) found median particle sizes of about 150 μm which were typically three to five times larger than were found during these tests. They also did not find any significant particle size distribution differences for different rain depths (or rain duration), in contrast to the Toronto tests, which were conducted at more likely rain intensities (3 to 12 mm/hr for two hours).

The particulate washoff values obtained during these Toronto tests were expressed in units of grams per square meter and grams per curb-meter, concentrations (mg/l), and the percent of the total initial loading washed off during the test. Plots of accumulative washoff are shown on Figures 4-4 through 4-11. These plots show the asymptotic washoff values observed in the tests, along with the measured total street dirt loadings. The maximum asymptotic values are the "available" street dirt loadings (N_o). The measured total loadings are seen to be several times larger than these "available" loading values. As an example, the asymptotic available total solids value for the HDS (high intensity rain, dirty street, smooth street) test (Figure 4-10) was about 3 g/m^2 while the total load on the street for this test was about 14 g/m^2, or about five times the available load. The differences between available and total loadings for the other tests were even greater, with the total loads typically about ten times greater than the available loads. The total loading and available loading values for dissolved solids were quite close, indicating almost complete washoff of the very small particles. However, the differences between the two loading values for SS were much greater. Shielding, therefore, may not have been very important during these tests, as almost all of the smallest particles were removed, even in the presence of heavy loadings of large particles.

The actual data are shown on these figures, along with the fitted Sartor and Boyd exponential washoff equations. In many cases, the fitted washoff equations greatly over-predicted suspended solids washoff during the very small rains (usually less than one to three mm in depth). In all cases, the fitted washoff equations described suspended solids washoff very well for rains greater than about 10 mm in depth.

Table 4-5 presents the equation parameters for each of the eight washoff tests for suspended solids. Pitt (1987) concluded that particulate washoff should be divided into two main categories, one for high intensity rains with dirty streets, possibly divided into categories by street texture, and the other for all other conditions. Factorial tests also found that the availability factor (the ratio of the available loading, N_o, to the total loading) varied depending on the rain intensity and the street roughness, as indicated below:

- Low rain intensity and rough streets: 0.045
- High rain intensity and rough streets, or low rain intensity and smooth streets: 0.075
- High rain intensity and smooth streets: 0.20

Obviously, washoff was more efficient for the higher rain energy and smoother pavement tests. The worst case was for a low rain intensity and rough street, where only about 4.5% of the street dirt would be washed from the pavement. In contrast, the high rain intensities on the smooth streets were more than four times more efficient in removing the street dirt.

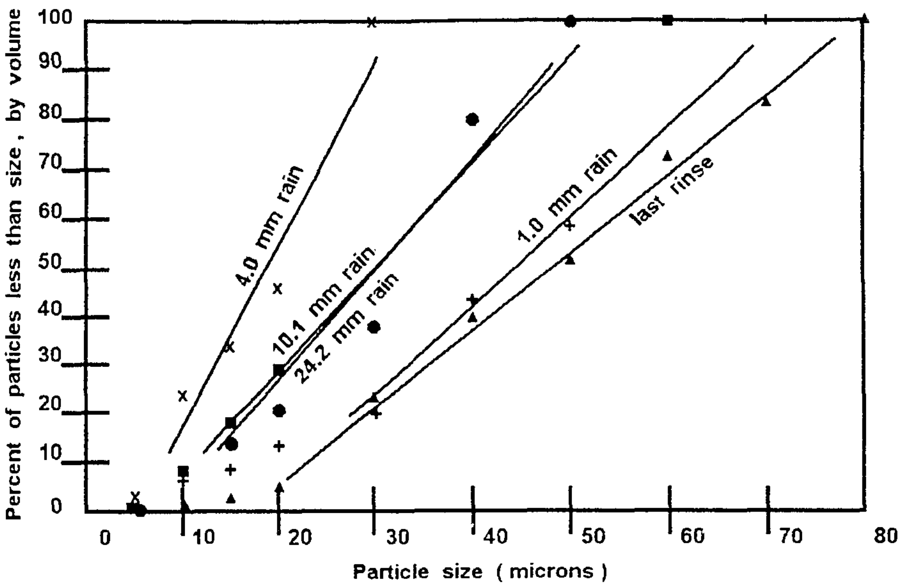

Figure 4-2. Particle size distribution of HDS test (high rain intensity, dirty, and smooth street) (Pitt 1987).

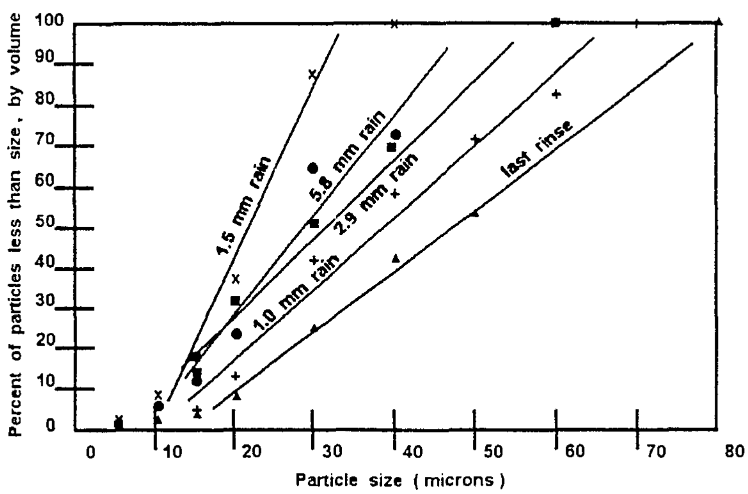

Figure 4-3. Particle size distribution for LCR test (light rain intensity, clean, and rough street) (Pitt 1987).

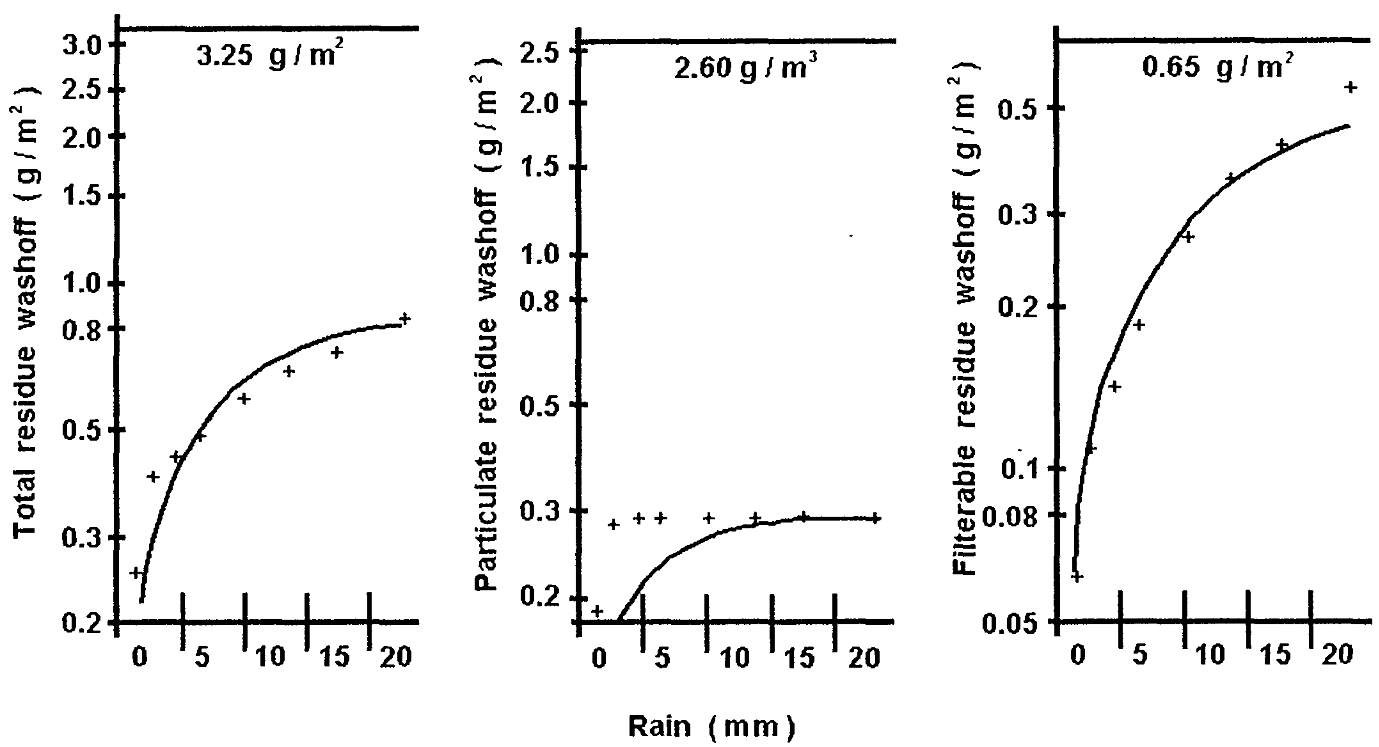

Figure 4-4. Washoff plots for HCR test (high rain intensity, clean, and rough street) (Pitt 1987).

R0009707

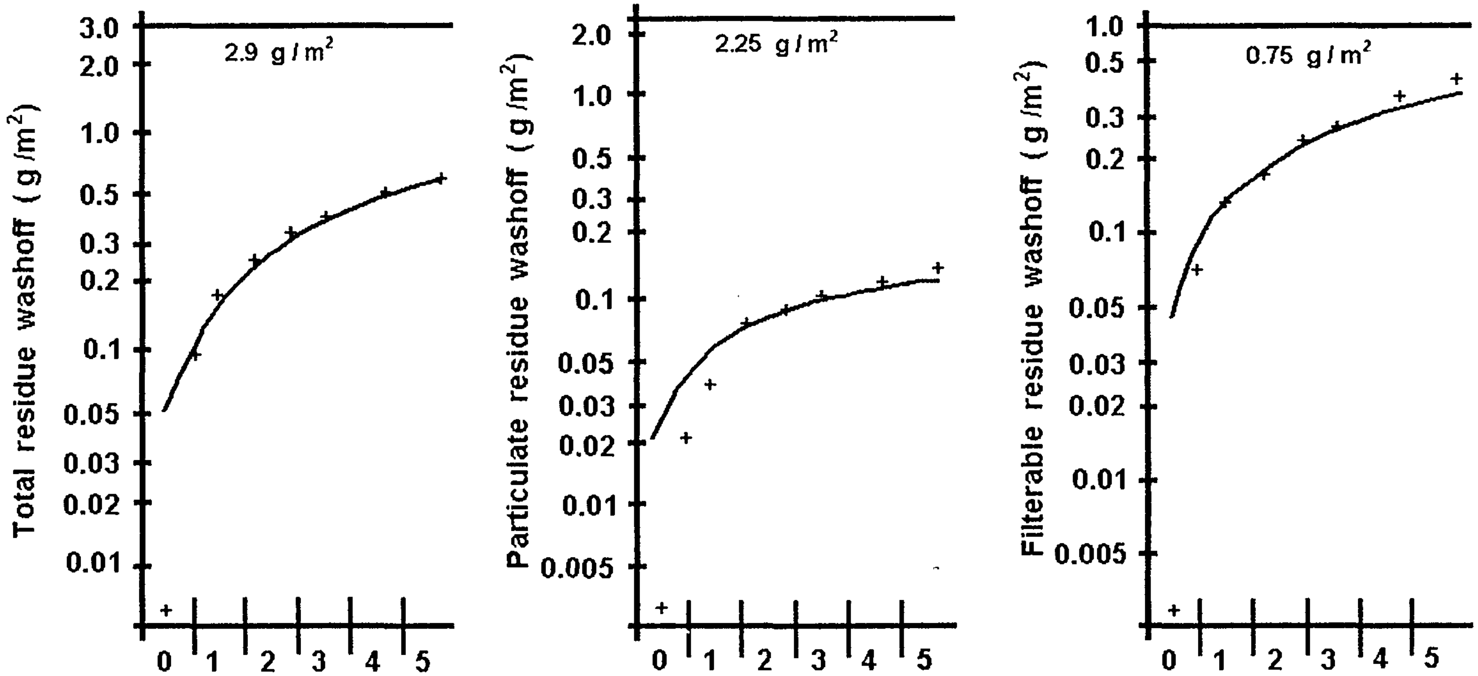

Figure 4-5. Washoff plots for LCR test (light rain intensity, clean, and rough street) (Pitt 1987).

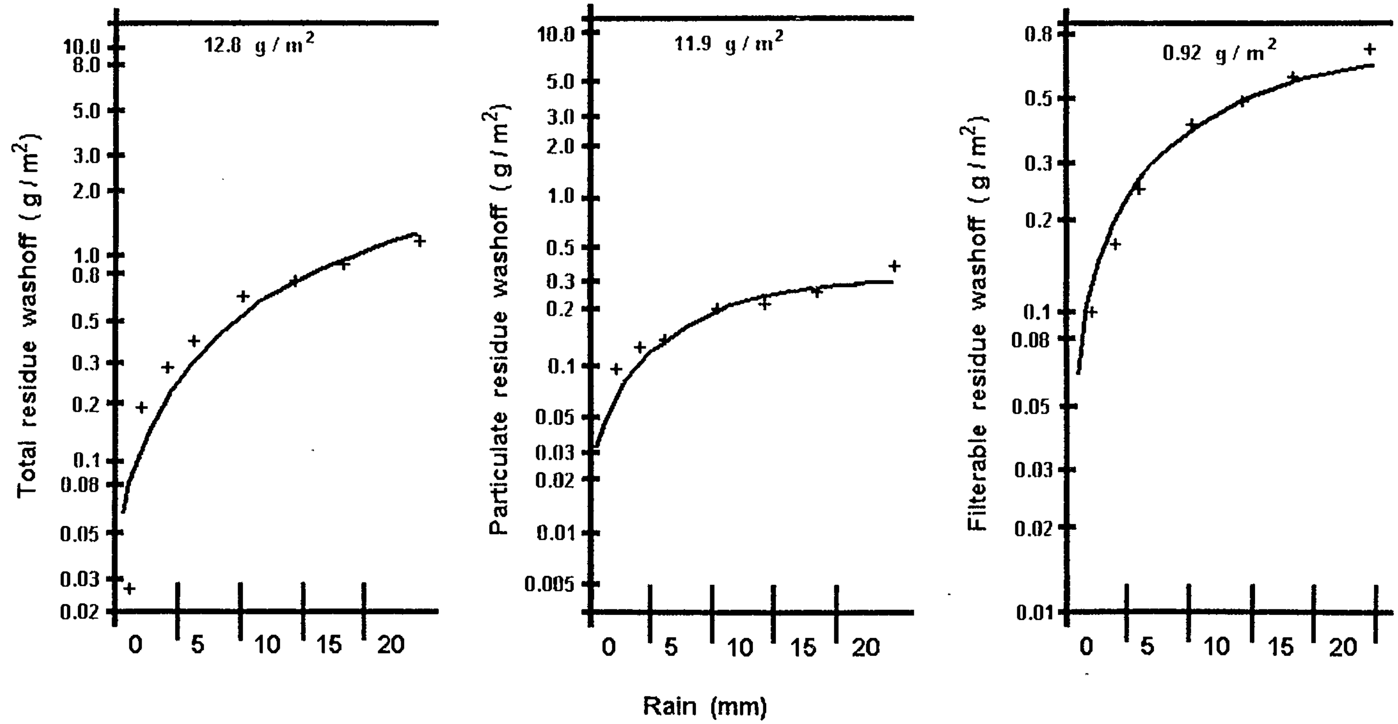

Figure 4-6. Washoff plots for HDR test (high rain intensity, dirty, and rough street) (Pitt 1987).

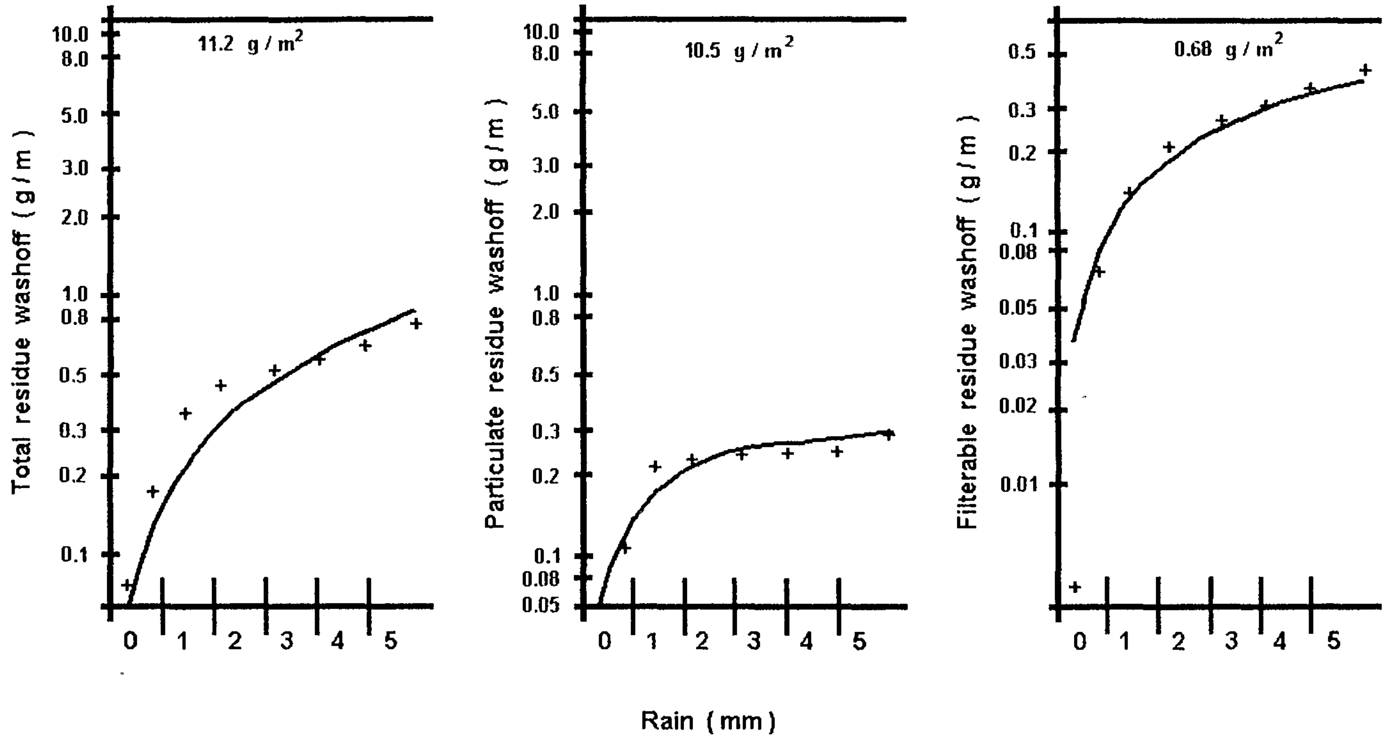

Figure 4-7. Washoff plots for LDR test (light rain intensity, dirty, and rough street) (Pitt 1987).

R0009710

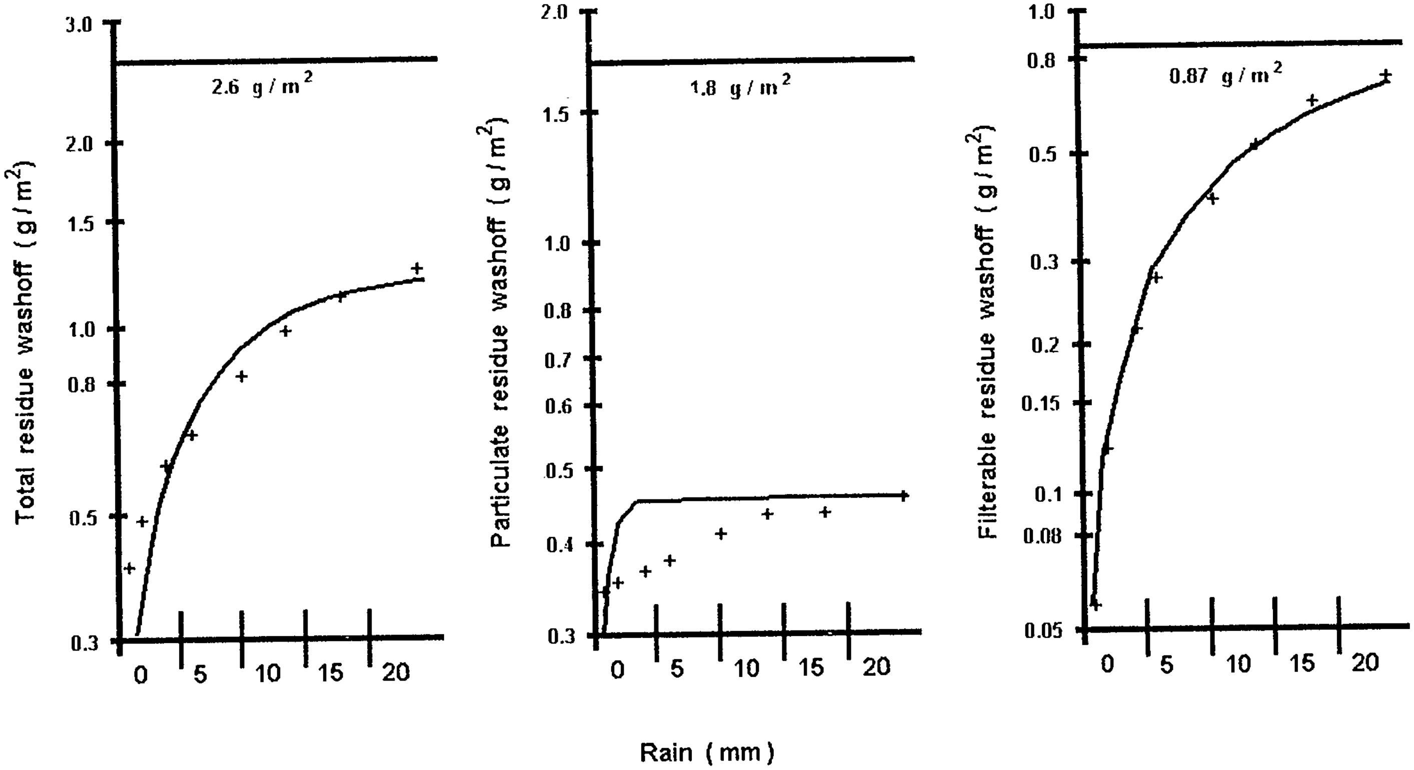

Figure 4-8. Washoff plots for HCS test (high rain intensity, clean, and smooth street) (Pitt 1987).

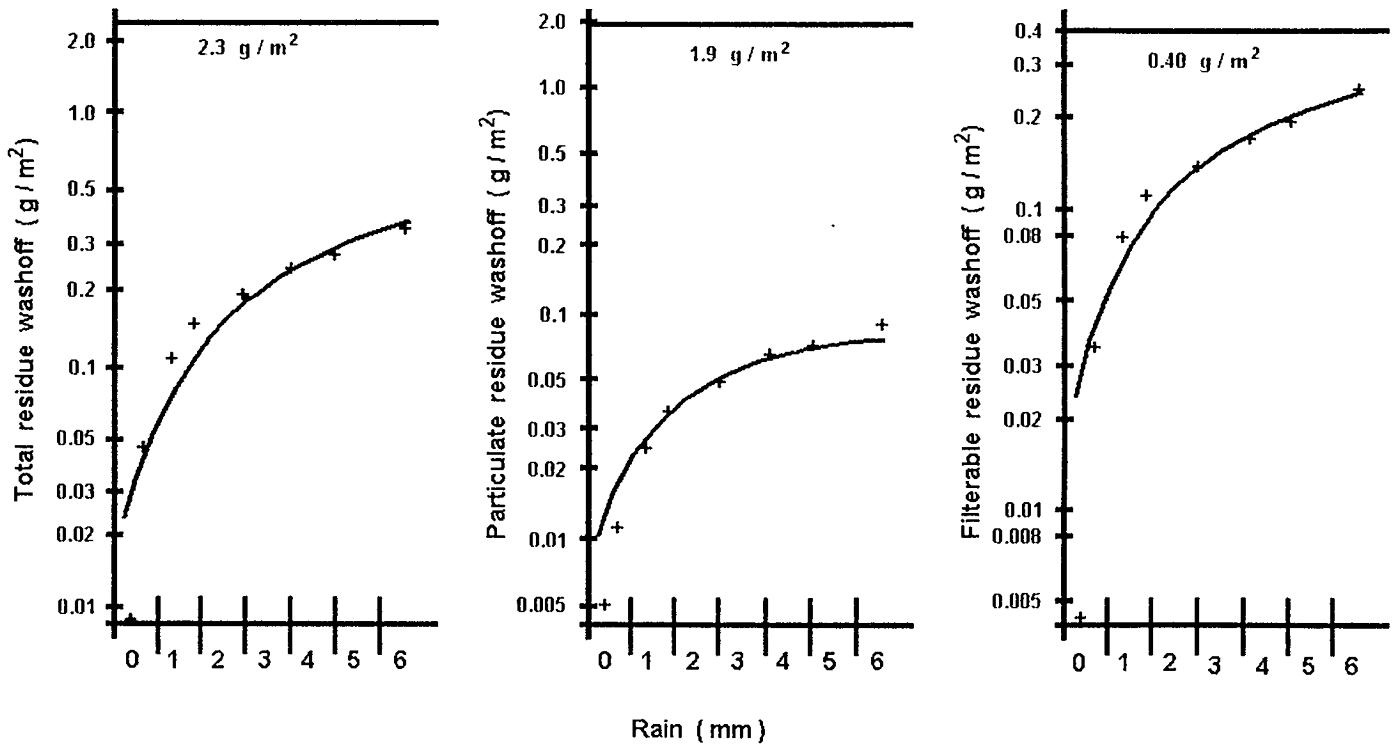

Figure 4-9. Washoff plots for LCS test (light rain intensity, clean, and smooth street) (Pitt 1987).

R0009712

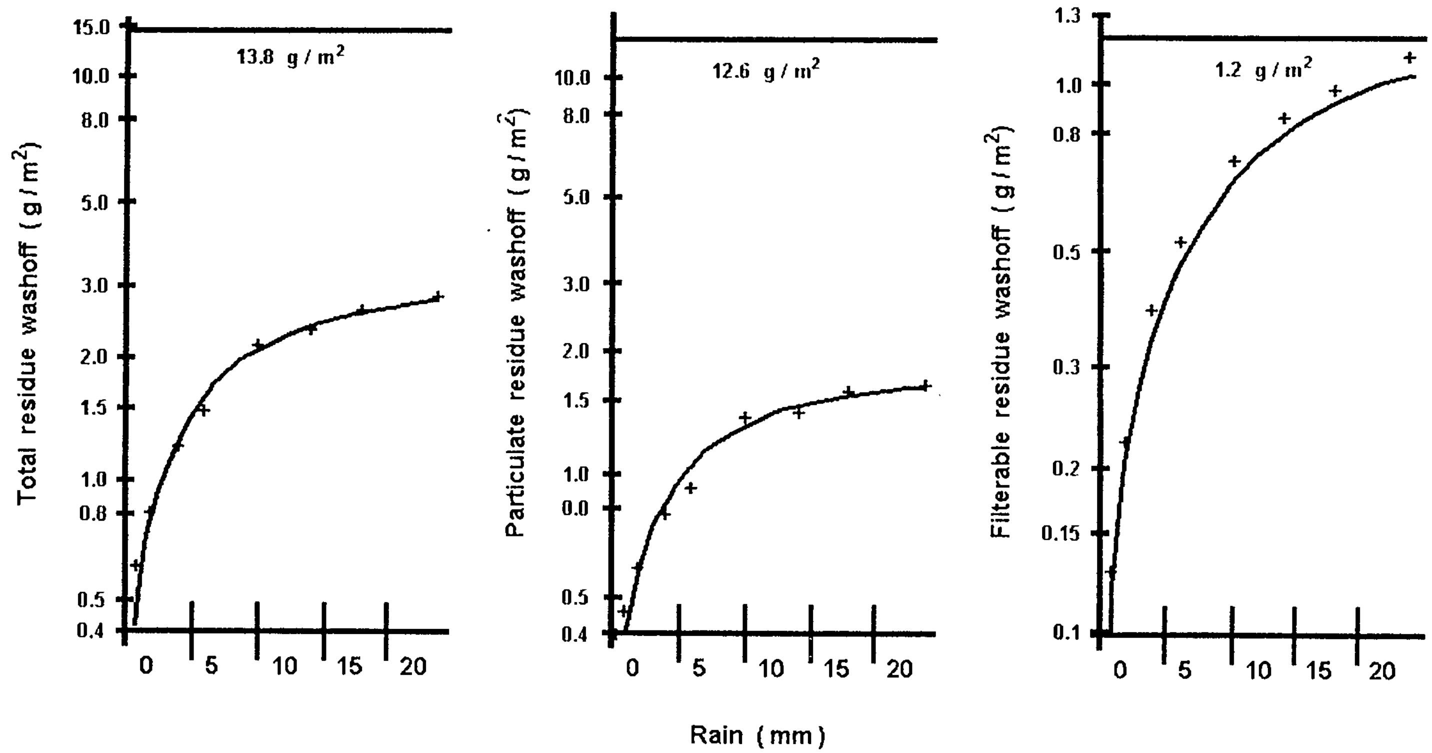

Figure 4-10. Washoff plots for HDS test (high rain intensity, dirty, and smooth street) (Pitt 1987).

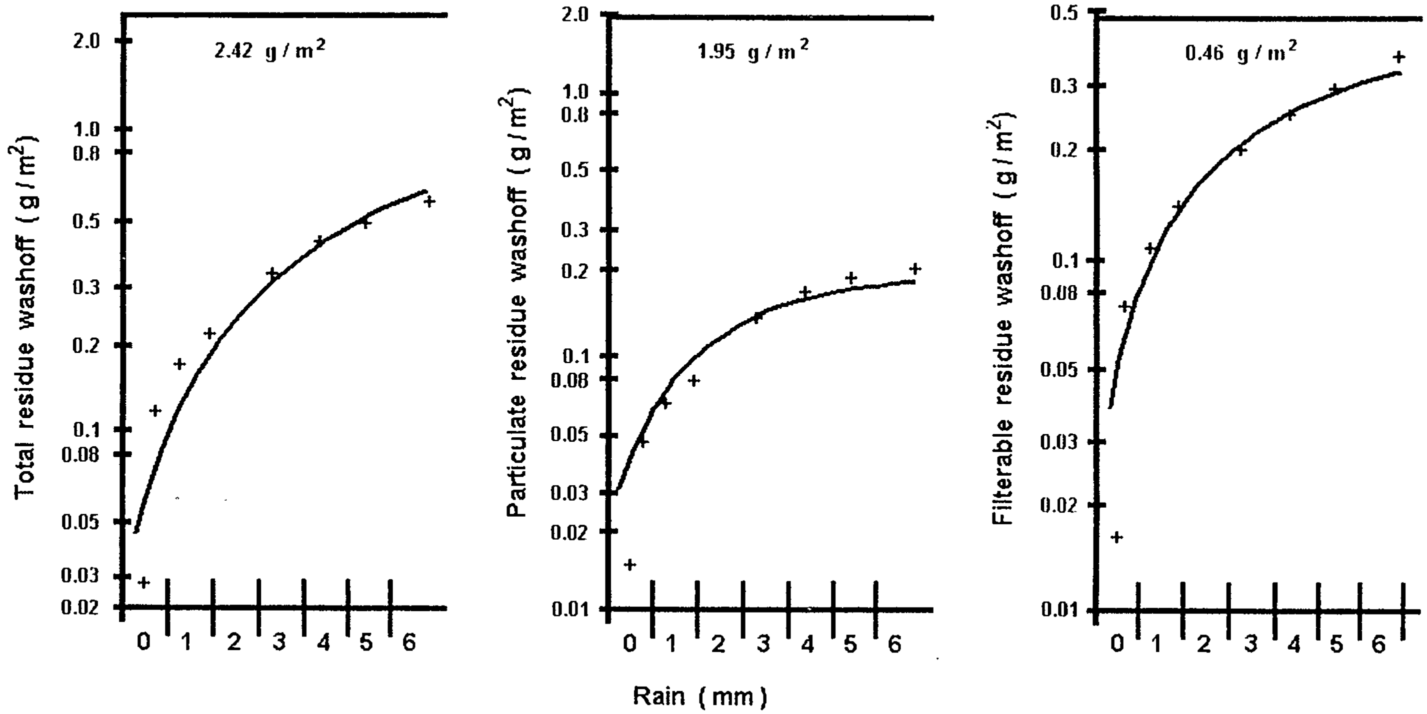

Figure 4-11. Washoff plots for LCS replicate test (light rain intensity, clean, and smooth street) (Pitt 1987).

R0009714

Table 4-5. Suspended solids washoff coefficients (Pitt 1987)[1].

Test condition code	Rain intensity category	Street dirt loading category	Street texture category	Calculated k (1/hr)	Standard error for k (1/hr)	Ratio of available load to total initial load
HCR	high	clean	rough	0.832	0.064	0.11
LCR	low	clean	rough	0.344	0.038	0.061
HDR	high	dirty	rough	0.077	0.008	0.032
LDR	low	dirty	rough	0.619	0.052	0.028
HCS	high	clean	smooth	1.007	0.321	0.26
LCS	low	clean	smooth	0.302	0.024	0.047
HDS	high	dirty	smooth	0.167	0.015	0.13
LCS	low	clean	smooth	0.335	0.031	0.11

1) Note:

$$N = N_o e^{-kR}$$

where: N = residual street dirt load, after the rain (lb/curb-mile)
N_o = initial street dirt load (lb/curb-mile)
R = rain depth (inches)
k = proportionality constant (1/hr)

Observed Particle Size Distributions in Stormwater

The particle size distributions of stormwater greatly affect the ability of most controls to reduce pollutant discharges. This research included particle size analyses of 121 stormwater samples from three states that were not affected by stormwater controls (southern New Jersey as part of the inlet tests; Birmingham, AL as part of the MCTT pilot-scale tests; and in Milwaukee and Minocqua, WI, as part of the MCTT full-scale tests). These samples represented stormwater entering the stormwater controls being tested. Particle sizes were measured using a Coulter Multi-Sizer IIe and verified with microscopic, sieve, and settling column tests.

Figures 4-12 through 4-14 are grouped box and whisker plots showing the particle sizes (in µm) corresponding to the 10^{th}, 50^{th} (median) and 90^{th} percentiles of the cumulative distributions. If 90% control of SS was desired, for example, then the particles larger than the 90^{th} percentile would have to be removed. The median particle sizes ranged from 0.6 to 38 µm and averaged 14 µm. The 90^{th} percentile sizes ranged from 0.5 to 11 µm and averaged 3 µm. These particle sizes are all substantially smaller than have been typically assumed for stormwater. In all cases, the New Jersey samples had the smallest particle sizes, followed by Wisconsin, and then Birmingham, AL, which had the largest particles. The New Jersey samples were obtained from gutter flows in a residential semi-xeroscaped neighborhood, the Wisconsin samples were obtained from several source areas, including parking areas and gutter flows mostly from residential, but from some commercial areas, and the Birmingham samples were collected from a long-term parking area.

Atmospheric Sources of Urban Runoff Pollutants

Atmospheric processes affecting urban runoff pollutants include dry dustfall and precipitation quality. These have been monitored in many urban and rural areas. In many instances, however, the samples were combined as a bulk precipitation sample before processing. Automatic precipitation sampling equipment can distinguish between dry periods of fallout and precipitation. These devices cover and uncover appropriate collection jars exposed to the atmosphere. Much of this information has been collected as part of the Nationwide Urban Runoff Program (NURP) and the Atmospheric Deposition Program, both sponsored by the USEPA (EPA 1983a).

This information must be interpreted carefully, because of the ability of many polluted dust and dirt particles to be resuspended and then redeposited within the urban area. In many cases, the measured atmospheric deposition measurements include material that was previously residing and measured in other urban runoff pollutant source areas. Also, only small amounts of the atmospheric deposition material would directly contribute to runoff. Rain is subjected to infiltration and the dry fall particulates are likely mostly incorporated with surface soils and only small fractions are then eroded during rains. Therefore, mass balances and determinations of urban runoff deposition and accumulation from different source areas can be highly misleading, unless transfer of material between source areas and the effective yield of this material to the receiving water is considered. Depending on the land use, relatively little of the dustfall in urban areas likely contributes to stormwater discharges.

Dustfall and precipitation affect all of the major urban runoff source areas in an urban area. Dustfall, however, is typically not a major pollutant source but fugitive dust is mostly a mechanism for pollutant transport, as previously mentioned. Most of the dustfall monitored in an urban area is resuspended particulate matter from street surfaces or wind erosion products from vacant areas (Pitt 1979). Point source pollutant emissions can also significantly contribute to dustfall pollution, especially in industrial areas. Transported dust from regional agricultural activities can also significantly affect urban stormwater.

Wind transported materials are commonly called "dustfall." Dustfall includes sedimentation, coagulation with subsequent sedimentation and impaction. Dustfall is normally measured by collecting dry samples, excluding rainfall and snowfall. If rainout and washout are included, one has a measure of total atmospheric fallout. This total atmospheric fallout is sometimes called "bulk precipitation." Rainout removes

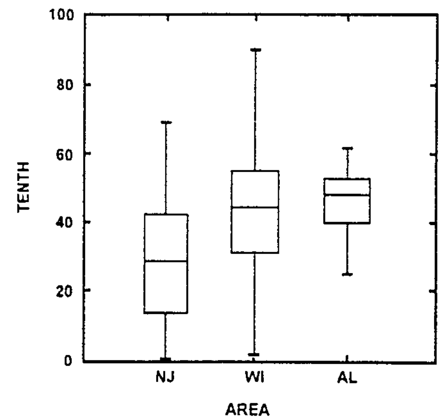

Figure 4-12. Tenth percentile particle sizes for stormwater inlet flows.

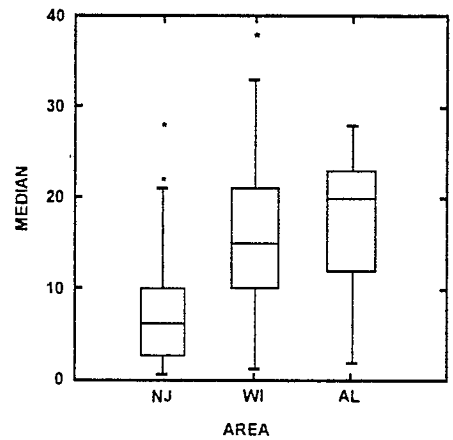

Figure 4-13. Fiftieth percentile particle sizes for stormwater inlet flows.

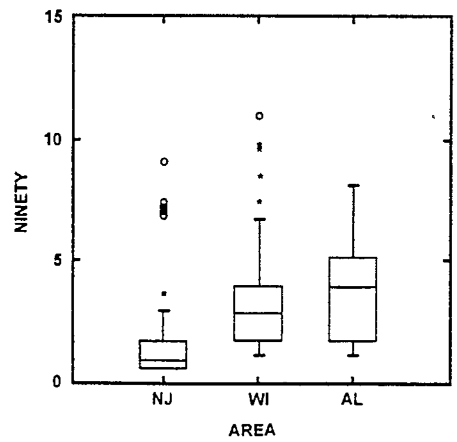

Figure 4-14. Ninetieth percentile particle sizes for stormwater inlet flows.

contaminants from the atmosphere by condensation processes in clouds, while washout is the removal of contaminants by the falling rain. Therefore, precipitation can include natural contamination associated with condensation nuclei in addition to collecting atmospheric pollutants as the rain or snow falls. In some areas, the contaminant contribution by dry deposition is small, compared to the contribution by precipitation (Malmquist 1978). However, in heavily urbanized areas, dustfall can contribute more of an annual load than the wet precipitation, especially when dustfall includes resuspended materials.

Table 4-6 summarizes rain quality reported by several researchers. As expected, the non-urban area rain quality can be substantially better than urban rain quality. Many of the important heavy metals, however, have not been detected in rain in many areas of the country. The most important heavy metals found in rain have been lead and zinc, both being present in rain in concentrations from about 20 µg/l up to several hundred µg/l. It is expected that more recent lead rainfall concentrations would be substantially less, reflecting the decreased use of leaded gasoline since these measurements were taken. Iron is also present in relatively high concentrations in rain (about 30 to 40 µg/l).

Table 4-6. Summary of reported rain quality.

	Rural-Northwest (Quilayute, WA)[1]	Rural-Northeast (Lake George, NY)[1]	Urban-Northwest (Lodi, NJ)[2]	Urban-Midwest (Cincinnati, OH)[3]	Other Urban[3]	Continental Avg. (32 locations)[1]
Suspended solids, mg/l				13		
Volatile suspended solids, mg/l				3.8		
Inorganic nitrogen, mg/l as N				0.69		
Ammonia, mg/l as N					0.7	
Nitrates, mg/l as N					0.3	
Total phosphates, mg/l as P					<0.1	
Ortho phosphate, mg/l as P				0.24		
Scandium, µg/l	<0.002	nd				nd
Titanium, µg/l	nd	nd				nd
Vanadium, µg/l	nd	nd				nd
Chromium, µg/l	<2	nd	1			nd
Manganese, µg/l	2.6	3.4				12
Iron, µg/l	32	35				
Cobalt, µg/l	0.04	nd				nd
Nickel, µg/l	nd	nd	3			43
Copper, µg/l	3.1	8.2	6			21
Zinc, µg/l	20	30	44			107
Lead, µg/l			45			

1) Rubin 1976
2) Wilbur and Hunter 1980
3) Manning et al. 1976

The concentrations of various urban runoff pollutants associated with dry dustfall are summarized in Table 4-7. Urban, rural and oceanic dry dustfall samples contained more than 5,000 mg iron/kg total solids. Zinc and lead were present in high concentrations. These constituents can have concentrations of up to several thousand mg of pollutant per kg of dry dustfall. Spring et al. (1978) monitored dry dustfall near a major freeway in Los Angeles, CA. Based on a series of samples collected over several months, they found that lead concentrations on and near the freeway can be about 3,000 mg/kg, but as low as about 500 mg/kg 150 m (500 feet) away. In contrast, the chromium concentrations of the dustfall did not vary substantially between the two locations and approached oceanic dustfall chromium concentrations.

Table 4-7. Atmosphere dustfall quality.

Constituent, (mg constituent/kg total solids)	Urban[1]	Rural/ suburban[1]	Oceanic	Near freeway (LA)[2]	500' from freeway (LA)[2]
pH				4.3	4.7
Phosphate-Phosphorous				1200	1600
Nitrate-Nitrogen, µg/l				5800	9000
Scandium, µg/l	5	3	4		
Titanium, µg/l	380	810	2700		
Vanadium, µg/l	480	140	18		
Chromium, µg/l	190	270	38	34	45
Manganese, µg/l	6700	1400	1800		
Iron, µg/l	24000	5400	21000		
Cobalt, µg/l	48	27	8		
Nickel, µg/l	950	1400			
Copper, µg/l	1900	2700	4500		
Zinc, µg/l	6700	1400	230		
Lead, µg/l				2800	550

1) Summarized by Rubin 1976
2) Spring 1978

Much of the monitored atmospheric dustfall and precipitation would not reach the urban runoff receiving waters. The percentage of dry atmospheric deposition retained in a rural watershed was extensively monitored and modeled in Oakridge, TN (Barkdoll et al. 1977). They found that about 98% of the lead in dry atmospheric deposits was retained in the watershed, along with about 95% of the cadmium, 85% of the copper, 60% of the chromium and magnesium and 75% of the zinc and mercury. Therefore, if the dry deposition rates were added directly to the yields from other urban runoff pollutant sources, the resultant urban runoff loads would be very much overestimated.

Tables 4-8 and 4-9 report bulk precipitation (dry dustfall plus rainfall) quality and deposition rates as reported by several researchers. For the Knoxville, KY, area (Betson 1978), chemical oxygen demand (COD) was found to be the largest component in the bulk precipitation monitored, followed by filterable residue and nonfilterable residue. Table 4-9 also presents the total watershed bulk precipitation, as the percentage of the total stream flow output, for the three Knoxville watersheds studies. This shows that almost all of the pollutants presented in the urban runoff streamflow outputs could easily be accounted for by bulk precipitation deposition alone. Betson concluded that bulk precipitation is an important component for some of the constituents in urban runoff, but the transport and resuspension of particulates from other areas in the watershed are overriding factors.

Rubin (1976) stated that resuspended urban particulates are returned to the earth's surface and waters in four main ways: gravitational settling, impaction, precipitation and washout. Gravitational settling, as dry deposition, returns most of the particles. This not only involves the settling of relatively large fly ash and soil particles, but also the settling of smaller particles that collide and coagulate. Rubin stated that particles that are less than 0.1 μm in diameter move randomly in the air and collide often with other particles. These small particles can grow rapidly by this coagulation process. These small particles would soon be totally depleted in the air if they were not constantly replenished. Particles in the 0.1 to 1.0 μm range are also removed primarily by coagulation. These larger particles grow more slowly than the smaller particles because they move less rapidly in the air, are somewhat less numerous and, therefore, collide less often with other particles. Particles with diameters larger than 1 μm have appreciable settling velocities. Those particles about 10 μm in diameter can settle rapidly, although they can be kept airborne for extended periods of time and for long distances by atmospheric turbulence.

The second important particulate removal process from the atmosphere is impaction. Impaction of particles near the earth's surface can occur on vegetation, rocks and building surfaces. The third form of particulate removal from the atmosphere is precipitation, in the form of rain and snow. This is caused by the rainout process where the particulates are removed in the cloud-forming process. The fourth important removal process is washout of the particulates below the clouds during the precipitation event. Therefore, it is easy to see that re-entrained particles (especially from street surfaces, other paved surfaces, rooftops and from soil erosion) in urban areas can be readily redeposited through these various processes, either close to the points of origin or at some distance away.

Pitt (1979) monitored airborne concentrations of particulates near typical urban roads. He found that on a number basis, the downwind roadside particulate concentrations were about 10% greater than upwind conditions. About 80% of the concentration increases, by number, were associated with particles in the 0.5 to 1.0 µm size range. However, about 90% of the particle concentration increases by weight were associated with particles greater than 10 µm. Pitt found that the rate of particulate resuspension from street surfaces increases when the streets are dirty (cleaned infrequently) and varied widely for different street and traffic conditions. The resuspension rates were calculated based upon observed long-term accumulation conditions on street surfaces for many different study area conditions, and varied from about 0.30 to 3.6 kg per curb-km (one to 12 lb per curb-mile) of street per day.

Table 4-8. Bulk precipitation quality.

Constituent (all units mg/l except pH)	Urban (average of Knoxville St. Louis & Germany)[1]	Rural (Tennessee)[1]	Urban (Guteburg, Sweden)[2]
Calcium	3.4	0.4	
Magnesium	0.6	0.1	
Sodium	1.2	0.3	
Chlorine	2.5	0.2	
Sulfate	8.0	8.4	
pH	5.0	4.9	
Organic Nitrogen	2.5	1.2	
Ammonia Nitrogen	0.4	0.4	2
Nitrite plus Nitrate-N	0.5	0.4	1
Total phosphate	1.1	0.8	0.03
Potassium	1.8	0.6	
Total iron	0.8	0.7	
Manganese	0.03	0.05	
Lead	0.03	0.01	0.05
Mercury	0.01	0.0002	
Nonfilterable residue	16		
Chemical Oxygen Demand	65		10
Zinc			0 08
Copper			0.02

1) Betson 1978
2) Malmquist 1978

Table 4-9. Urban bulk precipitation deposition rates (Betson 1978)[1].

Rank	Constituent	Average Bulk Deposition Rate (kg/ha/yr)	Average Bulk Prec. as a % of Total Streamflow Output
1	Chemical oxygen demand	530	490
2	Filterable residue	310	60
3	Nonfilterable residue	170	120
4	Alkalinity	150	120
5	Sulfate	96	470
6	Chloride	47	360
7	Calcium	38	170
8	Potassium	21	310
9	Organic nitrogen	17	490
10	Sodium	15	270
11	Silica	11	130
12	Magnesium	9	180
13	Total Phosphate	9	130
14	Nitrite and Nitrate-N	5.7	360
15	Soluble phosphate	5.3	170
16	Ammonia Nitrogen	3.2	1.100
17	Total Iron	1.9	47
18	Fluoride	1.8	300
19	Lead	1.1	650
20	Manganese	0.54	270
21	Arsenic	0.07	720
22	Mercury	0.008	250

1) Average for three Knoxville, KY, watersheds.

Murphy (1975) described a Chicago study where airborne particulate material within the city was microscopically examined, along with street surface particulates. The particulates from both of these areas were found to be similar (mostly limestone and quartz) indicating that the airborne particulates were most likely resuspended street surface particulates, or were from the same source.

PEDCo (1977) found that the re-entrained portion of the traffic-related particulate emissions (by weight) is an order of magnitude greater than the direct emissions accounted for by vehicle exhaust and tire wear. They also found that particulate resuspensions from a street are directly proportional to the traffic volume and that the suspended particulate concentrations near the streets are associated with relatively large particle sizes. The medium particle size found, by weight, was about 15 μm, with about 22% of the particulates occurring at sizes greater than 30 μm. These relatively large particle sizes resulted in substantial particulate fallout near the road. They found that about 15% of the resuspended particulates fall out at 10 m, 25% at 20 m, and 35% at 30 m from the street (by weight).

In a similar study Cowherd et al. (1977) reported a wind erosion threshold value of about 5.8 m/s (13 mph). At this wind speed, or greater, significant dust and dirt losses from the road surface could result, even in the absence of traffic-induced turbulence. Rolfe and Reinbold (1977) also found that most of the particulate lead from automobile emissions settled out within 100 m of roads. However, the automobile lead does widely disperse over a large area. They found, through multi-elemental analyses, that the settled outdoor dust collected at or near the curb was contaminated by automobile activity and originated from the streets.

Source Area Sheetflow and Particulate Quality

This section summarizes the source area sheetflow and particulate quality data obtained from several studies conducted in California, Washington, Nevada, Wisconsin, Illinois, Ontario, Colorado, New Hampshire, and New York since 1979. Most of the data obtained were for street dirt chemical quality, but a relatively large amount of parking and roof runoff quality data have also been obtained. Only a few of these studies evaluated a broad range of source areas or land uses.

Source Area Particulate Quality

Particulate potency factors (usually expressed as mg pollutant/kg dry particulate residue) for many samples are summarized on Tables 4-10 and 4-11. These data can help recognize critical source areas, but care must be taken if they are used for predicting runoff quality because of likely differential effects due to washoff and erosion from the different source areas. These data show the variations in chemical quality between particles from different land uses and source areas. Typically, the potency factors increase as the use of an area becomes more intensive, but the variations are slight for different locations throughout the country. Increasing concentrations of heavy metals with decreasing particle sizes was also evident, for those studies that included particle size information. Only the quality of the smallest particle sizes are shown on these tables because they best represent the particles that are removed during rains.

Warm Weather Sheetflow Quality

Sheetflow data, collected during actual rain, are probably more representative of runoff conditions than the previously presented dry particulate quality data because they are not further modified by washoff mechanisms. These data, in conjunction with source area flow quantity information, can be used to predict outfall conditions and the magnitude of the relative sources of critical pollutants. Tables 4-12 through 4-15 summarize warm weather sheetflow observations, separated by source area type and land use, from many locations. The major source area categories are listed below:

1. Roofs
2. Paved parking areas
3. Paved storage areas
4. Unpaved parking and storage areas
5. Paved driveways
6. Unpaved driveways
7. Dirt walks
8. Paved sidewalks
9. Streets
10. Landscaped areas
11. Undeveloped areas
12. Freeway paved lanes and shoulders

Toronto warm weather sheetflow water quality data were plotted against the rain volume that had occurred before the samples were collected to identify any possible trends of concentrations with rain volume (Pitt and McLean 1986). The street runoff data obtained during the special washoff tests reported earlier were also compared with the street sheetflow data obtained during the actual rain events (Pitt 1987). These data observations showed definite trends of solids concentrations verses rain volume for most of the source area categories. Sheetflows from all pervious areas combined had the highest total solids concentrations from any source category, for all rain events. Other paved areas (besides streets) had total solids concentrations similar to runoff from smooth industrial streets. The concentrations of total solids in roof runoff were almost constant for all rain events, being slightly lower for small rains than for large rains. No other pollutant, besides SS, had observed trends of concentrations with rain depths for the samples collected in Toronto. Lead and zinc concentrations were highest in sheetflows from paved parking areas and streets, with some high zinc concentrations also found in roof drainage samples. High bacteria populations were found in sidewalk, road, and some bare ground sheetflow samples (collected from locations where dogs would most likely be "walked").

Some of the Toronto sheetflow contributions were not sufficient to explain the concentrations of some constituents observed in runoff at the outfall. High concentrations of dissolved chromium, dissolved copper, and dissolved zinc in a Toronto industrial outfall during both wet and dry weather could not be explained by wet weather sheetflow observations (Pitt and McLean 1986). As an example, very few detectable chromium observations were obtained in any of the more than 100 surface sheetflow samples analyzed. Similarly, most of the fecal coliform populations observed in sheetflows were significantly lower than those observed at the outfall, especially during snowmelt. It is expected that some industrial wastes, possibly originating from metal plating operations, were the cause of these high concentrations of dissolved metals at the outfall and that some sanitary sewage was entering the storm drainage system.

Table 4-15 summarizes the very little filterable pollutant concentration data available, before this EPA project, for different source areas. Most of the available data are for residential roofs and commercial parking lots.

Table 4-10. Summary of observed street dirt mean chemical quality (mg constituent/kg solids).

Constituent	Residential	Commercial	Industrial
P	620 (4) 540 (6) 1100 (5) 710 (1) 810 (3)	400 (6) 1500 (5) 910 (1)	670 (4)
TKN	1030 (4) 3000 (6) 290 (5) 2630 (3) 3000 (2)	1100 (6) 340 (5) 4300 (2)	560 (4)
COD	100,000 (4) 150,000 (6) 180,000 (5) 280,000 (1) 180,000 (3) 170,000 (2)	110,000 (6) 250,000 (5) 340,000 (1) 210,000 (2)	65,000 (4)
Cu	162 (4) 110 (6) 420 (2)	130 (6) 220 (2)	360 (4)
Pb	1010 (4) 1800 (6) 530 (5) 1200 (1) 1650 (3) 3500 (2)	3500 (6) 2600 (5) 2400 (1) 7500 (2)	900 (4)
Zn	460 (4) 260 (5) 325 (3) 680 (2)	750 (5) 1200 (2)	500 (4)
Cd	<3 (5) 4 (2)	5 (5) 5 (2)	
Cr	42 (4) 31 (5) 170 (2)	65 (5) 180 (2)	70 (4)

References; location; particle size described:
(1) Bannerman et al. 1983 (Milwaukee, WI) <31µm
(2) Pitt 1979 (San Jose, CA) <45 µm
(3) Pitt 1985 (Bellevue, WA) <63 µm
(4) Pitt and McLean 1986 (Toronto, Ontario) <125 µm
(5) Pitt and Sutherland 1982 (Reno/Sparks, NV) <63 µm
(6) Terstriep et al. 1982 (Champaign/Urbana, IL) >63 µm

Table 4-11. Summary of observed particulate quality for other source areas (means for <125 μm particles) (mg constituent/kg solids).

	P	TKN	COD	Cu	Pb	Zn	Cr
Residential/Commercial Land Uses							
	1500	5700	240,000	130	980	1900	77
Roofs	600	790	78,000	145	630	420	47
Paved parking	400	850	50,000	45	160	170	20
Unpaved driveways	550	2750	250,000	170	900	800	70
Paved driveways	360	760	25,000	15	38	50	25
Dirt footpath	1100	3620	146,000	44	1200	430	32
Paved sidewalk	1300	1950	70,000	30	50	120	35
Garden soil	870	720	35,000	35	230	120	25
Road shoulder							
Industrial Land Uses							
Paved parking	770	1060	130,000	1110	650	930	98
Unpaved parking/storage	620	700	110,000	1120	2050	1120	62
Paved footpath	890	1900	120,000	280	460	1300	63
Bare ground	700	1700	70,000	91	135	270	38

Source: Pitt and McLean 1986 (Toronto, Ontario)

Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
<u>Total Solids (mg/l)</u>									
Residential:	58 (5) 64 (1) 18 (4)	1790 (5)	73 (5)		510 (5)		1240 (5)	49 (5)	325 (5) 235 (4)
Commercial:	95 (1) 190 (4)	340 (2) 240 (1) 102 (7)							325 (4)
Industrial:	113 (5)	490 (5)	270 (5)	1250 (5)	506 (5)	5620 (5)		580 (5)	1800 (5)
<u>Suspended Solids (mg/l)</u>									
Residential:	22 (1) 13 (5)	1660 (5)	41 (5)		440 (5)		810 (5)	20 (5)	242 (5)
Commercial:		270 (2) 65 (1) 41 (7)							242 (5)
Industrial:	4 (5)	306 (5)	202 (5)	730 (5)	373 (5)	4670 (5)		434 (5)	1300 (5)
<u>Dissolved Solids (mg/l)</u>									
Residential:	42 (10 5 (5)	130 (5)	32 (5)		70 (5)		430 (5)	29 (5)	83 (5) 83 (4)
Commercial:		70 (2) 175 (1) 61 (7)							83 (5)
Industrial:	109 (5)	184 (5)	68 (5)	520 (5)	133 (5)	950 (5)		146 (5)	500 (5)

Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data) (Continued).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
BOD$_5$ (mg/l)									
Residential:	3 (4)	22 (4)							13 (4)
Commercial:	7 (4)	11 (1) 4 (8)							
COD (mg/l)									
Residential:	46 (5) 27 (1) 20 (4)	173 (5)	22 (5)		178 (5)			62 (5)	174 (5) 170 (4)
Commercial:	130 (4)	190 (2) 180 (4) 53 (1) 57 (8)							174 (5)
Industrial:	55 (5)	180 (5)	82 (5)	247 (5)	138 (5)	418 (5)		98 (5)	322 (5)
Total Phosphorus (mg/l)									
Residential:	0.03 (5) 0.05 (1) 0.1 (4)				0.36 (5)		0 20 (5)	0.80 (5)	0.62 (5) 0.31 (4)
Commercial:	0.03 (4) 0.07 (4)	0.16 (1) 0.15 (7) 0.73 (5) 0.9 (2) 0.5 (4)							0.62 (5)
Industrial:	<0.06 (5)	2.3 (5)	0.7 (5)	1.0 (5)	0.9 (5)	3.0 (5)		0.82 (5)	1.6 (5)

Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data) (Continued).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
Total Phosphate (mg/l)									
Residential.	<0.04 (5) 0.08 (4)				<0.2 (5)		0.66 (5)	0.64 (5)	0 07 (5) 0 12 (4)
Commercial:	0.02 (4)	0 03 (5) 0.3 (2) 0.5 (4) 0.04 (7) 0.22 (8)	<0.02 (5)						0 07 (5)
Industrial:	<0.02 (5)	0.6 (5)	0 06 (5)	0.13 (5)	<0.02 (5)	0.10 (5)		0.03 (5)	0 15 (5)
TKN (mg/l)									
Residential:	1.1 (5) 0.71 (4)				3.1 (5)		1.3 (5)	1 1 (5)	2 4 (5) 2.4 (4)
Commercial:	4.4 (4)	3.8 (5) 4.1 (2) 1.5 (4) 1.0 (1) 0 8 (8)							2 4 (5)
Industrial:	1.7 (5)	2.9 (5)	3.5 (5)	2.7 (5)	5.7 (5)	7.5 (5)		4.7 (5)	5.7 (5)
Ammonia (mg/l)									
Residential:	0.1 (5) 0.9 (1) 0.5 (4)	0.1 (5)	0.3 (5)		<0 1 (5)		0.5 (5)	0 3 (5)	<0.1 (5) 0 42 (4)
Commercial:	1.1 (4)	1.4 (2) 0.35 (4) 0.38 (1)							<0.1 (5)
Industrial:	0.4 (5)	0.3 (5)	0.3 (5)	<0 1 (5)	<0.1 (5)	<0.1 (5)		<0 1 (5)	<0 1 (5)

Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data) (Continued).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
Phenols (mg/l)									
Residential:	2.4 (5)	12 2 (5)	30.0 (5)		9.7 (5)		<0.4 (5)	8.6 (5)	6 2 (5)
Industrial:	1.2 (5)	9.4 (5)	2.6 (5)	8.7 (5)	7.0 (5)	7.4 (5)		8.7 (5)	24 (7)
Aluminum (μg/l)									
Residential:	0.4 (5)	3.2 (5)	0.38 (5)		5.3 (5)		<0.03 (5)	0.5 (5)	1 5 (5)
Industrial:	<0.2 (5)	3.5 (5)	3.1 (5)	9 2 (5)	3.4 (5)	41 (5)		1.2 (5)	14 (5)
Cadmium (μg/l)									
Residential:	<4 (5) 0.6 (1)	2 (5)	<5 (5)		5 (5)		<1 (5)	<4 (5)	<5 (5)
Commercial:		5.1 (7) 0.6 (8)							<5 (5)
Industrial:	<4 (5)	<4 (5)	<4 (5)	<4 (5)	<4 (5)	<4 (5)		<4 (5)	<4 (5)
Chromium (μg/l)									
Residential:	<60 (5) <5 (4)	20 (5) 71 (4)	<10 (5)		<60 (5)		<10 (5)	<60 (5)	<60 (5) 49 (4)
Commercial:	<5 (4)	19 (7) 12 (8)							<60 (5)
Industrial:	<60 (5)	<60 (5)	<60 (5)	<60 (5)	<60 (5)	70 (5)		<60 (5)	<60 (5)

Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data) (Continued).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
Copper (µg/l)									
Residential	10 (5) <5 (4)	100 (5)	20 (5)		210 (5)		20 (5)	20 (5)	40 (5) 30 (4)
Commercial	110 (4)	40 (2) 46 (4) 110 (7)							40 (5)
Industrial:	<20 (5)	480 (5)	260 (5)	120 (5)	40 (5)	140 (5)		30 (5)	220 (5)
Lead (µg/l)									
Residential:	<40 (5) 30 (3) 48 (1) 17 (4)	250 (5)	760 (5)		1400 (5)		30 (5)	80 (5)	180 (5) 670 (4)
Commercial:	19 (4) 30 (1)	200 (2) 350 (3) 1090 (4) 146 (1) 255 (7) 54 (8)							180 (5)
Industrial:	<40 (5)	230 (5)	280 (5)	210 (5)	260 (5)	340 (5)		<40 (5)	560 (5)

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Table 4-12. Sheetflow quality summary for other source areas (mean concentration and source of data) (Continued).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets
Zinc (µg/l)									
Residential:	320 (5) 670 (1) 180 (4)	520 (5)	390 (5)		1000 (5)		40 (5)	60 (5)	180 (5) 140 (4)
Commercial:	310 (1) 80 (4)	300 (5) 230 (4) 133 (1) 490 (7)							180 (5)
Industrial:	70 (5)	640 (7)	310 (5)	410 (5)	310 (5)	690 (5)		60 (5)	910 (5)

References:

(1) Bannerman et al. 1983 (Milwaukee, WI) (NURP)
(2) Denver Regional Council of Governments 1983 (NURP)
(3) Pitt 1983 (Ottawa)
(4) Pitt and Bozeman 1982 (San Jose)
(5) Pitt and McLean 1986 (Toronto)
(7) STORET Site #590866-2954309 (Shop-Save-Durham, NH) (NURP)
(8) STORET Site #596296-2954843 (Huntington-Long Island, NY) (NURP)

Table 4-13. Sheetflow quality summary for undeveloped landscaped and freeway pavement areas (mean observed concentrations and source of data).

Pollutants	Landscaped Areas	Undeveloped Areas	Freeway Paved Lane and Shoulder Areas
Total Solids, mg/l	388 (4)	588 (4)	340 (5)
Suspended Solids, mg/l	100 (4)	400 (1) 390 (4)	180 (5)
Dissolved Solids, mg/l	288 (4)	193 (4)	160 (5)
BOD_5, mg/l	3 (3)	----	10 (5)
COD, mg/l	70 (3) 26 (4)	72 (1) 54 (4)	130 (5)
Total Phosphorus, mg/l	0.42 (3) 0.56 (4)	0.40 (1) 0.68 (4)	----
Total Phosphate, mg/l	0.32 (3) 0 14 (4)	0.10 (1) 0.26 (4)	0.38 (5)
TKN, mg/l	1.32 (3) 3.6 (4)	2.9 (1) 1.8 (4)	2.5 (5)
Ammonia, mg/l	1.2 (3) 0.4 (4)	0.1 (1) <0.1 (4)	----
Phenols, µg/l	0.8 (4)	----	----
Aluminum, µg/l	1 5 (4)	11 (4)	----
Cadmium, µg/l	<3 (4)	<4 (4)	60 (5)
Chromium, µg/l	10 (3)	<60 (4)	70 (5)
Copper, µg/l	<20 (4)	40 (1) 31 (3) <20 (4)	120 (5)
Lead, µg/l	30 (2) 35 (3) <30 (4)	100 (1) 30 (2) <40 (4)	2000 (5)
Zinc, µg/l	10 (3)	100 (1) 100 (4)	460 (5)

References:
(1) Denver Regional Council of Governments 1983 (NURP)
(2) Pitt 1983 (Ottawa)
(3) Pitt and Bozeman 1982 (San Jose)
(4) Pitt and McLean 1986 (Toronto)
(5) Shelly and Gaboury 1986 (Milwaukee)

Table 4-14. Source area bacteria sheetflow quality summary (means).

Pollutant and Land Use	Roofs	Paved Parking	Paved Storage	Unpaved Parking/ Storage	Paved Driveways	Unpaved Driveways	Dirt Walks	Paved Sidewalks	Streets	Land-scaped	Un-developed	Freeway Paved Lane and Shoulders
Fecal Coliforms (#/100 ml)												
Residential:	85 (2) <2 (3) 1400 (4)	250,000 (4)	100 (4)		600 (4)			11,000 (4)	920 (3) 6,900 (4)	3300 (4)	5400 (2) 49 (3)	1500 (7)
Commercial	9 (3)	2900 (2) 350 (3) 210 (1) 480 (5) 23,000 (6)										
Industrial:	1600 (4)	8660 (6)	9200 (4)	18,000 (4)	66,000 (4)	300,000 (4)		55,000 (4)	100,000 (4)			
Fecal Strep (#/100 ml)												
Residential.	170 (2) 920 (3) 2200 (4)	190,000 (4)	<100 (4)		1900 (4)		1800 (4)		>2400 (3) 7300 (4)	43,000 (4)	16,500 (2) 920 (3)	2200 (7)
Commercial:	17 (2)	11,900 (2) >2400 (3) 770 (1) 1120 (5) 62,000 (6)										
Industrial:	690 (4)	7300 (4)	2070 (4)	8100 (4)	36,000 (4)	21,000 (4)		3600 (4)	45,000 (4)			
Pseudo, Aerug (#/100 ml)												
Residential:	30,000 (4) 50 (4)	1900 (4)	100 (4)		600 (4)		600 (4)		570 (4)	2100 (4)		
Industrial:		5800 (4)	5850 (4)	14,000 (4)	14,300 (4)	100 (4)		3600 (4)	6200 (4)			

References:

(1) Bannerman et al. 1983 (Milwaukee, WI) (NURP)
(2) Pitt 1983 (Ottawa)
(3) Pitt and Bozeman 1982 (San Jose)
(4) Pitt and McLean 1986 (Toronto)
(5) STORET Site #590866-2954309 (Shop-Save-Durham, NH) (NURP)
(6) STORET Site #596296-2954843 (Huntington-Long Island, NY) (NURP)
(7) Kobriger et al. 1981 and Gupta et al. 1977

Table 4-15. Source area filterable pollutant concentration summary (means).

	Residential			Commercial			Industrial		
	Total	Filterable	Filterable (%)	Total	Filterable	Filterable (%)	Total	Filterable	Filt. (%)
Roof Runoff									
Solids (mg/l)	64 58	42 45	66 (1) 77 (3)				113	110	97 (3)
Phosphorus (mg/l)	0 054	0.013	24 (1)						
Lead (µg/l)	48	4	8 (1)						
Paved Parking									
Solids (mg/l)				240 102 1790	175 61 138	73 (1) 60 (4) 8 (3)	490	138	28 (3)
Phosphorus (mg/l)				0.16 0.9	0.03 0.3	19 (1) 33 (2)			
TKN (mg/l)				0.77	0.48	62 (5)			
Lead (µg/l)				146 54	5 8.8	3 (1) 16 (5)			
Arsenic (µg/l)				0.38	0.095	25 (5)			
Cadmium (µg/l)				0.62	0.11	18 (5)			
Chromium (µg/l)				11.8	2.8	24 (5)			
Paved Storage									
Solids (mg/l)				73	32	44 (3)	270	64	24 (3)

References:

(1) Bannerman et al. 1983 (Milwaukee) (NURP)
(2) Denver Regional Council of Governments 1983 (NURP)
(3) Pitt and McLean 1986 (Toronto)
(4) STORET Site #590866-2954309 (Shop-Save-Durham, NH) (NURP)
(6) STORET Site #596296-2954843 (Huntington-Long Island, NY) (NURP)

Other Pollutant Contributions to the Storm Drainage System

The detection of pentachlophenols in the relatively few samples previously analyzed indicated important leaching from treated wood. Frequent detections of polycyclic aromatic hydrocarbons (PAHs) during the U.S. Environmental Protection Agency's Nationwide Urban Runoff Program (EPA 1983a) may possibly indicate leaching from creosote treated wood, in addition to fossil fuel combustion sources. High concentrations of copper, and some chromium and arsenic observations also indicate the potential of leaching from "CCA" (copper, chromium, and arsenic) treated wood.

The significance of these leachate products in the receiving waters is currently unknown, but alternatives to these preservatives should be considered. Many cities use aluminum and concrete utility poles instead of treated wood poles. This is especially important considering that utility poles are usually located very close to the drainage system ensuring an efficient delivery of leachate products. Many homes currently use wood stains containing pentachlorophenol and other wood preservatives. Similarly, the construction of retaining walls, wood decks and playground equipment with treated wood is common. Some preservatives (especially creosote) cause direct skin irritation, besides contributing to potential problems in receiving waters. Many of these wood products are at least located some distance from the storm drainage system, allowing some improvement to surface water quality by infiltration through pervious surfaces.

Sources of Stormwater Toxicants

This project included the collection and analysis of 87 urban stormwater runoff samples from a variety of source areas under different rain conditions as summarized in Table 4-16. All of the samples were analyzed in filtered (0.45 μm filter) and non-filtered forms to enable partitioning of the toxicants into "particulate" (non-filterable) and "dissolved" (filterable) forms.

Table 4-16. Numbers of samples collected from each source area type.

Local Source Areas [1]	Residential	Commercial/ Institutional	Industrial	Mixed
Roofs	5	3	4	
Parking Areas	2	11	3	
Storage Areas	na	2	6	
Streets	1	1	4	
Loading Docks	na	na	3	
Vehicle Service Area	na	5	na	
Landscaped Areas	2	2	2	
Urban Creeks				19
Detention Ponds				12

1) All collected in Birmingham, AL.

Analyses and Sampling

The samples listed in Table 4-16 were all obtained from the Birmingham, AL, area. Samples were taken from shallow flows originating from homogeneous source areas by using several manual grab sampling procedures. For deep flows, samples were collected directly into the sample bottles. For shallow flows, a peristaltic hand operated vacuum pump created a small vacuum in the sample bottle, which then gently drew the sample directly into the container through a Teflon™ tube. About one liter of sample was needed, split into two containers: one 500 ml glass bottle with Teflon™ lined lid was used for the organic and toxicity analyses and another 500 ml polyethylene bottle was used for the metal and other analyses.

An important aspect of the research was to evaluate the effects of different land uses and source areas, plus the effects of rain characteristics, on sample toxicant concentrations. Therefore, careful records were obtained of the amount of rain and the rain intensity that occurred before the samples were obtained. Antecedent dry period data were also obtained to compare with the chemical data in a series of statistical tests.

All samples were handled, preserved, and analyzed according to accepted protocols (EPA 1982 and 1983b). The organic pollutants were analyzed using two gas chromatographs, one with a mass selective detector (GC/MSD) and another with an electron capture detector (GC/ECD). The pesticides were analyzed according to EPA method 505, while the base neutral compounds were analyzed according to EPA method 625 (but only using 100 ml samples). The pesticides were analyzed on a Perkin Elmer Sigma 300 GC/ECD using a J&W DB-1 capillary column (30m by 0.32 mm ID with a 1 µm film thickness). The base neutrals were analyzed on a Hewlett Packard 5890 GC with a 5970 MSD using a Supelco DB-5 capillary column (30m by 0.25 mm ID with a 0.2 µm film thickness). Table 4-17 lists the organic toxicants that were analyzed.

Metallic toxicants, also listed in Table 4-17, were analyzed using a graphite furnace equipped atomic absorption spectrophotometer (GFAA). EPA methods 202.2 (Al), 213.2 (Cd), 218.2 (Cr), 220.2 (Cu), 239.2 (Pb), 249.2 (Ni), and 289.2 (Zn) were followed in these analyses. A Perkin Elmer 3030B atomic absorption spectrophotometer was used after nitric acid digestion of the samples. Previous research (Pitt and McLean 1986; EPA 1983a) indicated that low detection limits were necessary in order to measure the filtered sample concentrations of the metals, which would not be achieved by use of a standard flame atomic absorption spectrophotometer. Low detection limits would enable partitioning of the metals between the solid and liquid phases to be investigated, an important factor in assessing the fates of the metals in receiving waters and in treatment processes.

Table 4-17. Toxic pollutants analyzed in samples.

Pesticides Detention Limit = 0.3 μg/l	Phthalate Esters Detention Limit = 0.5 μg/l	Polycyclic Aromatic Hydrocarbons Detention Limit = 0.5 μg/l		Metals Detention Limit = 1 μg/l
BHC (Benzene hexachloride)	Bis(2-ethylhexyl) Phthalate	Acenaphthene	Fluoranthene	Aluminum
Heptachlor	Butyl benzyl phthalate	Acenapthylene	Fluorene	Cadmium
Aldrin	Di-n-butyl phthalate	Anthracene	Indeno (1,2,3-cd) pyrene	Chromium
Endosulfan	Diethyl phthalate	Benzo (a) anthracene	Naphthalene	Copper
Heptachlor epoxide	Dimethyl phthalate	Benzo (a) pyrene	Phenanthrene	Lead
DDE (Dichlorodiphenyl dichloroethylene)	Di-n-octyl phthalate	Benzo (b) fluoranthene	Pyrene	Nickel
DDD (Dichlorodiphenyl dichloroethane)		Benzo (ghi) perylene		Zinc
DDT (Dichlorodiphenyl trichloroethane)		Benzo (k) fluoranthene		
Endrin		Chrysene		
Chlordane		Dibenzo (a,h) anthracene		

The Microtox™ 100% sample toxicity screening test, from Azur Environmental (previously Microbics, Inc.), was selected for this research after comparisons with other laboratory bioassay tests. During the first research, 20 source area stormwater samples and combined sewer samples (obtained during a cooperative study being conducted in New York City) were split and sent to four laboratories for analyses using 14 different bioassay tests. Conventional bioassay tests were conducted using freshwater organisms at the EPA's Duluth, MN, laboratory and using marine organisms at the EPA's Narragansett Bay, RI, laboratory. In addition, other bioassay tests, using bacteria, were also conducted at the Environmental Health Sciences Laboratory at Wright State University, Dayton, OH. The tests represented a range of organisms that included fish, invertebrates, plants, and microorganisms.

The conventional bioassay tests conducted simultaneously with the Microtox™ screening test for the 20 stormwater sheetflow and combined sewer overflow (CSO) samples were all short-term tests. However, some of the tests were indicative of chronic toxicity (e.g., life cycle tests and the marine organism sexual reproduction tests), whereas the others would be classically considered as indicative of acute toxicity (e.g., Microtox™ and the fathead minnow tests). The following list shows the major tests that were conducted by each participating laboratory:

1. University of Alabama at Birmingham, Environmental Engineering Laboratory
   Microtox™ bacterial luminescence tests (10-, 20-, and 35-minute exposures) using the marine *Photobacterium phosphoreum.*

2. Wright State University, Biological Sciences Department
   Macrofaunal toxicity tests:
      Daphnia magna (water flea) survival; *Lemma minor* (duckweed) growth; and *Selenastrum capricornutum* (green alga) growth.
   Microbial activity tests (bacterial respiration):
      Indigenous microbial electron transport activity;
      Indigenous microbial inhibition of β-galactosidase activity;
      Alkaline phosphatase for indigenous microbial activity;
      Inhibition of β-galactosidase for indigenous microbial activity; and
      Bacterial surrogate assay using O-nitrophenol-β-D-galactopyranside activity and *Escherichia coli.*

3. EPA Environmental Research Laboratory, Duluth, MN
   Ceriodaphnia dubia (water flea) 48-h survival; and
   Pimephales promelas (fathead minnow) 96-h survival.

4. EPA Environmental Research Laboratory, Narragansett Bay, RI
   Champia parvula (marine red alga) sexual reproduction (formation of cystocarps after 5 to 7 d exposure); and
   Arbacua punctulata (sea urchin) fertilization by sperm cells.

Table 4-18 summarizes the results of the toxicity tests. The *C. dubia. P. promelas,* and C. *Parvula* tests experienced problems with the control samples and, therefore, these results are therefore uncertain. The *A. pustulata* tests on the stormwater samples also had a potential problem with the control samples. The CSO test results (excluding the fathead minnow tests) indicated that from 50% to 100% of the samples were toxic, with most tests identifying the same few samples as the most toxic. The toxicity tests for the stormwater samples indicated that 0% to 40% of the samples were toxic. The Microtox™ screening procedure gave similar rankings for the samples as the other toxicity tests.

Laboratory toxicity tests can result in important information on the effects of stormwater in receiving waters, but actual in-stream taxonomic studies should also be conducted. A recently published proceedings of a conference on stormwater impacts on receiving streams (Herricks 1995) contains many examples of actual receiving water impacts and toxicity test protocols for stormwater.

Table 4-18. Fraction of samples rated as toxic.

Sample series	Combined sewer overflows (%)	Stormwater (%)
Microtox™ marine bacteria	100	20
C. Dubia	60	0[1]
P. promelas	0[1]	0[1]
C. parvula	100	0[1]
A. punctulata	100	0[1]
D. magna	63	40
L. minor	50[1]	0

1) Results uncertain, see text

All of the Birmingham samples represented separate stormwater. However, as part of the Microtox™ evaluation, several CSO samples from New York City were also tested to compare the different toxicity tests. These samples were collected from six CSO discharge locations having the following land uses:

1. 290 acres, 90% residential and 10% institutional.
2. 50 acres, 100% commercial.
3. 620 acres, 20% institutional, 6% commercial, 5% warehousing, 5% heavy industrial, and 64% residential.
4. 225 acres, 13% institutional, 4% commercial, 2% heavy industrial. and 81% residential.
5. 400 acres, 1% institutional and 99% residential.
6. 250 acres, 88% commercial. 6% warehousing, and 6% residential.

Therefore, there was a chance that some of the CSO samples may have had some industrial process waters. However, none of the Birmingham sheetflow samples could have contained any process waters because of how and where they were collected.

The Microtox™ screening procedure gave similar toxicity rankings for the 20 samples as the conventional bioassay tests. It is also a rapid procedure (requiring about one hour) and only requires small (<1 ml) sample volumes. The Microtox™ toxicity test uses marine bioluminescence bacteria and monitors the light output for different sample concentrations. About one million bacteria organisms are used per sample, resulting in highly repeatable results. The more toxic samples produce greater stress on the bacteria test organisms that results in a greater light attenuation compared to the control sample. Note that the Microtox™ procedure was not used during this research to determine the absolute toxicities of the samples or to predict the toxic effects of stormwater runoff on receiving waters. It was used to compare the relative toxicities of different samples that may indicate efficient source area treatment locations, and to examine changes in toxicity during different treatment procedures.

Potential Sources

A drainage system captures runoff and pollutants from many source areas, all with individual characteristics influencing the quantity of runoff and pollutant load. Impervious source areas may contribute most of the runoff during small storm events (e.g., paved parking lots, streets, driveways, roofs, and sidewalks). Pervious source areas can have higher material washoff potentials and become important contributors for larger storm events when their infiltration rate capacity is exceeded (e.g., gardens, bare ground, unpaved parking areas, construction sites, undeveloped areas). Many other factors also affect the pollutant contributions from source areas, including: surface roughness, vegetative cover, gradient and hydraulic connections to a drainage system; rainfall intensity, duration, and antecedent dry period; and pollutant availability due to direct contamination from local activities, cleaning frequency/efficiency, and natural and regional sources of pollutants. The relative importance of the different source areas is therefore a function of the area characteristics, pollutant washoff potential, and the rainfall characteristics (Pitt 1987).

Important sources of toxicants are often related to the land use (e.g., high traffic capacity roads, industrial processes, and storage area) that are unique to specific land uses activities. Automobile related sources affect the quality and quantity of road dust particles through gasoline and oil drips/spills, deposition of exhaust products, and wear of tire, brake, and pavement materials (Shaheen 1975). Urban landscaping practices potentially produce vegetation cuttings and fertilizer and pesticide washoff. Miscellaneous sources include holiday firework debris, wildlife and domestic pet wastes, and possible sanitary wastewater infiltration. In addition, resuspension and deposition of pollutants/particles via the atmosphere can increase or decrease the contribution potential of a source area (Pitt and Bozeman 1982, Bannerman et al. 1993).

Results

Table 4-19 summarizes the source area sample data for the most frequently detected organic toxicants and for all of the metallic toxicants analyzed. The organic toxicants analyzed, but not reported, were generally detected in five, or less, of the non-filtered samples and in none of the filtered samples. Table 4-19 shows the mean, maximum, and minimum concentrations for the detected toxicants. Note that these values are based only on the observed concentrations. They do not consider the non-detectable conditions. Mean values based on total sample numbers for each source area category would therefore result in much lower concentrations. The frequency of detection is therefore an important consideration when evaluating organic toxicants. High detection frequencies for the organics may indicate greater potential problems than infrequent high concentrations.

Table 4-19 also summarizes the measured pH and SS concentrations. Most pH values were in the range of 7.0 to 8.5 with a low of 4.4 and a high of 11.6 for roof and concrete plant storage area runoff samples, respectively. This range of pH can have dramatic effects on the speciation of the metals analyzed. The SS concentrations were generally less than 100 mg/l, with impervious area runoff (e.g., roofs and parking areas) having much lower SS concentrations and turbidities compared to samples obtained from pervious areas (e.g., landscaped areas).

Out of more than 35 targeted compounds analyzed, 13 were detected in more than 10% of all samples, as shown in Table 4-19. The greatest detection frequencies were for 1,3-dichlorobenzene and fluoranthene, which were each detected in 23% of the samples. The organics most frequently found in these source area samples (i.e., polycyclic aromatic hydrocarbons (PAH), especially fluoranthene and pyrene) were similar to the organics most frequently detected at outfalls in prior studies (EPA 1983a).

Roof runoff, parking area and vehicle service area samples had the greatest detection frequencies for the organic toxicants. Vehicle service areas and urban creeks had several of the observed maximum organic compound concentrations. Most of the organics were associated with the non-filtered sample portions, indicating an association with the particulate sample fractions. The compound 1,3-dichlorobenzene was an exception, having a significant dissolved fraction.

In contrast to the organics, the heavy metals analyzed were detected in almost all samples, including the filtered sample portions. The non-filtered samples generally had much higher concentrations, with the exception of zinc, which was mostly associated with the dissolved sample portion (i.e., not associated with the SS). Roof runoff generally had the highest concentrations of zinc, probably from galvanized roof drainage components, as previously reported by Bannerman et al. (1983). Parking and storage areas had the highest nickel concentrations, while vehicle service areas and street runoff had the highest concentrations of cadmium and lead. Urban creek samples had the highest copper concentrations, which were probably due to illicit industrial connections or other non-stormwater discharges.

Table 4-20 shows the relative toxicities of the collected stormwaters. A wide range of toxicities was found. About 9% of the non-filtered samples were considered highly toxic using the Microtox™ toxicity screening procedure. About 32% of the samples were moderately toxic and about 59% were considered non-toxic. The greatest percentage of samples considered the most toxic were from industrial storage and parking areas. Landscaped areas also had a high incidence of highly toxic samples (presumably due to landscaping chemicals) and roof runoff had some highly toxic samples (presumably due to high zinc concentrations). Treatability study activities indicated that filtering the samples through a range of fine sieves and finally a 0.45μm filter consistently reduced sample toxicities. The chemical analyses also generally found much higher toxicant concentrations in the non-filtered sample portions, compared to the filtered sample portions.

Table 4-19. Stormwater toxicants detected in at least 10% of the source area sheetflow samples (µg/l, unless otherwise noted).

	Roof areas		Parking areas		Storage areas		Street runoff		Loading docks		Vehicle service areas		Landscaped areas		Urban creeks		Detention ponds	
	NF[1]	F[2]	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F
Total samples	12	12	16	16	8	8	6	6	3	3	5	5	6	6	19	19	12	12
Base neutrals (detection limit = 0.5 µg/l)																		
1,3-Dichlorobenzene detection frequency = 20% N.F. and 13% F.																		
No. detected[3]		2	3	2	1	1	1	1	0	0	3	2	3	2	2	0	1	1
Mean[4]	52	20	34	13	16	14	5 4	3.3			48	26	29	5.6	93		27	21
Max.	88	23	103	26							72	47	54	7 5	120			
Min.[5]	14	17	3.0	2.0							6 0	4.9	4.5	3.8	65			
Fluoranthene detection frequency = 20% N.F. and 12% F.																		
No. detected	3	2	3	2	1	0	1	1	0	0	3	2	3	2	1	0	2	1
Mean	23	9.3	37	2.7	4.5	0	0.6	0.5			39	3.6	13	1 0	130		10	6.6
Max.	45	14	110	5.4							53	6.8	38	1 3			14	
Min.	7.6	4.8	3.0	2 0							0.4	0.4	0.7	0 7			6.6	
Pyrene detection frequency = 17% N,F, and 7% F.																		
No. detected	1	0	3	2	1	0	1	1	0	0	3	2	2	0	1	0	2	1
Mean	28		40	9.8	8		1.0	0.7			44	4.1	5.3		100		31	5 8
Max.			120	20							51	7.4	8.2				57	
Min.			3.0	2.0							0.7	0.7	2 3				6.0	
Benzo(b)fluoranthene detection frequency = 15% N.F. and 0% F.																		
No. detected	4	0	3	0	0	0	1	0	0	0	2	0	1	0	2	0	0	0
Mean	76		53				14				98		30		36			
Max.	260		160								110				64			
Min.	6 4		3.0								90				8.0			
Benzo(k)fluoranthene detection frequency = 11% N.F. and 0% F.																		
No. detected	0	0	3	0	0	0	1	0	0	0	2	0	1	0	2	0	0	0
Mean			20				15				59		61		55			
Max.			1								103				78			
Min.			3.0								15				31			
Benzo(a)pyrene detection frequency = 15% N.F. and 0% F.																		
No. detected	4	0	3	0	0	0	1	0	0	0	2	0	1	0	2	0	0	0
Mean	99		40				19				90		54		73			
Max.	300		120								120				130			
Min.	34		3.0								60				19			

Table 4-19. Stormwater toxicants detected in at least 10% of the source area sheetflow samples (μg/l, unless otherwise noted).Continued.

	Roof areas		Parking areas		Storage areas		Street runoff		Loading docks		Vehicle service areas		Landscaped areas		Urban creeks		Detention ponds	
	NF[1]	F[2]	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F
Total samples	12	12	16	16	8	8	6	6	3	3	5	5	6	6	19	19	12	12
Bis(2-chloroethyl) ether detection frequency = 12% N.F. and 2% F.																		
No. detected		1	2	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
Mean	42	17	20				15				45	23	56		200		15	
Max.	87	2	39															
Min.	20		2.0								6.0	4.9	4.5	3.8	65			
Bis(chloroisopropyl) ether detection frequency = 13% N.F. and 0% F.																		
No. detected	3	0	3	0	0	0	0	0	0	0	2	0	1	0	2	0	0	0
Mean	99		130								120		85		59			
Max.	150		400								160				78			
Min.	68		3.0								74				40			
Naphthalene detection frequency = 11% N.F. and 6% F.																		
No. detected	2	0	1	1	0	0	0	0	0	0	2	1	1	0	1	1	2	2
Mean	17		72	6.6							70	82	49		300	6.7	43	12
Max.	21										100						68	17
Min.	13										37						18	6.6
Benzo(a)anthracene detection frequency = 10% N.F. and 0% F.																		
No. detected	1	0	3	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0
Mean	16		24								35		54		61			
Max.			73								39							
Min.			3.0								31							
Butylbenzyl phthalate detection frequency = 10% N F. and 4% F.																		
No. detected	1	0	2	1	0	0	0	0	0	0	2	2	1	0	1	0	1	0
Mean	100		12	3.3							26	9.8	130		59		13	
Max.			21								48	16						
Min.			3.3								3.8	3						
Pesticides (detection limit = 0.3 μg/l)																		
Chlordane detection frequency = 11% N.F. and 0% F.																		
No. detected	2	0	2	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0
Mean	1.6		1.0		1.7		0.8			0.8								
Max.	2.2		1.2		2.9													
Min.	0.9		0.8		1.0													

Table 4-19. Stormwater toxicants detected in at least 10% of the source area sheetflow samples (µg/l, unless otherwise noted).Continued.

	Roof areas		Parking areas		Storage areas		Street runoff		Loading docks		Vehicle service areas		Landscaped areas		Urban creeks		Detention ponds	
	NF[1]	F[2]	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	F
Total samples	12	12	16	16	8	8	6	6	3	3	5	5	6	6	19	19	12	12
Metals (detection limit = 1 µg/l)																		
Lead detection frequency = 100% N F and 54% F																		
No detected		1	16	8	8	7	6	4	3	1	5	2	6	1	19	15	12	8
Mean	41	1 1	46	2 1	105	2 6	43	2 0	55	2 3	63	2 4	24	1 7	20	1 4	19	1 0
Max	170		130	5 2	330	5 7	150	3 9	80		110	3 4	70		100	1 6	55	1 0
Min	1 3		1 0	1 2	3 6	1 6	1 5	1 1	25		27	1 4	1 4		1 4	<1	1	<1
Zinc detection frequency = 99% N F and 98% F																		
No detected	12	12	16	16	8	7	6	6	2	2	5	5	6	6	19	19	12	12
Mean	250	220	110	86	1730	22	58	31	55	33	105	73	230	140	10	10	13	14
Max	1580	1550	650	560	13100	100	130	76	79	62	230	230	1160	670	32	23	25	25
Min	11	9	12	6	12	3 0	4 0	4 0	31	4 0	30	11	18	18	<1	<1	<1	<1
Copper detection frequency - 98% N F and 78% F																		
No detected	11	7	15	13	8	6	6	5	3	2	5	4	6	6	19	17	12	8
Mean	110	2 9	116	11	290	250	280	3 8	22	8 7	135	8 4	81	4 2	50	1 4	43	20
Max	900	8 7	770	61	1830	1520	1250	11	30	15	580	24	300	8 8	440	1 7	210	35
Min	1.5	1 1	10	1 1	10	1 0	10	1 0	15	2 6	1 5	1 1	1 9	0 9	<1	<1	0 2	<1
Aluminum detection frequency = 97% N F and 92% F																		
No. detected	12	12	15	15	7	6	6	6	3	1	5	4	5	5	19	19	12	12
Mean	6850	230	3210	430	2320	180	3080	880	780	18	700	170	2310	1210	620	190	700	210
Max	71300	1550	6480	2890	6990	740	10040	4380	930		1370	410	4610	1860	3250	500	1570	360
Min	25	6 4	130	5 0	180	10	70	18	590		93	0 3	180	120	<5	<5	<5	<5
Cadmium detection frequency = 95% N F. and 69% F																		
No detected	11	7	15	9	8	7	6	5	3	3	5	3	4	2	19	15	12	9
Mean	3 4	0 4	6 3	0 6	5 9	2 1	37	0 3	1 4	0 4	9 2	0 3	0 5	0 6	8 3	0 2	2	0 5
Max.	30	0 7	70	1.8	17	10	220	0 6	2 4	0 6	30	0 5	1	1	30	0 3	11	0 7
Min	0 2	0 1	0 1	0 1	0 9	0 3	0 4	0 1	0 7	0.3	1 7	0 2	0 1	0 1	<0 1	<0 1	0 1	0 4
Chromium detection frequency = 91% N F and 55% F																		
No. detected	7	2	15	8	8	5	5	4	3	0	5	1	6	5	19	15	11	8
Mean	85	1 8	56	2 3	75	11	9 9	1 8	17		74	2 5	79	2 0	62	1 6	37	2 0
Max	510	2 3	310	5 0	340	32	30	2 7	40		320		250	4 1	710	4 3	230	3 0
Min	5 0	1 4	2 4	1 1	3 7	1 1	2 8	1 3	2 4		2 4		2 2	1 4	<0 1	<0 1	<0 1	<0 1

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Table 4-19. Stormwater toxicants detected in at least 10% of the source area sheetflow samples (µg/l, unless otherwise noted).Continued.

	Roof areas		Parking areas		Storage areas		Street runoff		Loading docks		Vehicle service areas		Landscaped areas		Urban creeks		Detention ponds	
	NF[1]	F[2]	NF	F.	NF.	F.	NF	F.	NF.	F	NF.	F.	NF	F.	NF.	F	NF	F
Total samples	12	12	16	16	8	8	6	6	3	3	5	5	6	6	19	19	12	12
Nickel detection frequency = 90% N.F. and 37% F.																		
No. detected		0	14	4	8	1	5	0	3	1	5	1	4	1	18	16	11	8
Mean	16		45	5 1	55	87	17		6 7	1.3	42	31	53	2.1	29	2.3	24	3 0
Max.	70		130	13	170		70		8.1		70		130		74	3 6	70	6 0
Min.	2.6		4.2	1.6	1.9		1.2		4.2		7.9		21		<1	<1	1 5	<1
Other constituents (always detected, analyzed only for non-filtered samples)																		
pH																		
Mean	6.9		7.3		8.5		7.6		7.8		7.2		6 7		7 7		8 0	
Max.	8 4		8.7		12		8.4		8.3		8.1		7.2		8.6		9 0	
Min.	4.4		5.6		6.5		6 9		7.1		5.3		6.2		6.9		7 0	
Suspended solids																		
Mean	14		110		100		49		40		24		33		26		17	
Max.	92		750		450		110		47		38		81		140		60	
Min.	0.5		9.0		5 0		7.0		34		17		8 0		5 0		3 0	

1) N.F.: concentration associated with a nonfiltered sample.
2) F.: concentration after the sample was filtered through a 0.45 µm membrane filter.
3) Number detected refers to the number of samples in which the toxicant was detected.
4) Mean values based only on the number of samples with a definite concentration of toxicant reported (not on the total number of samples analyzed).
5) The minimum values shown are the lowest concentration detected, they are not necessarily the detection limit.

Replicate samples were collected from several source areas at three land uses during four different storm events to statistically examine toxicity and pollutant concentration differences due to storm and site conditions. These data indicated that variations in Microtox™ toxicities and organic toxicant concentrations may be partially explained by rain characteristics. As an example, high concentrations of many of the PAHs were associated with long antecedent dry periods and large rains (Barron 1990).

Table 4-20. Relative toxicity of samples using Microtox™ (non-filtered).

Local Source Areas	Highly Toxic (%)	Moderately Toxic (%)	Not Toxic (%)	Number of Samples
Roofs	8	58	33	12
Parking Areas	19	31	50	16
Storage Areas	25	50	25	8
Streets	0	67	33	6
Loading Docks	0	67	33	3
Vehicle Service Areas	0	40	60	5
Landscaped Areas	17	17	66	6
Urban Creeks	0	11	89	19
Detention Ponds	8	8	84	12
All Areas	9	32	59	87

Microbics suggested toxicity definitions for 35 minute exposures:
Highly toxic - light decrease >60%
Moderately toxic - light decrease <60% & >20%
Not toxic - light decrease <20%

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Handbook

Urban Runoff Pollution Prevention and Control Planning

STORM WATER MANAGEMENT

50 percent of the total solids and heavy metals could be removed from urban runoff when city streets were cleaned once or twice a day. When the streets were cleaned only once or twice a month, the removal rate dropped to less than 5 percent (U.S. EPA, 1979). Increased frequency also could result in increased fugitive air emissions. Regular street sweeping and catch basin cleaning can, in any case, remove some of the large floatable litter that is unsightly in urban surface waters. Street sweeping twice a week and catch basin cleaning once or twice a year have been found effective in removing these large floatable pollutants (U.S. EPA, 1983). Determining the effectiveness of street sweeping programs, however, is difficult because of variations in pollutant buildup and storm events. In addition, studies have shown that the choice of sweeping equipment can significantly affect the effectiveness of cleaning programs (Pitt, 1989).

Commercial/Industrial Runoff Control. Certain commercial and industrial sites can be responsible for disproportionate contributions of some pollutants (e.g., grit, oils, grease, and toxic materials) to the drainage system. Typical sources of potential concern include gasoline stations, railroad yards, freight loading areas, and parking lots. In specific cases where significant pollutant loadings to the system are contributed by well-defined locations of limited area, pretreatment of the runoff from these areas could be a practical and effective control measure. Pretreatment measures can be required as part of a community's regulations. Examples of pretreatment measures include oil/water separators for gasoline stations, or the use of modified catch basin designs to enhance the retention of oil and grease or solids. Procedures for the detection and location of illicit connections to separate storm drains by testing for specific chemical tracers could be applied to identify commercial or industrial sources contributing substantial levels of problem pollutants.

Solid Waste Management. Most communities have programs to collect and dispose of solid waste in an effort to maintain clean streets and provide a service for local residents and businesses. Some communities provide added services during times of particularly high waste generation. For example, some municipalities in the northern United States provide extra collection services during the fall to collect leaves—an added service that helps keep leaves from blowing into surface waters. A study of storm water runoff into Minneapolis lakes found that phosphorus levels were reduced by 30 to 40 percent when street gutters were kept free of leaves and lawn clippings (MPCA, 1989). Actual reductions of pollutant loads, however, are difficult to predict. In general, any solid waste that is picked up and disposed of in a controlled manner will be less likely to enter a drainage system.

Animal Waste Removal. Domesticated and wild animal wastes represent a source of bacteria and other pollutants that can be washed into surface waters by urban runoff. These pollutants can be reduced by reducing the animal waste on paved surfaces. Municipalities often enact and enforce leash laws and pet waste cleanup ordinances. The effectiveness of these programs in reducing pollutant loads is unknown, however, and usually depends on voluntary actions by private citizens.

Toxic and Hazardous Waste Management. Improper dumping of household and automotive toxic and hazardous wastes into municipal storm inlets, catch basins, and other storm drainage system entry points can result in significant discharges of pollutants to surface waters during rainstorms. This dumping can be a particular problem in urban areas where individuals change the oil or antifreeze in their cars and dispose of the wastes in nearby catch basins. In addition, homeowners and small businesses sometimes dispose of products such as waste paints and solvents in storm water inlets and catch basins. To address the problem, municipalities can educate residents on the consequences of dumping these wastes into storm drainage system entry points. In addition, communities can develop hazardous- and toxic-waste collection days to dispose of or recycle these wastes properly. Also, storm drain systems can be labeled with warnings about the pollution problems associated with dumping wastes. The effectiveness of such programs, however, cannot be determined in advance because of the voluntary nature of compliance. For business and industry, an inspection, testing, and enforcement program (similar to an industrial pretreatment program) can be developed.

Reduced Fertilizer, Pesticide, and Herbicide Use. Fertilizers, pesticides, and herbicides washed off the ground during storms can contribute to water pollution. Agricultural, park land, and other land uses can be sources of these pollutants. Many communities use these chemicals on park lands, and homeowners utilize them on their lawns. Controlling the use of these chemicals on municipal lands and educating the public can help reduce nutrient and toxic pollutant concentrations in urban runoff.

Reduced Roadway Sanding and Salting. In areas of the United States with freezing road conditions, sand and salt are used in the winter to improve driving conditions. Salt and sand can be washed off roadways, however, and pollute receiving waters. The problem is exacerbated during spring snowmelt and early spring rainstorms when most of these pollutants are available for transport. These problems can be reduced by minimizing the use of chemicals for snow and ice control to the minimum necessary for public safety and

Technical Report

CRWR 263

CHARACTERIZATION OF HIGHWAY RUNOFF IN THE AUSTIN, TEXAS AREA

by

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1. INTRODUCTION

Nonpoint pollution resulting from storm water runoff has recently been recognized as one of the leading causes of the degradation of the quality of receiving waters in the United States. The area southwest of Austin is part of the recharge zone of the Barton Springs portion of the Edwards aquifer. This is a karst aquifer, which is characterized by numerous caves, sinkholes, and other solution features. Recharge enters the aquifer directly through fractures and other openings a the surface, so very little filtration of the runoff occurs before entering the aquifer. The aquifer provides the sole source of drinking water for approximately 35,000 residents of Hays and Travis counties. Construction of new highways in the recharge area of the aquifer led to the concern that nonpoint source pollution from highway runoff could pose a serious threat to the quality of the groundwater and the health of area residents.

Accurate knowledge of the quantity and quality of runoff is required to assess the impacts of runoff on the environment and to develop appropriate mitigation technologies. A comprehensive study of the effects of runoff from highway construction and operation was undertaken by the Center for Research in Water Resources to help develop this information. The primary objective of this portion of the research study was the development and execution of a program to characterize the quantity and quality of runoff from existing highways in the Austin, Texas area.

This portion of the research study focused on the characterization of the quantity and quality of runoff from existing sections of the MoPac expressway and estimation of the pollutant loads resulting from runoff from existing and newly completed sections of highway under different vehicle use patterns. The effects of drainage system type, traffic volume, and surrounding land use on highway storm water runoff characteristics were investigated. In addition to the average quality of runoff, the temporal variation in quality was also studied. A "first flush" effect (i.e., higher concentrations of pollutants at the beginning of runoff events) has been reported in several studies and is often used as the justification for the design standards which require capture and treatment of the first 1/2 inch (or other arbitrary volume) of storm water runoff. The information developed in this study should result in improvement in the design of drainage and treatment systems for highway storm water runoff. Better designs will act to reduce the impact of highway derived nonpoint source pollution on the environment.

2. MATERIALS AND METHODS

2.1 Site Descriptions

Three sites along the MoPac Expressway in the Austin, Texas area were selected for monitoring runoff from highways. The locations were identified as MoPac at West 35th Street, MoPac at Convict Hill Road and MoPac at Walnut Creek. The sites differed in daily traffic flow, surrounding land use, and drainage area. Accessibility for runoff sampling also was a consideration in site selection. Runoff samples were collected during the time period of September 1993 though May 1995. The physical characteristics of the sites are discussed below.

2.1.1 MoPac at West 35th Street

MoPac at West 35th Street is a high traffic site located in central Austin (Figure 2.1). The land use of the area is mixed residential and commercial. Samples were collected from a storm drain inlet located along the gutter of a curbed section of the three southbound lanes. The catchment covers an area of 5,341 m^2 which is 100% asphalt. The average daily volume of traffic at this site was approximately 60,000 vehicles per day, ranging from a maximum of 6,000 vehicles per hour to a minimum of about 100 vehicles per hour. Induction coils installed in each lane of traffic recorded traffic counts during each rainfall event.

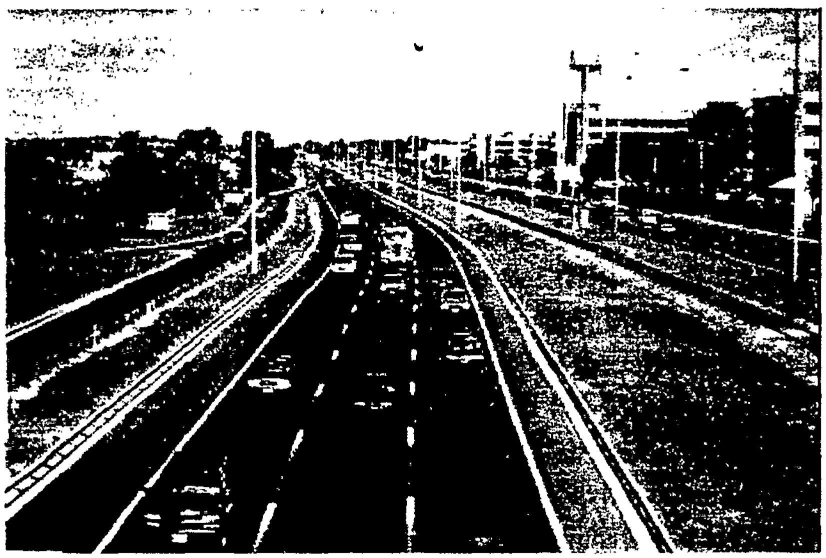

Figure 2.1 Photograph of MoPac at West 35th Street

2.1.2 MoPac at Convict Hill Road

MoPac at Convict Hill Road is a low traffic site located on the southwestern edge of Austin (Figure 2.2). The land around Convict Hill Road is mostly residential and rural property. Runoff was collected from the down spout of the northbound lanes of the MoPac overpass over Convict Hill Road. This outfall drains 526 m^2 of bridge deck, which is 100% asphalt paved and has two lanes of traffic and wide shoulders. One meter high concrete barriers are located along each side of the roadway. The average traffic count in April 1995 was approximately 8780 vehicles per day, ranging from less than 10 vehicles per hour to nearly 1400 vehicles per hour.

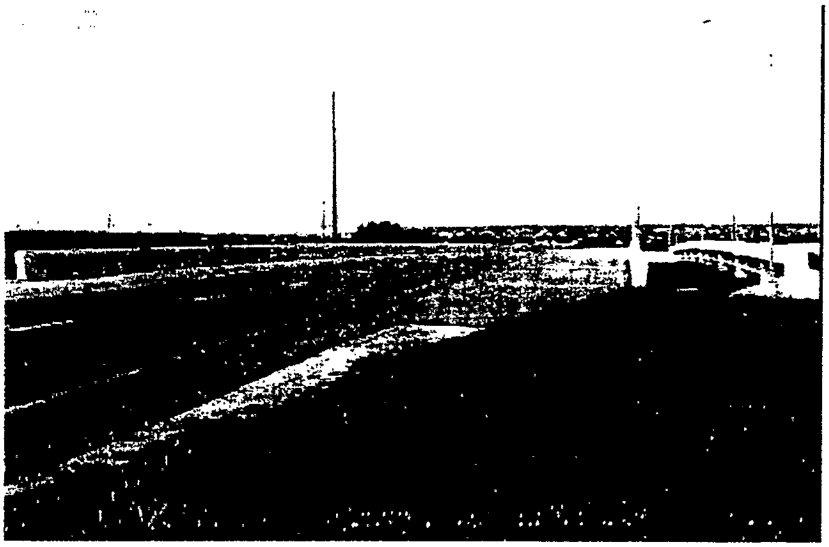

Figure 2.2 Photograph of MoPac at Convict Hill Road

2.1.3 MoPac at Walnut Creek

The Walnut Creek site is located in north Austin and consists of a combination of paved highway and grassy shoulder and median (Figure 2.3). The land use classification of the area is mostly commercial and high density residential. Water was collected from a 10.46 ha (104,600 m^2) area. Approximately 37.6% of the drainage area is paved with asphalt and consists exclusively of the six north- and south-bound lanes of MoPac. No curb or gutter was installed and the highway runoff drains into a large grassy median. Runoff from the median enters a 1.22 m diameter storm sewer system through drop inlets. In April 1995, approximately 47,000 vehicles per day were recorded for this section of MoPac. The hourly traffic counts ranged from about 100 to 3600 vehicles.

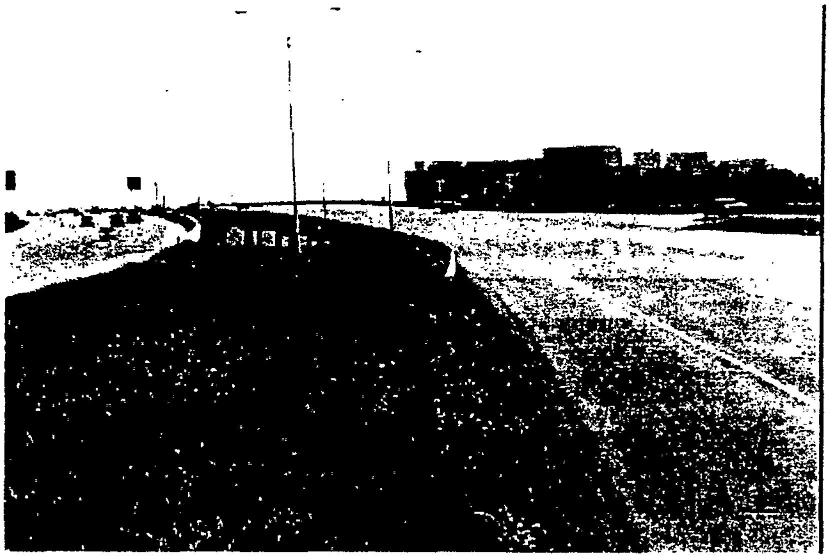

Figure 2.3 Photograph of MoPac at Walnut Creek

A summary of the physical characteristics of the three sites is presented in Table 2.1. Drainage area and average daily traffic also are included in this table. The traffic count at the low traffic volume site (Convict Hill Road) was only 20 percent of the traffic count at the site which had the highest traffic volume (35th Street). The size of the catchment at Convict Hill Road was only 10 percent of the highway surface drained at 35th Street. The traffic mix, and prevailing weather conditions were similar at all sites.

2.2 Climatic Conditions

The National Weather Service data indicate that annual rainfall in Austin, Texas is 82.6 cm; however, during the 12 month period July 1993 - July 1994, the total rainfall was only 44.4 cm. The National Weather Service data indicate that average storm event is 1.4 cm at storm intensities of about 0.18 cm/hr and storm duration of 11.8 hrs. However, storm characteristics vary greatly. Coefficients of variations associated with the data reported for average rainfalls were 1.63 for total volume of rainfall, 1.47 for rainfall intensity, and 1.9 for storm duration.

The National Weather Service data indicate that the wettest seasons occurred during the Spring and Fall. Dry conditions prevailed in the summer months. The rainfall intensity of events that occurred during the late fall and winter months was usually light and occurred over long duration (several hours to over a day). Rainfall events that occurred during the early fall and spring months ranged from drizzle to heavy down pours. Midsummer rainfall events are rare in Austin and tend to be heavy downpours resulting from electrical storms. Dry conditions were prevalent in Austin from June to August of 1994 with less than 0.25 mm of rain at any of the three sites for a period of 40 days.

Table 2.1 Summary of Characteristics of Three Highway Runoff Sampling Sites

	Convict Hill Road	Walnut Creek	West 35th Street
Drainage area	526 m^2	104,600 m^2	5,341 m^2
Pavement	100% asphalt	37% asphalt	100 % asphalt
Lanes of Traffic	2 (3.66 m)	6 (3.66 m each)	3 (3.66 m)
Shoulders	2.44 m and 6.71 m	2.4 m	2.4 m and 3.3 m
Curb/Guardrail	1 m retainer	none	15 cm curb
Average Daily Traffic	8,780	47,240	58,150
Speed Limit	88 km/hr	88 km/hr	88 km/hr
Land Use	rural/residential	commercial/ high density residential	commercial/ residential

2.3 Water Quantity Measurements

Automatic flow measuring and sampling systems were installed and operated at three (3) sites: MoPac at West 35th Street, MoPac at Convict Hill Road, and MoPac at Walnut Creek. The monitoring system installed at MoPac at 35th Street was in operation from October 1993 through July 1995, and the units at the other two sites were in operation April 1994 through July 1995. Water levels at each site were measured using bubble flow meters (ISCO 3230). The water levels were converted into a flow rate based on rating curves developed for each site. The information recorded at the automatic sampling station included rainfall volume, runoff flow rate, and the sampling times. These data were downloaded from the flow meters to a laptop computer, and were converted to text format and exported to Microsoft Excel.

Each sampling station included a 12 volt battery to power the flow meter, sampler, and recorder. A solar panel (Solarex Megamodule MSX60) recharged the battery. The flow meter, sampler, and battery were housed in a large steel enclosure. A rain gauge (ISCO 674) also was placed at each site to measure rainfall. Because of the relatively small size of each of the contributing watersheds, a single gauge at each site was determined to be sufficient for accurately measuring rainfall volume and intensity.

2.3.1 Flow Measurement at West 35th Street

Water level was read from a bubbler tube located at the bottom of the curbing system before the water entered the catchment inlet. A rating curve was developed for this location by discharging water from a fire hydrant approximately 100 meters upstream of the level measuring location. The water was discharged at metered flow rates to construct the rating curve. The water elevation recorded at different flow rates by the flow meter allowed the development of an accurate relationship between water level and flow rate. The flow meter was active at this site for more than one year. Monitoring flow rates of numerous storms produced an average runoff coefficient of about 0.90 which is consistent with values commonly reported in the literature for 100% impervious surfaces. The runoff coefficient calculations are shown in Figure 2.4.

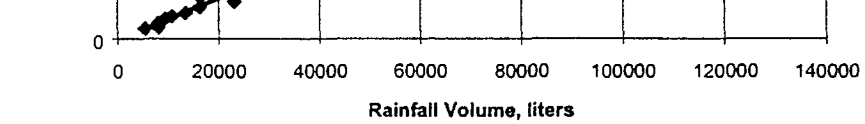

Figure 2.4 Runoff Coefficient for MoPac and West 35th Street

2.3.2 Flow Measurement at Convict Hill Road

Runoff discharge at the Convict Hill Road site was measured using a weir installed on a collection box at the base of a 6-inch diameter down spout. The weir was a compound weir, consisting of three sections: a bottom section which was 20.32 cm high with 30 degree throat, a middle portion which was 4.83 cm high with a 90 degree cross section and a top section which was a rectangular weir which had 5.33 cm sides. Depth of water in the collection box was measured and the discharge was calculated from a rating curve for each section.

$$Q = 137.7H^{2.5} \text{ (30 degree)}$$
$$Q = 372.9H^{2.5} \text{ (90 degree)}$$

where: Q = flow rate (L/s), and
H = head (m).

An identical weir was calibrated at the Center for Research in Water Resources (CRWR) laboratory. The observed discharge of the 30 degree section was almost identical to that predicted by the formulas. The recommended length and weir elevation of the collection box were limited by the height of the down spout at the base of the bridge support and the concrete pad that was located below it. However, the consistency of the results and the resulting runoff coefficient indicated that the system employed was reliable and yielded accurate flow data. The runoff coefficient calculated in this manner was about 0.94. The runoff-rainfall relationship is shown in Figure 2.5.

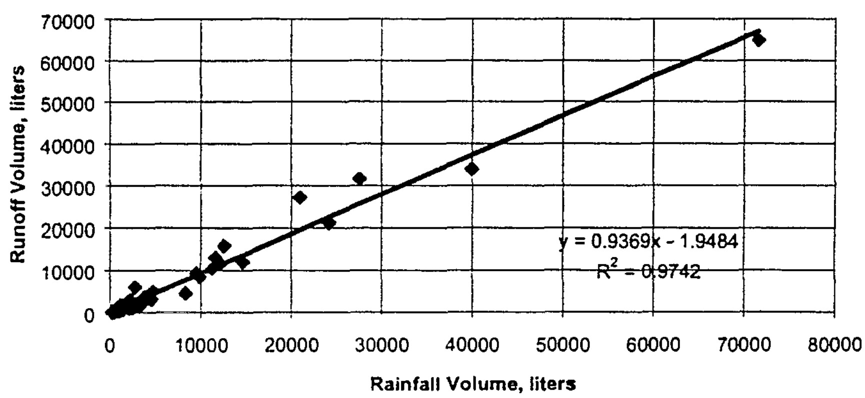

Figure 2.5 Runoff Coefficient for MoPac at Convict Hill Road

2.3.3 Flow Measurement at Walnut Creek

Samples were collected by an automatic sampler from the 1.22 m diameter outfall of the system prior to the discharge entering Walnut Creek. Flow in the storm sewer system at Walnut Creek was calculated using the Manning formula for pipe flow. The slope of the pipe (S), the roughness coefficient (n), the diameter of the pipe (D), and the depth of water in the pipe (d), were used to calculate the flow rate using:

$$Q = \frac{1000}{n} A R^{2/3} S^{1/2}$$

where:
- Q = flow rate (L/s),
- A = cross-sectional area of flow (m^2),
- R = hydraulic radius (m),
- S = pipe slope, and
- n = the roughness coefficient of the pipe (n = 0.013).

The rainfall runoff relationship is shown in Figure 2.6. The larger scatter of the points is the result of the large percentage of the area which is grass covered and where the initial moisture content of the soil strongly influences the volume of runoff. The average runoff coefficient for this site was approximately 0.10, which is in the expected range of values for a site of these characteristics.

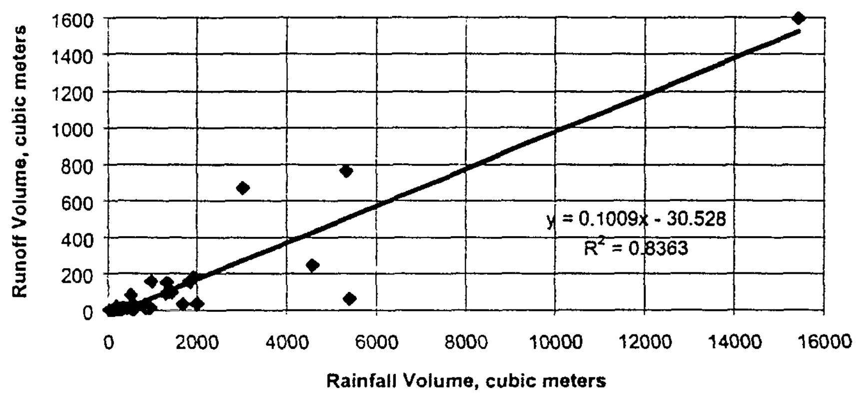

Figure 2.6 Runoff Coefficient for MoPac and Walnut Creek

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The calculated runoff for the three sites are presented in Table 2.2. These runoff coefficients were determined from an analysis of volume of runoff collected and the volume of rainfall occurring in natural rainfall events.

Table 2.2 Runoff Coefficients

Sampling Site	Calculated Runoff Coefficient
MoPac at Convict Hill Road	0.94
MoPac at Walnut Creek	0.10
MoPac at West 35th Street	0.85

A second sampler installed at the Walnut Creek site collected runoff directly from the northbound lanes of MoPac. Water falling from a down spout located in the Walnut Creek overpass was collected in a 190L barrel. Flow out of an orifice at the base of the barrel was calculated using Bernoulli's formula. The formula used to measure flow was:

$$Q = C_D \cdot A_O \sqrt{2 \cdot g \cdot H}$$

where: Q = flow rate (L/s),
C_D = a coefficient of discharge (0.6),
A_o = the area of the orifice (m^2),
g = gravity (9.81 m/s^2),
H = the depth of water above the orifice (m).

The area drained is approximately 1,060 m^2. Only about 50% of the runoff was collected during heavier storms, because of the large distance the runoff fell before collection in the barrel. The sample collection interval was determined based on experience at the 100% paved sites at Convict Hill Road and West 35th Street.

2.4 Water Quality Sampling

Water quality samples were collected during runoff events at each site with an automatic sampler (ISCO 3700). The automatic samplers were programmed to sample based on the volume of runoff flowing past the sampling point or based on time after runoff initiated the sampling program. At Walnut Creek and Convict Hill Road the sampler was programmed to draw samples at set volumes of flow. At the 35th Street site, the sampler was initially programmed to collect samples on a timed basis, but was later converted to collect flow weighted composite samples. The sampler was initiated by the flow meter when the water level at the collection site exceeded a predetermined value. Samples were collected and analyzed according to the methodology specified by the U.S. Environmental Protection Agency (EPA).

Initially, the samplers were configured to collect samples in twenty-four 350 mL bottles. Therefore either six samples in four bottles each, or four samples in six bottles each were composited on a flow weighted basis. Later, four 3.8 L glass bottles were installed in the automatic samplers to facilitate the collection of larger volumes of samples for analysis. The samplers were programmed to collect four flow weighted composite samples representing different portions of the runoff so that pollutant concentrations as a function of runoff volume could be investigated. Flow intervals were changed to reflect weather patterns at different times of the year.

2.5 Chemical Analyses

During rainfall events the runoff flow rates were measured and samples were collected automatically. Water quality parameters analyzed in the laboratory for all runoff samples included: turbidity, total and volatile suspended solids (TSS and VSS), 5-Day Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), oil and grease (O&G), nutrients (nitrate and total phosphorus), heavy metals (iron, lead, cadmium, nickel, zinc, and copper), and bacteria (total coliform, fecal coliform, and fecal streptococcus). Analyses were performed at The Center for Research in Water Resources in Austin, Texas. Results of all analyses performed as part of this study are reported in the Appendix.

The detection limits for the analytical procedures (analyses and instrumentation) used to determine constituents in the rainfall and runoff samples are summarized in Table 2.3. The detection limit was used in calculating EMCs for concentrations of constituents which were present in the runoff samples at concentrations below the detection limit. Therefore, the EMC of a constituent which is present below the detection limit will be reported as being greater than the actual concentration in the sample.

Table 2.3 Detection Limits at CRWR Laboratory

Analytical Procedure	Detection Limit (mg/L)
TSS	4
VSS	4
BOD	2
COD	5
Total Carbon	10.0
Dissolved Total Carbon	10.0
Nitrate	0.10
Total Phosphorus	0.005-0.05
Oil and Grease	1.0
Copper	0.002-0.006
Chromium	0.0023-0.007
Cadmium	0.0013-0.004
Nickel	0.005-0.015
Iron	
Lead	0.0014-0.042
Zinc	0.0007-0.005

3. RESULTS

3.1 Water Quality of Highway Runoff

Summary water quality characteristics for runoff samples are presented as median event mean concentrations (EMC) in Table 3.1. The concentrations measured in flow weighted composite samples at were used to calculate the EMC. The EMC's for each constituent were derived from the average value of the constituent for each of the runoff events monitored and for which a sufficient volume of runoff was generated to complete the chemical analyses. Median EMCs for the rainfall which could be sampled (i.e. sufficient accumulation to yield the volume required for analyses) also are included in Table 3.1. The volume of rainfall collected usually was insufficient to allow complete chemical characterization.

Table 3.1 Constituents in Highway Runoff

Parameter	35th Street		Convict Hill Rd.		Walnut Creek		Rainfall
	Median	Mean	Median	Mean	Median	Mean	Median
Total Coliform (CFU/100ml)	13000	48000	4200	7900	189000	145000	0
Fecal Coliform (CFU/100ml)	5800	13000	1000	22000	102000	116000	0
Fecal Streptococcus (CFU/100ml)	12000	16000	3800	17000	78000	89000	0
pH	7.15	6.94	5.61	6.14	6.51	7.16	
TSS (mg/L)	131	202	118	142	19	27	0
VSS (mg/L)	36	41	20	22	7	7	0
BOD_5 (mg/L)	12.2	16.5	5.0	6.3	3.5	4.1	ND[a]
COD (mg/L)	126	149	40	48	35	33	6
Total Carbon (mg/L)	47	58	21	24	16	18	ND
Dissolved Tot. Carbon (mg/L)	25	31	11	14	13	15	ND
NO_3-N (mg/L)	1.03	1.25	0.73	0.96	0.28	0.36	0.52
Total Phosphorus (mg/L)	0.33	0.42	0.11	0.13	0.10	0.10	0.05
Oil & Grease(mg/L)	4.1	6.5	1.7	2.2	0.5	0.5	ND
Cu (mg/L)	0.034	0.038	0.007	0.010	0.008	0.007	0.003
Fe (mg/L)	2.606	3.537	1.401	2.437	0.361	0.442	0.079
Pb (mg/L)	0.050	0.099	0.016	0.041	0.007	0.009	ND
Zn (mg/L)	0.208	0.237	0.050	0.077	0.022	0.019	0.019

a) ND = not detected

Nickel and cadmium were rarely present at concentrations above detection limits; therefore they are not shown in Table 3.1. Many of the constituents found in runoff are present in measurable quantities in the rainfall itself. The impact of constituents in rainfall on the quality of highway runoff is limited to nutrients and some metals.

Median EMCs for the runoff at the high traffic sites compare well with the data summarized by Driscoll (1990a, b, and c) for various locations throughout the United States with the exception of lead and zinc. Table 3.2 shows the comparison between the median concentrations measured at 35th Street with the median value reported by Driscoll et al. (1990a) for all sites with average daily traffic greater than 30,000 vehicles per day. The concentrations are extremely similar except for lead which is much lower at 35th Street. The elimination of lead in gasoline is probably responsible for this difference.

Table 3.2 Comparison of High Traffic Site Concentrations

Parameter	MoPac at 35th Street (mg/L)	Driscoll et al. (1990a) - (mg/L)
TSS	131	142
VSS	36	39
COD	126	114
NO_2+NO_3	1.03[a]	0.76
Copper	0.034	0.054
Lead	0.050	0.400
Zinc	0.208	0.329

a) NO_3 only

Table 3.3 contains a comparison with the median EMC at Convict Hill Road with the median value reported by Driscoll et al. (1990a) for all sites with an average daily traffic of less than 30,000 vehicles per day. Concentrations at Convict Hill Road were lower for metals and COD, but were much higher for suspended solids. Three factors may have contributed to the higher solids concentrations. Urban development was occurring near this site during the monitoring period. The increased construction traffic may have contributed more solids than a normal vehicle mix might. In addition, the concrete barrier lining the roadway may retain more solids on the road surface, which would then be mobilized during storms. In contrast to most low traffic, rural highways, the catchment sampled had an impervious cover of 100% so that the runoff did not flow across any grassy areas which might have reduced solids concentrations.

Table 3.3 **Comparison of Low Traffic Site Concentrations**

Parameter	MoPac at Convict Hill Rd. (mg/L)	Driscoll et al. (1990a) (mg/L)
TSS	118	41
VSS	20	12
COD	40	49
NO_2+NO_3	0.73[a]	0.46
Copper	0.007	0.022
Lead	0.016	0.080
Zinc	0.050	0.080

a) NO_3 only

The event mean concentrations reported for the site having the high traffic density are higher for all water quality parameters than the observed EMC's for the other sites. However, the event mean concentrations observed at the site with medium traffic density are lower than those observed for the other two sites, including the low traffic site. This phenomenon may be explained by the fact that the runoff from the highway at the high traffic and low traffic sites is directly from the pavement into a catch basin where the samples are collected. However, the highway runoff at the medium traffic density site passes over approximately 60 m of grassy area (swale) before entering the storm drain pipe from which samples are collected. The lower concentrations of the various water quality parameters at this site may reflect removal by the grassy swale. The effects of the grassy swale on the water quality at this site is reported in Section 3.3.

3.2 Estimate of Annual Pollutant Loads

The product of the volume of runoff from a section of highway, over a given period of time, and the concentration of a specific constituent yields the pollutant load contributed by the highway. For many types of water bodies, the pollutant load is a more important indicator of potential water quality impacts than is EMC. Annual constituent loads for the three highway sites were calculated based on the "simple method" described by Schueler (1987).

$$L = \left[\frac{(P)(CF)(R_v)}{20.4} \right] (C_i)$$

where: L = Annual pollutant load (kg/ha)

P = Annual precipitation (825 mm/yr)

CF = Correction factor that adjusts for storms where no runoff occurs (0.9)

R_v = Average runoff coefficient

C_i = Event mean concentration (mg/L)

Estimated annual loadings (grams per square meter of pavement) are presented in Table 3.4. The loads for each site were normalized by watershed area to facilitate a comparison between the three sites.

Table 3.4 Estimated Annual Pollutant Loadings

Pollutant	35th Street (kg/ha)	Convict Hill Rd. (kg/ha)	Walnut Creek (kg/ha)
TSS	229	145	3.3
VSS	46	23	0.8
BOD_5	18.7	6.5	0.5
COD	169	49	4.0
Total Carbon	66	25	2.2
Dissolved Tot. Carbon	35	14	1.8
NO_3-N	1.42	0.98	0.04
Total Phosphorus	0.48	0.13	0.01
Oil & Grease	7.36	2.25	0.06
Cu	0.043	0.010	0.001
Fe	4.008	2.497	0.053
Pb	0.112	0.042	0.001
Zn	0.269	0.079	0.002

All estimated loadings at Walnut Creek are far less than those at the other two sites. This is the result of the initial low concentrations of constituents in the runoff at Walnut Creek combined with the low runoff coefficient caused by the grassy swale. Differences between expected loads at 35th Street and Convict Hill Road are primarily the result of differences in the EMC's for the constituents.

3.3 Effect of Drainage System Type

Grassy swales are vegetated ditches which have gentle slopes and cover large areas of land. Swales have been shown in studies to effectively remove many constituents from highway runoff. The swales promote settling of suspended solids and infiltration of the runoff into the soil. A curb and gutter system, which tends to concentrate and transport constituents in highway runoff, also is eliminated by a grassy swale (Schueler, 1991). Factors reported to affect the removal efficiency include type of grass, grass density, blade size, blade shape, flexibility and texture (Umeda, 1988). Channel dimensions and swale area affect removal efficiencies and the amount of infiltration that occurs.

A second sampler was installed to collect runoff directly from the road surface for comparison with the runoff from the swale to investigate the effect of the grassy swale on the runoff quality at the Walnut Creek site. A limited number of samples were collected from the overpass and concentrations of constituents were similar to those at Convict Hill Road. The data observed for the runoff samples collected from the two surfaces (the overpass before the runoff reached the grassy swale and from the outfall into which the runoff flowed after passage through the grassy median strip) at MoPac at Walnut Creek are presented in Table 3.5.

Table 3.5 Removal Efficiency of a Grassy Swale

Parameter	Roadway	Grassy Swale	Removal (%)
Total Coliform (CFU/100mL)	3,678	188,197	-
Fecal Coliform (CFU/100mL)	1,934	101,545	-
Fecal Streptococcus (CFU/100mL)	6,909	89,482	-
TSS (mg/L)	104	27	74
VSS (mg/L)	23	7	72
BOD_5 (mg/L)	7.5	4.1	46
COD (mg/L)	51	33	35
Total Carbon (mg/L)	34	18	48
Dissolved Tot. Carbon (mg/L)	17	15	9
NO_3-N (mg/L)	0.88	0.36	59
Total Phosphorus (mg/L)	0.15	0.10	31
Oil & Grease (mg/L)	3.9	0.5	88
Cu (mg/L)	0.014	0.007	49
Fe (mg/L)	2.066	0.442	79
Pb (mg/L)	0.014	0.009	35
Zn (mg/L)	0.074	0.019	74

Significant pollutant removal occurs for all constituents except bacteria and dissolved total carbon. These reductions in concentration are similar to that reported by other studies. Schueler et al. (1991) reported that well-designed, well-maintained grassed swales may remove up to 70% of TSS, 30% of total phosphorus, 25% of total nitrogen, and 50-90% of various trace metals. Little et al. (1982) found removal efficiencies of 67-93% of oil and grease, and TSS and VSS reductions of at least 65%.

The use of a grassy swale as a runoff control device raises some concerns. The bacterial counts found in samples of runoff from the swale were much higher than at the other sites. The concentrations also show that more bacteria are in the samples from the outfall than in the runoff of the roadway. Apparently, the soil of the swale or the storm sewer act as a source of bacteria. It is unlikely, given the setting, that the high levels of fecal coliform and fecal streptococcus are of human origin or that they are indicative of significant human health risk.

3.4 Pollutant Washoff Patterns

Concentrations of pollutants in runoff are often higher at the beginning of a runoff event, a phenomenon commonly referred to as the "first flush." Many storm water treatment systems are designed to capture the initial runoff from storm events to remove and treat the runoff with the highest concentrations of pollutants. It is thought by many that the majority of pollutants are contained in the first flush. Suspended solids often display the first flush effect as shown in Figure 3.1. If the rate that material is washed from the road is proportional to the amount on the road then a simple exponential function will describe the instantaneous concentrations. The magnitude of the first flush phenomenon varied between events and monitored sites in this study.

The first flush effect was more evident at West 35th Street than at Convict Hill Road or Walnut Creek because the concentrations of the constituents were higher at West 35th Street and changes were more evident. A first flush was most pronounced during short storms with fairly constant rainfall intensities. For longer events, changes in traffic volume, rainfall intensity and other variables reduced the magnitude of the first flush. Vehicles acted as a continuing source of pollutants during storm events, so complete washoff never occurred. For all storms monitored at this site the percentage of total mass

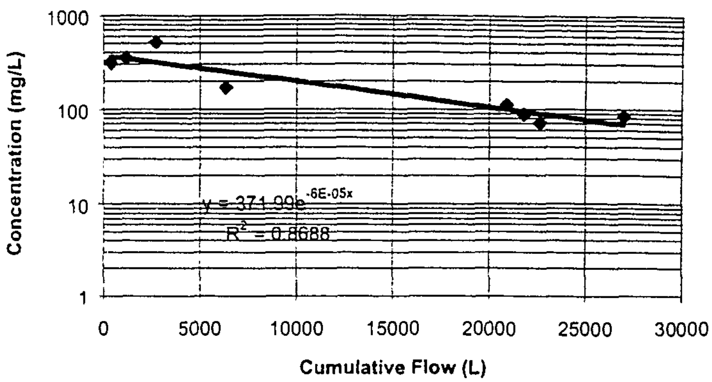

Figure 3.1 Washoff of TSS at 35th Street, 10/29/93

discharged at any point in the storm was only slightly higher than the percentage of the total runoff volume at that point. A more detailed description of the first flush effect at 35th Street is contained in CRWR Technical Report #264 (Irish et al, 1995).

At Convict Hill Road most sample collection was limited to the first 12.1 mm of runoff, because of the requirements of the NPDES permit and the rainfall characteristics in the Austin area. This limited the evaluation of the first flush characteristics at this site. Higher concentrations were recorded during approximately the first 3 mm of runoff for most constituents; however, the concentrations quickly became approximately constant for the duration of the sampling period. The typical pattern is shown in Figure 3.2 for TSS. Since the concentration of TSS stabilizes at approximately 100 mg/L, significant loading continues for the duration of the sampling period.

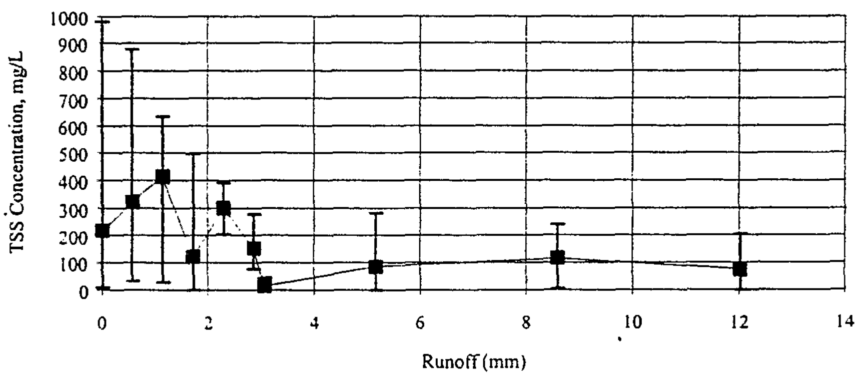

Figure 3.2 TSS Washoff Pattern at Convict Hill Road Site

First flush effects were less evident at Walnut Creek than at the other two sites because of the lack of variability and low concentrations of constituents in runoff. Low concentrations of most pollutants minimized the differences in concentrations between the start and end of the storm. The range of concentrations tend to narrow with more rainfall and average concentrations near the end of the storm are smaller than those observed at the start of the storm. Only a few constituents showed somewhat higher concentrations at the beginning of an event. The higher concentrations were limited to approximately the first 5 mm of runoff. The concentrations stabilized at this point resulting in continued input of each constituent for the duration of the event.

Although concentrations were somewhat higher at the beginning of runoff events at the sites monitored in this study, the effect was not pronounced. Concentrations stabilized at elevated levels resulting in a continuous input of pollutant load for the duration of the event. Decisions about the size of proposed runoff controls should be based on the assumption that storm water runoff has a constant concentration for each storm event.

4. SUMMARY AND CONCLUSIONS

Water quality of highway runoff in the Austin, Texas area was determined by monitoring runoff at three locations on MoPac, which represented different daily traffic volumes, surrounding land uses, and highway drainage system types. MoPac at West 35th Street is a high traffic site (60,000 vehicles per day) located in central Austin. The land use of the area is mixed residential and commercial. MoPac at Convict Hill Road is a low traffic site (8700 vehicles per day) located on the southern edge of Austin. The land use around Convict Hill Road is mostly residential and rural undeveloped. The Walnut Creek site is located in north Austin and consists of a combination of paved highway and grassy shoulder and median. The land use classification of the area is mostly commercial and high density residential, and approximately 47,000 vehicles per day pass this location. At Walnut Creek, the highway runoff crosses a large grassy median before entering the storm sewer system where the samples were collected. The watersheds of the other two sites were 100 % impervious.

Runoff flow rates were measured and samples were collected automatically during rainfall events. Water quality parameters analyzed in the laboratory for all runoff samples included: turbidity, total and volatile suspended solids (TSS and VSS), 5-Day Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), oil and grease (O&G), nutrients (nitrate and total phosphorus), heavy metals (iron, lead, cadmium, nickel, zinc, and copper), and bacteria (total coliform, fecal coliform, and fecal streptococcus).

The highest concentrations of all constituents were measured at the high traffic site at 35th Street. The lowest concentrations were found at the Walnut Creek monitoring site. The concentrations at all sites were similar to median values compiled in a nationwide study of highway runoff quality.

The total load of pollutant discharged is more important for estimating water quality impacts for many receiving waters than is concentration. Pollutant load is a function of concentration and volume of runoff. Normalized for surface area, the greatest loads were generated at 35th Street, while the lowest amounts were found at the Walnut Creek monitoring site. The monitored watershed at Walnut Creek had a runoff coefficient of only about 10 % while the other two sites had runoff coefficients of approximately 90 %. The lower concentrations at Walnut Creek combined with the much lower flows at this site were responsible for the low loads at this site.

Little adverse impact would be expected for all but the most sensitive receiving waters based on the quantity and quality of highway runoff generated during storms. The water quality of highway runoff is generally similar to that reported for urban runoff, and does not contain appreciably higher concentrations of toxic metals or oil and grease. The impacts of highway runoff alone, like many other nonpoint sources of pollution generally are not significant when considered singly, but may result in degradation of water quality when combined with other sources such as urban runoff.

The effectiveness of grassy swales for treating highway runoff was evaluated by comparing the runoff at Walnut Creek, before and after passing across a swale. The grassy swale proved effective for reducing the concentrations of most constituents in runoff. The low runoff coefficient due to infiltration of runoff into the swale produced a large reduction (90%) in pollutant load discharged. This reduction of runoff volume effectively reduces the impact of constituents whose concentrations are not reduced by the swale. Large increases in bacteria counts occurred in either the swale or the storm sewer system; however, they probably do not indicate the presence of a significant human health threat. The use of a grassy swale precludes the installation of hazardous material traps designed to catch spills of gasoline or other chemicals during traffic accidents.

A first flush effect (i.e., higher pollutant concentrations at the beginning of an event) was very evident during selected events, but was generally limited to a small volume. When all monitored events were considered, the overall effect was small or negligible. The concentrations appeared to be affected by changes in traffic volume, rainfall intensity, and other factors. In addition, vehicles provided a continuous input of pollutants to the road surface and runoff for the duration of runoff events. In considering the potential effectiveness of storm water treatment systems, constant concentrations for individual storm events should be assumed.

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APPENDIX

Table A-1 Event Mean Concentrations for Events at West 35th Street

DATE	Flow (liters)	TSS (mg/L)	VSS (mg/L)	BOD (mg/L)	COD (mg/L)	TC (mg/L)	DTC (mg/L)	N (mg/L)	TP (mg/L)	O&G (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	T.col. CFU/100 mL	F.col.	F.strep.
9/13/93	450	58	26	19	248	N/A	N/A	2.74	0.61	4.2	0.04	0.3	0.02	N/A	N/A	N/A	N/A
10/12/93	1832	106	26	25	190	84	72	3.26	0.61	3.2	0.04	1.2	0.44	0.28	N/A	N/A	N/A
10/19/93	10243	385	36	12	42	32	15	0.52	0.30	0.8	0.05	2.0	0.12	0.18	N/A	28004	3356
10/19/93	1264	157	42	28	195	79	33	1.11	0.50	4.3	0.08	5.6	0.24	0.36	12470	48662	39701
10/19/93	1601	116	47	28	185	68	31	1.07	0.47	4.7	0.08	4.4	0.23	0.34	NA	30197	23479
10/28/93	26957	147	33	18	126	53	33	0.84	0.33	9.6	0.06	2.5	0.09	0.24	5199	2029	4113
11/1/93	5620	175	44	21	209	82	45	2.11	0.39	5.0	0.07	2.7	0.19	0.29	N/A	N/A	N/A
12/21/93	6271	48	8	0	149	66	38	1.32	0.30	5.9	0.06	3.5	0.13	0.22	N/A	N/A	N/A
1/12/94	10408	123	24	6	142	35	33	1.41	0.15	4.1	0.01	0.7	0.03	0.06	N/A	366	2350
1/19/94	10444	286	81	40	336	145	80	3.44	1.04	35.1	0.05	5.7	0.04	0.36	N/A	N/A	15849
1/21/94	5988	79	40	43	264	128	85	2.36	0.51	24.0	0.04	5.3	0.05	0.30	N/A	3750	28044
2/21/94	87156	370	40	5	88	16	11	0.37	0.33	N/A	0.12	3.1	0.12	0.23	N/A	N/A	N/A
2/27/94	45877	N/A	N/A	N/A	N/A	39	10	0.43	N/A	N/A	0.04	7.7	0.27	0.59	787	N/A	N/A
3/8/94	65514	N/A	N/A	7	64	33	13	0.49	0.27	N/A	N/A	4.7	0.15	0.31	N/A	N/A	N/A
3/12/94	31975	40	20	9	75	26	19	1.08	0.12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3/14/94	36692	313	37	9	79	46	14	0.41	0.30	N/A	0.02	4.4	0.10	0.21	2694	N/A	2896
3/26/94	1964	131	57	15	90	N/A	N/A	1.03	N/A	N/A	N/A	N/A	N/A	N/A	32203	N/A	1021
4/4/94	41803	808	86	23	135	79	20	0.73	0.70	N/A	0.05	9.7	0.23	0.26	6153	407	19421
4/10/94	7627	540	114	23	292	153	53	0.96	0.73	N/A	0.07	7.8	0.21	0.51	N/A	N/A	N/A
4/14/94	13203	914	130	22	203	80	20	0.00	0.93	N/A	0.05	7.5	0.18	0.40	N/A	N/A	N/A
4/18/94	12084	N/A	N/A	N/A	217	61	28	1.39	0.76	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4/27/94	3471	126	44	56	452	123	89	3.66	1.09	N/A	N/A	N/A	N/A	N/A	14715	7032	85896
4/28/94	31525	266	49	10	80	39	18	0.62	0.39	N/A	0.02	2.0	0.06	0.16	N/A	N/A	N/A
5/1/94	11322	33	24	12	167	37	29	0.902	N/A	N/A	0.0188	0.4465	0.0000	0.0340	N/A	N/A	N/A
5/1/94	24113	184	60	4	115	37	13	0.360	0	N/A	0.0020	0.4590	0.0350	0.0390	N/A	N/A	N/A
6/2/94	37176	287	42	10	125	49	25	0.922	0	4	0	10	0	0	N/A	N/A	N/A
6/12/94	5496	372	56	N/A	124	130	78	0.000	1	N/A	0	10	0	1	N/A	N/A	N/A
6/13/94	25782	110	23	9	41	36	22	0.620	0	N/A	0	3	0	0	N/A	N/A	N/A

Table A-1 Event Mean Concentrations for Events at West 35th Street (Con't)

DATE	Flow (liters)	TSS (mg/L)	VSS (mg/L)	BOD (mg/L)	COD (mg/L)	TC (mg/L)	DTC (mg/L)	N (mg/L)	TP (mg/L)	O&G (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	T.col. CFU/100 mL	F.col.	F.strep.
8/13/94	23669	105	22	9	94	38	32	1.35	0.33	3.54	0.005	1.5	0.014	0.132	N/A	N/A	N/A
8/14/94	43020	67	13	10	70	27	23	1.40	0.23	3.66	0.002	1.1	0.014	0.083	N/A	N/A	2222
8/21/94	23660	58	22	15	167	59	51	1.02	0.30	N/A	0.021	1.8	0.028	0.131	37420	23875	19700
9/7/94	31634	91	36	37	464	N/A	N/A	3.65	0.60	2.51	0.034	1.0	0.014	0.248	601564	N/A	19878
9/9/94	443549	27	23	14	184	68	49	1.94	0.19	4.17	0.016	0.9	0.007	0.095	N/A	N/A	30669
9/15/94	33746	160	39	9	64	29	13	0.25	0.42	N/A	0.006	1.2	0.007	0.143	N/A	N/A	N/A
10/7/94	108126	93	28	27	209	75	52	1.76	0.60	3.95	0.028	1.4	0.084	0.192	8354	724	622
10/25/95	43590	N/A	N/A	N/A	18	5	5	N/A	0.07	N/A	0.005	0.7	0.015	0.057	N/A	N/A	1730
10/28/94	16200	129	42	16	124	54	22	N/A	0.25	3.70	0.029	3.8	0.027	0.204	40851	34307	36628
11/15/94	23946	96.00	32.00	N/A	135	64.9	27.5	N/A	0.26	N/A	N/A	N/A	N/A	N/A	18333	7000	16667
12/2/94	45312	205	28	12	65	38	9	0.48	0.30	3.20	0.013	1.7	0.012	0.107	N/A	N/A	N/A
12/9/94	7408	20.00	8.00	14	152	53.1	40.4	2.20	0.19	5.1	0.012	0.404	0.007	0.068	N/A	N/A	N/A
12/14/94	21710	80	28	19	157	60	30	1.32	0.31	N/A	0.020	2.9	0.019	0.149	17824	13995	29138
12/15/94	206825	88	32	7	89	36	13	0.44	0.22	N/A	0.015	1.8	0.019	0.111	4943	3662	N/A
2/11/95	9549	128.00	48.00	31	N/A	99.5	73.7	N/A	0.78	3.5	0.062	2.958	0.026	0.192	47000	600	5350
2/24/95	47345	336	48	N/A	196	95	26	2.27	0.65	N/A	0.068	8.8	0.037	0.316	N/A	N/A	N/A
3/7/95	20806	57	30	8	55	25	14	1.43	0.18	3.30	0.021	1.4	0.023	0.102	1334	70	3155
3/13/95	45325	225	24	7	68	25	10	0.63	0.25	4.10	N/A	N/A	N/A	N/A	391	85	1118
4/20/95	51063	218	35	5	48	15	4	0.21	0.19	N/A	N/A	N/A	N/A	N/A	14385	N/A	11546
5/8/95	37976	165	41	9	55	32	N/A	N/A	0.33	N/A	N/A	N/A	N/A	N/A	N/A	18915	6921
5/18/95	20960	N/A	N/A	N/A	N/A	36.5	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A	N/A	4500	22500

Table A-2 Event Mean Concentraitons for Events at Convict Hill

Date	Rainfall (in)	Rainfall (mm)	Flow (gal)	Flow (L)	TSS mg/L	VSS mg/L	BOD mg/L	COD mg/L	TC mg/L	DTC mg/L	N mg/L	TP mg/L	O&G mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Zn mg/L	T.col. CFU/100 mL	F.col. CFU/100 mL	F.strep. CFU/100 mL
4/29/94	0.09		375		239	39	10	72	49	28	1.47	0.062	NA	0.015	NA	NA	0.063	NA	NA	20500
5/2/94	0.11		375		86	23	6	78	41	23	0.89	0.109	NA	0.020	2.9	NA	0.081	NA	NA	NA
5/13/94	0.46		1050		403	42	5	92	39	17	0.71	0.260	NA	0.010	8.9	0.141	0.174	NA	NA	0
5/14/94	0.25		350		348	20	7	NA	29	11	0.78	0.358	1.5	0.009	4.0	0.090	0.099	12000	400	7667
5/16/94	0.07		400		6	6	7	46	24	21	0.75	0.078	2.0	0.002	1.0	0.033	0.053	2000	167	20667
6/10/94	0.17		400		512	50	24	174	89	43	NA	0.380	NA	0.032	11.8	0.223	0.310			
6/19/94	0.23		400		4	0	5	75	20	20	0.60	NA	1.9	0.011	4.5	0.100	0.292	NA	NA	NA
6/21/94	0.16		600		40	12	6	68	31	22	1.61	0.112	2.4	0.001	0.5	0.171	0.033	NA	NA	NA
8/8/94	0.18		600		176	68	13	114	NA	NA	NA	0.200	8.1	0.003	2.2	0.021	0.042	0	0	100
8/9/94	0.36		900		42	14	3	32	11	5	0.21	0.048	1.6	0.001	0.9	0.007	0.010	7550	1250	775
8/16/94	0.3		900		80	8	10	39	23	21	1.80	NA	1.7	0.001	1.1	0.007	0.028	NA	NA	NA
8/22/94	0.27		900		40	12	3	15	14	11	0.43	0.060	0.8	0.002	0.8	0.012	0.017	NA	NA	3525
9/7/94	0.17		450		292	44	16	49	22	19	1.02	0.080	1.8	0.009	1.8	0.017	0.079	11500	9500	4000
9/8/94	0.27		900		0	0	5	17	5	5	0.53	0.025	0.4	0.003	0.3	0.016	0.022	1750	NA	750
9/9/94	0.47		1800		3	2	3	10	5	5	0.40	0.025	1.3	0.008	0.5	0.007	0.028	6788	NA	1475
10/7/94	0.37		1350		68	7	8	49	21	16	0.60	0.077	0.9	0.003	0.8	0.011	0.019	NA	NA	NA
10/14/94	0.24		1275		24	16	6	43	32	14	0.78	0.030	2.4	0.003	0.9	0.021	0.055	14800	110000	90000
10/25/94	0.56		1800		146	15	4	19	18	8	NA	0.041	0.9	0.003	0.7	0.009	0.016	NA	NA	9500
10/27/94	0.29		1575		68	16	4	40	24	10	NA	0.113	1.8	0.007	2.5	0.014	0.215	4500	6000	20625
11/5/94	0.49		1800		192	24	3	29	19	8	NA	0.078	0.9	0.007	1.5	0.013	0.045			NA
11/15/94	0.15		300		12	4	5	33	20	17	NA	0.060	1.7	0.006	1.2	0.014	0.081	4000	1500	3600
12/2/94	0.3		900		156	28	5	39	21	5	0.39	0.070	7.6	0.007	1.4	0.007	0.052		186667	156667
12/9/94	0.09		375		136	28	3	29	13	12	0.55	0.005	NA	NA	NA	NA	NA	NA	NA	NA
12/15/94		23.16		11679	96	21	3	41	23	10	0.23	0.14	2.6	0.004	1.2	0.015	0.037	1099	1349	2866
1/13/95		19.56		7137	346	29	5	26	17	10	0.18	0.14	N/A	0.005	1.4	0.014	0.035	0	0	0
2/13/95		2.75		4522	24	8	13	46	23	15.3	1.75	0.13	3.6	0.032	2.1	0.024	0.075	1150	350	1450
2/24/95		8.32		9381	245	20	N/A	85	45	14	1.37	0.19	N/A	0.032	6.8	0.027	0.118	NA	NA	NA
3/7/95		8.35		9230	147	26	4	31	19	4	1.24	0.12	0.9	0.014	1.8	0.027	0.049	681	404	834
3/13/95		30.46		15087	118	3	2	16	12	9	5.50	0.09	N/A	0.024	2.3	0.024	0.042	119	NA	150

Table A-2 Event Mean Concentraitons for Events at Convict Hill (Con't)

Date	Rainfall (in)	Rainfall (mm)	Flow (gal)	Flow (L)	TSS mg/L	VSS mg/L	BOD mg/L	COD mg/L	TC mg/L	DTC mg/L	N mg/L	TP mg/L	O&G mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Zn mg/L	T.col. CFU/100 mL	F.col. CFU/100 mL	F.strep. CFU/100 mL
3/16/95		5.81		2244	148	24	2	44	29.1	10	1.75	0.16	2.0	N/A	N/A	N/A	N/A	2550	100	3300
4/4/95		16.76		12091	153	30	5	40	21	10	0.20	0.19	1.1	N/A	N/A	N/A	N/A	8366	2306	13266
4/18/95		9.84		6838	86	26	7	38	24	11	0.79	0.20	N/A	N/A	N/A	N/A	N/A	56103	698	19212
4/19/95		7.33		3336.6	260	52	7	57	32.1	10	0.35	0.26	N/A	N/A	N/A	N/A	N/A	17500	NA	20000
4/20/95		19.03		8420	198	20	4	21	12	10	0.11	0.13	N/A	N/A	N/A	N/A	N/A	NA	NA	NA
5/8/95		27.42		11723	85	15	3	18	13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5829	667	4175
5/18/95		7.11		2574	N/A	N/A	N/A	N/A	14.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66000	25500

Table A-3 EMC's at Walnut Creek for Events with Flow Similar to Base Flow (Swale)

Date	Rainfall (mm)	Flow (L)	TSS (mg/L)	VSS (mg/L)	BOD (mg/L)	COD (mg/L)	TC (mg/L)	DTC (mg/L)	N (mg/L)	TP (mg/L)	O&G (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	T.col. (mg/L)	F.col. (mg/L)	F.strep. (mg/L)
5/16/94			0	0	3	26	42	39	0.54	0.09	1.00	0.019	0.10	0.062	0.027	35000	10000	25000
6/3/94			18	6	4	55	39	38	N/A	0.09	1.30	0.001	0.27	0.062	0.042	na	na	na
8/8/94			136	48	12	124	51	33	3.10	0.38	NA	0.001	1.12	0.007	0.047	tntc	tntc	200000
8/15/94			39	12	8	42	41	47	2.45	0.23	0.50	0.001	0.31	0.009	0.004	356667	150000	15000
8/21/94			32	0	7	47	32	27	0.60	0.12	0.50	0.011	0.98	0.021	0.018	na	na	na
9/8/94			26	4	4	16	10	8	0.52	0.13	0.70	0.005	0.80	0.007	0.032	100375	na	na
9/12/94			8	4	1	36	17	13	0.33	NA	0.70	0.001	0.49	0.007	0.008	na	na	na
10/14/94			28	8	4	27	43	38	2.05	0.15	NA	0.004	0.12	0.007	0.013	na	na	na
10/16/94			8	3	4	27	53	51	1.21	0.01	0.70	0.002	0.09	0.007	0.041	na	na	na
11/15/94			4	0	6	28	38	36	N/A	0.11	N/A	N/A	N/A	N/A	N/A	133	100	233
12/14/94			10	8	3	36	43	42	0.67	0.11	0.80	0.002	0.17	0.014	0.009	20375	12375	10875
1/13/95			14	1	2	6	46	45	1.24	0.01	1.40	0.007	0.03	0.014	0.009	0	0	0
3/13/95			15	1	2	18	32	28	1.22	0.09	2.35	0.004	0.17	0.014	0.009	na	na	na
3/16/95			7	1	3	22	38	27	0.81	0.05	2.80	0.006	0.43	0.014	0.007	4417	7133	7000
4/4/95			61	11	2	14	35	30	0.37	0.04	1.00	0.005	0.24	0.014	0.011	825	163	725
4/20/95			9	3	4	30	39	31	0.53	0.05	N/A	N/A	N/A	N/A	N/A	44000	5400	103500

Table A-4 EMC's at Walnut Creek for Events with Significant Storm Flow (Swale)

Date	Rainfall (mm)	Flow (L)	TSS (mg/L)	VSS (mg/L)	BOD (mg/L)	COD (mg/L)	TC (mg/L)	DTC (mg/L)	N (mg/L)	TP (mg/L)	O&G (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	T.col. (mg/L)	F.col. (mg/L)	F.strep. (mg/L)
4/29/94	14.46	66284	62	12	5	35	12	13	0.49	0.22	N/A	0.013	0.25	N/A	0.041	na	na	na
4/30/94	4.83	37536	15	4	3	40	24	24	0.45	0.12	N/A	0.013	0.14	N/A	0.024	na	na	na
5/2/94	8.3	41068	19	N/A	3	47	34	30	0.28	0.10	N/A	0.012	0.47	N/A	0.020	na	na	na
5/28/94	12.43	31004	10	4	3	30	24	25	0.87	0.10	N/A	N/A	N/A	N/A	N/A	na	na	na
10/7/94	124.91	1473204	8	0	3	20	5	5	0.23	0.11	0.50	0.003	0.71	0.021	0.001	380000	185000	153333
10/18/94	14.99	154861	55	9	5	38	16	10	0.20	0.09	0.89	0.003	1.09	0.007	0.031	144958	116085	79830
5/8/95	44.44	197330	20	10	5	21	9	0	0.00	0.00	0.00	0.000	0.00	0.000	0.000	39634	3552	35283

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Table A-5 EMC's at Walnut Creek for Direct Road Runoff

Date	Rainfall (mm)	Flow (L)	TSS (mg/L)	VSS (mg/L)	BOD (mg/L)	COD (mg/L)	TC (mg/L)	DTC (mg/L)	N (mg/L)	TP (mg/L)	O&G (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Zn (mg/L)	T.col. (mg/L)	F.col. (mg/L)	F.strep. (mg/L)
10/17/94	5.33	757	216	52	5	42	58.3	12.8	0.26	0.17	1.70	0.01	1.67	0.01	0.07	na	na	na
11/5/94	5.33	1514	24	20	3	4	5	5	N/A	0.04	N/A	0.01	0.40	0.01	0.01	na	na	na
11/15/94	5.08	2271	40	12	8	71	35	28	N/A	0.19	2.50	0.01	2.34	N/A	0.10	2500	1363	4775
12/2/94	5.08	946	100	16	9	56	29.6	14.5	0.35	0.14	4.10	0.01	1.28	0.01	0.06	na	na	na
12/14/94	3.05	2839	42	22	9	84	40	24	1.19	0.17	7.90	N/A	N/A	N/A	N/A	5000	5100	21600
1/13/95			24	11	4	42	25	17	1.60	0.05	3.0	0.004	0.8	0.017	0.042	625	625	250
2/13/95	0.75	307	44	16	22	99	43.4	29.3	N/A	0.16	5.1	0.022	2.1	0.020	0.105	3500	350	500
2/24/95	11.39	1909	143	13	N/A	97	47	14	1.60	0.20	5.7	0.037	5.3	0.032	0.147	5793	4886	12381
3/13/95	32.23	4184	128	7	3	28	17	11	0.34	0.11	2.3	0.025	2.3	0.017	0.045	314	324	584
3/16/95	5.3	1705	240	40	9	24	50.8	16.5	1.40	0.22	3.8	0.017	4.0	0.014	0.124	2000	1200	4400
4/4/95	0.25	618	190	54	8	31	45	15	0.76	0.21	2.9	0.004	0.6	0.004	0.027	9690	1622	10779
4/20/95	9.14	1007	128	24	7	68	33.3	13.6	0.43	0.17	N/A	N/A	N/A	N/A	N/A	na	na	na
5/8/95	57.58	4595	33	12	3	16	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	na	na	na

The Virginia Department of Conservation and Recreation has developed the Virginia Stormwater Management Handbook, First Edition, in order to provide guidance for compliance with the Virginia Stormwater Regulations. (4VAC3-20 et seq.) The technical material provided in the Handbook includes hydrologic and hydraulic analysis procedures. This information was derived in part from SCS sources such as the SCS National Engineering Handbook (NEH), and the SCS Engineering Field Manual (EFM), and others.

A brief Summary of the Handbook is provided here.

Chapter 1: Virginia Stormwater Management Program, provides an overview of the various State regulations which address water quality and nonpoint source pollution.

Chapter 2: Stormwater Management and Urban BMPs, presents the basic components of stormwater management, as found in the Virginia SWM Regulations, and follows them through the BMP sizing and selection criteria. Most importantly, this Chapter presents the basics of Regional Stormwater Management and Comprehensive Watershed Management.

Chapter 3: Minimum Standards, provides the technical design requirements and specifications, and maintenance requirements for stormwater BMPs defined in the Regulations. These minimum standards represent current, and in some cases innovative, design information pulled together under one cover in order to promote consistency in the design and construction, and therefore the effectiveness, of stormwater BMPs. These BMPs include: **3.01** Earthen Embankments; **3.02** Principal Spillways; **3.03** Vegetated Emergency Spillway; **3.04** Sediment Forebay; **3.05** Landscaping; **3.06** Retention Basins; **3.07** Extended Detention Basin; **3.08** Detention Basin; **3.09** Constructed Stormwater Wetlands; **3.10** Infiltration Practices; **3.11** Bio-Retention; **3.12** Sand Filters; **3.13** Grassed Swale; **3.14** Vegetated Filter Strip; and **3.15** Manufactured BMP Systems.

Chapter 3 Appendix: Design & Plan Review, Inspection and As-Built, and Maintenance Checklist.

Chapter 4:Hydrologic Methods, presents four methods for conducting a hydrologic analysis and determining the peak discharge from a watershed or drainage area. These methods include the Rational Method, Modified Rational Method, SCS TR-55 Graphical Peak Discharge Method, and Tabular Hydrograph Method. Also included is a basic overview of various types of design hydrographs used in stormwater modeling.

Chapter 4 Appendix: Various hydrological data including soil classifications, rainfall tables, etc.

Chapter 5: Engineering Calculations, provides very detailed calculation procedures for designing BMPs using standard hydraulic equations. These procedures include storage volume requirements, water quality and channel erosion control volume calculations, extended detention calculations, principal spillway and emergency spillway design, anti-seep collar design, outlet protection, riser floatation calculations, and water quality calculation procedures.

Chapter 5 Appendix: Hydraulic calculation worksheets, water quality criteria worksheets, etc.

Chapter 6: Example Problems, provides some design examples including hydrologic and hydraulic analyses.

Technical Bulletins: Purchasers of the Handbook will automatically receive three Technical Bulletins which will provide additional and updated information and guidance. These Technical Bulletins will provide information on local program development, local program funding ideas and experiences, innovative BMP design, BMP pollutant removal efficiencies, BMP maintenance, etc.

MINIMUM STANDARD 3.12

GENERAL INTERMITTENT SAND FILTERS

View BMP Images

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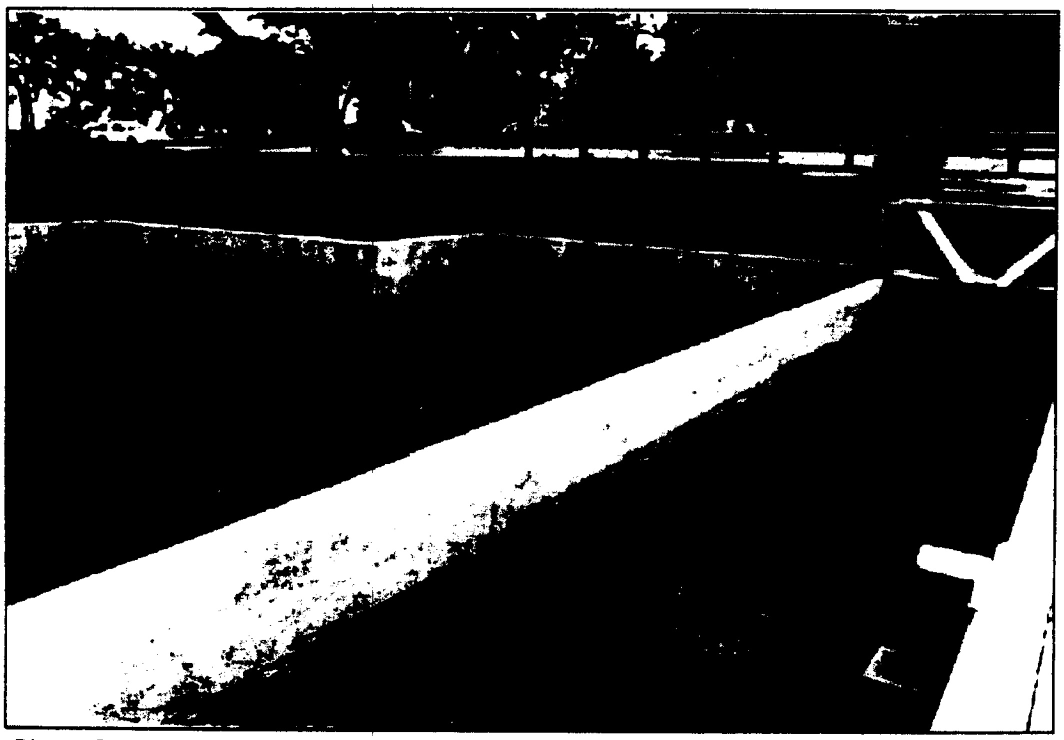
MINIMUM STANDARD 3.12

GENERAL INTERMITTENT SAND FILTER PRACTICES

Definition

Intermittent sand filter facilities capture, pretreat to remove sediments, store while awaiting treatment, and treat to remove pollutants (by percolation through sand media) the most polluted stormwater (the water quality volume) from a site. Intermittent sand filter BMPs may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins. They have been successfully used in Austin Texas, the District of Columbia, The State of Delaware, and in Alexandria, Virginia over the last two decades. **Figure 3.12-1** is a photograph of a sand filter BMP in Austin.

FIGURE 3.12 - 1
Austin Partial Sedimentation Surface Sand Filter



(Photo Courtesy of City of Austin, Texas)

Purpose

Intermittent sand filter facilities are primarily used for water quality control. However, they do provide detention and slow release of the water quality volume from the site being treated. Whether this amount will be sufficient to provide the necessary peak flow rate reductions required for channel erosion control is dependent upon site conditions (hydrology) and required discharge reductions. The 10-year and 100-year flows will usually exceed the detention capacity of a sand media filter. When this occurs, separate quantity facilities must be provided. Table 3.12-1 contains the target removal efficiencies of sand and other soil media filter BMPs. Table 3.12-2 contains the results of an extensive sand filter monitoring study in Alexandria conducted for the Chesapeake Bay Local Assistance Department (Bell, Stokes, Gavan, and Nguyen, 1995).

TABLE 3.12-1
Pollutant Removal Efficiency for Intermittent Sand Filter Facilities

BMP Description	Target Phosphorus Removal Efficiency
Intermittent Sand Filter treating 0.5 inches of runoff from the impervious area.	65%

Pollutant Removal Mechanisms at Work in Intermittent Sand Filter BMPs

Pollutant removal processes at work in intermittent sand filters are complex and involve physical, chemical, and biological transformations (Tchobanoglous and Burton, 1991; Anderson, Siegrist, and Otis, Undated). The most obvious mechanism is physical straining of suspended solids and particulate nutrients.

Suspended Solids

Mechanical straining, straining due to chance contact, and sedimentation are the principal mechanisms by which suspended solids are removed, although the growth of bacterial colonies within the sand grains may also cause autofiltration (Tchobanoglous and Burton, 1991).

Table 3.12-2

Pollutant Removal Efficiencies for a Delaware Sand Filter in Alexandria

Constituent	Mass Balance Removal Efficiency (%)
Cadmium	NA
Copper	NA
Zinc	>90.7
Iron	NA
Ammonia Nitrogen	>39.0
Nitrite Nitrogen	>45.8
Nitrate Nitrogen	-62.7
NO_x	-53.3
Total Kjeldahl Nitrogen	70.6
Total Phosphorous	63.1/72.3[1]
Ortho-Phosphorous	>68.3/74.4[1]
Total Suspended Solids	>78.8/>83.9[2]
Hardness	38.5
Biochemical Oxygen Demand (5 Day)	>77.5
Total Petroleum Hydrocarbons	>84[3]
Total Organic Carbon	65.9

[1] Excluding Anaerobic Incident Data [2] Excluding Storms with Heavy Iron Export
[3] Average Removal from Alaska Marine Lines Filter 3 in Seattle, Washington (Horner,1995)

Phosphorous

Phosphorous removal is performed by physiochemical processes such as mechanical and chance contact straining, precipitation, and adsorption (Piluk and Hao, 1989; Laak, 1986).

There are three general types of adsorption (the condensation and concentration of ions or molecules of one material [the adsorbate] on the surface of another [the adsorbent]): physical, chemical, and exchange. Physical adsorption results from the weak forces of attraction between molecules and is generally quite reversible. Chemical adsorption results from much stronger forces comparable to those leading to the formation of chemical compounds, with the adsorbed material forming a one molecule thick layer over the surface of the absorbent until the capacity of the absorbent is exhausted. Chemical adsorption is seldom reversible. Exchange adsorption, on the other hand, results from electrical attraction between the adsorbate and the surface, such as occurs with ion exchange. Ions of the adsorbate concentrate on the surface of the adsorbent as a result of electrical attraction to opposite charges on the surface. It is sometimes difficult to assign a given adsorption to a specific type (Sawyer, Mcarty, and Parkin, 1994).

Although exchange adsorption may also be involved, most adsorption in intermittent sand filters appears to be chemical adsorption (Piluk and Hao, 1989; Otis, Undated; Anderson, Siegrist, and Otis, Undated).

In addition to the **filter mass available**, the adsorption of phosphorous in sand filters is also affected by the pH of the material being filtered (with higher removal rates occurring with the reduction of pH), temperature, contact time, and the character of the filter media (Laak, 1986). Sands containing iron, aluminum, or calcium have a higher phosphorous removal potential because phosphorous will combine with these elements through chemical precipitation and become relatively insoluble (Laak, 1986, Tchobanoglous and Burton, 1991). If the filter becomes anaerobic, the bonding with iron may break down, releasing orthophosphates (Harper and Herr, 1993). However, aerobic filters enriched with iron may attain almost complete phosphorous removal until the filter capacity is exhausted, and properly sized filters may have a life of up to 20 years (Laak, 1986). Sand particles with sufficient iron content may become positively charged, leading to more favorable medium-particle interactions and increased removal rates (Stenkamp and Benjamin, 1994). Entrapment in the filter of a high percentage of the iron in the runoff being treated may provide a source to replenish used up phosphorous adsorption capacity.

Nitrogen and Biochemical Oxygen Demand

Mineralization of organic nitrogen into ammonium (NH^-_4) may occur under either aerobic or anaerobic conditions if the required naturally occurring chemoautotrophic bacteria (organisms which obtain energy by oxidizing simple chemical compounds) are present (*Nitrosomonas, Nitrosococcus, Nitrospira, Nitrosolobus, Nitrososovibrio*)((Laak, 1986; The Cadmus Group, 1991).

Organic N • • Bacterial enzymes • • NH_4^- + other products

Positively charged ammonium ions are then adsorbed to negatively charged sand filter particles through exchange adsorption (The Cadmus Group, 1991).

The transformation of ammonia (NH_3) and ammonium into nitrite and nitrate (NO_2^- and NO_3^-) and the removal of BOD_5 occur under aerobic conditions by microorganisms (such as *Nitrosomonas* and *Nitrobacter*) present in the sand bed (Tchobanoglous and Burton, 1991;, Laak, 1991; The Cadmus Group, 1991).

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$NH_4^+ + 1.5O_2$ • •*Nitrosomonas*, etc • • $NO_2^- + 2H + H_2O$ + Energy

$NO_2^- + 0.5O_2$ • •*Nitrobacter* • • NO_3^- + Energy

Since nitrite and nitrate are soluble anions, they are not affected by the cation exchange complex of the filter, but rather tend to leach readily to the filter effluent (Gold, Lamb, Loomis, and McKiel, Undated). However, anaerobic microenvironments (sometimes called "microsites") routinely coexist in principally aerobic intermittent sand filters (Tchobanoglous and Burton,1991; Gold, Lamb, Loomis, and McKiel, Undated). Naturally occurring anaerobic bacteria (*Pseudomonas, Micrococcus, Achromobacter, Bacilluss*) in these pockets may convert much of the nitrite into nitrate and the nitrate to nitrogen gas, resulting in total nitrogen removal in intermittent sand filters ranging up to 45-50 percent (Tchobanoglous and Burton, 1991; Laak, 1986; Ronayne, Paeth, and Osborne, Undated).

NO_3^- + Organic Carbon • •Denitrifying bacteria • • $N_2 + H_2O + CO_2$ + Cells

Organic carbon must be present for denitrification to occur, but low organic carbon/nitrogen rations will suffice (1:2 or less) (Laak, 1986, p.62). Some studies indicate that optimal denitrification occurs at ratios of 1:1-3:1 (Gold, et al, p.298). The maximum rate of denitrification occurs at temperatures above 10 degrees C and at a pH above 5.5, with the optimum pH range falling between 7.0 and 8.0. (The Cadmus Group, 1991, p.11). However, home wastewater systems have demonstrated excellent denitrification performance when the wastewater temperature was as low as 4 degrees C (Piluk and Hoa, 1989).

Heavy Metals

More than 70 percent of heavy metals in stormwater runoff is in particulate form (Harper and Herr, 1993). Over 70 percent of particulate heavy metals are of greater than 104 microns in size (Shaver and Baldwin, 1990). Particle settling in presettling basins and mechanical straining appear to be the principal mechanism for removing heavy metals in stormwater intermittent sand filter systems. Some iron may be removed by reacting with phosphorous in the runoff being treated.

Hydrocarbons

Mechanical straining and physical adsorption appear to be the mechanisms removing hydrocarbons which reach the sand filter.

Conditions Where Practice Applies

Intermittent sand filters are suitable for use in ultra-urban settings with a high degree of imperviousness where the land cost or loss of economic return on real estate required to construct retention basins may be prohibitive. They are generally suited for high pollutant removal on medium to high density development (65 to 100% impervious cover). Specific conditions such as drainage area size and development conditions are discussed with each type of intermittent sand filter. Because they are subject to failure by clogging, intermittent sand filters are not recommended for use on watersheds where sediment loadings can be significant. Wherever possible, their use should be limited to treating runoff from impervious surfaces. Most of the practices discussed below are designed to treat runoff from watersheds with at least 65% impervious cover. Where other runoff must be treated, sediment protection must be increased to severely curtail the sediment load reaching the filter media.

Planning Considerations

Site Conditions

1. *Size and Topography of the Site*

Some types of intermittent sand filter BMPs are especially suited to larger drainage sheds, while others have upper size limits on their effective use. **Table 3.12-3** outlines drainage shed size applications of various types of intermittent sand filter facilities. On larger sites with multiple drainage sheds, a variety of BMPs might prove to be most cost effective.

TABLE 3.12 - 3
Appropriate Intermittent Sand Filter Applications to Various Site Areas

Type of Intermittent Sand Filter	Appropriate Drainage Shed to filter
District of Columbia Underground Vault Sand Filters	Medium (0.25-1.25 impervious acres)
Delaware Sand Filters	Small-Medium (≤ 1.25 impervious acres)
Austin Full Sedimentation Sand Filters (Surface or Vault)	Large (≥ 1.25 impervious acres)
Austin Partial Sedimentation Sand Filters (Surface)	Medium-Large
Austin Partial Sedimentation Sand Filters (Underground)	Medium

2. *Stormwater Infrastructure Serving Site*

Both the size and the elevations of stormwater infrastructure serving the site as a whole are important considerations. A critically important design parameter is the potential difference in elevation of the receiving manhole in the stormwater infrastructure and the elevation of the closest manhole in the new storm sewer system draining the site to be served. This will determine the depth of water than can be pooled above the filter media with the system operating on gravity flow. Almost all intermittent sand filter BMPs are designed to flow by gravity. However, in commercial and industrial applications where dedicated maintenance crews with familiarity with mechanical equipment will be available, pumped flow should be considered a viable alternative.

3. *Depth to Seasonally High Groundwater Table*

The liner or concrete shell of intermittent sand filter BMPs is usually placed at least 2 to 4 feet above the seasonally high water table or bedrock in order to assure dry conditions for construction and to minimize infiltration of groundwater into the filter structure. However, in some cases, it may be economical and practical to place filter shells below the seasonally high water table. In such cases, floatation effects must be countered by providing extra weight or hold down components in the filter shell.

4. *Value of the Real Estate and Expected Income from Development*

The value of real estate in highly urbanized areas may drive the overall cost of traditional structural BMPs too high for serious consideration. In Alexandria, for example, the cost of real estate alone to construct retention ponds averages $60,000 per impervious acre treated, while the cost of real estate for extended detention basins averages $40,000 per impervious acre treated. The overall costs of underground vault sand filters, which may be placed under parking lots and private streets or even within building structures and therefore have no real estate cost, can become quite competitive under such circumstances. The income stream from increased development allowed by underground BMPs should also be considered in such analyses.

5. *Aesthetic and Land Use Considerations*

Most traditional stormwater BMPs may be severely lacking in visual attractiveness. This may be especially true with some extended detention basins and retention basins lacking a base flow to prevent eutrophication during hot, dry weather. Questions also often arise about the use of valuable open space on projects for BMPs instead of alternative uses such as recreation. Most sand filter BMPs are visually unobtrusive and may be used in situations where aesthetic considerations or open space use are important.

Sediment Control

Intermittent sand filter BMPs which have been subjected to heavy sediment loadings have historically failed very quickly (LaRock, 1988; Harper and Herr, 1993). In a study in Denver, Colorado, Urbonis, Doerfer, and Tucket found that the hydraulic conductivity of a sand filter serving an equipment parking lot dropped rapidly as sediment accumulated on the surface of the filter (Urbonis, Doerfer, and Tucker, 1996) . A layer of sediment approximately 1/16 inch (1.6 millimeters) thick was found to limit hydraulic conductivity to 0.05 feet per hour (1.6 ft/day), considerably less than the design coefficient of permeability used by Northern Virginia jurisdictions in the design of sand filters (*ibid.*; Bell, Stokes, Gavan, and Nguyen, 1995). The filter media of intermittent sand filter BMPs must therefore be protected from excessive sediment loads. This requires isolation during construction of the development, site design to restrict the amount of runoff from pervious areas reaching the filter after construction, and proper sizing of sediment removing features of the BMP to match final site conditions.

1. ***Construction Runoff***

> *Sand filter BMPS must **never** be placed in service until all site work has been completed and stabilization measures have been installed and are functioning properly.*

When this precaution has not been taken in the past, the sand filter BMPs have become clogged with sediment from upland construction operations almost immediately, requiring complete reconstruction of the sand filter and sometimes the collector pipe system. This can prove very expensive. However, since most sand filter BMPs are constructed off-line with a flow splitting device employed to divert only the Water Quality Volume to the filter, the BMP may usually be completely constructed but isolated from runoff by blocking the inflow pipe until the site is fully stabilized.

2. ***Urban Runoff***

While experience indicates that intermittent sand filters fail very quickly when directly exposed to runoff from watersheds with low imperviousness and poor vegetated cover (LaRock, 1988; Harper and Herr, 1993), filters which treat runoff from almost exclusively impervious areas, such as highway surfaces, may perform satisfactorily for several years with very little maintenance (Shaver and Baldwin, 1991).

An 18-month, comprehensive study of runoff from street surfaces in 12 cities throughout the U.S. determined that, while most particulate matter is in the fractions equating to sand and gravel, the approximately 6 percent of particles in the silt and clay soil size contain over half the phosphorous and some 25 percent of other pollutants (Sartor, Boyd, and Agardy, 1974). **Table 3.12-4** illustrates this finding.

In planning the layout for a site on which sand filter BMPs are to be employed, care should be taken to direct only runoff from impervious surfaces to the filter insofar as possible. The drainage sheds feeding sand filter BMPs with only partial sediment protection (as delineated in the individual BMP discussions which follow) should ***never*** contain less than 65% impervious cover. Even when full sediment protection is provided in the form of a carefully sized presettlement basin, the amount of runoff from pervious areas directed to the filter must be minimized. The Denver study also indicates that full sediment protection may be required in areas subject to heavy atmospheric deposition of suspended solids even when only runoff from impervious surfaces is being treated.

The presettling basin or sedimentation chamber of an intermittent sand filter BMP is expected to remove all but the very fine particles of sediment, while most of the other pollutant removal is expected to occur in the sand filter, where the very fine particles will be trapped.

TABLE 3.12-4
Percent of Street Pollutants in Various Particle Size Ranges

	Particle Size (Microns)					
Pollutant	**>2000**	**840-2000**	**246-840**	**104-246**	**43-104**	**<43**
Total Solids	24.4	7.6	24.6	27.8	9.7	5.9
Volatile Solids	11.0	17.4	12.0	16.1	17.9	25.6
COD	2.4	4.5	13.0	12.4	45.0	22.7
BOD_5	7.4	20.1	15.7	15.2	17.3	24.3
TKN	9.9	11.6	20.0	20.2	19.6	18.7
Phosphates	0	0.9	6.9	6.4	29.6	56.2
All Toxic Metals	16.3	17.5	14.9	23.5	-	27.8

(Source: Shaver and Baldwin, 1990; adapted from Sartor, Boyd, and Agardy, 1974)

Trash Exclusion

Underground vault BMPs are confined space under Occupational Safety and Health Regulations and are therefore more expensive to enter and maintain than open facilities. Future operations and maintenance costs can substantially reduced by assuring that trash is, insofar as possible, excluded from entering the vault. Grated storm inlets and trash racks in flow splitters are two ready solutions to this problem.

Projected Hydrocarbon Loadings

Sand filters will quickly clog when subjected to direct heavy hydrocarbon loadings. Where such loadings are expected, a design which removes unemulsified hydrocarbons in a separate chamber or structure in the treatment train ahead of the filter should be selected.

Maintenance

The maintenance requirements for intermittent sand filters must be considered during the planning and design of the facility. All chambers of underground sand filters must have personnel access manholes and built-in access ladders . Access roads or streets must be of sufficient width and bearing capacity to support dump trucks loaded with accumulated sediments or heavy vacuum (e.g."VACTOR") trucks for removing accumulated sediments and hydrocarbons from sediment chambers and traps on a regular basis. Approximately every 3-5 years, the filter can be expected to clog to the point that replacement of the top few inches of sand or, where employed, the layer of washed gravel and the top layer of filter cloth will be required. **A minimum maintenance headspace of 60 inches above the filter is required in underground vault filters BMPs.** A 36-38-inch diameter maintenance manhole with a small, concentric personnel access lid or a rectangular load bearing access door (minimum 4 ft. x 4 ft.) should be positioned directly over the center of the filter. Large sedimentation basins and open filters must be equipped with access ramps to allow small earthmoving equipment such as "Bobcats" and light trash raking equipment to go into the basins. Finally, before finalizing the BMP design, follow the advice of Joseph J. Skupien, Principal Hydraulic Engineer of Somerset County, New Jersey, and "close your eyes, kick back, and think your BMP through a full year of operations, visualizing how it will perform under the conditions of all four seasons."

General Design Criteria

The purpose of this section is to provide recommendations and minimum criteria for the design of intermittent sand filter practices intended to comply with the Virginia Stormwater Management program's runoff quality requirements.

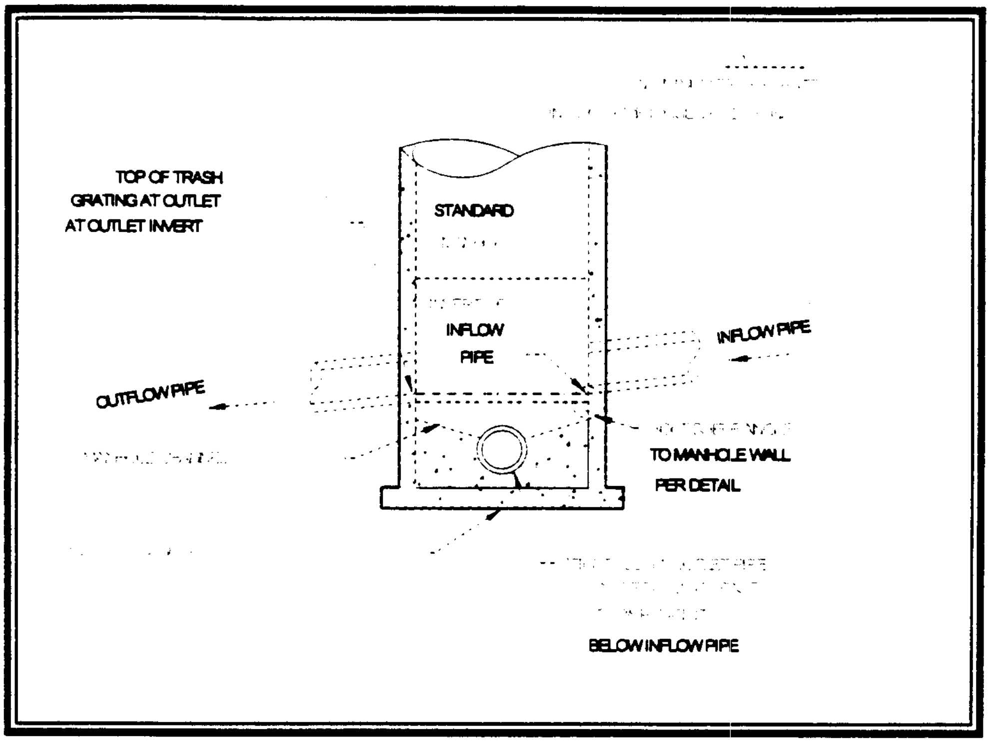
Several types of intermittent sand filter facilities are recognized for stormwater quality management purposes, including ***District of Columbia Underground Vault Filters***, ***Delaware Sand Filters***, ***Austin Full Sedimentation Sand Filters***, and ***Austin Partial Sedimentation Sand Filters***.

The general design criteria presented below apply to the design of intermittent sand filter facilities for ***water quality control***. This implies that the volume of runoff to be treated is determined by the **water quality volume** (the first 0.5 inches of runoff from the impervious surfaces on the site or drainage shed) and the desired pollutant removal efficiency.

Isolating the Water Quality Volume

The usual method for isolating the WQV is to construct an isolation/diversion weir in the stormwater channel or pipe, with the elevation of the weir set to allow overflow when the BMP is completely full. Additional runoff greater than the WQV spills over the weir to enter a peak flow rate reducer or exit directly to the storm sewer, minimizing mixing with the water in the BMP. Another approach is to provide a lower pipe to feed the filter until it fills, after which water rises in the slitter manhole and continues down a higher pipe. **Figure 3.12 - 2** illustrates this approach (source: Montgomery County, Maryland).

FIGURE 3.12 - 2
Flow Splitting Manhole Structure



Sizing Procedure

The majority of jurisdictions which are employing sand filter BMPs use hydraulic calculations based on Darcy's Law to establish the filter area that will allow flow-through of the treatment volume within the desired time frame, typically 40-48 hours (Austin, 1988, Shaver and Baldwin, 1991, Truong, 1989). Florida uses more complex falling-head computations and allows a drawdown time of up to 72 hours (Livingston, McCarron, Cox, and Sanzone, 1988). However, creating storage for the full WQV in shallow configuration systems may result in a larger filter than the hydraulic calculations would indicate (Alexandria, 1992).

Virginia uses the Austin Sand Filter Formula derived from Darcy's Law by the Austin Environmental and Conservation Services Department to size sand filters (Austin, 1988):

$A_f = I_a H d_f / k(h+d_f)t_f$ where,

A_f = surface area of sand bed (acres or sq. ft.)
I_a = impervious drainage area contributing runoff to the basin (acres or sq. ft.)
H = runoff depth to be treated (ft.)
d_f = sand bed depth (ft.)
k = coefficient of permeability for sand filter (ft/hr)

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h = average depth (ft.) of water above surface of sand media between full and empty basin conditions (½ max. depth)
t_f = time required for runoff volume to pass through filter media (hrs.)

1. Coefficient of Permeability

When first installed, the coefficient of permeability of sand filters may be as high as 3.0 ft/hour, but these will typically decrease dramatically after the first few storms. Actual observations of filters in Austin, Texas, established that "ripe" filters stabilized in the range of 0.5-2.7 ft/day for filters with partial sedimentation control (Austin, 1988). This is probably caused by a combination of clogging of some filter pores from sediment loads and initial consolidation of the filter sand. **Figure 3.12 - 3** illustrates the similar rapid decrease in coefficient of permeability as sediment loads accumulated on a sand filter in Denver, Colorado (Urbonas, Doerfer, and Tucker, 1996). Falling head tests on a one year old Delaware Sand Filter in Alexandria, Virginia, resulted in an average coefficient of permeability of 8.5 ft/day (Bell, Stokes, Gavan, and Nguyen, 1995). The Alexandria filter was treating only runoff from pavement surfaces, and the mean input concentration of total suspended solids was only in the range of 75 milligrams/liter (75ppm)(*ibid)*. The Denver runoff, by contrast, had a mean concentration of 400 ppm (Urbonas, Doerfer, and Tucker, 1996), while the filters observed by Austin lacked full sedimentation protection. Use of conservative values for the coefficient of permeability is clearly indicated.

Based on long term observation of existing sand filter basins, Austin uses k values of 3.5 feet per day for systems with full sedimentation pretreatment and 2.0 feet per day for systems with only partial sedimentation pretreatment (full sedimentation pretreatment is defined as complete removal of particles with a diameter equal to or greater than 20 microns). Virginia jurisdictions utilizing intermittent sand filter BMPs have also adopted these values. Full sedimentation may usually be accomplished by capturing the WQV and releasing it to the filter over 24 hours. **Figure 3.12-4** illistrates a full sedimentation basin in Austin. Partial sedmientation basins, such as the one shown on **Figure 3.12-1**, should hold at least 20 percent of the WQV.

2. Drawdown time

Both Austin and the Virginia jurisdictions employ a BMP drawdown time (t_f) of 40 hours. This allows the filter to fully drain down and dry out to maintain an aerobic environment between storms (filters which remain continually wet may develop anaerobic conditions, under which previously captured iron phosphates may break down and wash out).

3. Simplified Filter Formula for Filters with Full Sedimentation Protection

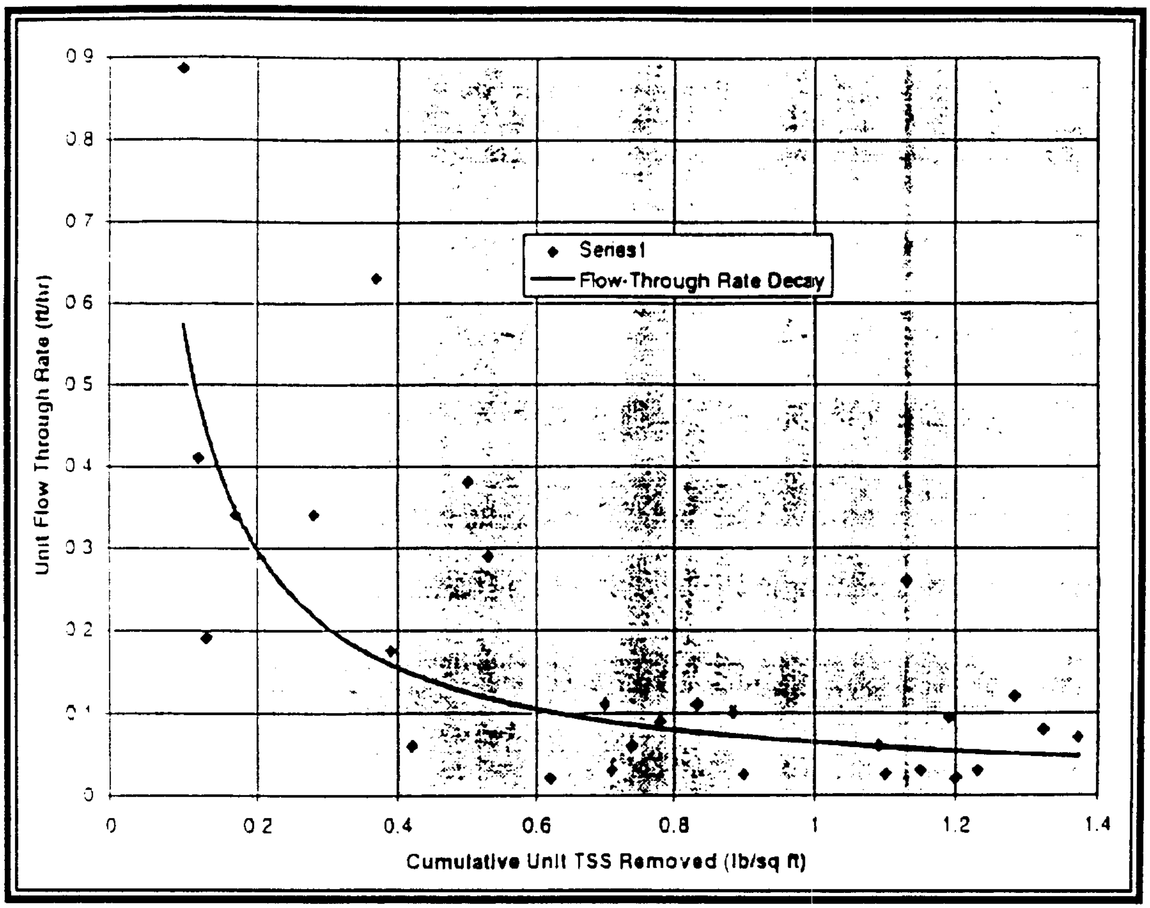
(Sedimentation Basin containing full WQV with 24-hour drawdown to filter)

With k = 3.5 ft/day (0.146 ft/hour) and t_f = 40 hours, the sand filter formula reduces to:

$$A_{f(FS)} = 310 I_a d_f / (h + d_f)$$

where A_f is in ft^2 and I_a is in acres.

FIGURE 3.12-3
Degradation of Hydraulic Conductivity of Denver Sand Filter



(Source: Urbonas, Doeffler, and Tucker, 1996)

4. **Simplified Filter Formula for Filters with Partial Sedimentation Protection**
(Sediment Chamber containing 20% of WQV with free hydraulic flow to filter)

With k = 2.0 ft/day (.0833 ft/hour) and t_f = 40 hours, the formula reduces to:

$$A_{f(PS)} = 545 I_a d_f / (h + d_f)$$

where A_f is in ft^2 and I_a is in acres.

FIGURE 3.12-4

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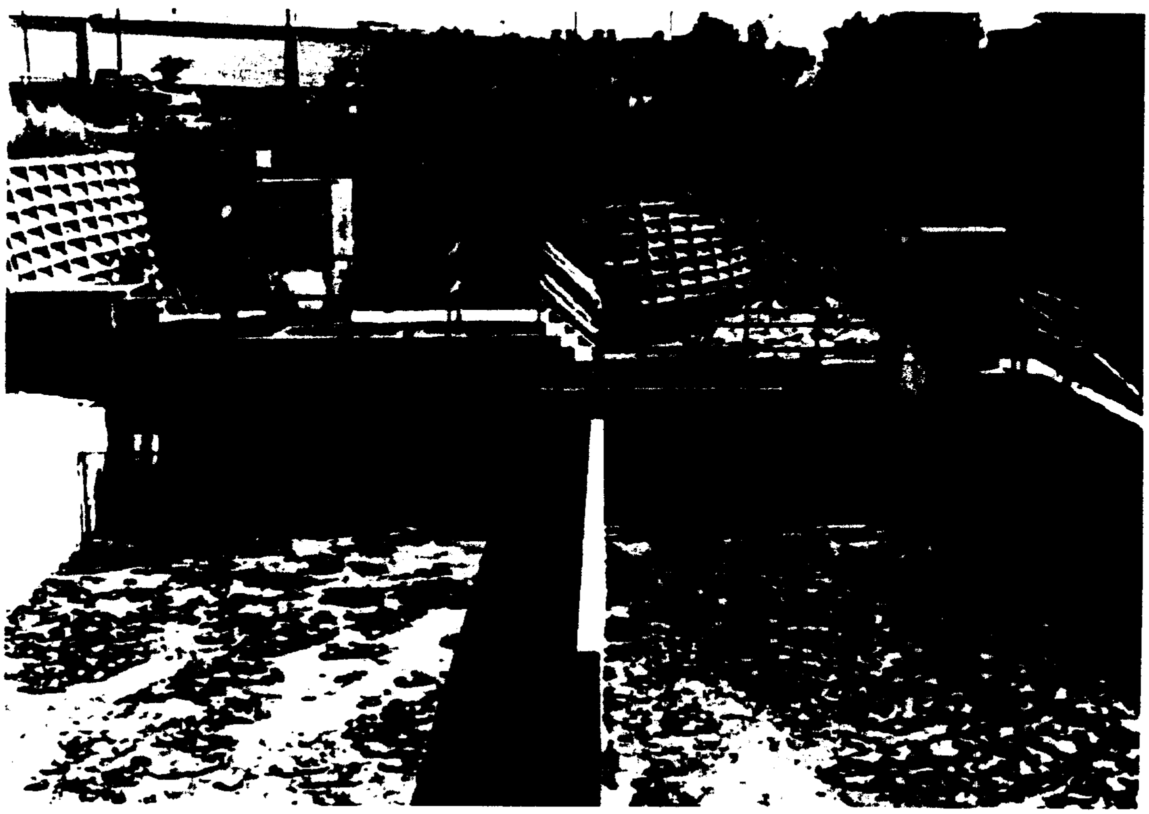
Full Sedimentation Basin on Austin Sand Filter



Exclusion of Continuous Flows and Chloronated Flows

Intermittent sand filter BMPs will **NOT** function properly if subjected to continuous or frequent flows. The basic principles upon which they operate assume that the sand filter will dry out and reaerate between storms. If the sand is kept continually wet by such flows as basement sump pumps, anaerobic conditions will develop, creating a situation under which previously captured iron phosphates degrade, leading to **export** of phosphates rather than the intended high phosphorous removal (Bell, Stokes, Gavan, and Nguyen, 1995). It is also essential to **exclude flows containing chlorine and other swimming pool and sauna chemicals** since these will kill the bacteria upon which the principle nitrogen removal mechanisms depend.

> ***Continuous or frequent flows (such as basement sump pump discharges, cooling water,condensate water, ariesian wells, etc.) and flows containing swimming pool and sauna chemiclals*** *must be* ***EXCLUDED*** *from routing through intermittent sand filter BMPs since such flows will cause the BMP to* ***MALFUNCTION!***

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Checklists

The **Construction Inspection and As-Built Survey Checklist** found in **Appendix 3D** is for use in inspecting intermittent sand filter facilities during construction and, where required by the local jurisdiction, engineering certification of the filter construction. The **Operation and Maintenance Checklist**, also found in **Appendix 3D**, is for use in conducting maintenance inspections of intermittent sand filter facilities.

MINIMUM STANDARD 3.12A

WASHINGTON D.C. UNDERGROUND VAULT SAND FILTER
(WET SEDIMENTATION CHAMBER)

Definition

A Washington D.C. vault sand filter is an underground stormwater sand filter contained in a structural shell with three chambers. The shell may be either precast or cast-in-place concrete, corrugated metal pipe, or fiberglass tanks. This BMP was developed by Mr. Hung V. Truong of the D.C. Environmental Regulation Administration. **Figure 3.12A-1** depicts Mr. Truong's system.

The three feet deep plunge pool in the first chamber and the throat of the second chamber, which are hydraulically connected by an underwater rectangular opening, absorbs energy and provides pretreatment, trapping grit and floating organic material such as oil, grease, and tree leaves.

The second chamber also contains a typical intermittent sand filter. The filter material consists of gravel, sand, and filter fabric. At the bottom is a subsurface drainage system of pierced PVC pipe in a gravel bed. The primary filter media is 18-24 inches of sand. A layer of plastic reinforced geotextile filter cloth secured by gravel ballast is placed on top of the sand. The top filter cloth is a pre-planned failure plane which can readily be replaced when the filter surface becomes clogged. A dewatering drain controlled by a gate valve must be installed to facilitate maintenance.

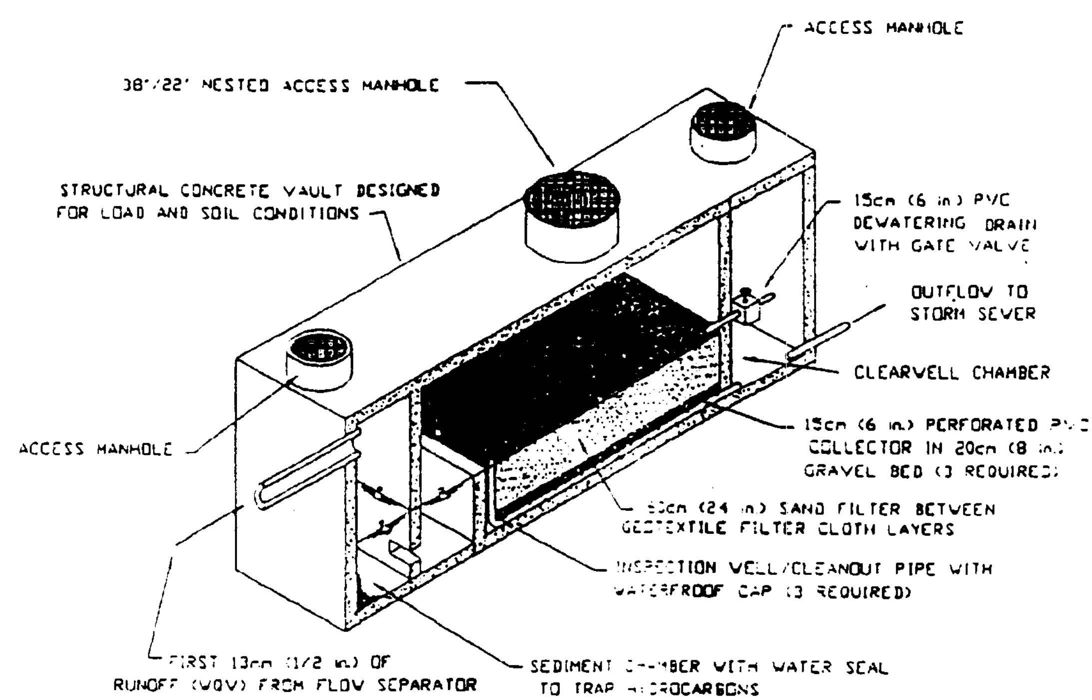
The third chamber, or clearwell, collects the flow from the underdrain pipes and directs it to the storm sewer.

In Virginia, D.C. Sand Filters will normally be placed off-line and be sized to treat the WQV.

Purpose

D.C. Sand Filters are primarily used for water quality control. However, they do provide detention and slow release of the water quality volume from the site being treated. Whether this amount will be sufficient to provide the necessary peak flow rate reductions required for channel erosion control is dependent upon site conditions (hydrology) and required discharge reductions. The 10-year and 100-year flows will usually exceed the detention capacity of a sand media filter. When this occurs, separate quantity must be provided.

FIGURE 3.12A - 1
Washington D.C. Underground Vault Sand Filter



Conditions Where Practice Applies

D.C. Sand Filters are ultra-urban BMPs best suited for use in situations where space is too constrained and/or real estate values are too high to allow the use of conventional retention ponds. Where possible, runoff treated should come only from impervious surfaces.

Drainage Area

Drainage areas served by one vault filter should be limited to 1.25 acres. For larger drainage sheds, either multiple vault filters or Austin Full Sedimentation Filters (surface or vault) should be utilized.

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Development Conditions

D.C. Sand Filters are generally suitable BMPs for medium to high density commercial or industrial development. Because of confined space entry restrictions and maintenance requirements, they are not generally suitable for residential applications except for apartment complexes or large condominiums where a dedicated maintenance force will be present.

Planning Considerations

Refer to the **Planning Considerations** for **General Intermittent Sand Filter Practices, Minimum Standard 3.12,** previously discussed in this section. Of special concern are the stormwater infrastructure serving the site and the requirement to isolate the sand filter from receiving flows until the drainage shed is fully stabilized.

Potential and existing elevations of stormwater infrastructure serving the site will determine one of the most critical design parameters: the maximum depth to which runoff may be pooled over the filter and preserve a gravity flow configuration (whatever the pooling depth, there must be a minimum of five feet of clearance between the top of the filter and the top slab of the filter shell to allow filter maintenance).

Sand filter BMPS must ***never*** *be placed in service until all site work has been completed and stabilization measures have been installed and are functioning properly.*

Design Criteria

The purpose of this section is to provide recommendations and minimum criteria for the design of D.C. Sand Filter BMPs intended to comply with the Virginia Stormwater Management program's runoff quality requirements.

Refer to the **General Design Criteria** previously discussed under **General Intermittent Sand Filter Practices, Minimum Standard 3.12**

Filter Sizing Criteria

The D.C. Sand Filter is a partial sedimentation protection intermittent sand filter BMP. To compute the minimum area of filter required, utilize the Austin Filter Formula for partial sedimentation treatment:

$$A_{fm(PS)} = \frac{545 I_a d_f}{(h + d_f)}$$

where,

A_{fm} = minimum surface area of sand bed (square feet)
I_a = impervious cover on the watershed in acres
d_f = sand bed depth (normally 1.5 to 2ft)
h = average depth of water above surface of sand media between full and empty basin conditions (ft.)

Structural Requirements

The load-carrying capacity of the filter structure must be considered when it is located under parking lots, driveways, roadways, and, certain sidewalks (such as those adjacent to State highways). Traffic intensity may also be a factor. The structure must be designed by a licensed structural engineer and the structural plans require approval by the plan approving jurisdiction.

Design Storm

The inlet design or integral large storm bypass must be adequate for isolating the WQV from the design storm for the receiving storm sewer system (usually the 10 year storm) and for conveying the peak flow of that storm past the filter system. Since D.C. Sand Filters will be used only as off-line facilities in Virginia, the interior hydraulics of the filter are not as critical as when used as an on-line facility. The system should draw down in approximately 40 hours.

Infrastructure Elevations

For cost considerations, it is preferable that D.C. Sand Filters work by gravity flow. This requires sufficient vertical clearance between the invert of the prospective inflow storm piping and the invert of the storm sewer which will receive the outflow. In cases where gravity flow is not possible, a clearwell sump and pump are required to discharge the effluent into storm sewer. Such an application would be appropriate in commercial or industrial situations where a dedicated maintenance force will be available (shopping malls, apartment houses, factories of other industrial complexes, etc.).

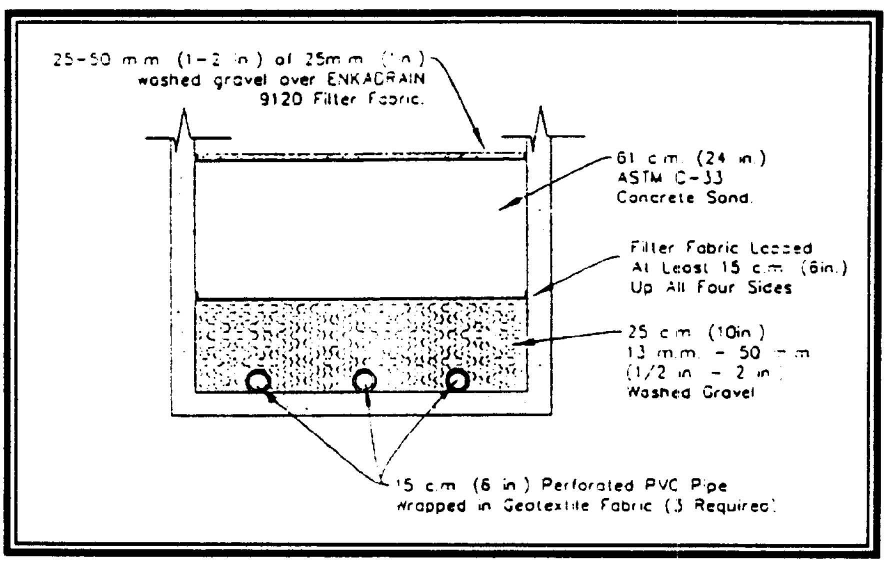
Accessibility and Headroom for Maintenance

Both the sedimentation basin and the filter must be accessible to approriate equipment and vacuum trucks for removing accumulated sediments and trash. The sedimentation basin must be cleaned approximately once per year, and the filter will likely need raking on that frequency to remove trash and restore permeability. When filters are placed in underground vaults, all three chambers must have personnel access manholes and built-in access ladders. **A minimum headspace of 60 inches above the filter is required to allow such maintenance and repair.** A 38-inch diameter maintenance manhole with eccentric nested covers (a 22-inch personnel access lid inside the 38-inch diameter lid) or a rectangular load bearing access door (minimum 4 ft. x 4 ft.) should be positioned directly over the center of the filter.

Construction Specifications

Figure 3.12A-2 is a cross-section of the filter chamber.

FIGURE 3.12A - 2
D.C. Sand Filter Cross-Section



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Depth of Sedimantation Pool

The sedimentation "plunge pool" must be at least 36 inches deep to properly remove sediment and absorb energy from the incoming flow.

Depth of the Underwater Opening Between Chambers

To preserve an effective hydrocarbon trap, the top of the underwater opening between chambers must be at least 18 inches below the depth of the weir which divides the filter from the pool. To retain sediment in the first chamber, the bottom of the opening should be at least six inches above the floor. The area of the opening should be at least 1.5 times the cross-sectional area of the inflow pipe(s) to assure that the water level remains equal between the first and second chambers.

Total Depth of Filter Cross-Section

The total depth of the filter cross-section must match the height of the weir dividing the sedimentation pool from the filter. Otherwise, a "waterfall" effect will develop which will gouge out the front of the filter media. If a sand filter less than 24 inches is used, the gravel layer must be increased accordingly to preserve the overall filter depth.

Upper Aggregate Layer

The washed aggregate or gravel layer at the top of the filter shall be at least one inch thick and meet ASTM standard specifications (1-inch maximum diameter).

Geotextile Fabrics

The filter cloth layer beneath the upper aggregate layer shall be reinforced by an HDPE or PVC geomatrix (such as ENKADRAIN 9120) and meet the specifications shown in **Table 3.12C-1**. The filter fabric between the sand layer and the collector gravel shall conform to the specifications in **Table 3.12A-2**. The fabric rolls must be cut with sufficient dimensions to cover the entire wetted perimeter of the filtering area and lap up the filter walls at least six-inches.

Sand Filter Layer

For applications in Virginia, use **ASTM C33 Concrete Sand** or sand meeting the Grade A fine aggregate gradation standards of Section 202 of the VDOT ***Road and Bridge Specifications.*** The top of the sand filter must be completely level.

TABLE 3.12A - 1
Specifications for Nonwoven Geotextile Fabric on Top of D.C. Sand Filter

Property	Test Method	Unit	Specification
Unit Weight	ASTM D-1777	Oz./Sq.yd.	4.3 (minimum)
Flow Rate	Falling Head Test	Gpm/Sq.ft.	120 (minimum)
Puncture Strength	ASTM D-751 (Modified)	Lb.	60 (minimum)
Thickness	--	In.	0.08 (minimum)

Table 3.12A - 2
Specifications for Nonwoven Geotextile Fabric Beneath Sand in D.C. Filter

Property	Test Method	Unit	Specification
Unit Weight	--	Oz./sq.yd.	8.0 (min.)
Filtration Rate	--	In/sec	0.08 (min.)
Puncture Strength	ASTM D-751 (Modified)	Lb.	125 (min.)
Mullen Burst Strength	ASTM D-751	Psi	400 (min.)
Equiv. Opening Size	U.S. Standard Sieve	No.	80 (min.)
Tensile Strength	ASTM D-1682	Lb.	300 (min.)

Gravel Bed Around Collector Pipes

The gravel layer surrounding the collector pipes shall be ½ to two (2) inch diameter gravel and provide at least two (2) inches of cover over the tops of the drainage pipes.

Underdrain Piping

The underdrain piping consists of three 6-inch schedule 40 or better polyvinyl perforated pipes reinforced to withstand the weight of the overburden. Perforations should be 3/8 inch, and each row of perforations shall contain at least six (6) holes. Maximum spacing between rows of perforations shall be six (6) inches.

The minimum grade of piping shall be 1/8 inch per foot (one [1] percent slope). Access for cleaning all underdrain piping is needed. Clean-outs for each pipe shall extend at least six (6) inches above the top of the upper filter surface, e.g. the top layer of gravel.

Each pipe shall be thoroughly wrapped with 8 oz./sq.yd. geotextile fabric meeting the specification in **Table 3.12A-2** above.

Dewatering Drain

When the filter is placed in an underground vault, A 6-inch dewatering drain controlled by a gate valve shall be installed between the filter chamber and the clearwell chamber with its invert at the elevation of the top of the filter. The dewatering drain penetration in the chamber dividing wall shall be sealed with a flexible strip joint sealant which swells in contact with water to form a tight pressure seal.

Access Manholes

When the filter is installed in an underground vault, access to the headbox (sediment chamber) and the clearwell shall be provided through at least 22-inch manholes. Access to the filter chamber shall be provided by a rectangular dood (minimum size: 4 feet by four feet) of sufficient strength to carry prospective imposed loads or by a manhole of at least 3- inch diameter with an offset concentric 22-inch lid (Neenah R-1741-D or equivalent).

Protection from Construction Sediments

The site erosion and sediment control plan must be configured to permit construction of the filter system while maintaining erosion and sediment control.

No runoff is to enter the sand filtration system prior to completion of all construction and site revegitation. Construction runoff shall be treated in separate sedimentation basins and routed to by-pass the filter system. Should construction runoff enter the filter system prior to site revegitation, all contaminated materials must be removed and replaced with new clean materials.

Watertight Integrity Test

After completion of the filter shell but before placement of the filter layers, entrances to the structure shall be plugged and the shell completely filled with water to demonstrate water tightness. Maximum allowable leakage is 5 percent of the filter shell volume in 24 hours. Should the structure fail this test, it shall be made watertight and successfully retested prior to placement of the filter layers.

Hydraulic Compaction of Filter Components

After placement of the collector pipes, gravel, and lower geotextile layer, fill the shell with filter sand to the level of the top of the sediment pool weir. Direct clean water into the sediment chamber until both the sediment chamber and filter chamber are completely full. Allow the water to draw down until flow from the collector pipes ceases, hydraulically compacting the filter sand. After allowing the sand to dry out for a minimum of 48 hours, refill the shell with sand to a level one inch beneath the top of the weir and place the upper geotextile layer and gravel ballast.

Portland Cement Concrete

Concrete liners may be used for sedimentation chambers and for sedimentation and filtration basins. Concrete shall be at least five (5) inch thick Class A3 defined in the Virginia Department of Transportation *Road and Bridge Specifications*.

Maintenance/Inspection Guidelines

The following maintenance and inspection guidelines are not intended to be all inclusive. Specific facilities may require other measures not discussed here.

Inspection Schedule

The water level in the filter chamber shall be monitored by the owner on a quarterly basis and after every large storm for the first year after completion of construction and a log shall be maintained of the results indicating the rate of dewatering after each storm and the water depth for each observation. Once the governing jurisdiction staff indicates that satisfactory performance of the structure has been demonstrated, the monitoring schedule can be reduced to an semiannual basis.

The BMP shall be inspected annually by representatives of the owner and the governing jurisdiction to assure continued proper functioning.

Sediment Chamber Pumpout

The sediment chamber must be pumped out halfway through the inspection cycle (e.g. after six months) and after each joint owner-governing jurisdiction annual inspection. If the chamber contains an oil skim, it should be removed by a firm specializing in oil recovery and recycling. The remaining material may then be removed by vacuum pump and disposed of in an appropriate landfill. **After each cleaning, refill the first chamber to a depth of three feet with clean water to reestablish the water seals.**

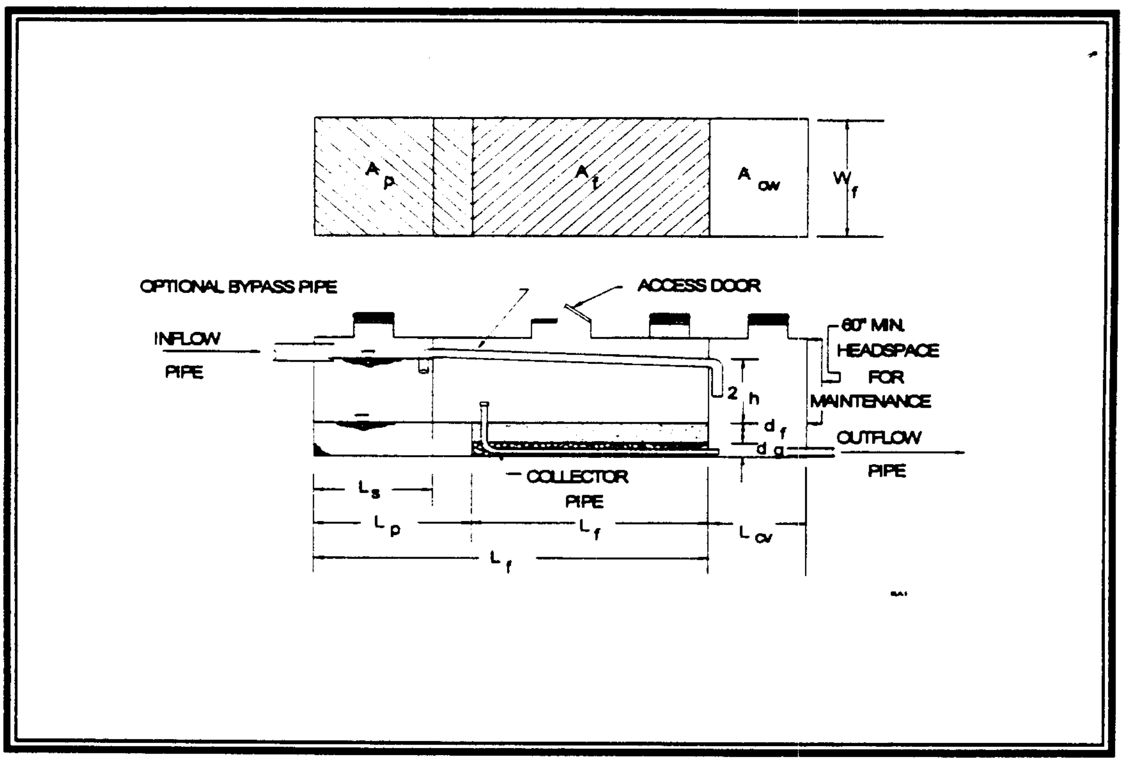
When the filter will no longer draw down within the required 40-hour period, the top layer of filter cloth and ballast gravel must be removed and replaced with new materials conforming to the original specifications. Any discolored or sediment contaminated sand shall also be removed and replaced.

Design Procedures

The following design procedure is structured to assure that the desired water quality volume is captured and treated by the D.C.Sand Filter. The procedure assumes that a filter shell with a rectangular cross-section is to be used.

Figure 3.12A-3 shows the dimensional relationships for a D.C. Sand Filter.

FIGURE 3.12A - 3
Dimensional Relationships for a D.C. Sand Filter



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Standard Design Logic

Employ the following design logic to design D.C. Sand Filters for use in Virginia:

1. Determine Governing Site Parameters

Determine the Impervious area on the site (I_a in acres), the water quality volume to be treated (WQV in $ft.^3 = 1816\, I_a$), and the site parameters necessary to establish 2h, the maximum ponding depth over the filter (storm sewer invert at proposed connection point, elevation to inflow invert to BMP, etc).

2. Select Filter Depth and Determine Maximum Ponding Depth

Considering the data from Step 1) above, select the Filter Depth ((d_f) and determine the maximum achievable ponding depth over the filter (2h).

3. Compute the Minimum Area of the Sand Filter (A_{fm})

To compute the area of the filter, use the formula:

$$A_{fmPS} = \frac{545 I_a d_f}{(h + d_f)}$$

A_{fm} = minimum surface area of sand bed (square feet)
I_a = impervious cover on the watershed in acres
d_f = sand bed depth (normally 1.5 to 2ft)
h = average depth of water above surface of sand media between full and empty basin conditions (ft.)

4. Select Filter Width and Compute Filter Length and Adjusted Filter Area

Considering site constraints, select the Filter Width (W_f). Then compute the Filter Length (L_f) and the Adjusted Filter Area (A_f)

$$L_f = A_{fm}/W_f$$

$$A_f = W_f \times L_f$$

Note: From this point forward, computations assume a rectangular filter.

5. Compute the Storage Volume on Top of the Filter (V_{Tf})

$$V_{Tf} = A_f \times 2h$$

6. Compute the Storage in the Filter Voids (V_v)
   (Assume 40% voids in filter media)

$$V_v = 0.4 \times A_f \times (d_f + d_g)$$

7. Compute Flow Through Filter During Filling (V_Q)
   (Assume 1-hour to fill per D.C. practice)

$$V_Q = \frac{kA_f(d_f + h)}{d_f} \text{ ; use } k = 2 \text{ ft./day} = 0.0833/\text{hr.}$$

8. Compute Net Volume to be Stored Awaiting Filtration (V_{st})

$$V_{st} = WQV - V_{Tf} - V_v - V_Q$$

9. Compute Length of the Permanent Pool (Lpm)

$$Lpm \quad \frac{V_{st}}{(2h \times W_f)}$$

10. Compute Minimum Length of the Sediment Chamber (Lsc)
    (to contain 20% of WQV per Austin practice)

$$L_{sm} = \frac{0.2WQV}{(2h \times W_f)}$$

11. Set Final Length of the Permanent Pool (L_p)

$$\text{If } L_{pm} \geq L_{sm} + 2 \text{ ft., make } L_p = L_{pm}$$

$$\text{If } L_{pm} < L_{sm} + 2 \text{ ft., make } L_p = L_{sm - 2 \text{ ft.}}$$

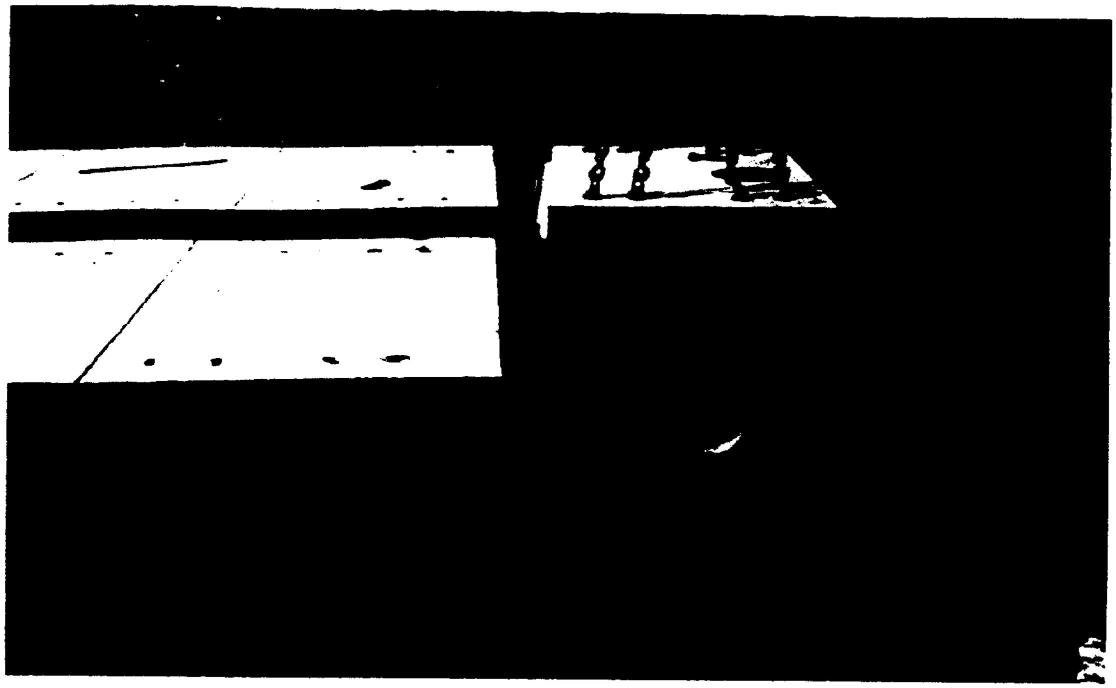
It may be economical to adjust final dimensions to correspond with standard precast structures or to round off to simplify measurements during construction.

Set the length of the clearwell (L_{cw}) for adequate maintenance and/or access for monitoring flow rate and chemical composition of the effluent (minimum = 3 ft.)

Minimizing Filter Shell Costs

Underground vault sand filter costs have been widely varying because many developers have simply had their foundation contractors cast the vault in place. Each installation therefore became a prototype with associated costs and overhead. Precast manufacturers currently offer precasting services for D.C. and other types of sand filter vaults, which should stabilize underground vault costs. **Figure 3.12A-4** is a photograph of a segmented precast filter shell installation in Alexandria.

FIGURE 3.12A - 4
Installing Precast D.C. Sand Filter Shell in Alexandria

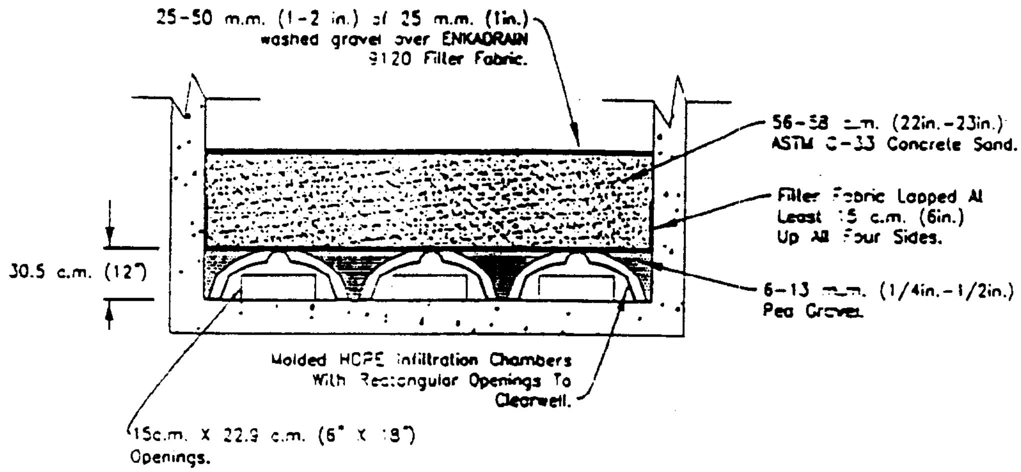


(Photo Courtesy of Rotondo Precast, Fredericksburg, Virginia)

Checklists

Worksheet 3.12A is for use in sizing calculations for D.C. Sand Filters. The **Construction Inspection and As-Built Survey Checklist** found in **Appendix 3D** is for use in inspecting intermittent sand filter facilities during construction and, where required by the local jurisdiction, engineering certification of the filter construction. The **Operation and Maintenance Checklist**, also found in **Appendix 3D**, is for use in conducting maintenance inspections of intermittent sand filter facilities.

FIGURE 3.12A - 5
D.C. Filter Cross-Section with HDPE Infiltration Chamber Collector System



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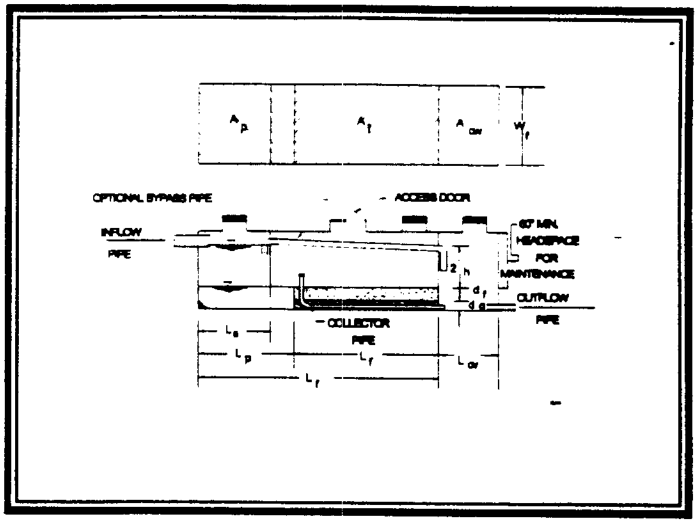
WORKSHEET 3.12A
SIZING COMPUTATIONS FOR D.C. UNDERGROUND VAULT SAND FILTER

Page 1 of 4

Part 1: Select maximum ponding depth over filter:

2h = _______ ft;

h = [ ] ft



From Pollutant Load Sheets:

I_a = [ ] acres

WQV = [ ] ft^3

Outflow by gravity possible ___

Effluent pump required ___

Part 2: Compute Minimum Area of Filter (A_{fm}):

$$A_{fm} = \frac{545 I_a d_f}{(d_f + h)}$$

= [545 x ______ x ______] / [______ + ______]

= [ ] ft^2

Part3: Considering Site Constraints, Select Filter Width (W_f) and Compute Filter Length (L_f) and Adjusted Filter Area (A_f):

W_f = [ ] ft;

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WORKSHEET 3.12A
SIZING COMPUTATIONS FOR D.C. UNDERGROUND VAULT SAND FILTER
Page 2 of 4

$L_f = A_{fm} / W_f$

= ________/________

= ______, say [   ] ft

$A_f = W_f \times L_f$ = ________ x ________

= [   ] ft²

Part 4: Compute the Storage Volume on Top of the Filter(V_{Tf})

$V_{Tf} = A_f \times 2h$ = ________ x ________

= [   ] ft³

Part 5: Compute Storage in Filter Voids (V_v):
(Assume 40% voids in filter media)

$V_v = 0.4 \times A_f \times (d_f + d_g)$

= 0.4 x ________ x (________ + ________)

= [   ] ft³

Part 6: Compute Flow Through Filter During Filling Period (V_Q):
(Assume 1-hour to fill per D.C. practice)

$V_Q = \frac{kA_f(d_f + h)}{d_f}$; use k = 2 ft/day = 0.0833 ft/hr

= [0.0833 x ________ x (________ + ________)]/________

= [   ] ft³

WORKSHEET 3.12A
SIZING COMPUTATIONS FOR D.C. UNDERGROUND VAULT SAND FILTER

Page 3 of 4

Part 7: Compute Net Volume to be Stored Awaiting Filtration (V_{st}):

$V_{st} = WQV - V_{Tf} - V_{v} - V_{Q}$

= _______ - _______ - _______ - _______

= [ ] ft^3

Part 8: Compute Minimum Length of Permanent Pool (L_{pm}):

$L_{pm} = \frac{V_{st}}{(2h \times W_f)}$ = _______ / (_______ x _______)

= [ ] ft

Part 9: Compute Minimum Length of Sediment Chamber (L_{sm})
(to contain at least 20% of WQV per Austin practice)

$L_{sm} = \frac{0.2WQV}{(2h \times W_f)}$ = _______ / _______

= [ ] ft

Part 10: Set Final Length of Permanent Pool (L_p)

L_{sm} + 2ft = _______ + 2 = [ ] ft

If $L_{pm} \geq L_{sm}$ + 2ft, Make $L_p = L_{pm}$ [ ] = ft

If $L_{pm} < L_{sm}$ + 2ft, make $L_p = L_{sm}$ +2ft = [ ]

WORKSHEET 3.12A
SIZING COMPUTATIONS FOR D.C. UNDERGROUND VAULT SAND FILTER

Part 11: Set Length of Clearwell (L_{cw}) for Adequate Maintenance Access (Minimum = 3 ft) and Compute Final Inside Length (L_{ti}):

L_{cw} = [ ] ft;

Sum of interior partition thicknesses (t_{pi}) = ________ ft

$L_{ti} = L_f + L_p + L_{cw} + t_{pi}$

= ________ + ________ + ________ + ________

= [ ] ft

Part 12: Design Effluent Pump if Required

Since pump must be capable of handling flow when filter is new, use k = 12 feet/day = 0.5 ft/hr

$$Q = \frac{kA_f(d_f + h)}{d_f}$$

= [0.5 x ________ x (________ + ________)] / ________

= [ ] ft^3/hr ; /3600 = [ ] cfs;

x 448 = [ ] gpm

Part 13: Design Structural Shell to Accommodate Soil and Load conditions at Site:

It may be economical to adjust final dimensions upward to correspond with standard precast structures or to round dimensions upward to simplify layout during construction.

MINIMUM STANDARD 3.12B

DELAWARE SAND FILTER (DSF) SYSTEMS

Definition

Mr. Earl Shaver of the Delaware Department of Natural Resources and Environmental Control has developed a surface sand filter system for use in Delaware ([illegible]

As originally conceived, the Delaware Sand Filter is an **on-line** facility processing all stormwater exiting the treated site up to the point that its overflow limit is reached (Delaware provides for treating the first one inch of runoff). However, when employed in Virginia, it will usually be provided with an integral flow-splitter to isolate and treat the Water Quality Volume.

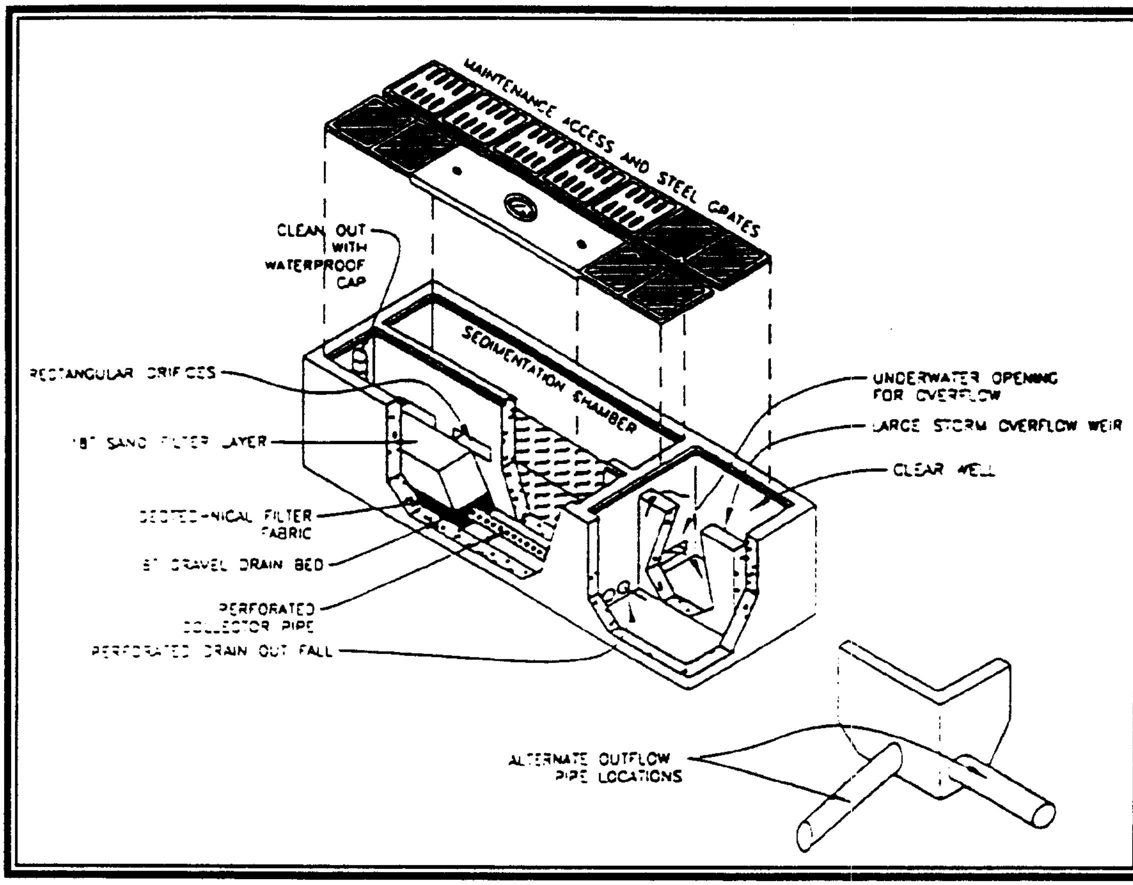
Figure 3.12B-1 shows a schematic drawing of the Delaware Sand Filter as used in Virginia. The system consists of two parallel concrete trenches connected by close-spaced wide notches in the wall dividing the trenches. The trench adjacent to the site being served is the sedimentation chamber. When accepting sheet flow, it is fitted with a grated cover. Concentrated stormwater may also be conveyed to the chamber in enclosed storm drain pipes. The second chamber, which contains the sand filter, is always fitted with a solid cover.

Storm flows enter the sedimentation chamber through the grates, causing the sedimentation pool to rise and overflow into the filter chamber through the weir notches in the dividing wall, assuring that the water to be treated **arrives at the filter as sheet flow**. This is essential to prevent scouring out the sand. The permanent pool in the sedimentation chamber is dead storage, which inhibits resuspension of particles that were deposited in earlier storms and prevents the heavier sediments from being washed into the filter chamber. Floatable materials and hydrocarbon films, however, may reach the filter media through the surface outflow.

The second trench contains at least 18 inches of ASTM C-33 Concrete Sand . When used in Virginia, an underdrain capability must be provided. Runoff percolates through the sand to the underdrain (s) and exits into the flow splitter/clearwell.

A transverse flow-splitter/clearwell at the lower end of the structure collects treated effluent and overflow and conveys the water to the storm sewer. When the filter shell fills with the Water Quality Volume, excess flow is forced through the underwater opening from the sedimentation chamber to the "wet" section of the clearwell to overflow the weir to the outflow pipe chamber. Floating trash and hydrocarbons are retained in the sedimentation chamber by this "trap."

FIGURE 3.12B - 1
Precast Delaware Sand Filter as Used in Virginia



Purpose

Delaware Sand Filters primarily used for water quality control. However, they do provide detention and slow release of the water quality volume from the site being treated. Whether this amount will be sufficient to provide the necessary peak flow rate reductions required for channel erosion control is dependent upon site conditions (hydrology) and required discharge reductions. The 10-year and 100-year flows will usually exceed the detention capacity of a sand media filter. When this occurs, separate quantity must be provided.

Conditions Where Practice Applies

Delaware Sand Filters are ultra-urban BMPs best suited for use in situations where space is too constrained and/or real estate values are too high to allow the use of conventional retention ponds. A major advantage of the Delaware Sand Filter is that it can be installed in shallow configurations, which is especially critical in flatter regions where high water tables or shallow storm sewers exist. The simplicity of the system and the ready accessibility of the chambers for periodic maintenance allow it to be used where a filter built in confined space is unacceptable. Where possible, only runoff from impervious surfaces should be treated.

Drainage Area

Drainage areas served by one filter should be limited to approximately one acre. For larger drainage sheds, multiple DSFs may be used.

Development Conditions

Delaware Sand Filters are generally suitable BMPs for medium to high density commercial or industrial development. Because of confined space entry restrictions and maintenance requirements, they are not generally suitable for residential applications except for apartment complexes or large condominiums where a dedicated maintenance force will be present.

Planning Considerations

Refer to the **Planning Considerations** for **General Intermittent Sand Filter Practices, Minimum Standard 3.12,** previously discussed in this section. Of special concern are the stormwater infrastructure serving the site and the requirement to isolate the sand filter from receiving flows until the drainage shed is fully stabilized.

Potential and existing elevations of stormwater infrastructure serving the site will determine one of the most critical design parameters: the maximum depth to which runoff may be pooled over the filter and preserve a gravity flow configuration.

> *Sand filter BMPS must **never** be placed in service until all site work has been completed and stabilization measures have been installed and are functioning properly.*

Design Criteria

The purpose of this section is to provide recommendations and minimum criteria for the design of Delaware Sand Filter BMPs intended to comply with the Virginia Stormwater Management program's runoff quality requirements.

Refer to the **General Design Criteria** previously discussed under **General Intermittent Sand Filter Practices, Minimum Standard 3.12**

Filter Sizing Criteria

Because of the shallow configuration of this BMP, resulting in low levels of hydraulic head above the filter, application of the usual partial sedimentation filter formula may not create enough storage volume to contain the WQV. With the dimensional relationships shown in **Figure 3.12B-2** and k = 2.0 ft/day, the required DSF filter area to contain the WQV may be written as follows:

$$A_f = \frac{1816 I_a}{(4.1h + 0.9)} = \frac{WQV}{(4.1h + 0.9)}$$

where:

A_f = the **area of the filter** in sq.ft.
I_a = the impervious area on the watershed in acres
h = 1/2 the maximum ponding depth over the filter (ft.)

If the maximum ponding depth above the filter (2h) is less than 2.67 feet (2'-8"), the WQV storage requirement governs and the above foumula must be used to size the filter (Alexandria, 1992). If the the maximum ponding depth above the filter (2h) is 2.67 feet or greater, use the partial sedimentation filter formula:

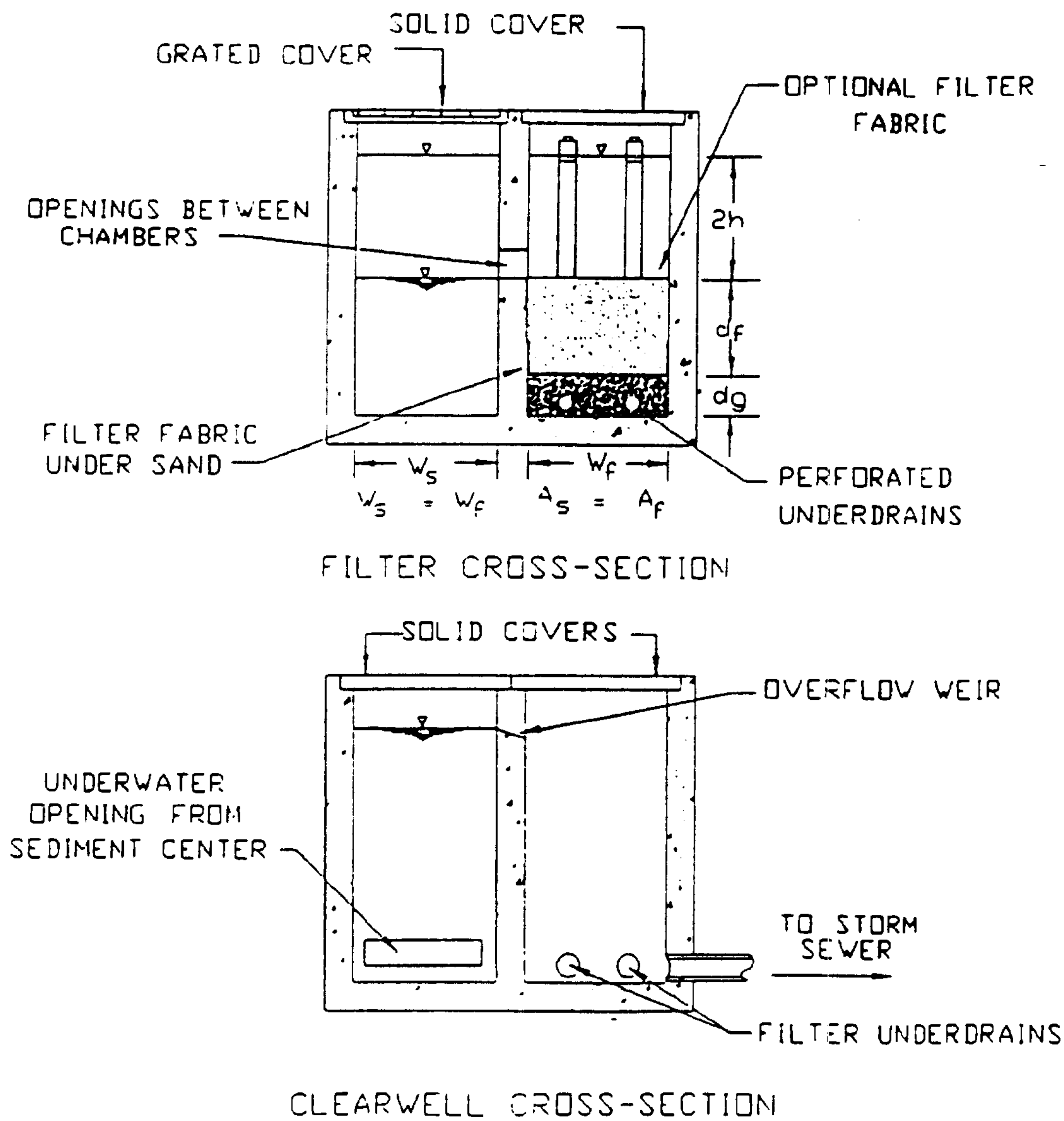
$$A_f = \frac{545 I_a d_f}{(h + d_f)}$$

Where d_f = depth of the filter media in ft. (1.5-2.0)

Delaware and Virginia make the area of the sediment chamber(A_s) equal the area of the filter:

$$A_f = A_s$$

FIGURE 3.12B- 2
Dimensional Relationships for Delaware Sand Filter



Structural Requirements

When the system is placed in a street or parking lot, it must be designed to support traffic wheel loads. When placed completely off the pavement, lower structural loads will be involved. The structure must be designed by a licensed professional engineer, and the design must be approved by the governing jurisdiction.

Design Storm

The inlet integral large storm bypass must be adequate for isolating the WQV from the design storm for the receiving storm sewer system (usually the 10 year storm) and for conveying the peak flow of that storm past the filter system. The system should draw down in approximately 40 hours.

Infrastructure Elevations

For cost considerations, it is preferable that Delaware Sand Filters work by gravity flow. This requires sufficient vertical clearance between the invert of the prospective inflow storm piping and the invert of the storm sewer which will receive the outflow. In cases where gravity flow is not possible, a clearwell sump and pump are required to discharge the effluent into storm sewer. Such an application would be appropriate in commercial or industrial situations where a dedicated maintenance force will be available (shopping malls, apartment houses, factories of other industrial complexes, etc.).

Construction Specifications

Upper Aggregate Layer

Some jurisdictions require a layer of filter cloth and gravel on top of the filter. When used, the washed aggregate or gravel layer at the top of the filter shall be one inch thick and meet ASTM standard specifications (1 inch maximum diameter.)

Geotextile Fabrics

When used, the filter fabric beneath the one-inch layer of gravel on top of the filter shall be Enkadrain 9120 filter fabric or equivalent with the specifications shown in **Table 3.12B - 1**.

Table 3.12B - 1
Specifications for Nonwoven Geotextile Fabric on Top of Delaware Sand Filter

Property	Test Method	Unit	Specification
Unit Weight	ASTM D-1777	Oz./sq.yd.	4.3 (min.)
Flow Rate	Falling Head Test	Gpm/sq.ft.	120 (min.)
Puncture Strength	ASTM D-751 (Modified)	Lb.	60 (min.)
Thickness	--	In.	0.8 (min.)

In instances where heavy hydrocarbon loadings are expected, a layer of activated carbon impregnated filter fabric such as Enkadrain PF-3 may be advantageous. When used, a plan to dispose of the hydrocarbon laden used filter fabric must be approved by the applicable jurisdiction prior to placing the sand filter in service.

The filter cloth layer beneath the sand shall conform to the specifications shown in **Table 3.12B-2**.

Table 3.12B - 2
Specifications for Nonwoven Geotextile Fabric Beneath Sand in Delaware Sand Filter

Property	Test Method	Unit	Specification
Unit Weight	--	Oz./sq.yd.	8.0 (min.)
Filtration Rate	--	In/sec	0.08 (min.)
Puncture Strength	ASTM D-751 (Modified)	Lb.	125 (min.)
Mullen Burst Strength	ASTM D-751	Psi	400 (min.)
Equiv. Opening Size	U.S. Standard Sieve	No.	80 (min.)
Tensile Strength	ASTM D-1682	Lb.	300 (min.)

The fabric rolls must be cut with sufficient dimensions to cover the entire wetted perimeter of the filtering area and lap up the filter walls at least six-inches.

Sand Filter Layer

For applications in Virginia, use **ASTM C33 Concrete Sand.** The top of the sand filter must be completely level. No grade is allowable.

Gravel Bed Around Collector Pipes

The gravel layer surrounding the collector pipes shall be ½ to two (2) inch diameter gravel and provide at least two (2) inches of cover over the tops of the drainage pipes. The gravel and the sand layer above must be separated by a layer of geotextile fabric meeting the specification listed above.

Underdrain Piping

When round perforated pipes are used, the underdrain piping shall consist of a minimum of two (2) schedule 40 or better four (4) inch polyvinyl perforated pipes reinforced to withstand the weight of the overburden. Perforations shall be 3/8 inch, and each row of perforations shall contain at least four (4) holes. Maximum spacing between rows of perforations shall be six (6) inches.

The minimum grade of piping shall be 1/8 inch per foot (one [1] percent slope). Access for cleaning all underdrain piping is needed. Clean-outs for each pipe shall extend at least six (6) inches above the top of the upper filter surface.

Each pipe shall be thoroughly wrapped with 8 oz./sq.yd. geotextile fabric meeting the specification in **Table 3.12B - 2** above.

Alternative Underdrains

Shallow rectangular drain tiles may be fabricated from such materials as fiberglass structural channels, saving several inches of filter depth. Drain tiles shall normally be in two-foot lengths and spaced to provide gaps 1/8-inch less than the smallest gravel sizes on all four sides. Sections of tile may be cast in the dividing wall between the filter and the clearwell to provide shallow outflow oricices. Flat perforated drainage piping such as AdvantEdge® may also be used to reduce the depth of filter. Another approach is to raise a grate on small masonary units above the floor of the shell, lay a layer of PVC or polyethelene geomatrix on the grate to spread the load, and install the filter cloth and sand above this matting; molded HDPE infiltration chambers may also be used as shown in **Figure 3.12A-5.** The entire bottom of the filter shell thus becomes a collector channel. When the shell bottom is so used, it shall have a minimum slope of 1/8 inch per foot (1%).

Weepholes

In addition to the underdrain pipes, weepholes may be installed between the filter chamber and the clearwell to provide relief in case of pipe clogging. The weepholes shall be three (3) inches in diameter. Minimum spacing shall be nine (9) inches center to center. The openings on the filter side of the dividing wall shall be covered to the width of the trench with 12 inch high plastic hardware cloth of 1/4 inch mesh or galvanized steel wire, minimum wire diameter 0.03-inch, number 4 mesh hardware cloth anchored firmly to the dividing wall structure and folded a minimum of 6 inches back under the bottom stone.

Protection from Construction Sediments

The site erosion and sediment control plan must be configured to permit construction of the filter system while maintaining erosion and sediment control.

No runoff is to enter the sand filtration system prior to completion of all construction and site revegitation. Construction runoff shall be treated in separate sedimentation basins and routed to by-pass the filter system. Should construction runoff enter the filter system prior to site revegitation, all contaminated materials must be removed and replaced with new clean materials.

Watertight Integrity Test

After completion of the filter shell but before placement of the filter layers, entrances to the structure shall be plugged and the shell completely filled with water to demonstrate water tightness. Maximum allowable leakage is 5 percent of the filter shell volume in 24 hours. Should the structure fail this test, it shall be made watertight and successfully retested prior to placement of the filter layers.

Hydraulic Compaction of Filter Components

After placement of the collector pipes, gravel, and lower geotextile layer, fill the shell with filter sand to the level of the top of the sediment pool weir. Direct clean water into the sediment chamber until both the sediment chamber and filter chamber are completely full. Allow the water to draw down until flow from the collector pipes ceases, hydraulically compacting the filter sand. After allowing the sand to dry out for a minimum of 48 hours, refill the shell with sand to a level one inch beneath the top of the weir and place the upper geotextile layer and gravel ballast.

Grates and Covers

When placed in traffic lanes, grates and covers must withstand H-20 wheelloadings. Use of standard Virginia Department of Transportation (VDOT) grates (Grate D1-1) will often be most cost-effective. Where allowed by local jurisdictions, galvanized steel bar grates are economical.

Portland Cement Concrete

Portland Cement concrete used for the trench structure shall conform to the A3 specification of the Virginia Department of Transportation ***Road and Bridge Specifications***, latest edition.

Maintenance/Inspection Guidelines

The following maintenance and inspection guidelines are not intended to be all inclusive. Specific facilities may require other measures not discussed here.

Inspection Schedule

During the first year of operation, the cover grates or precast lids on the chambers must be removed quarterly and a joint owner-jurisdiction inspection made to assure that the system is functioning. Once the jurisdiction inspectors are satisfied that the system is functioning properly, this inspection may be made on an annual basis for other than auto-related activities.

Sediment Chamber Pumpout

The sediment chamber must be pumped out when the joint owner-jurisdiction determines that . If the chamber contains an oil skim, it should be removed by a firm specializing in oil recovery and recycling. The remaining material may then be removed by vacuum pump and disposed of in an appropriate landfill. **After each cleaning, refill the first chamber with clean water to reestablish the water seals to the clearwell.**

Sand Filter

When deposition of sediments in the filtration chamber indicate that the filter media is clogging and not performing properly, sediments must be removed (a small shovel may be all that is necessary) along with the top two to three inches of sand. The coloration of the sand will provide a good indication of what depth of removal is required. Clean sand must then be placed in the filter to restore the design depth. Where a layer of geotechnical fabric overlays the filter, the fabric shall be rolled up and removed and a similar layer of clean fabric installed. Any discolored sand shall also be removed and replaced. Disposal of petroleum hydrocarbon contaminated sand or filter cloth should be coordinated with the appropriate environmental official of the local jurisdiction. On filters which employ an upper geotextile layer and ballast, the top layer of filter cloth and ballast gravel must be removed and replaced with new materials conforming to the original specifications when the filter will no longer draw down within the required 40-hour period. Any discolored or sediment contaminated sand shall also be removed and replaced with sand meeting the original specifications (ASTM C-33 Concrete Sand).

Concrete Shell Inspection

Concrete will deteriorate over time, especially if subjected to live loads. The concrete shell, risers, etc., must be examined during each annual inspection to identify areas that are in need of repair, and such repairs must be promptly effected.

Grass Clippings

Grass clippings from landscape areas on the drainage watershed flowing into the DSF must be bagged and removed from the site to prevent them washing into and contaminating the sediment chamber and filter.

Trash Collection

Trash collected on the grates protecting the inlets shall be removed no less frequently than weekly to assure preserving the inflow capacity of the BMP.

Design Procedures

The following design procedure is structured to assure that the desired water quality volume is captured and treated by the Delaware Sand Filter. The procedure assumes that a filter shell with a rectangular cross-section is to be used. **Figure 3.12B-2** shows the dimensional relationships required to compute the design.

Standard Design Logic

Employ the following design logic to design Delaware Sand Filters for use in Virginia:

1. Determine Governing Site Parameters

Determine the Impervious area on the site (I_a in acres), the water quality volume to be treated (WQV in $ft.^3 = 1816\,I_a$), and the site parameters necessary to establish 2h, the maximum ponding depth over the filter (storm sewer invert at proposed connection point, elevation to inflow invert to BMP, etc).

2. Select Filter Depth and Determine Maximum Ponding Depth

Considering the data from Step 1) above, select the Filter Depth ((d_f) and determine the maximum achievable ponding depth over the filter (2h).

3. Calculate the Required Surface Areas of the Chambers

If the maximum ponding depth above the filter (2h) is less than 2.67 feet (2'-8"), the WQV storage requirement governs and the above foumula must be used:

$$A_f = \frac{1816 I_a}{(4.1h + 0.9)} = \frac{WQV}{(4.1h + 0.9)}$$

where:

A_f = the **area of the filter** in sq.ft.

I_a = the impervious area on the watershed in acres

h = 1/2 the maximum ponding depth over the filter (ft.)

If the the maximum ponding depth above the filter (2h) is 2.67 feet or greater, use the partial sedimentation filter formula:

$$A_f = \frac{545 I_a d_f}{(h + d_f)}$$

where:

d_f = depth of the filter media in ft. (1.5-2.0)

Delaware and Virginia make the area of the filter equal the area of the sediment chamber:

$$A_f = A_s$$

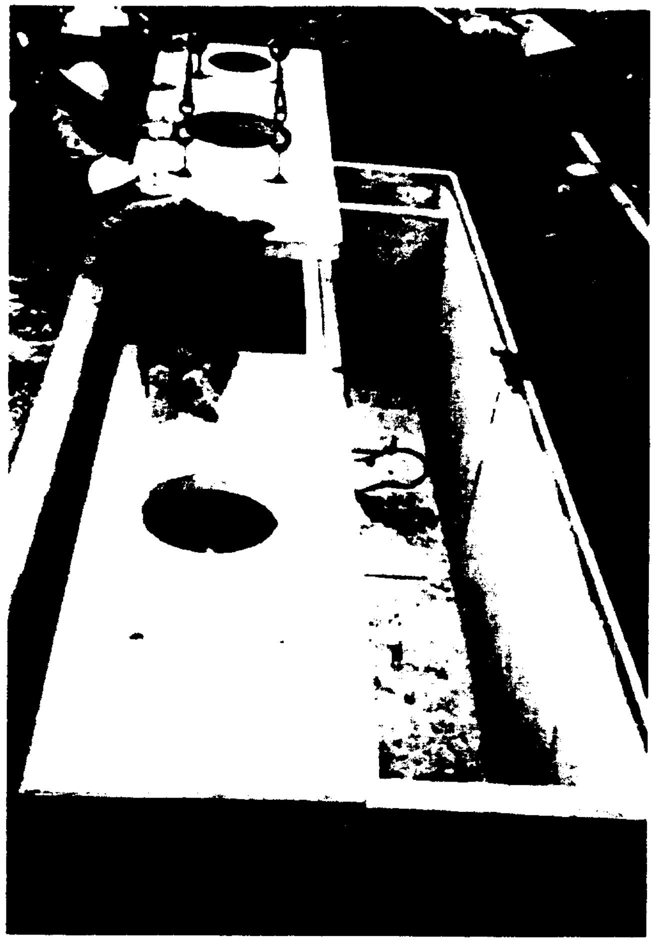
4. Establish Dimensions of the Facility

Site considerations usually dictate the final dimensions of the facility. Sediment trenches and filter trenches normally be 18-30 inches wide. Use of standard VDOT D1-1 grates requires a trench width of 26". Some jurisdictions restrict the maximum allowable trench width to 36 inches.

Minimizing Filter Shell Costs

Underground vault sand filter costs have been widely varying because many developers have simply had their foundation contractors cast the vault in place. Each installation therefore became a prototype with associated costs and overhead. Precast manufacturers currently offer precasting services for D.C. and other types of sand filter vaults, which should stabilize underground vault costs. **Figure 3.12B3** is a photograph of a segmented precast shell installation in Alexandria.

FIGURE 3.12B - 3
Installing Precast Delaware Sand Filter Shell in Alexandria, Virginia



(Photo Courtesy of Rotondo Precast, Fredericksburg, Virginia)

Checklists

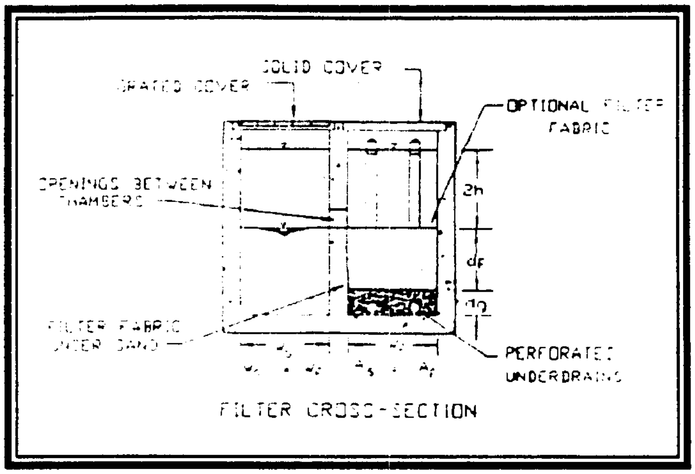
Worksheet 3.12B is for use in sizing calculations for Delaware Sand Filters. The **Construction Inspection and As-Built Survey Checklist** found in **Appendix 3D** is for use in inspecting intermittent sand filter facilities during construction and, where required by the local jurisdiction, engineering certification of the filter construction. The **Operation and Maintenance Checklist,** also found in **Appendix 3D**, is for use in conducting maintenance inspections of intermittent sand filter facilities.

WORKSHEET 3.12B
SIZING COMPUTATIONS FOR STANDARD DELAWARE SAND FILTER
Page 1 of 2

Part 1: Select maximum ponding depth over filter:

2h = ________ft;

h = [   ] ft



From Pollutant Load Sheets:

I_a = [   ] acres

WQV = [   ] ft^3

Outflow by gravity possible____; Effluent pump required _____

Part 2: Compute Minimum Area of Filter (A_{fm}) and Sediment Pool (A_{sm}):

a) If 2h ≥ 2.67 feet, use the formula:

$$A_{sm} = A_{fm} = \frac{545 I_a d_f}{(d_f + h)}$$

= [545 x ______ x ______] / [______ + ______]

= [   ] ft^2

b) If 2h < 2.67 feet, use the formula:

$$A_{sm} = A_{fm} = \frac{1816\ I_a}{(4.1h + 0.9)} = \frac{WQV}{(4.1h + 0.9)}$$

= ________ / [(4.1 x ________) + 0.9]

= [   ] ft^2

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WORKSHEET 3.12B
SIZING COMPUTATIONS FOR STANDARD DELAWARE SAND FILTER
Page 2 of 2

Part 3: Considering Site Constraints, Select Filter Width (W_f) and Sediment Pool Width (W_s) and Compute Filter Length (L_f) and Adjusted Filter Area (A_f) and Sediment Chamber Area (A_s):

$W_s = W_f =$ [ ] ft;

$L_s = L_f = A_{fm} / W_f$

= ________ / ________

= ________, [ ] say ft

$A_s = A_f = W_f \times L_f =$ ________ x ________

= [ ] ft^2

Part 4: Design Structural Shell to accommodate Soil and Load Conditions at Site:

(Separate computations by a structural engineer).

Part 5: Design Effluent Pump if Required:

Since pump must be capable of handling flow when filter is new, use k = 12 feet/day = 0.5 ft/hr

$$Q = \frac{kA_f(d_f + h)}{d_f}$$

= [0.5 x ________ x (________ + ________)]/________

= [ ] ft^3/hr ; /3600 [ ] = cfs;

x 448 = [ ] gpm

MINIMUM STANDARD 3.12C

AUSTIN SURFACE SAND FILTER SYSTEMS

Definition

The City of Austin, Texas, hase been using open basin intermittent sand filtration BMPs for treating stormwater runoff since the early 1980's. The Austin program is managed by the Environmental and Conservation Services Department, which has published design criteria in their *Environmental Criteria Manual* (Austin, 1988). Austin places heavy emphasis on pretreating the stormwater runoff in a sediment trapping presettling basin to protect the filter media from excessive sediment loading. The particles selected by Austin for complete removal in the full sedimentation protection basins are those which are greater than or equal in size to silt with a particle diameter of 0.00007 foot (20 microns) and a specific gravity of 2.65.

Figure 3.12C-1 illustrates an Austin Full Sedimentation Sand Filter application at a shopping center. In this system the sedimentation structure is a concrete basin designed to hold the entire WQV and then release it to the filtration basin over a 24-hour draw-down period. **Figure 3.12C-2** shows an alternative design which allows a smaller sedimentation chamber (20 percent of the WQV) while increasing the filter size to compensate for increased clogging of the filter media. Although the systems shown utilize concrete basins, a sediment pond and a geomembrane-lined filter built directly into he ground may be used where terrain and soil conditions allow.

Purpose

Austin Sand Filters are used primarily for water quality control. However, they do provide detention and slow release over time of the WQV. Whether this amount will be sufficient to provide the necessary peak flow rate reductions required for channel erosion control is dependent upon the site conditions. However, in cases where quantity detention beyond the volume of the WQV is required, an attractive alternative may well be to utilize a combined detention basin/pre-settling basin configuration, with the controlled release of the entire stored volume to the sand filter facility.

FIGURE 3.12C - 1

Austin Full Sedimentation Sand Filter System at Barton Ridge Plaza

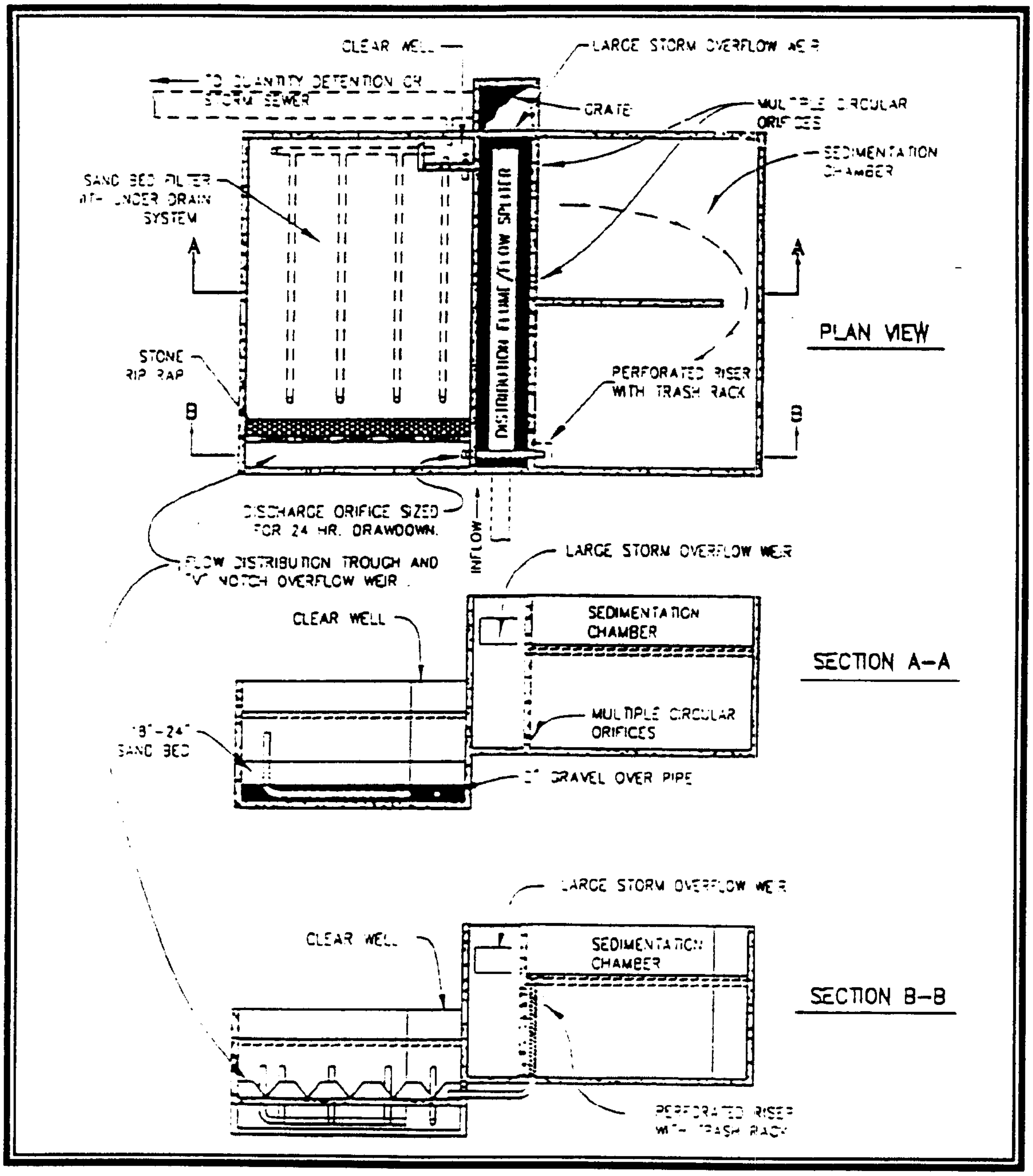

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FIGURE 3.12C - 2

Sedimentation Basin of Jolleyville Partial Sedimentation System

(Poto Courtesy of the City of Austin, Texas)

Conditions Where Practice Applies

Austin Sand Filters Filters are ultra-urban BMPs best suited for use in situations where space is too constrained and/or real estate values are too high to allow the use of conventional retention ponds. Unlike D.C. and Delaware Sand Filters, when full sedimentation protection is provided, Austin filters may be used in situations where a higher amount of pervious surfaces are present or where higher sediment loads from deposition of wind-blown sediments are encountered. Because of their design, they may also be used on much larger drainage sheds.

Drainage Area

Austin full sedimentation and partial sedimentation basin sand filters have been used on drainage sheds up to 30 acres, and with great economy of scale. **Table 3.12-1** illustrates the relative costs of varying sized systems in Austin in mid-1990.

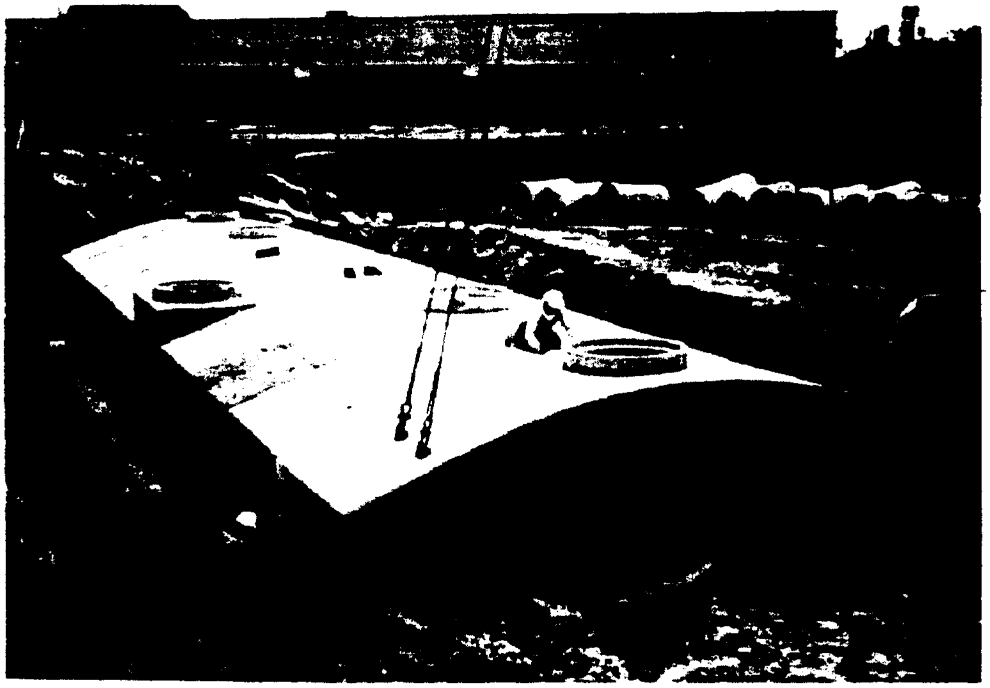
TABLE 3.12C - 1
***Cost of Austin Sand Filtration Systems** (June 1990)*

Drainage Area (Acres)	Water Quality Volume (ft^3)	Cost/Acre ($/acre)	Cost/ft^3 ($/$ft^3$)	Total Cost ($)
1.0	1815	13,613* 19,058#	7.50* 10.50#	13,613* 19,058#
2.0	3,630	8,440* 9,801#	4.65* 5.40#	16,880* 19,602#
5.0	9,075	5,136	2.83	25,682
10.0	18,150	3,812	2.10	38,115
15.0	27,225	3,086	1.70	46,283
20.0	36,300	2,723	1.50	54,450
30.0	54,450	2,360	1.30	70,785

Footnotes:
* Calculated from data provided by Murfee Engineers
# Calculated from data provided by Austin Stormwater Management staff
All other values derived from combined data

While Austin has traditionally built these systems in open basins, there appears no reason why the basic designs cannot be adapted to underground vault construction where real estate values are high enough to justify their use. Austin Partial Sedimentation Sand Filters have been built in underground vaults in Alexandria on sheds of three-four acres of impervious cover. Precast segmented underground vaults are now available in very large configurations. Besides the modified precast box culvert technology illustrated under **MS 3.12A: D.C. Sand Filters**, precast arch technology has also been adapted to the construction of underground vaults. **Figure 3.12C-3** shows such a system. It appears that approximately five acres of impervious cover is the uper limit of the area that should be treated by a single underground vault system.

FIGURE 3.12C - 3
Underground Vault Fabricated From Precast Bridge Arch Components



(Photo Courtesy of BridgeTek Bridge Technologies, LLC., Fredericksburg, Virginia)

Development Conditions

Austin Sand Filters are generally suitable BMPs for medium to high density commercial or industrial development. Because of confined space entry restrictions when constructed in underground vaults and maintenance requirements, they are not generally suitable for residential applications except for apartment complexes or large condominiums where a dedicated maintenance force will be present.

Planning Considerations

Refer to the **Planning Considerations** for **Minimum Standard 3.12: General Intermittent Sand Filter Practices**. Of special concern are the stormwater infrastructure serving the site and the requirement to isolate the sand filter from receiving flows until the drainage shed is fully stabilized.

Potential and existing elevations of stormwater infrastructure serving the site will determine one of the most critical design parameters: the maximum depth to which runoff may be pooled over the filter and preserve a gravity flow configuration (whatever the pooling depth, there must be a minimum of five feet of clearance between the top of the filter and the top slab of the filter shell to allow filter maintenance).

*Sand filter BMPS must **never** be placed in service until all site work has been completed and stabilization measures have been installed and are functioning properly.*

Design Criteria

The purpose of this section is to provide recommendations and minimum criteria for the design of Austin Sand Filter BMPs intended to comply with the Virginia Stormwater Management program's runoff quality requirements.

Refer to the **General Design Criteria** previously discussed under **General Intermittent Sand Filter Practices, Minimum Standard 3.12**

Filter Sizing Criteria

1. ***Full Sedimentation with Filtration***

In this configuration, the sedimentation basin receives the WQV and detains it for a minimum draw-down time (time required to empty the basin from a full WQV condition) of 24 hours. The effluent from the sedimentation basin is discharged into the filtration basin..

Austin conducted a literature review of sedimentation basins and slow rate filters to establish design criteria.

For filtration basins, surface area is the primary design parameter. The required surface area is a function of sand permeability, bed depth, hydraulic head and sediment loading. A filtration rate of 0.0545 gallons per minute per square foot has been selected for design criteria (10.5 feet per day or 3.4 million gallons per acre per day). This filtration rate is based on a Darcy's Law coefficient of permeability k =3.5 feet per day, an average hydraulic head (h) of three (3) feet and a sand bed depth (d_f) of 18 inches, and a filter drawdown time, t_f of 40 hours.

Substituting these values in the basic Austin Filter Formula shown in **General Intermittent Sand Filter Practices, Minimum Standard 3.12** yields:

$A_f = I_a H / 18$

where "A_f" is the minimum surface area of the filtration media in acres, "I_a" is the contributing impervious runoff area in acres and "H" is the runoff depth in feet (0.5 inch = 0.0417 feet when treating the WQV).

When treating the first 1/2-inch of runoff, this formula reduces to

$A_f = 0.0023 I_a = 100\ Ft^2$ of filter per impervious acre.

This formula is obviously based on a number of simplifying assumptions. Determining the actual average depth of ponding over the filter is an extremely complex proposition considering thet the runoff is being released from the sedimentation chamber to the filter at first a rising and then a falling head and then percolating through the sand filter at first a rising and then a falling head. However, this design procedure has worked well for austin for over a decade and may be therefore be considered to be vaild.

When treating a volume greater than the WQV (as when a combined quantity detention/presettling basin is utilized) use the following formula:

$A_f = 0.0023 I_a \times (TV / WQV)$

Where TV = the full retention volume of the detention basin/presettling basin.

2. ***Partial Sedimentation with Filtration***

In this configuration, the sedimentation basin or chamber holds a minimum of 20 percent of the WQV and is hydraulically connected to the filter basin with orifices or slots which allow the water level to equalize between the two chambers.

For Austin Sand Filters with partial sedimentation protection, utilize the following formula:

$$A_{f(m)(PS)} = \frac{545 I_a d_f}{(h + d_f)}$$

where,

I_a = impervious cover on the watershed in acres
d_f = sand bed depth (normally 1.5 to 2ft)
h = average depth of water above surface of sand media between full and empty basin conditions (ft.)

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Sedimentation Basin Sizing

1. ***Full Sedimentation with Filtration***

The sedimentation basin must hold the entire WQV (or larger treatment volume) and release it to the filter over 24 hours. The volume of the basin is thus set by the amount of area to be treated. For sedimentation basins, the removal of discrete particles by gravity settling is primarily a function of surface loading, "Q_o/A_s ", where "Q_o " is the rate of outflow from the basin and "A_s" is the basin surface area. Basin depth is of secondary importance as settling is inhibited only when basin depths are too shallow (particle resuspension and turbulence effects). For sedimentation, surface area is the primary design parameter for a fixed minimum draw-down time, t_d, of 24 hours. Removal efficiency, E, is also a function of particle size distribution. For design purposes, the particles selected for complete removal in the sedimentation basin are those which are greater than or equal in size to silt with the following characteristics: particle diameter 0.00007 foot (20 microns) and specific gravity of 2.65. These are typical values for urban runoff.

Presettling basins are usually sized using the Camp-Hazen equation (Claytor and Schueler, 1996):

$$A_S = -(Q_O / w) \times \text{Ln}(1 - E)$$

Where,

A_S = Surface area (ft^2) of the sedimentation basin
E = Trap efficiency, which is the target removal efficiency of suspended solids (use 90%)
w = Particle settling velocity; for silt, use 0.0004 ft/sec
Q_O = rate of outflow from the basin = WQV (or treatment volume) divided by the detention time (24 hours)

Substituting the values recommended above yields the simplified formula:

$$A_S = 0.066 \times WQV \quad (ft^2)$$

For 1816 ft^3, this yields an area of 120 ft^2. However, Austin recommends that the sedimentation basin be no more that 10 feet deep, which yields a surface area approximately 115% of the basin Camp-Hazen area. The Austin formula for minimum surface area is:

$$A_S = 0.0042\ I_a$$

Where I_a is the contributing impervious runoff area in acres

2. **Partial Sedimentation with Filtration**

The minimum area of the sediment chamber may be computed by the formula:

$$A_S = WQV / 2h$$

Where 2h = the maximum depth of ponding over the filter and the sediment chamber.

Additional Full Sedimentation Basin Considerations

1. ***Inlet Structure***

The inlet structure design must be adequate for isolating the water quality volume from the design storm and to convey the peak flow for the design storm past the basin. The water quality volume should be discharged uniformly and at low velocity into the sedimentation basin in order to maintain near quiescent conditions which are necessary for effective treatment. It is desirable for the heavier suspended material to drop out near the front of the basin; thus a drop inlet structure is recommended in order to facilitate sediment removal and maintenance. Energy dissipation devices may be necessary in order to reduce inlet velocities which exceed three (3) feet per second.

2. ***Outlet Structure***

The outlet structure conveys the water quality volume from the sedimentation basin to the filtration basin. The outlet structure shall be designed to provide for a minimum draw-down time of 24 hours. A perforated pipe or equivalent is the recommended outlet structure. The 24 hour draw-down time should be achieved by installing a throttle plate or other flow control device at the end of the riser pipe (the discharges through the perforations should not be used for draw-down time design purposes)

3. ***Basin Geometry***

The shape of the sedimentation basin and the flow regime within this basin will influence how effectively the basin volume is utilized in the sedimentation process. The length to width ratio of the basin should be 2:1 or greater. Inlet and outlet structures should be located at extreme ends of the basin in order to maximize particle settling opportunities.

Short-circuiting (i.e., flow reaching the outlet structure before it passes through the sedimentation basin volume) flow should be avoided. Dead storage areas (areas within the basin which are by-passed by the flow regime and are, therefore, ineffective in the settling process) should be minimized. Baffles may be used to mitigate short circuiting and/or dead storage problems. The sedimentation illustrated in **Figure 3.12C-1** (photo in **Figure 3.12-4**) illustrates the use of baffles to improve sedimentation basin performance.

4. ***Sediment Trap (Optional)***

A sediment trap is a storage area which captures sediment and removes it from the basin flow regime. In so doing the sediment trap inhibits resuspension of solids during subsequent runoff events, improving long-term removal efficiency. The trap also maintains adequate volume to hold the water quality volume which would otherwise be partially lost due to sediment storage. Sediment traps may reduce maintenance requirements by reducing the frequency of sediment removal. It is recommended that the sediment trap volume be equal to ten (10) percent of the sedimentation basin volume. Water collected in the sediment trap shall be conveyed to the filtration basin in order to prevent standing water conditions from occurring. All water collected in the sediment trap shall drain out within 60 hours. The invert of the drain pipe should be above the surface of the sand bed filtration basin. The minimum grading of the piping to the filtration basin should be 1/4 inch per foot (two (2) percent slope). Access for cleaning the sediment trap drain system is necessary.

Design Storm

The inlet design or integral large storm bypass must be adequate for isolating the WQV from the design storm for the receiving storm sewer system (usually the 10 year storm) and for conveying the peak flow of that storm past the filter system. Since D.C. Sand Filters will be used only as off-line facilities in Virginia, the interior hydraulics of the filter are not as critical as when used as an on-line facility. The system should draw down in approximately 40 hours.

Infrastructure Elevations

For cost considerations, it is preferable thatAustin Sand Filters work by gravity flow. This requires sufficient vertical clearance between the invert of the prospective inflow storm piping and the invert of the storm sewer which will receive the outflow. In cases where gravity flow is not possible, a clearwell sump and pump are required to discharge the effluent into storm sewer. Such an application would be appropriate in commercial or industrial situations where a dedicated maintenance force will be available (shopping malls, apartment houses, factories of other industrial complexes, etc.).

Special Considerations for Underground Filter Systems

When Austin Sand Filters are placed underground, a number of special considerations pertain. The restrictive orifice or gate valve for controlling the release of water from a separate sedimentation vault should be placed in a manhole located between the sedimentation vault and the filter vault. The sedimentation vault should contain a sediment sump into which accumulated sediments may be flushed with a high pressure hose for removal by vacuum trucks. Water should enter the filter vault in a separate headbox with a permanent pool for energy absorbtion and a hydrocarbon trap like that of a D.C. Sand Filter. The filter vault should also contain a separate clearwell.

Structural Requirements

The load-carrying capacity of the filter structure must be considered when it is located under parking lots, driveways, roadways, and, certain sidewalks (such as those adjacent to State highways). Traffic intensity may also be a factor. The structure must be designed by a licensed structural engineer and the structural plans require approval by the plan approving jurisdiction.

Accessibility and Headroom for Maintenance

Both the sedimentation basin and the filter must be accessible to appropriate equipment and vacuum trucks for removing accumulated sediments and trash. The sedimentation basin must be cleaned approximately once per year, and the filter will likely need raking on that frequency to remove trash and restore permeability. When filters are placed in underground vaults, all chambers must have personnel access manholes and built-in access ladders. **A minimum headspace of 60 inches above the filter is required to allow such maintenance and repair.** A 38-inch diameter maintenance manhole with eccentric nested covers (a 22-inch personnel access lid inside the 38-inch diameter lid) or a rectangular load bearing access door (minimum 4 ft. x 4 ft.) should be positioned directly over the center of the filter. A 30-inch manhole should also be placed directly over the sediment sump in an underground sedimentation vault. Similar manholes must be positioned to provide access for a high-pressure hose to reach all points in the sediment vault.

Construction Specifications

Sedimentation Basin Liners

Impermeable liners may be either clay, concrete or geomembrane. If geomembrane is used, suitable geotextile fabric shall be placed below and on the top of the membrane for puncture protection. Clay liners shall meet the specifications in **Table 3.12C-2**:

The clay liner shall have a minimum thickness of 12 inches.

If a geomembrane liner is used it shall have a minimum thickness of 30 mils and be ultraviolet resistant.

The geotextile fabric (for protection of geomembrane) shall meet the specifications in **Table 3.12C-3**.

TABLE 3.12C - 2
Clay Liner Specifications

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	Cm/Sec	1×10^{-6}
Plasticity Index of Clay	ASTM D-423 & D-424	%	Not less than 15
Liquid Limits of Clay	ASTM D-2216	%	Not less than 30
Clay Compaction	ASTM-2216	%	95% of Standard Proctor Density
Clay Particles Passing	ASTM D-422	%	Not less than 30

Source: City of Austin

TABLE 3.12C - 3
Geotextile Specification for Basin Liner "Sandwich"

Property	Test Method	Unit	Specification
Unit Weight		Oz./Sq.Yd.	8 (minimum)
Filtration Rate		In./Sec.	0.08 (minimum)
Puncture Strength	ASTM D-751 (Modified)	Lb.	125 (minimum)
Mullen Burst Strength	ASTM D-751	Psi.	400 (minimum)
Tensile Strength	ASTM D-1682	Lb.	300
Equiv. Opening Size	U.S. Standard Sieve	No.	80 (minimum)

Source: City of Austin

Equivalent methods for protection of the geomembrane liner will be considered on a case by case basis. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing and abrasion.

Portland Cement Concrete

Concrete liners may be used for sedimentation chambers and for sedimentation and filtration basins. Concrete shall be at least five (5) inch thick C A3 defined in the Virginia Department of Transportation *Road and Bridge Specifications*

Outlet Structure for Full Sedimentation Basin

A perforated pipe or equivalent is the recommended outlet structure. The 24-hour draw-down should be achieved by installing a throttle plate or other control device at the end of the riser pipe (the discharges through the perforations should not be used for draw-down time design purposes). The perforated riser pipe should be selected from **Table 3.12-4.**

TABLE 3.12C - 4
Perforated Riser Pipes

Riser Pipe Nominal Diameter (inches)	Vertical Spacing Between Rows (Center to Center in Inches)	Number of Perforations Per Row	Diameter of Perforations (inches)
6	2.5	9	1
8	2.5	12	1
10	2.5	16	1

Source: City of Austin

A trash rack shall be provided for the outlet. Openings in the rack should not exceed 1/3 the diameter of the vertical riser pipe. The rack should be made of durable material, resistant to rust and ultraviolet rays. The bottom rows of perforations of the riser pipe should be protected from clogging. To prevent clogging of the bottom perforations it is recommended that geotextile fabric be wrapped over the pipe's bottom rows and that a cone of one (1) to three (3) inch diameter gravel be placed around the pipe. If a geotextile fabric wrap is not used then the gravel cone must not include any gravel small enough to enter the riser pipe perforations. **Figure 3.12C-4** illustrates these considerations.

Outlet Structure for Partial Sedimentation Basin

The outlet structure should be a berm or wall with multiple outlet ports or a gabion so as to discharge the flow evenly to the filtration basin. Rock gabions should be constructed using 6-8 inch diameter rocks. The berm/wall/gabion height should not exceed six (6) feet and high flows should be allowed to overtop the structure (weir flow). Outlet ports should not be located along the vertical center axis of the berm/wall so as to induce flow-spreading. The outflow side should incorporate features to prevent gouging of the sand media (e.g., concrete splash pad or riprap)

Sand Filter Layer

For applications in Virginia, use **ASTM C33 Concrete Sand** or sand meeting the Grade A fine aggregate gradation standards of Section 202 of the VDOT ***Road and Bridge Specifications.*** The top of the sand filter must be completely level.

Geotextile Fabrics

The filter cloth layer beneath the sand shall conform to the specifications shown in **Table 3.12C-5**: The fabric rolls must be cut with sufficient dimensions to cover the entire wetted perimeter of the filtering area and lap up the filter walls at least six-inches.

FIGURE 3.12C - 4
Riser Pipe Detail for Full Sedimentation Basin

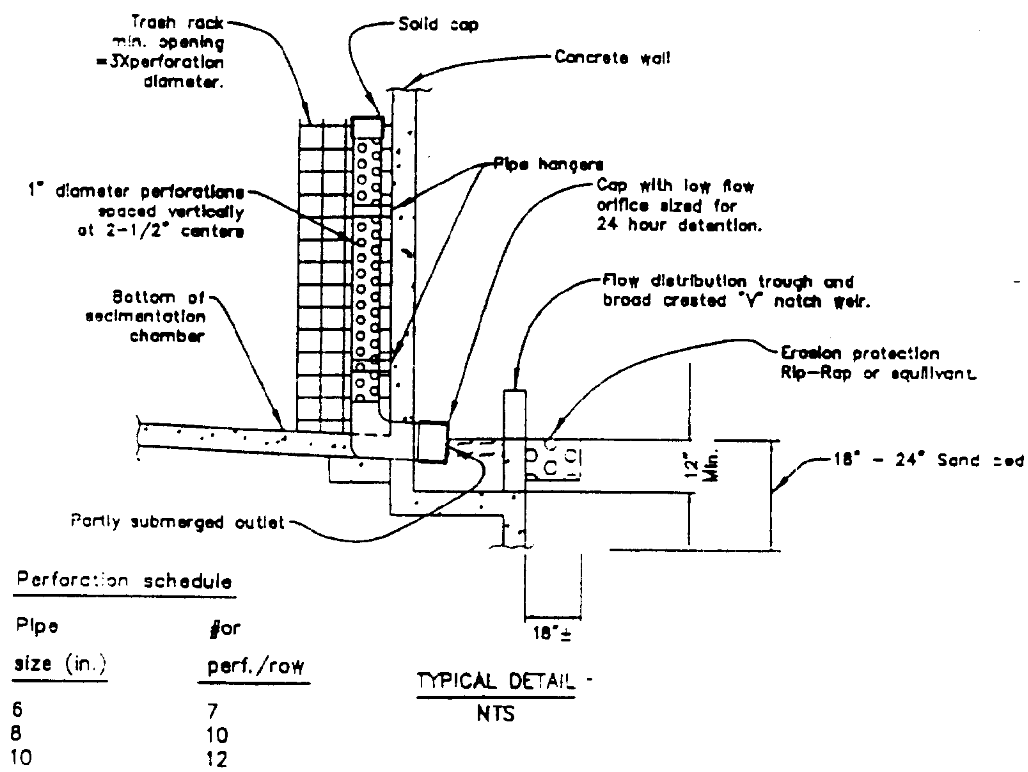


Table 3.12C - 5
Specifications for Nonwoven Geotextile Fabric Beneath Sand in Austin Sand Filter

Property	Test Method	Unit	Specification
Unit Weight	--	Oz./sq.yd.	8.0 (min.)
Filtration Rate	--	In/sec	0.08 (min.)
Puncture Strength	ASTM D-751 (Modified)	Lb.	125 (min.)
Mullen Burst Strength	ASTM D-751	Psi	400 (min.)
Equiv. Opening Size	U.S. Standard Sieve	No.	80 (min.)
Tensile Strength	ASTM D-1682	Lb.	300 (min.)

Gravel Bed Around Collector Pipes

The gravel layer surrounding the collector pipes shall be ½ to two (2) inch diameter gravel and provide at least two (2) inches of cover over the tops of the drainage pipes. The gravel and the sand layer are usually separated by a layer of geotextile fabric meeting the specification listedabove. However, on small underground vault partial sedimentation systems, some jurisdictions allow the substitution for an additional six-inch layer of 1/4-inch washed pea gravel in lieu of the filter fabric. In such cases, hydraulic compaction and refilling of the filter is especially important. **FIGURE 3.12C-5** shows a cross-section of a filter with the usual configuration. **FIGURE 3.12C-6** shows an underground vault filter with a six-inch pea gravel layer.

Underdrain Piping

The underdrain piping consists of 4-inch or 6-inch schedule 40 or better polyvinyl perforated pipes reinforced to withstand the weight of the overburden. Perforations should be 3/8 inch, and each row of perforations shall contain at least four holes for four-inch pipe and six holes for six-inch pipe. Maximum spacing between rows of perforations shall be six (6) inches. Maximum spacing between pipes shall be 10 feet.

The minimum grade of piping shall be 1/8 inch per foot (one [1] percent slope). Access for cleaning all underdrain piping is needed. Clean-outs for each pipe shall extend at least six (6) inches above the top of the upper filter surface, e.g. the top layer of gravel.

Each pipe shall be thoroughly wrapped with 8 oz./sq.yd. geotextile fabric meeting the specification in **Table 3.12C-1** above.

FIGURE 3.12C - 5

Austin Sand Filter Cross-Section With Filter Fabric Layer

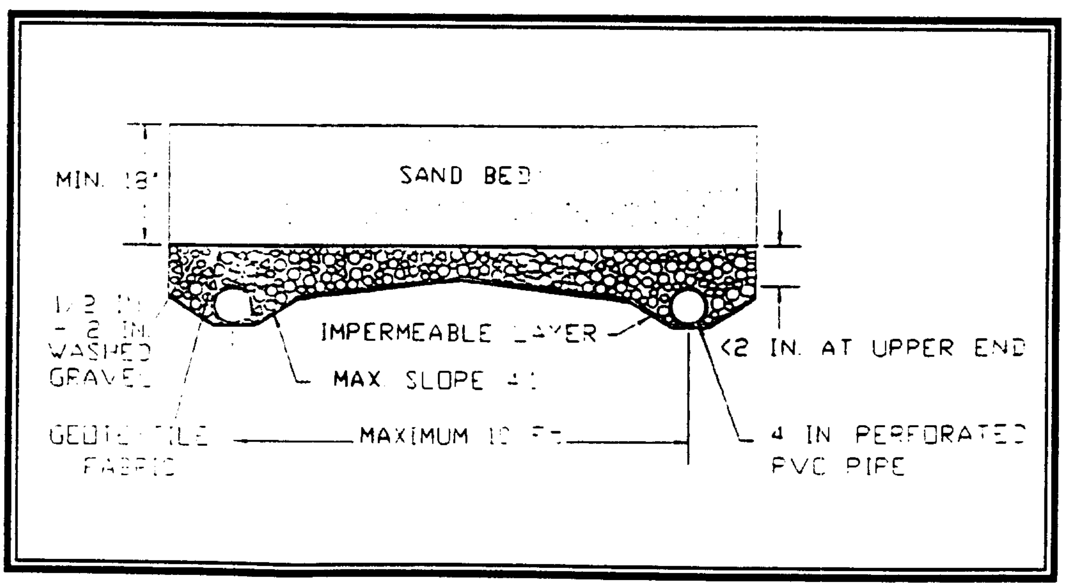
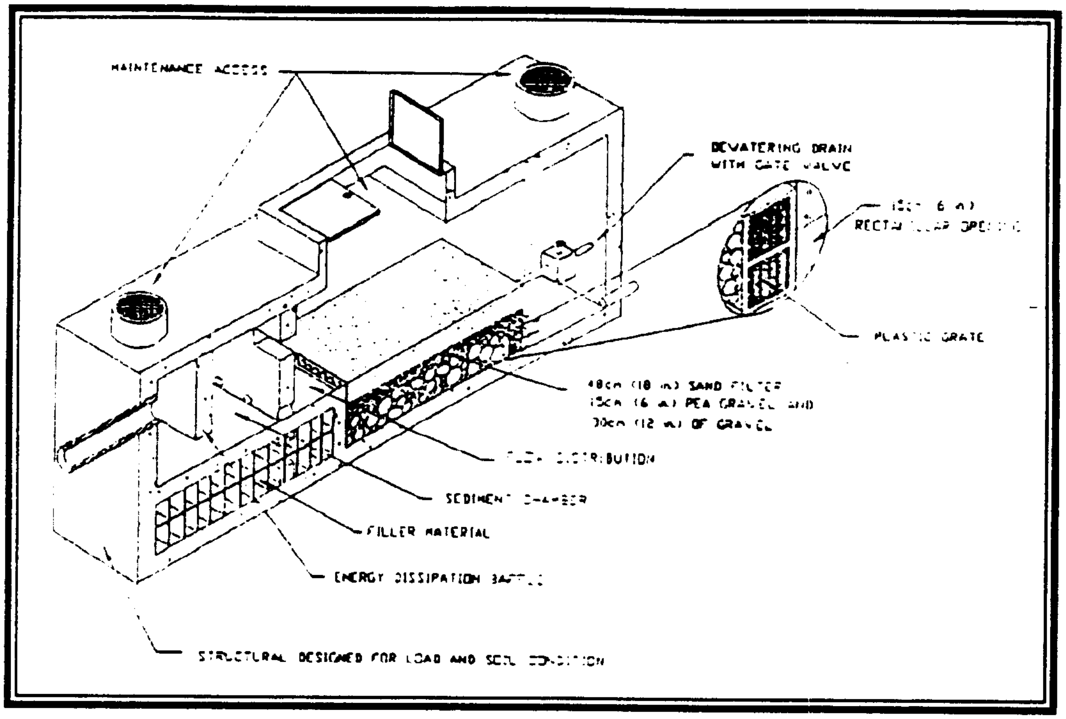


FIGURE 3.12C - 6
Partial Sedimentation Vault Filter With Pea Gravel Layer



Protection from Construction Sediments

The site erosion and sediment control plan must be configured to permit construction of the filter system while maintaining erosion and sediment control.

No runoff is to enter the sand filtration system prior to completion of all construction and site revegitation. Construction runoff shall be treated in separate sedimentation basins and routed to by-pass the filter system. Should construction runoff enter the filter system prior to site revegitation, all contaminated materials must be removed and replaced with new clean materials.

Watertight Integrity Test

After completion of the filter shell but before placement of the filter layers, entrances to the structure shall be plugged and the shell completely filled with water to demonstrate water tightness. Maximum allowable leakage is 5 percent of the filter shell volume in 24 hours. Should the structure fail this test, it shall be made watertight and successfully retested prior to placement of the filter layers.

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Hydraulic Compaction of Filter Components

After placement of the collector pipes, gravel, and lower geotextile layer, fill the shell with filter sand to the level of the top of the sediment pool weir. Direct clean water into the sediment chamber until both the sediment chamber and filter chamber are completely full. Allow the water to draw down until flow from the collector pipes ceases, hydraulically compacting the filter sand. After allowing the sand to dry out for a minimum of 48 hours, refill the shell with sand to a level one inch beneath the top of the weir and place the upper geotextile layer and gravel ballast.

Note: The following Construction Specifications apply to Austin Sand Filters which are to be constructed in underground vaults.

Depth of Plunge Pool in Filter Headbox

The energy absorbing "plunge pool" must be at least 36 inches deep to properly absorb energy from the incoming flow and trap any hydrocarbons which pass through the sedimentation vault.

Depth of the Underwater Opening Between Chambers

To preserve an effective hydrocarbon trap, the top of the underwater opening between the headbox and the filter chamber must be at least 18 inches below the depth of the weir which divides the filter from the pool. To retain sediment in the first chamber, the bottom of the opening should be at least six inches above the floor. The area of the opening should be at least 1.5 times the cross-sectional area of the inflow pipe(s) to assure that the water level remains equal between the first and second chambers.

Total Depth of Filter Cross-Section

The total depth of the filter cross-section must match the height of the weir dividing the sedimentation pool from the filter. Otherwise, a "waterfall" effect will develop which will gouge out the front of the filter media. If a sand filter less than 24 inches is used, the gravel layer must be increased accordingly to preserve the overall filter depth.

Dewatering Drain

When the filter is placed in an underground vault, A 6-inch dewatering drain controlled by a gate valve shall be installed between the filter chamber and the clearwell chamber with its invert at the elevation of the top of the filter. The dewatering drain penetration in the chamber dividing wall shall be sealed with a flexible strip joint sealant which swells in contact with water to form a tight pressure seal.

Access Manholes

When the filter is installed in an underground vault, access to the headbox (sediment chamber) and the clearwell shall be provided through at least 22-inch manholes. Access to the filter chamber shall be provided by a rectangular door (minimum size: 4 feet by four feet) of sufficient strength to carry prospective imposed loads or by a manhole of at least 3- inch diameter with an offset concentric 22-inch lid (Neenah R-1741-D or equivalent).

Restrictive Orifice Manhole Between Vaults

The restrictive orifice or gate valve on the outlet pipe from the sedimentation vault should be placed in a manhole between the sedimentation and filter vaults with ready personnel access. **Figure 3.12C-7** illustrates this principle.

Maintenance/Inspection Guidelines

The following maintenance and inspection guidelines are not intended to be all inclusive. Specific facilities may require other measures not discussed here.

Major Maintenance Requirements for Sedimentation Basins

1. Removal of silt when accumulation exceeds six (6) inches in sediment basins without sediment traps. In basins with sediment traps, removal of silt shall occur when the accumulation exceeds four (4) inches in the basins, and sediment traps shall be cleaned when full.

2. Removal of accumulated paper, trash and debris every six (6) months or as necessary.

3. Vegetation growing within the basin is not allowed to exceed 18 inches in height at any time.

4. Corrective maintenance is required any time a sedimentation basin does not drain the equivalent of the Water Quality Volume within 40 hours (i.e., no standing water is allowed).

5. Corrective maintenance is required any time the sediment trap (optional) does not drain down completely within 96 hours (i.e., no standing water allowed).

Major Maintenance Requirements for Filtration Components

1. Removal of silt when accumulation exceeds 1/2 inch. - Removal of accumulated paper, trash and debris every six (6) months or as necessary.

2. Vegetation growing within the basin is not allowed to exceed 18 inches in height.

3. Corrective maintenance is required any time draw-down does not occur within 36 hours after the sedimentation basin has emptied.

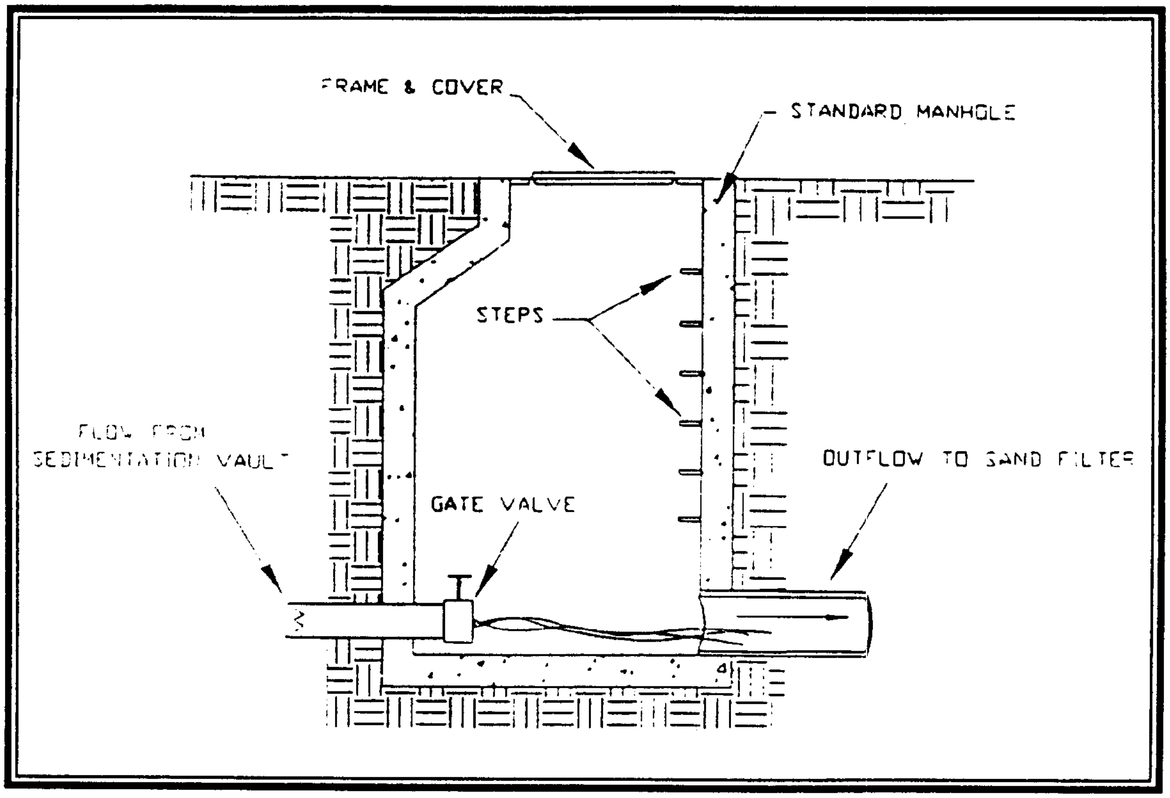
4. When an underground vault filter will no longer draw down within the required 36-hour period because of clogging with silt (approximately every 3-5 years), the upper layer of gravel and

geotechnical cloth must be replaced with new clean materials meeting the original specifications.

5. Monitoring manholes, flumes, and other facilities shall be kept clean and ready for use.

The BMP shall be inspected annually by representatives of the owner and the governing jurisdiction staff to assure continued proper functioning.

FIGURE 3.12C - 7
Restrictive Orifice Access Manhole



Sediment Chamber Pumpout

Full sedimentation chambers or basins require flushing and pumpout with a vacuum truck approximately once per year.

Concrete Shell Inspection

Concrete will deteriorate over time, especially if subjected to live loads. The concrete shell, risers, etc., must be examined during each annual inspection to identify areas that are in need of repair, and such repairs must be promptly effected.

Design Procedures

The following design procedure is structured to assure that the desired water quality volume is captured and treated by theAustin Filter. The procedure assumes that a filter shell with a rectangular cross-section is to be used.

Standard Design Logic

Employ the following design logic to design Austin Sand Filters for use in Virginia:

1. Determine Governing Site Parameters

Determine the Impervious area on the site (I_a in acres), the water quality volume to be treated (WQV in $ft.^3 = 1816\ I_a$), and the site parameters necessary to establish 2h, the maximum ponding depth over the filter (storm sewer invert at proposed connection point, elevation to inflow invert to BMP, etc).

2. Select Filter Depth and Determine Maximum Ponding Depth

Considering the data from Step 1) above, select the Filter Depth ((d_f) and determine the maximum achievable ponding depth over the filter (2h).

3. For Full Sedimantation Systems, size the sedimentation basin (vault) to hold the WQV with a minimum depth of 10 feet.

4. Compute the Minimum Area of the Sand Filter (A_{fm})

For systems with full sediment protection, provide a dediment chamber of sufficient volume to hold the WQV. Make the depth ≤ ten feet. To compute the area of the filter, use the formula:

$$A_f = 100 I_a$$

Where I_a = the impervious acreage on the drainage shed.

For systems with only partial sediment protection, utilize the formula:

$$A_{fm(PS)} = \frac{545 I_a d_f}{(h + d_f)}$$

A_{fm} = minimum surface area of sand bed (square feet)
I_a = impervious cover on the watershed in acres
d_f = sand bed depth (normally 1.5 to 2ft)
h = average depth of water above surface of sand media between full and empty basin conditions (ft.)

5. Select Filter Width and Compute Filter Length and Adjusted Filter Area

Considering site constraints, select the Filter Width (W_f). Then compute the Filter Length (L_f) and the Adjusted Filter Area (A_f)

$$L_f = A_{fm}/W_f$$

$$A_f = W_f \times L_f$$

Sizing computations are completed at this point for the full sediment protection system. The only remaining task is to assure that the filter chamber is sized to contain a minimum of 20 % of the WQV. The logic continues for the partial sedimentation system.

6. Compute the Storage Volume on Top of the Filter (V_{Tf})

$$V_{Tf} = A_f \times 2h$$

7. Compute the Storage in the Filter Voids (V_v)
(Assume 40% voids in filter media)

$$V_v = 0.4 \times A_f \times (d_f + d_g)$$

8. Compute Flow Through Filter During Filling (V_Q)
(Assume 1-hour to fill per D.C. practice)

$$V_Q = \frac{kA_f(d_f + h)}{d_f}\text{ ; use } k = 2\text{ ft./day} = 0.0833\text{/hr.}$$

9. Compute Net Volume to be Stored Awaiting Filtration (V_{st})

$$V_{st} = WQV - V_{Tf} - V_v - V_Q$$

10. Compute Length of Sediment chamber (L_{SC})

$$L_{SC} = \frac{V_{st}}{(2h \times W_f)}$$

11. Compute Minimum Length of Sediment Chamber (L_s)
(to contain 20% of WQV per Austin practice)

$$L_{sm} = \frac{0.2WQV}{(2h \times W_f)}$$

12. Set Final Length of the Sediment Chamber (L_{SCF})

If $L_{SC} \geq L_s$, make $L_{SCF} = L_{SC}$

If $L_{SC} < L_{sm}$, make $L_{SCF} = L_{sm}$

It may be economical to adjust final dimensions to correspond with standard precast structures or to round off to simplify measurements during construction.

Checklists

The **Construction Inspection and As-Built Survey Checklist** found in **Appendix 3D** is for use in inspecting intermittent sand filter facilities during construction and, where required by the local jurisdiction, engineering certification of the filter construction. The **Operation and Maintenance Checklist**, also found in **Appendix 3D**, is for use in conducting maintenance inspections of intermittent sand filter facilities.

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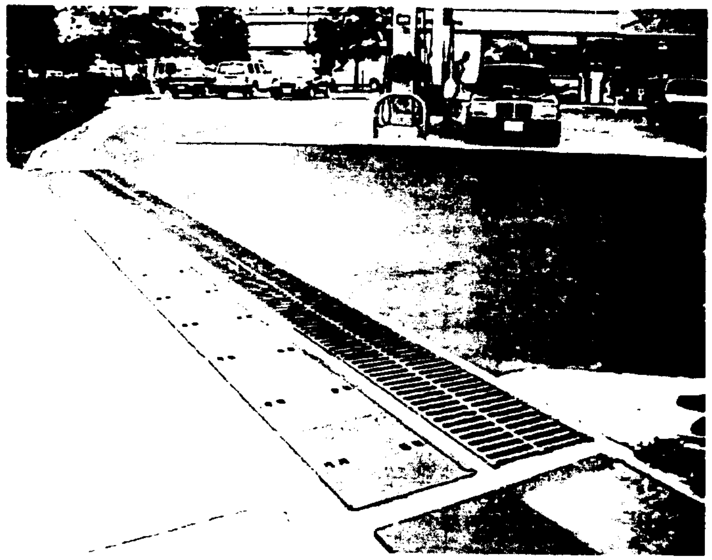


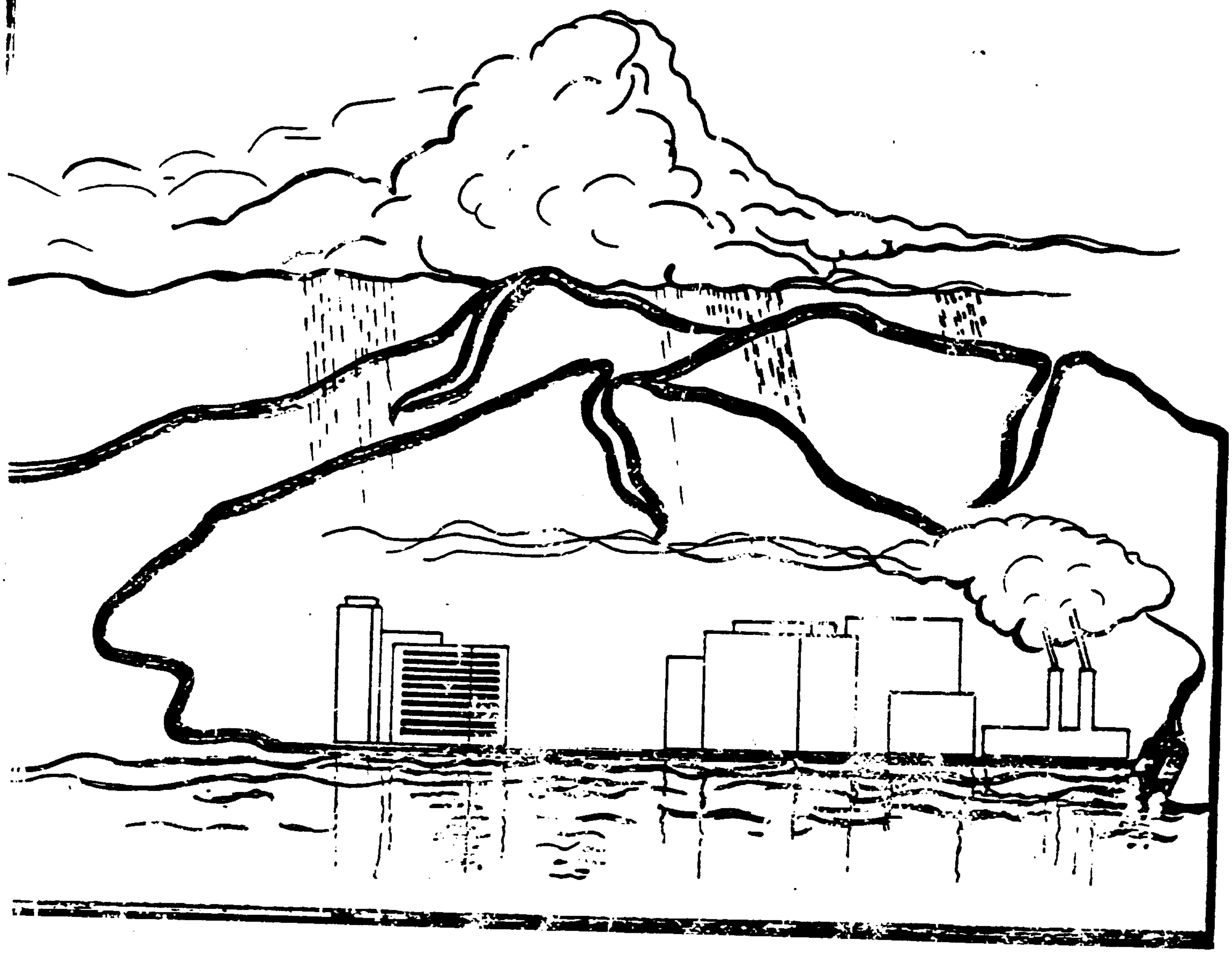
Sand Filter at entrance to service station.

Sand Filter under construction. Note curb cuts for inflow to wet chamber with weir overflow into sand chamber.

General Intermittent Sand Filters

United States
Environmental Protection
Agency

EPA830-R-92-001
October 1992



Report on

The EPA Storm Water Management Program

Conducted for the U.S. EPA Office of Wastewater Enforcement and Compliance
by The Rensselaerville Institute

Volume 1

R0009869

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We also acknowledge the efforts of those persons who participated in the focus groups, the expert surveys, the public forums, and the "design team" session. The thoughtfulness of opinions and insights voiced is impressive.

We are encouraged by the willingness of people with very different perspectives to not only listen carefully to each other but to seek common ground. The prospects for collaborative work are strong.

Mary E. Marsters
Harold S. Williams
The Rensselaerville Institute

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In December 1991, the Deputy Administrator of the U.S. Environmental Protection Agency (EPA) asked the Office of Water to undertake a research project with two objectives: 1) identify ways to improve and streamline the existing storm water regulatory program implemented by the agency under Section 402 (p) (2) of the Clean Water Act; and 2) define and annotate options for controlling sources of storm water runoff designed for Phase II of this same section.

In response to this request, the Office of Wastewater Enforcement and Compliance (OWEC) engaged The Rensselaerville Institute to develop a two-part project to gather and integrate diverse opinion and insight on ways to improve the efficiency and effectiveness of the existing Phase I program and the best possible response for the Phase II program designed to cover remaining storm water sources and problems.

Part I of the project was conducted during February and March, 1992 when six focus groups were held around the U.S. to gain user feedback on how the current regulations and implementation procedures could be improved and streamlined. These groups, which included representation by both public- and private-sector permittees as well as regulatory agencies, private consulting firms, industry, and environmental interests, identified numerous ways EPA and others could address permitting and compliance procedures seen as difficult or problematic.

Part II of the project began with an Expert Survey of 32 persons highly knowledgeable in storm water and its control who represented different perspectives (academic/research, state/local government,. commercial development, environmental advocacy, and consultant/engineering) and different geographic areas. Experts were asked to respond to a set of options for targeting and controlling sources and to suggest additional alternatives as well. Insights on voluntary measures that have proven effective in storm water control were solicited through a separate survey of five experts in nonpoint program approaches.

Based on the results of these surveys, three public meetings were announced in the Federal Register and held in Denver, San Francisco and Washington, DC during June, 1992. Those attending were divided into teams and asked to define their own preferred strategies for a Phase II program response, including definition of sources to be regulated, the preferred method of control (permit-based or other) and their sense of both timetable and the role EPA should play.

Finally, a small group of insightful individuals representing diverse viewpoints from both point source and nonpoint source programs was convened for a strategy design meeting for the purpose of adding greater depth and breadth to one or more Phase II approaches identified in the public meetings. From this group, a ten-point strategy was created, as well as a series of recommendations to EPA on developing the second phase of the storm water program.

This Executive Summary presents the findings from each of these activities in summary form. More complete recommendations are contained in the body of Volume I. The project data base is contained in Volume II.

Summary of Findings on Improving Phase I of the Storm Water Program

Forty individuals participated in focus groups held in Atlanta, GA; Hartford, CT; Chicago, IL; Washington, DC; Seattle, WA; and Phoenix, AZ. Together, the participants included all identified viewpoints and separable interests--including EPA regional staff, state and local government officials, engineering consultants, environmental advocates, and representatives of corporations included in Phase I permitting.

Participants responded to a set of questions which probed for opinion and insight on such matters as the unclear aspects of the Phase I regulations, additional steps that should be taken to simplify the process and help permittees to achieve compliance, and the relative merits of individual and group permits. In addition to participant responses to core questions, the afternoon of each session was used to further elaborate problems and solutions of interest to participants in an informative format.

While many issues raised were location- or source-specific, some spanned geographic and demographic boundaries. Eight issues common across all focus groups were identified as key areas to be clarified and/or modified to improve program implementation:

1. EPA has not been clear about the intended goals of the regulations. A stronger sense of the relative importance of storm water in the framework of environmental risk is needed, as is clarity about short range and long term targets. There is a difference, for example between clean water standards and stream health standards. It is clear that there are storm water permits. It is not clear how the permits reflect a coherent program.

2. The expense of program implementation is significantly higher than EPA has estimated. There is great concern over what the program's real costs have been in terms of dollars and manpower costs of preparing a permit application, and the anticipated costs of achieving compliance. A broader concern: municipalities now beleaguered by resource shortfalls cannot reasonably afford the combined costs of compliance with all environmental regulations.

3. The administrative complexity of the program is enormous at the federal, state and local levels, and has quickly outpaced the availability of resources and manpower needed to carry it out. In some cases, field staff have been

pulled in simply to process the paperwork involved.

4. Clarification is needed on the roles and expectations EPA has for itself, states and permittees. What is clear to everyone is that EPA does not have the capacity to administer and enforce the program alone. This cannot be seen as an EPA program administered in a "command and control" style totally from Washington. It must involve active participation, not simply passive compliance, from all levels involved.

5. More technical support for the program is needed. Expanded information explaining the regulations and how to implement them is especially needed. Also, there should be less "national level" support and more focus on regional conditions. Much of the content of storm water workshops held at EPA headquarters is irrelevant to any given participant.

6. States need EPA to either clarify how to interpret unclear points of the regulations, or allow them the latitude to make the interpretations themselves. One unclear area is the inconsistencies and inequalities created by use of industrial SIC codes in such areas as transportation. Another murky area is the group application process.

7. EPA should consider consolidating programs in order to address water pollution in an efficient and cost-effective manner. A watershed approach is preferable to current practices of separating problems by media.

8. General permits are "the way to go" and EPA should continue to focus on and accelerate efforts in this direction.

Many focus group members made a point of indicating their pleasure with the focus group format used and the ways in which EPA had 1) encouraged interaction and customer insight and 2) listened carefully to their advice. A complete report on focus group responses and conclusions is contained in the body of this publication.

Summary of Findings on Designing Phase II of the Storm Water Program

Expert Survey

The second part of the Rensselaerville project began with a survey of a select group of 32 point source storm water program experts from across the country. The purpose was to solicit opinions on ways to implement the second phase of the storm water program. Five perspectives were represented: academic/research; commercial development; consultant engineering/legal; environmental advocacy; and state/local government. A first mail-back survey round gained opinion and consensus on relevant issues and options for addressing Phase II sources. Data from the first set of returned surveys were analyzed and given back to participants in a second survey round, which refined positions and created more options for Phase II consideration.

To ensure inclusion of all critical perspectives, five nonpoint source program experts were asked to provide feedback, with emphasis on potential voluntary approaches for addressing Phase II sources.

While approaches recommended differed by profession and geography, these common targeting themes emerged for identifying whom to include in Phase II:

- develop a geographically-based phasing plan by watershed impairment/severity of threat;
- determine selection criteria for pollution sources and use these to identify municipalities that should participate;
- do pilot projects first, evaluate, and then develop and implement a strategy;
- encourage and fund comprehensive basin research and planning to guide targeting;
- require Phase II industries to be covered under Phase I general permits;
- develop national guidelines, and leave selection of sites and methods to state discretion;
- require smaller communities (< 100,000) to apply for permits only when their storm water contributes a significant pollution problem;
- designate problem areas, establish permit requirements for municipals regardless of population, and allow municipals to exclusively regulate industries; and
- initiate a focused dialogue with key stakeholders (applies to both targeting and controls).

Common themes expressed for control strategies included:

- build a Best Management Practices (BMPs) menu that can be used by states to implement and verify progress;

- require localities to select from a list of BMPs the ones most appropriate for their needs and apply industry-specific BMPs nationwide with allowance for state/local officials to modify;

- provide nationwide public education and community-wide public education on the need for storm water control;

- establish national or industry-specific minimum practices for controlling storm water;

- implement good housekeeping and source reduction practices;

- require routine certification and audit of storm water pollution plans and practices;

- establish industry-specific and watershed-specific BMPs; and

- establish BMPs required nationwide and strictly enforce. Require facilities to further treat storm water discharges where BMPs are not effective.

The strongest additional factor in nonpoint survey responses was the degree of emphasis placed on education at all levels, including the general public, local and state officials, and local businesses and industry. Education was seen as the key to making voluntary approaches effective. Voluntary compliance, in turn, was then advanced as highly cost effective.

Respondents feel that EPA must be the "stick" that would fall--with permit requirements, fines, etc.--if a storm water source does not voluntarily take action and achieve certain minimum goals. But limited manpower and financial resources form a rationale for not addressing Phase II with the costly conventional federal mandates of Phase I.

Public Meetings

Three meetings were conducted to gain public responses to options for targeting and controlling Phase II sources. They were held in Denver, CO; San Francisco, CA; and Washington, DC during June, 1992. At each meeting, three experts selected from the Expert Survey process presented their ideas on a regulating strategy for the moratorium sources. Participants were then divided into small task teams, and given the charge of devising their own strategies for targeting and controlling Phase II sources. A strategy template was provided to guide group consideration of three key issues: 1) who should be covered under Phase II; 2) what controls are needed; 3) over what timeframe the program should be implemented. At the end of each public meeting, the task teams presented their options to other participants for discussion.

Common strategy characteristics emerged, in many cases paralleling those apparent in the expert survey. For targeting:

- o Targeting should be done by watershed. Information gathered from Phase I should help identify sensitive watersheds. This may require intergovernmental agreements.

- o The focus should be on "bad actors", i.e., those that are known problem sources. The ones most frequently identified were: gas/auto service industries, transportation, highway systems, land use development and agricultural sources. There needs to be the ability for facilities not contributing impairment of water to gain an exemption from permits, fees, implementation of BMPs. Categories are an ineffective way to designate covered sources - should be done by the degree of risk a given facility poses, because it may not be a whole industry, but rather individual facilities.

- o Small municipalities should be included, but they should have a much simpler application process. Or, only small municipalities where a storm water problem is identified should there be required action.

- o EPA should defer on selecting targeted sources until the agency has carefully looked at the data gathered during Phase I. Numerous sources of information are available which would help determine targeting priorities, e.g., information gathered through 305b reports, information from Phase I program sources, the NURP study.

For needed and desirable controls, these themes emerged:

- ☐ If a permitting process is to be continued for point sources, NPDES general permits should be used, and focus should be on implementing Best Management Practices (BMPs). Permits should be simpler, and much less costly. EPA should make clearer to the applicant what information is required, e.g. provide the permittee with a "checklist of inclusions" for the application, develop a menu of BMPs. Permit exemptions should be granted to those targeted sources who offer no contribution to the problem.

- ☐ Education should be seen not as an "add-on", but rather as a primary tool for effective control. Locally implemented education for public and industry is especially important; the premise is that information and conviction born of education will encourage many to take the needed preventive and remedial steps.

- ☐ More emphasis should be placed on voluntary programs, e.g., 319 nonpoint source-like programs. For facilities with contact with storm water, there should be little or no government intervention, but rather emphasis on pollution prevention incentives, BMPs, and measures of pollution prevention.

Pollution prevention programs should be emphasized, particularly with new development. Some suggested prevention methods included: recycling storm water, "good housekeeping" practices, plantings to minimize runoff, street sweeping of work areas on a daily basis, storm water collection methods, coverage of storage areas, changing manufacturing processes to minimize pollutants, and improvement of air emissions.

- Closer correlation should exist between the severity of the problem and the degree of controls required. Fines and fee structures could be used as "carrot-stick" measures.

- BMPs should be required based upon the specific pollutant problem. EPA should develop a menu of BMPs to assist businesses in determining the appropriate BMP for their problem.

In terms of a timetable for phasing in Phase II, two widespread opinions emerged:

- A minimum of two years is needed to prepare for Phase II, with at least a year dedicated to looking at data gained from Phase I of the storm water program. Effectiveness of presently used BMPs needs to be studied to determine differences in effectiveness between geographic locations and pollutants.

- Whatever the period established for phase-in, it should not begin <u>until</u> promulgation of the regulations.

A final question in the strategy template: **"For whatever strategy is chosen, what could EPA do to make the decision-making process for Phase II more responsive?"** generated responses focused on some common themes:

- Coordinate information dissemination, e.g., set up regional clearinghouses offering such program information as general permit writing, effective applications of BMPs, and examples of successful efforts from programs around the country.

- Provide funding not for program implementation but for needed research, e.g., on BMP effectiveness, and for demonstration projects.

- Set broad guidelines for the program and establish minimum standards, and then allow state and local regulatory agencies determine how to achieve them.

- Develop and implement training programs for regulators, including regional and state, on the program. These people are the ones who will be the informational source for the regulated community, and need to know the details of the program.

As with the focus groups the participants in the public meetings felt positive about the format used. A mail-back survey returned by more than 30% of meeting participants showed that they strongly favored this interactive process over what they perceived as the conventional practice of a stream of public comments that encouraged adversarial positioning and boredom for those listening. Comments of attendees included:

- "The opportunity to formulate an entire strategy to deal with this issue was very useful;"

- "I obtained a better point of view of government's problems and felt that government representatives also obtained a better point of view of industry's problems;"

- "Result was a much less confrontational and much more problem-solving atmosphere;" and

- "It was a valuable way to address drafting of regulations, allowing the regulated community to feel a part of the process."

The body of this report contains a further elaboration of the process and the ways in which it might be used by the EPA in other communication and outreach efforts.

Design Team Meeting

A meeting of seven point and non-point storm water program experts, all of whom were survey respondents, and selected EPA staff was convened in Washington DC on September 17-18, 1992. The purpose was to gain the experts' varied insights on development of the Phase II storm water program and to build a strategy, or multiple strategies, for addressing Phase II sources.

Many discussions were specific to certain types of activity--not only municipal or industrial, but to specific kinds and levels of enterprise. Others focused on regional differences--for example the strong distinctions from places that are uniformly wet, uniformly dry, or highly volatile in hydrological terms. Still others found differentiation in scale--such as the difference in impact a regulation would have on a city as compared to a small town. These distinct findings are contained in the full report which follows in this volume.

A broader set of ten recommendations emerged for the major Phase II challenge which generally transcend such differences. They include:

1. **It is possible and desirable to identify priority target areas for which there is widespread consensus concerning their contribution to water pollution.** These areas begin with new development and redevelopment--both residential and commercial. They also include transportation corridors, dense existing development and automotive services.

2. **EPA needs to communicate more clearly and regularly with everyone impacted by the storm water regulations.** The priority focus should be less on the amount of communication and more on different kinds of communication.

3. **EPA could improve program effectiveness, efficiency and cost control in Phase II by "starting small".** The concept of regional and even local prototypes is a way of getting proposed new Phase II frameworks into the hands of users in prompt fashion to build and refine based on early use.

4. **Selectivity in data collection and monitoring is essential.** At present, some data collection frameworks consume tremendous time and money only to yield bad or useless data or murky or disputed conclusions. At other times, very simple actions taken with known consequences require simple verification, not extensive measuring.

5. **More customer differentiation is also needed.** At present the mind-set appears to be that one size fits all. While giving the appearance of equity, this concept actually creates strong inequalities. The same programs and regulations that befit a large corporation or municipality are simply not equitable for smaller enterprise and communities, for example.

6. **While the ultimate goal is water quality standards, this is very difficult to achieve and/or to measure in the short term.** Therefore, while retaining water quality standards as the ultimate goal, EPA should be focusing on best management practices, and in particular those that reflect preventive and non-structural solutions.

7. **The most functional unit of both analysis and intervention is the watershed.** Most people in our samples for opinion and recommendation strongly suggested the watershed approach--not only on the macro level (e.g., Chesapeake Bay) but the micro-level as well.

8. **EPA's role is to offer technical support and direction more than program funding or even full guidelines for state and local implementation.** In particular, building useful data bases and collection methodologies not only on water quality but on practices to achieve it is critical. Such practices should include education, given that prevention and voluntary compliance are much less costly than litigation.

9. **A collaborative approach to developing effective solutions is possible.** The interactive elements of this project are one reflection of the ability of those with strikingly different perspectives (ranging from strong environmental protection to a focus on economic development) to work cooperatively.

10. **Agriculture's absence from the storm water program is notable and regrettable.** In many regions, agriculture (which includes livestock as well as crops) is a primary contributor to surface water pollution. Permitting or in other ways controlling the transport of agricultural products introduces intervention too late.

The remainder of Volume I amplifies these findings and presents the rationales and key data points which underlie them. Volume II includes the complete data base, including all instruments used to collect and analyze information.

PART I: IMPROVING PHASE I OF THE STORM WATER PROGRAM

In December, 1991, the Deputy Administrator of the U.S. Environmental Protection Agency asked the Office of Water to undertake a project that would achieve two results: first, identify ways to improve and streamline the existing storm water regulatory program currently being implemented by the agency; and second, develop options for controlling sources of storm water runoff not currently required to be permitted under Section 402(p)(2) of the Clean Water Act.

In response to this request, the Office of Wastewater Enforcement and Compliance (OWEC), working with The Rensselaerville Institute, developed a two-part project. This section addresses the outcomes from Part I, which focused on identifying improvements to the existing regulatory program.

Description

As the first part of The Rensselaerville Institute's project to help EPA assess the effectiveness and efficiency of the existing Storm Water Program, focus groups were held in diverse regions of the country to gain feedback on how the regulations promulgated on November 16, 1990 could be streamlined and improved. Six such meetings comprising representatives from state, municipal, private industrial and environmental groups were conducted between February 24 - March 2, 1992.

A total of 40 individuals participated in the focus groups, which were held in Atlanta, GA; Hartford, CT; Chicago, IL; Washington, DC; Seattle, WA; and Phoenix, AZ. The format for each meeting was the same: participants provided feedback on eleven questions developed by EPA and Institute staff. The questions:

1. Which aspects of the storm water regulations are least clear?

2. What additional steps would be helpful in assisting permittees achieve compliance in the allotted timeframe? Who should take those steps?

3. Exactly what kinds of guidance and information are needed to help people implement the program? How would you prioritize these listed storm water program activities in terms of their usefulness?

4. Is there a need for EPA to do more national workshops on the storm water regulations? What about regional or local workshops? On which subjects?

5. What support should states, as opposed to EPA or other organizations, be expected to provide to their "universe" of permittees? What resources do they need in order to provide those supports?

6. If you had to name three ways to streamline the permitting process, what would they be?

7. What could EPA do to encourage those states without general permit authority to get it? What steps are needed to get general permits out? What simple, short-term grassroots efforts can associations and trade groups take to help this effort, and how could EPA support those efforts?

8. What outreach efforts to explain to permittees what they have to do to comply with the regulations have been most effective to date? Are there informational pieces that EPA could prepare that would best help these efforts?

9. What are the techniques, methods or strategies you would recommend to help permittees achieve water quality standards? In what timeframe should permittees be required to comply with WQS?

10. Given that construction activities are most often local in nature and temporary in duration, do you have suggestions about how EPA could more effectively regulate such activities?

11. What suggestions would you offer in terms of the most efficient way to enforce EPA existing regulation requirements, both application requirements and substantive permitting requirements?

Responses to question #6 were revisited in the afternoon of each session, when participants were asked to further define their recommendations, indicate who they felt should be responsible for initiating the changes, and list the initial steps they would take.

Response summaries were drafted following each meeting and sent to participants for additions and modifications. Their changes were incorporated into their respective reports. This overall report summarizes, interprets, and analyzes group discussions and conclusions.

Focus Group Findings

Despite the many issues surrounding implementation of the regulations, the consensus of all focus groups, including industrial representatives, was that storm water control is needed and appropriate. There was general agreement that storm water is a significant contributor to water pollution. Some felt that a regulatory program was appropriate to address the problem. A number of participants expressed that, overall, the storm water program is significantly more rational and easier to deal with than other EPA water programs, for example, the wetlands program.

Yet the storm water regulations still inspire much confusion and frustration. There is frustration with EPA, as well. Many felt there was a lack of consideration given to their inputs by the agency prior to promulgation of the regulations, and some thought that EPA had been unresponsive to questions and concerns voiced since the regulations went into effect. When pressed, however, most admitted that they perceived this to be an endemic or generic problem of government. For a few, this perception will not be changed. However, most were impressed that EPA was now willing to actually look at the storm water program and solicit input from those dealing with the regulations on how they could be improved or streamlined.

Reservation was voiced, however, that EPA would do nothing with the recommendations generated from these focus groups. Their concern was that the results would have as little impact on EPA's decision-making and responsiveness as had previous efforts to make their opinions known.

It is critical, therefore, that EPA identify those procedural changes made in response to the recommendations, and make them known both to focus group participants specifically and to the permitted and regulatory communities in general.

The range of concerns voiced was large, and differed between geographic regions and the representational make-up of the group. Each group raised issues that were quite specific to themselves or their region, e.g., New York City was concerned about the effects of tidal flow and backwater as they relate to water quality; Utah and other arid and semi-arid states were concerned about sampling procedures when there was scarce rainfall; Seattle felt that the regulations did not allow its storm water program to build on earlier work; general contractors do not understand why concrete mixing requires a separate permit even though it is done on the construction site, etc. The specificity of concerns for each group is reflected in the individual summary reports, which are included in Volume II.

Some issues and concerns identified, however, spanned geographic and demographic boundaries. They were raised across groups as key areas in need of clarification and/or modification. There were seven broad areas identified where members felt efforts should be made to improve and streamline the storm water regulations.

1. **Permittees and regulatory agencies feel that the EPA has not been clear about the intended goals of the regulations. A view of the "bigger picture" is wanted.**

   While group members agree that storm water is a contributory factor to water pollution, there does not seem to be an understanding of what EPA hopes to achieve with the regulations promulgated in November 1990. A frequently heard comment was that "the big picture" is missing. Participants felt that EPA has not been clear about how these regulations will accomplish the goal of achieving clean water, and in what timeframe. This has hampered efforts to comply because many do not understand what they should be setting as performance targets.

   One participant said, "What is a clean urban stream?" The point: participants were not sure what goals they need to attain to comply with the regulations and protect themselves from being sued or fined for non-attainment. Almost all participants felt that water quality standards were useful as the ultimate goal toward which to work, but were unachievable in a two- or three-year period. When asked what they felt would be a reasonable timeframe, estimates ranged from five to thirty years, with a few participants indicating that, given the large number of pollutant sources impacting on a given water body, achievement of water quality standards through the storm water program alone is a strong improbability. One participant stated that the scientific community's perspective is, "...there is no way water quality standards can be achieved with known storm water technologies"; it will take further research and development of BMPs before water quality standards could be achieved.

It was clear that members need more guidance about where the program is headed. Participants want EPA to be more explicit about what should be achieved in terms of improvement of water quality in the timeframes that have been given and with the technologies that are presently available.

Group members were aware that environmental advocacy groups will bring pressure on EPA to hold to established numerical water quality standards, and that reducing or replacing them is not likely a viable option. As one representative from an environmental advocacy organization stated regarding water quality standards, "...(they are) the heart of the Clean Water Act." Participants felt, however, that EPA needs to explicitly acknowledge that cleaning up the waters of the U.S. is a long-term effort that requires federal, state and local governments to work in partnership with permittees rather than through "command and control" relationships. Permittees fear being sued for non-compliance when in fact they are making the best efforts possible.

Permittees and regulatory agencies want EPA to provide them the time and support they need to design and implement storm water programs that make sense in terms of effectiveness and cost. They feel that EPA, by not clearly stating goals, has hampered efforts to deal with the problem; permittees are not sure which approaches to take because they don't know what they have to achieve. They want the guidance and information necessary to implement the most appropriate measures available for their discharges, and the time to evaluate those efforts. As one group member observed, "...What is needed is a longer period (than the permit period) to do BMPs - and then monitor their effectiveness. Where necessary, go back and change things. It's an evolutionary process. This is not a quick tech fix! EPA is creating more problems than answers. October 1 should not be 1992, it should be 1995."

If EPA is to achieve success with the program, it needs to address confusion over program goals and timeframes. The agency needs to be explicit about what it expects industrial and municipal permittees to accomplish in the first permit period, what they expect them to achieve in the longer term, and what they anticipate the impact of the storm water program to be on overall water quality.

2. **The cost of program implementation is significantly higher than EPA estimates. There is great concern over what the program's real costs have been in terms of dollars and manpower.**

A great concern of focus group members was the excessive cost of preparing a permit application, and the anticipated costs of achieving compliance. A number of state representatives indicated that implementation of their state program took, in terms of staff time alone, more than all other water programs combined - without the concomitant added federal dollars that those programs provided. That EPA has provided minimum federal dollars for the program is a major issue. Municipalities and industries were concerned with the significant additional costs of manpower and technology needed for both application and compliance. One focus group participant brought for discussion a study done by the School of Public and Environmental Affairs at Indiana University. The study has identified that the actual mean cost for Part 1 of the municipal application process for 59 cities exceeded by six times the EPA-estimated costs of the program [Gebhardt & Lindsey (1992), "NPDES Requirements for Municipal Separate Storm Sewer Systems: Costs and Concerns"].

That EPA has set aside some monies to assist in program development is not commonly known information. There was confusion among a number of focus group members about the availability and applicability of grant monies, e.g. 104(b) funds, that are dedicated to implementation of the program. For example, within the same focus group, one person said that they had applied for and received the funds to help prepare their application; another member replied that they were told that the monies could not be used for that purpose. Members of some groups were unaware that the funds were available at all. This indicates that communication from EPA has been inadequate in letting eligible groups know that there are some, albeit limited, dollars available to help them in setting up their programs, and that there has been inconsistent communication about the guidelines for use of those funds. Further, every person who indicated knowledge of the money also noted that the funds available were minuscule in comparison to what was needed to actually get their programs up and running.

Some states have developed the necessary revenue-gathering mechanisms to fund their storm water program. One state representative indicated that, by charging permit fees, they have been able to hire six staff people for the program. A few other state representatives indicated that storm water utilities had been successful in helping to raise the funds necessary for program operations. A significant number, however, contend that their state does not have the funds to implement the program, nor do they have a system devised to raise these funds. Therefore, wholehearted efforts are not being made to respond to the regulations. Further, some states have implied that they do not consider storm water a priority, and therefore are not willing to devote any portion of their budget to the program. This latter point creates a significant problem for the thousands of permittees in such a state that are then without a critical support system to provide them guidance and technical assistance.

The storm water field in general is perplexed that EPA could promulgate these regulations, without at least providing "seed monies" to assist the application process and help states set up their own revenue-generating systems. To some, the message EPA sent by not providing funds is that the agency itself is not invested in the program. If EPA plans to continue to regulate storm water without providing financial assistance, one way it could assist permittees is to provide guidance and examples of successful fund raising systems that some states have devised, e.g., storm water utilities.

3. **The administration of the program is enormous. Clarification is needed on the roles and expectations EPA has for itself, states and permittees.**

Much of the controversy surrounding the regulations arises from unclear delineation of the roles, responsibilities and authority of each level. What is clear to everyone is that EPA alone does not have the capacity to administer and enforce the program. Therefore, much responsibility must fall on state and municipal levels. However, the regulations do not delineate the responsibilities of each level. Group members were clear that they want EPA to be more decisive and explicit about what is expected of states and municipalities in terms of administration and enforcement, and the areas where they will be allowed authority and flexibility in decision-making.

Some state and local governments have not waited for EPA to define their roles. The regulatory deadlines were powerful motivators for them to move forward without such guidance. Thus, frequently heard was states' hesitancy to discuss with EPA what they were doing programmatically, because they were afraid they might not be doing it "right", i.e. in accord with what EPA wants done. They were concerned about asking EPA for clarity they feared the agency might take away their assumed authority since it had not been specifically assigned in the first place. A number of state representatives admitted that they interpret the regulations in their own way rather than wait for EPA to provide interpretation. As one state representative put it, "...we looked at the regs as guidance rather than rules. We do it our own way. We are not sure if it is appropriate, (so) I have concerns asking for guidance from EPA because they may take away our latitude to make our own judgments."

The vagueness in assignment of responsibility and authority has clearly hampered program implementation. It may have been the intention of EPA to be less specific so that other entities would make their own interpretations, but they clearly do not feel comfortable assuming responsibility or authority. Many have been frustrated by the agency's lack of response when trying to gain clarity of the regulations. For example, one trade association representative stated that, in order to inform his membership about the regulations, he wanted to publish in their trade newsletter an article that outlined their members' responsibilities under them. To ensure that his interpretation was in accord with EPA's, he submitted the article to

EPA for review. In his words, "I waited a month, and when EPA did not respond, I went ahead and printed it. They [EPA] didn't like that."

Some state representatives said that they were unwilling to help industrial people make decisions on whether they are covered by the regulations, because they do not want to be held accountable when EPA has not specifically given states the authority to make interpretations of the SIC codes. Participants felt that the states are more likely than EPA to know the specifics of the industries in their boundaries, and also to know which ones are high-risk pollutant sources. But states do not feel that EPA has given them the authority to use that knowledge to make their own judgments on whether an industry is covered or not.

Industries also feel unsure about their responsibilities under the regulations, and are turning to the states for guidance. The regulations are unclear, for example, about what level of program implementation is expected in a given timeframe. As one state representative put it, "...there needs to be some guidance from EPA to the states on what (industries) need to do!"

States feel they have more knowledge of the industrial risks within their boundaries, and know what is needed to bring those risks into compliance. A number of focus group members cited the uselessness of having EPA develop requirements and guidance for any given industry when it did not understand specific industries. They felt it far more effective for EPA to work with industrial representatives when developing materials to ensure clarity and correctness. This would likely create the added benefit of gaining industry's commitment to achieving certain results.

Given the magnitude of these regulations, the lack of funding available to support implementation, the fiscal constraints under which all levels of government are operating, and the limited staff at each level, working in partnership with states and permittees rather than through a "command and control" relationship could get the program in place more quickly and maximize its effectiveness. EPA needs to determine each government level's responsibilities, be explicit about what decisions and flexibility can be allowed, and be clear about what results are expected from each level of government if given the authority to interpret certain aspects of the regulations.

4. **More supporting information for the program is needed, and dissemination of that information needs to be improved.**

Information supplementary to the regulations, explaining them and providing explicit information on how to implement them, was cited as a critical need that had only partially been met. All focus group members gave feedback on those pieces of EPA-generated information they thought was useful, what they felt was not helpful, and what other information they desired or felt was needed. They also addressed the regulations themselves as a source of information.

a. Written Documents

Written information EPA has provided to supplement the regulations, such as guidance documents and supportive materials, received overall good reviews. Numerous participants stated that both the Industrial and Municipal Permit Application Guidances were helpful.

The primary problem with much of the written guidance and information is that it is coming out too late to be useful. A number of participants indicated that a model general permit would have been helpful, but that they were at the point of writing their own, so for them it was too late. Often group members' suggestions for specific informational documents were accompanied by the caveat that it was needed now, e.g., permit writers guidance; Model Permits for MS4s; a BMP manual; Construction Activity Guidance.

Not everyone wants to receive new information at this point in the program. A number of participants said, "Don't do anything...We have a track; anything that would confuse that would be a problem. Even clarification. We have an idea for what we want to do and if guidance comes out now, it might conflict with what we want to do."

One person commented that EPA should prepare guidance documents so that they can be released concurrently with promulgation of the regulations. This would avoid not having them ready in a useful timeframe. A number of participants felt that EPA should be more willing to release information in draft form if the final document is going to be late. EPA should make preparing information for Phase II of the program a priority; the timeliness of delivery is a reflection of the program's credibility and of EPA's commitment to the program. It is clear that those who have gone forth without the support of written guidance are going to be highly resistant to any input by EPA that would require them to modify what has already been done.

Dissemination of EPA documents has been inconsistent. Regions vary in their thoroughness of distribution. One group member said, "...EPA needs to be better at getting this stuff to us. I often have somebody walk into the office with something that has been out for three months that I have not seen." This frustration was echoed in a number of the focus groups. EPA needs to publish a list of available documents which people can request either in writing or through the Hotline.

b. Verbal Communications

The Storm Water Hotline received mixed reviews from group members. The primary response was that it effectively addressed very basic questions, but that the program had advanced quickly to the point where more technical information was needed. Trust in the ability of those answering the phones to address complex issues was low. However, this is not an unusual response to Hotlines; often callers complain that information given is inadequate, inconsistent, or not appropriate to the situation of the caller.

Some focus group members stated they were pleased with the response they had gotten from the Hotline. Some indicated that they were relieved just to have someone to call for program information. Others felt it was a good way to confirm their "hunches". Overall, given the size of the program and the number of phone calls that have been received, the perception of the Hotline is relatively positive.

Some alternative roles were suggested for the Hotline. Members stated that it could be used as an information clearinghouse, having available a list of sources that callers could turn to for more technical information. One person suggested that operators have lists of experts in categories to whom they could refer callers for more information.

One frustration voiced was that reaching EPA staff people was a problem. This has created for some the perception that EPA headquarters staff are unapproachable. On the practical side, however, responding to all the phone calls they receive would tie up all available staff for the duration of the program; headquarters staff would do nothing but answer phone calls. Yet it is important to recognize that this problem influences people's perception of EPA's commitment to the program. Perhaps with EPA's attention to the more substantive items listed in this report, e.g., getting documentation out in a more timely manner and with more thorough dissemination, etc., this perception will self-correct.

c. Workshops and Presentations

All groups felt that workshops of national scope were no longer needed, because the issues being dealt with were now more technically specific to certain industries or areas. The consensus was that state and local workshops, providing industry-specific guidance and information on water pollution control, were most needed. Most felt that such workshops should be sponsored and planned by trade associations and other membership associations like APWA, WEF, ASIWPCA, etc. rather than EPA. They did feel that EPA should be a speaker at the programs, and be willing to help address the federal perspectives in response to local concerns.

A main concern of group members, from coast to coast, is reaching those industries who are covered by the regulations; many businesses covered under the regulations do not know that they must apply for a permit. Trade associations were recommended as one of the best ways to get to the harder-to-reach permittees (usually referred to as "Mom-and-Pops"), but even they are limited to those businesses who are members. Group members mentioned other avenues through which they have tried to reach these businesses, such as direct mailings to municipalities and working through Chambers of Commerce. None have been completely effective. Most members said that this was not solely EPA's responsibility, but also one of states, local governments and trade associations as well. EPA could support this effort by suggesting methods for reaching these businesses, and contacts at the national level that could be helpful, e.g., Small Business Administration.

d. The Regulations as Information

The Federal Register notice of the regulations was considered by participants to be a key source of information about the program. Numerous comments were made about its inability to convey needed information clearly and concisely. Length, layout, language and accessibility were identified as deterrents for many "laypeople" to comprehend them.

One member said the length was approximately 127 pages too long; he felt it should have been three pages, with a focus on what the regulations will do to reduce water pollution. Many felt that the regulations were not user-friendly because of the language used, which they referred to as "legalese". One person remarked, "What is needed is an English version of the regs!" The citations were claimed to be confusing, and some felt substantive requirements were "buried" in the wrong section, e.g., important permitted industrial activities were in the Definitions section, and municipal requirements were scattered throughout rather than placed in a "Municipals" section. Another noted that the three-column format was difficult to read for most not used to the Federal Register format.

Many noted that the Federal Register is a publication that may be picked up by some large businesses, but would rarely find its way into the smaller ones. Given the widespread impact of the regulations, there is valid concern that EPA views the Federal Register as a primary method to "get the word out." They felt this was not a good assumption, since circulation of the Federal Register is very limited, leaving the vast majority of those industries covered by the regulations unaware that they are affected.

There is need for a more clearly stated version of the storm water regulations. Trade associations have done a great deal to try to reduce the regulations to laymen's terms for their members. But when supplemental guidance documents, which are more reader-friendly than the regulations, are not quickly forthcoming and the regulations provide the only source of information, confusion is inevitable.

5. The regulations lack clarity on a number of key aspects. State authorities need EPA to either clarify these points of the regulations, or they need EPA to allow them the latitude to make the interpretations themselves.

During each focus group, members discussed many particular points of the regulations that they had found unclear. These varied from group to group, depending on the perspectives represented. As one would guess, points that to a municipal person lacked clarity were often different than issues of concern to an industrial representative. For example, industrial representatives spoke of confusion with deadlines as a result of the Surface Transportation Act amendments, how to pick the appropriate permit to apply for, and how industries connected to municipal sewer systems should deal with the regulations. Municipal representatives, on the other hand, mentioned specific sampling and field screening methods, the definition of Maximum Extent Practicable, what to do about application sampling requirements in the face of drought conditions, and how to classify industrial parks as issues that lacked clarity. Further, participants felt there were some aspects where there was room for interpretation. Important to them was knowing where they would have latitude to make interpretations.

Presented here are the areas commonly identified as in need of clarification by EPA.

a. Who is covered under the Industrial SIC codes:

Every group questioned EPA's use of the Standard Industrial Classification codes to determine which industries should be included under the regulations. The consensus was that these codes, which are economic indicators, are inappropriate for regulations that deal with environmental issues. Their use has caused a great deal of confusion as various industries try to apply them to their "primary" activities. Businesses don't know how to use them to determine if they are included under the regulations - and regulatory agencies are very reluctant to make that call for them given the "downside" of either decision. Group members indicated that the Transportation category (#8) and the category of Exposure (#11) were the most problematic and inconsistent.

One state representative said that trying to get businesses past this first decision point had consumed most of the manpower in their office. They were receiving 80-90 phone calls a day just on that question; they had to hire a "temp" to respond to these phone calls and refer callers either to an EPA field office or a consultant. Another group member said that they did one informational mailing to businesses in their county, and were flooded with 7,000 phone calls; they did not know how to respond to callers, so they ended up hiring a consultant to handle the questions.

One comment from a member in the Phoenix group accurately represents the feeling expressed across focus groups: "It is virtually impossible to determine who needs a permit...You are not looking at the runoff quality with the SIC codes. I do not know of an existing code that looks at runoff, and that ought to be the basis of the code (used for these regulations)."

EPA needs to clarify how these codes are to be used. As one member stated, "OMB decided to use the SIC codes for other than they were intended. EPA (therefore) must define how to use it; this needs research and an environmental interpretation done." EPA also needs to be explicit about states' liability if their interpretations of coverage are different from what EPA's would have been. One group member suggested that EPA put together a brief (1-2 page) guidance summary to help industries decide whether they are covered, and also to develop descriptive categories of industries covered. EPA needs to define the minimum criteria for coverage to help regulatory agencies and industries determine their status, and then give latitude to states to use Best Professional Judgment when making decisions to include or exclude a given industry.

b. **Exposure:**

The category of "exposure" was cited by all groups as one of the two most difficult to determine. Members requested that EPA allow regulatory agencies to use Best Professional Judgment in determining which industries should be covered. Examples were mentioned, included the artist doing metal sculptures (all his activities took place indoors), and the farmer trucking potatoes to the potato chip factory (he was advised to cover his load with a tarp). As one member stated, decisions on whether an industry falls under the exposure category need to be determined on a case-by-case basis, and may require a site visit for a final decision to be made. Members did feel this category was "good" because it is the only one that is risk-based, yet "bad" primarily because exposure is "fuzzy".

EPA needs to allow states to develop their own definition and criteria for exposure, reach agreement with them, and be comfortable with the possibility that states may be different. The enormous number of covered industries under the category would otherwise exhaust EPA's resources to deal with it.

c. **The group application process**:

Focus group members feel that the group application process has created significant confusion among permittees; there is no such thing as a group permit, yet there are large numbers of industries that participated in a group application still under the impression that they will be covered by a group permit. As a number of participants stated, "(those who applied for one) think group applications mean group permits. And that is not the case."

One industrial member voiced their frustration: "Industry feels that the group application was misrepresented. (We thought,) this looks good; we can band together, demonstrate our likeness, devise sampling techniques, and regulate accordingly. Then we heard that you don't get a group permit; you get sent to the next tier down - the state. And the state then decides what you get... This has discouraged us from being proactive, forward thinking, because the rules keep changing in mid-stream."

Some members thought the group application was a useful process. One stated, "The group application process will get the best information at the least cost. It is the best research process because you can control it. For example, the textile industry: consultants will get together with them to determine how sampling and BMPs will be done. It provides a source of comparison within industry."

EPA needs to let participating industries know what the process is about, what the next steps will be for them after application review, and where there will be extended timeframes for them to submit a NOI under a general permit or an individual permit application.

6. **EPA needs to consider consolidating programs in order to address water pollution in an efficient and cost-effective manner.**

All groups suggested that EPA look at consolidating the different water programs for greater cost-efficiency and effectiveness. Rather than looking at it by different water source, e.g., storm water, wastewater, wetlands, etc., limited federal resources could be applied on a prioritized basis by watershed. Group members felt that this approach would eliminate redundant efforts across programs, allow dollars to be spent by risk priority rather than through separate program allocation, and have a more profound effect on reducing water pollution.

The perception is that present programs are more interested in "bean counting"; that is, keeping their present funding levels at the expense of the environment. One group member said, "Avoid bean counting...Transfer the funds to where it makes sense. Some water bodies have five different funding streams. (EPA) should look at one water body, and look at point and non-point factors. See if we can pull the program together to yield an environmentally efficient program that brings all this together. This would form a prototype of pollution elimination by integration of programs." Another suggested the development of a "water pollution block grant."

In no group was there a concrete discussion on how EPA would accomplish this at a federal level, although many thought that a start would be to get people from each of the programs to "sit down together in the same room" to discuss ways of working together toward the same goals. State representatives were aware of program separation at their level, and cited the different funding streams - with some programs having far more than others - available for each one. It is clear that most would like to see a strategy in place that allows monies to be allocated based upon watershed priority. This ability to be able to shift funds between programs many felt would have eased the financial burden of getting their storm water programs up and running.

7. **EPA should continue to focus on general permits in order to get the program implemented as efficiently as possible.**

One of the most-mentioned ways of reducing regulatory burden was the use of general permits to cover as many industries as possible. Many state participants voiced frustration at EPA's slowness in getting a model general permit out, and some remarked on their slowness in reviewing state applications for general permit authority. One indicated that it had taken their state nine months for approval. Yet groups were unanimous that general permits are an excellent way to streamline the program.

Participants felt that states should **want** permit authority; as one member put it, "...they should want control over their own destiny." States that have not applied for general permit authority, such as New York, are seen by permit applicants as unhelpful. One voiced frustration that his state DEC office could not provide assistance when he needed it, because the state had chosen to "ignore" the regulations; he has looked to the regional EPA office for assistance, even though he was not sure that was the "right" route for him to go. Another state representative said that her state wants authority because "they could then issue more permits, cover more people. It's revenue-producing, and the dollars would come into (our) department."

Many participants predicted that states without general permit authority will be overwhelmed by the number of individual permits. They felt that EPA, as well as state and national trade associations, should make states aware of the consequences of not having general permit authority. One suggestion often heard was to get trade associations involved in lobbying state legislatures to put pressure on their state government. Some members recommended that EPA also put pressure on states to apply for permit authority by using a carrot-stick approach: assist them to apply, but withhold program monies from non-delegated states. Others suggested that the carrot be dollars, such as the 106 monies, used as an incentive. Participants felt that getting most industries into the program under a general permit umbrella would establish a baseline for the program so that a tiered approach could be used to identify and deal with pollutant sources.

It was evident from comments that some state representatives would like to see a model general permit. They are looking for guidance in developing their own, and models--either EPA-generated or state-generated--would obviously assist states in drafting their own. Critical to this effort is that this assistance be made available as quickly as possible.

There is a common thread across these seven issues. That thread is the need for more and clearer communication, from use of terminology and language more familiar to the "layperson", to explicit guidance on fund raising approaches to support program implementation.

In many organizations, "improved communication" is cited as a sought-after end, but it is often set forth without identification of the means by which to achieve it. With this project, EPA addressed the means by asking the "experts"--those people at the regional, state and local levels who have to ensure that the regulations are implemented--where communication has faltered and what is needed to address the problem. It will be the continued involvement of these people in working on solutions that will ensure successful achievement of the end.

PART II: DESIGNING PHASE II OF THE STORM WATER PROGRAM

The second part of The Rensselaerville Institute project was conducted during April-September 1992. It consisted of three distinct efforts: a survey of point source and nonpoint source program experts to gain their insights on the development of a strategy for Phase II of the storm water program; three public meetings to gain citizen advice on key elements that should be considered for the Phase II program; and facilitation of a "design team" effort with selected experts to generate a detailed strategy to guide EPA in planning and implementing Phase II of the storm water program.

For each effort, the focus was on three elements: **targeting** (which sources shall be included and by what categories); **control** (e.g., should permits be used or another strategy developed); and **timetable** (with what schedule and over what period of time should Phase II be implemented, particularly with regard to the October 1, 1992 deadline established in the Clean Water Act amendment).

This report profiles project activities, then summarizes the findings from each of them. The reader is referred to the supporting documentation in Volume II of this report for the database compiled during this project, including analysis and comments from the Expert Survey.

Expert Survey

Part II of the project began with survey input from a select group of 32 storm water experts from throughout the country. Five perspectives were represented: academic/research; commercial development; consultant engineering/legal; environmental advocacy; and state/local government. A Delphi-type survey approach was used to obtain initial opinion and consensus on relevant issues and options for addressing Phase II sources.

Two survey rounds were conducted with point source program experts. The instruments presented respondents with a series of potential targeting and control strategies along with timing options. Survey participants were asked to identify the strengths and weaknesses as well as steps and resources needed to implement each option and were also given the chance to suggest an alternative strategy to the ones presented.

Five nonpoint program experts received one survey designed to capture more specific information on voluntary approaches for achieving program success. They were asked to provide the same level of detail for their preferred strategy as point source experts. Please see Volume II of this report for survey transcripts and analyses.

Survey Findings

Respondents were asked to identify, from a list of 18 potential sources, which sources they felt to be the top five that "must be" regulated in Phase II. In descending order with frequency of response in parentheses, the sources identified were:

1. "Some industrial activities not covered under Phase I because of anomalies in the SIC codes." (24)

2. "Suburban areas of large metro areas outside city boundaries." (20)

3. "Some commercial activities with industrial components." (18)

4. "Large retail complexes." (15)

5. "State highway systems." (13)

The themes that characterized the designation of these sources as the top five included: 1) contribution to pollution load; 2) risk posed; 3) administrative efficiency of control; and 4) cost-effectiveness of control.

Respondents were presented with specific strategies for targeting and controlling Phase II storm water sources. They were asked to assign a level of desirability and feasibility to each. The scale used ranged from "1" (least desirable, least feasible) to "7" (most desirable, most feasible).

The three targeting strategies, and ratings and comments they received, are listed below.

Responses to Strategy I were spread across the scale; 39% of respondents felt it was "very desirable" and 36% rated it "not desirable". The same response pattern was given to feasibility: 21% rated it highly feasible while 29% rated it not feasible. That strategy was:

Strategy I: "Eliminate Phase II as a separate part of the storm water program and expand the current designation authority under Section 402 (p)(2)(e)."*

> *** 402(p)(2)(e): A discharge for which the Administrator or the State, as the case may be, determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.**

Some of the comments made by experts regarding this strategy included:

- "Gives the Administrator too much authority."
- "This approach provides the greatest flexibility and provides time so that we can learn from current programs."
- "Not feasible...unfortunately, the science is often not good enough to pinpoint culprits; the database...is weak; it is difficult to single out one of many candidate polluters."
- "Allows resources to be focused strictly on problem sources from the Phase II universe."
- "Arbitrary and capricious interpretation of intent of Congress."
- "Very desirable and feasible. It makes sense to target programs to areas that contribute to water quality standard violations and are significant contributors of pollutants."

Responses to Strategy I were the most mixed. While some saw it desirable because sources covered would be more selective and limited and therefore the program would require less resources and administration to implement, others did not support it because they were unsure what criteria would be used for targeting sources, and were concerned about the types of information used in decision-making as well as the experience of those making the decisions.

Most respondents felt that <u>Strategy II</u> would be costly, complex and unwieldy, and resemble Phase I in terms of its drain on resources and manpower. Some respondents felt it would expand the number of groups opposing storm water regulations.

Strategy II: "Cover all remaining point source storm water discharges under existing Phase I requirements."

This strategy received a mean rating for desirability of <u>2.25</u> and a mean rating of feasibility of <u>2.43</u>.

Some of the comments regarding this strategy included:

- "Inadequate resources would pose a major implementation problem."
- "Ill advised and will be increasingly costly. There is no need to promulgate new regulations that we know will not be enforced."
- "Would be an administrative nightmare."
- "Too broad with respect to potential benefits."

<u>Strategy III</u> was seen by a majority of respondents to be the most equitable and rational of the three choices, as well as the most scientifically based. Concern that political pressures might sway the development of targeting criteria was expressed by some respondents. That strategy is:

Strategy III: "Apply Phase II controls selectively (e.g. on the basis of such factors as population density, pollutant loadings, or geographic targeting, or others you find to be appropriate)."

This strategy received a mean rating for desirability of <u>4.64</u> and a mean rating of feasibility of <u>3.75</u>. It was rated the most desirable and feasible of the three suggested strategies.

Some expert comments on this strategy were:

- "Best of all worlds - reasonably objective."
- "Strategy III is the most desirable of the three strategies because it maximizes efficiency, effectiveness, and the flexibility to address water pollution problems based on site-specific factors, especially risk."
- "Sound on a technical basis, but probably requires too many resources, particularly information needed to do intelligent targeting."

- "Desirable - this focuses scarce resources on likely and easily identifiable problem areas. Feasible - the factors (e.g. population density) are easily identifiable."

In the second round of surveys, respondents were asked to recommend a fourth strategy if they did not support one of the three suggested by EPA. Most frequently mentioned was a strategy that was **a combination of Strategies I and III.**

Four control strategies were presented to respondents for similar ratings of desirability and feasibility. These strategies were:

1. **"Mandatory reliance on general permits."**

2. **"Direct regulation under a national Phase II guideline, which may well require a national rulemaking by EPA."**

3. **"Requiring direct regulation of Phase II municipalities under 100,000 and requiring them to develop necessary controls for priority sources discharging into the municipal storm water system."**

4. **"Control under the nonpoint source program authorized under Section 319 of the Clean Water Act."**

Desirability ratings for the first three strategies were approximately the same: respondents felt that they were "somewhat" desirable. The fourth strategy was rated as slightly less desirable. The greatest feasibility was assigned to Strategy 1. The least feasible strategy, in the respondents' opinions, was Strategy 4.

In the second survey round, respondents were asked to describe implementation of their preferred strategy. When asked what minimum control strategies they would use, the following methods were mentioned:

- a menu or roster of BMPs from which could be selected the most appropriate approaches for the industry or watershed;

- public education;

- erosion and sediment control methods;

- "good housekeeping" and source reduction/elimination methods;

- establishment of national minimum standards;

- elimination of illicit connections;

- emphasis on pollution prevention.

Few respondents saw the implementation of Phase II to be a short-term process. Most suggested a phase-in approach over a period of five to ten years. During this time, BMPs could be tested for effectiveness and cost-benefit in terms of reducing and eliminating storm water pollutant problems, and programs could establish solid components of education, training and technical assistance.

Nonpoint Source Perspectives

Nonpoint program experts also favored Strategy III: "Apply Phase II controls selectively..." for targeting Phase II sources, with a mean rating of 4.0 on Desirability. The ratings ranged, however, from "1" (not desirable) to "6" (very desirable). Some of the comments included:

- "Is inequitable. Establishes economic hardships for those required to participate. Only strength is less administrative burden."
- "Would be easy to identify sources that fall under criteria. Could be preventive since you are not waiting for a problem to happen."
- "Excellent in theory, but would require a lot of data for prioritization, and would create confusion for some period of time."

The survey instrument used for nonpoint program experts was a modified version of the point source expert survey that included a fourth EPA-suggestedtargeting strategy for consideration. It was:

Strategy IV: "Target and address problems and significant storm water sources and pollutant loadings by using Section 319 and CZARA programs."

Respondents' mean ratings of the strategy were 3.2 for desirability and 2.8 for feasibility. Comments included:

- "These programs lack real regulatory teeth. CZARA 6217 applies only to coastal regions. They just aren't aggressive enough."
- "Section 319 is broader than NPDES and has more technical experience with BMPs. CZARA 6217 results in specification by EPA of management measures, in effect setting standards and providing impetus to explore alternatives."
- "Since only limited 319 funds are available, it would be difficult to get much done."

- "This is an important piece of a multifaceted approach, but not adequate alone."

Respondents were given the same control strategies for consideration as the point source program experts. Of the four, #3: "Requiring direct regulation of Phase II municipalities under 100,000..." was most favored, with a mean rating of 5.2 for desirability and 3.8 for feasibility. This control strategy was the only one to receive ratings higher than "5" for either desirability or feasibility.

The majority of respondents were opposed to extending the October 1, 1992 deadline. The reasons given included:

- "The longer we wait to address the problem, the more costly, less technically capable and less environmentally effective the solution will be. There are more opportunities today, especially in less populated areas, than tomorrow to solve and prevent problems."

- "Storm water-related use impairment is a serious problem. Currently, there is little being done to remediate existing problems and no assurance that problems related to new development will be prevented. It is clear that the voluntary approach is not adequate."

- "Things aren't getting better. Forum and impetus are already in place - capitalize on it."

Many of the recommendations made by point source program experts for targeting and controlling storm water sources were echoed by nonpoint survey respondents. Some of the targeting similarities include:

- selection of Strategy III: "Apply Phase II controls selectively..." as the most desirable of EPA-suggested strategies. The most mentioned reasons for preference were ease of identifying targeted sources, and the more efficient use of resources;

- target by watershed impairment/threat severity;

- conduct pilot projects first, evaluate, and then develop and implement a strategy;

- develop minimum national guidelines, and leave selection of sites and methods to state discretion;

- initiate a focused dialogue with key stakeholders (for both targeting and controls).

Some of the similarities in preferred control strategies included:

- build a BMP menu that can be used to implement and verify progress; allow selection of most appropriate BMPs based on industry and watershed;

- provide public education on need for storm water control;

- provide national criteria with flexibility for local implementation of most appropriate controls;

- develop baseline control standards for all new development.

One primary difference between point and nonpoint respondents was the application of the "stick" by EPA, with the "stick" being the requirement of permits for those sources that did not achieve significant movement toward program goals via voluntary efforts within a reasonable timeframe. As one nonpoint respondent phrased it, EPA should keep permit requirements as the "gorilla in the closet" to be used as needed when voluntary efforts were not adequate for the problem.

A number of nonpoint respondents indicated that the 319 and CZARA 6217 programs do not have the "teeth" they need to ensure compliance. Most feel that a combination of programs is needed for successful achievement of water quality goals.

EPA STORM WATER PUBLIC MEETINGS

Description of the Meeting Format:

Three public meetings were conducted to gain citizen suggestions on options for targeting and controlling Phase II sources. These meetings were held in Denver, CO; San Francisco, CA; and Washington, DC. Approximately 200 people attended the three meetings.

At each meeting, three experts selected from the survey process presented their ideas on a regulating strategy for the moratorium sources. Following their presentations, attendees were divided into small task teams with an assigned facilitator, and given the charge of devising their own strategies for targeting and controlling Phase II sources. The strategy template provided to guide group consideration of key issues is presented below. During the latter half of the meeting, each task team presented their option to the other attendees for discussion.

Teams were asked to consider these issues:

1. Targeting (What light industrial, commercial, retail, residential, or other areas or other areas do you include in Phase II?)

2. Control (Do you use continued reliance on the existing NPDES permitting process or something else such as nonpoint source programs, selected permitting based on risk, geographic targeting, etc.?)

3. Timetable (How would you phase in the major components of the strategy and over what timeframe? Do you suggest full implementation on October 1, 1992 [as stated in CWA] or do you recommend a different set of deadlines and why?)

4. Key steps to implement (Please indicate up to five critical, major steps to take in implementing your strategy and the timetable for each.)

5. How will costs of your strategy be distributed over key players and how will costs be understood and controlled?

6. What measures of performance will you use and how will you verify the environmental results? (Do you rely on numerical measures and quantitative pollution indices or other factors?)

7. Strategy Strengths (Name four key strengths of your strategy which, in your judgement, make it preferable over alternative strategies.)

8. Strategy Vulnerabilities (Name four most critical points at which your strategy is most vulnerable to failure or shortfall in implementation.)

9. For whatever strategy is chosen, what could EPA do to make the decision-making process for Phase II more responsive?

Meeting Findings:

A total of sixteen task teams presented their strategies for Phase II of the storm water program. The individual task team strategy outlines offered a diversity of approaches for designing, implementing, monitoring, and funding Phase II of the storm water program. Individual strategies presented a large range of methods for targeting and controlling sources, and many different timeframes over which the program could be phased in.

Despite the different representations, experiences and expertise, there were points of congruence between many of the proposed strategies. Common strategy characteristics across task teams included the following:

1. **Targeting:**

a. Targeting should be done by watershed. Information gathered from Phase I should help identify sensitive watersheds. May require intergovernmental agreements.

b. The focus should be on "bad actors", i.e. those that are known problem sources. The ones most frequently identified were: gas/auto service industries, transportation, highway systems, land development and agricultural sources. There needs to be the ability for facilities not contributing impairment of water to gain an exemption from permits, fees, implementation of BMPs. Categories are an ineffective way to designate covered sources. Selection should be done by the degree of risk a given facility poses rather than categorical inclusion.

c. Small municipalities should have a much simpler application process, or have the opportunity to be excluded if they do not contribute to the pollution problem. In addition to impact on a watershed, proximity to larger municipalities should be considered as well.

d. EPA should defer on selecting targeted sources until the agency has carefully looked at the data gathered during Phase I. Numerous sources of information are available which would help determine targeting priorities, e.g. information gathered through 305b reports, information from Phase I program sources, NURP.

2. **Controls:**

a. If a permitting process is to be continued for point sources, NPDES general permits should be used, and focus should be on BMPs. Permits should be simpler, and much less costly. EPA should make clearer to the applicant what information is required, e.g. checklist of inclusions, menu of BMPs. Exemptions should be available for non-contributors.

b. Education should be a primary form of control. It is important at all levels and for all audiences, yet is often overlooked or underrated.

c. There should be more emphasis on voluntary programs, e.g. the "319" nonpoint source program. For facilities with contact with storm water, there should be little or no more government intervention, but rather emphasis on pollution prevention incentives, BMPs, and practical measures of pollution prevention.

Pollution prevention programs should be emphasized, particularly with new development. Some suggested prevention methods include: recycling storm water, good housekeeping practices, plantings to minimize runoff, street sweeping of work areas on a daily basis, storm water collection methods, coverage of storage areas, changing manufacturing processes to minimize pollutants, improvement of air emissions.

d. BMPs should be required based upon the specific pollutant problem and strategies known to be effective in its mitigation or elimination. The focus must be a known connection between solution and its effect on the problem. BMPs must also recognize financial constraints, providing actions that are relatively higher in terms of cost-effectiveness.

3. **Timetable:**

a. A minimum of two years is needed to prepare for Phase II, with at least a year dedicated to looking at data gained from Phase I of the storm water program. Effectiveness of presently used BMPs needs to be looked at to determine differences in effectiveness between geographic locations and pollutants.

b. Whatever the period established for phase-in, it should not begin until promulgation of the regulations.

4. **Role of EPA Headquarters.**

a. Research, information dissemination, technical assistance.
EPA should also provide focus within these areas. Also, the current efforts are too diffuse, and imply a complexity that makes applications seem difficult and formidable.

b. Funding, not for program implementation, but for research.
Two areas of research requested are water basin pollution control and determination of effectiveness of BMPs. The majority of participants recognize that EPA does not have the fiscal resources to fund programs. What they do want from EPA is guidance in establishing fund raising mechanisms, such as storm water utilities.

c. Establishing broad guidelines for the program within which local flexibility is allowed and encouraged.
Flexibility, at the same time, does not provide an excuse for inaction or postponement. Rather, it recognizes that different actions and action sequences are appropriate to different contexts and conditions.

d. Responsibility for training regulators in the storm water program.

Until those administering the program are well equipped to enable action, effective responses will be difficult.

Please see Volume II of this report for copies of the individual strategies developed at each of the public meetings.

Reflections on Meeting Format

A presumption shared by EPA and the contractor, The Rensselaerville Institute, was that the conventional format for public hearings and meetings is of limited value in engaging citizens or of making the critical transition from criticism to advice on how best to do things. Given this belief, a different format was devised that proved quite different from the typical approach of lectures by experts and/or testimonies read to the record by concerned citizens.

In the interactive approach used, participants were advised that they would be asked to form into task teams to first listen to experts offer their insights, then to develop, as a team, a preferred strategy for responding to Phase II of the storm water program. Each team comprised a cross-section of those attending--including where there are possible strong environmental, industrial, and local government perspectives.

In all three meetings, participants accepted the format and energetically engaged in the task of constructing a preferred solution. This included the session held in Washington, D.C. where participants from major interest groups were in the habit of providing critical feedback and criticism more than engaging in a positive design process.

To gauge participant responses to the different public meeting format, a mail-back questionnaire was used inviting comments by the some two hundred participants in the three public meetings. Approximately 35% of those attending completed the survey. They were first asked to comment on their assessment of the more traditional public hearing format. Most held a clear and consistent view of the traditional approach as focusing primarily on prepared statements. Where dialogue was included, it was seen as argumentative and contentious. The general conclusions:

- opinions are solicited for the record and to insure the perception of public participation but not to provide genuine input. The sense is not of active government listening.

- primary participants are those with strong convictions and often special interests; they are not a representative sampling of public opinion and tend to run the gamut of extreme perspectives on a given issue.

- sessions tend to become adversarial or at best argumentative. No mechanism for cooperation is available and differences tend to get magnified, not resolved.

- the focus is on the problem much more than on ideas for resolving it. On the one hand this attracts critics more than implementors. On the other, it provides little guidance to people who full well know the problem and are looking for ways to deal with it.

Participants were much more positive about the format used. Among the sentiments voiced:

1. Participants had a full chance to participate--not only to be heard but to be directly engaged in finding solutions.

   "It was a valuable way to address the drafting of regulations--allowing the regulated community to feel part of the process";

   "Encouraged the regulated community to get involved and feel involved";

   "Participants felt that EPA was actually listening and dialoguing."

2. The process was genuinely two-way, allowing both EPA staff and those effected to better understand each other.

   "It made you appreciate the USEPA's tough job of satisfying the concerns of many people while protecting the environment";

   "Felt it draws out better data";

   "Actually got to interact one on one with industry and government and consultant representatives. Obtained a better point of view of government's problems and felt that government representatives also obtained a better point of view of industry's problems."

3. The format created an atmosphere for cooperation and even for collaboration among people with very different viewpoints.

   "The meeting went a long way towards promoting the creative thinking, open discussion, and presentation of ideas";

   "Group discussion is a fine vehicle to provide input as well as learning tool. It forces you to think through participation, rather than just simply sitting and trying to absorb by osmosis.";

"Small diverse groups allowed ideas to be evaluated fairly and fostered "brainstorming" and allowed ideas to be developed to better fit broad based objectives."

The positive elements of the meeting extended beyond the effective communication of opinion and position to EPA to broader understandings of issues, complexities, and solutions. Indeed, the sessions seemed as influential in creating new insights as in communicating old ones.

Respondents suggested two primary ways to improve the format for future uses. The first is the need for more detailed advance preparation--in part, needed to change the mind-set and expectations which people tend to have for a traditional public hearing or meeting. The second suggestion: minimize expert presentations, even when used in the "pump-priming" mode employed in this session. Trust the process and get right to the participants.

When asked if they would advise the EPA to use this kind of interactive task-focussed approach with other meetings designed to get public input, over 90% said "Yes." Two persons indicated that it depends on the issue and only two indicated that they preferred to remain more passive.

THE "DESIGN TEAM" MEETING

Meeting Description:

A meeting of seven point and non-point storm water program experts, all of whom were survey respondents, and selected EPA staff was convened in Washington, D.C. on September 17-18, 1992. The purpose was to gain the experts' insights on development of Phase II storm water regulations, and the intended outcome was to build a strategy, or multiple strategies, for regulating Phase II sources.

Participants included:

Mr. Gail Boyd
Woodward-Clyde Consultants, Portland, Oregon

Ms. Diane Cameron
Natural Resources Defense Council, Washington, D.C.

Mr. Dennis Dreher
Northeastern Illinois Planning Commission

Mr. Tom Mumley
San Francisco Bay Regional Water Quality Control Board

Mr. Earl Shaver
State of Delaware Department of Natural Resources and Environmental Control

Ms. Coleen Sullins
State of North Carolina Division of Environmental Management

The participants selected were deemed, by their peers nationwide and EPA, insightful and highly articulate exponents of all major viewpoints on the storm water program.

Also in attendance were these key people from U.S. EPA:

Mr. Michael Cook, Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Geoffrey Grubbs, Director
Assessment and Watershed Protection Div.
U.S. EPA, Office of Wetlands, Oceans and Watersheds

Mr. James Horne, Special Assistant to the Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Ephraim King, Chief
NPDES Program Branch, Permits Div.
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Jack Lehman, Deputy Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Session Findings:

1. Development of a ten-point outline describing a potential strategy for Phase II of the storm water program.

Consistent with the overall purpose of the meeting, participants identified ten core elements that they feel constitute a potential strategy for Phase II of the storm water program. These elements are:

A. Objective: To get certain BMPs, ordinances and education programs into place over a 10-15 year period. Progress would be measured by getting these elements into place, with direction toward water quality standards and beneficial uses over a longer period of time. EPA would work with all states to help them develop Phase II programs.

B. Priorities: EPA would set these. They would include: the sources listed by the group, using a watershed approach where feasible, focusing first on those local governments with the size and capability to get going.

C. Education/outreach/technical assistance: these are all critical components of a successful program.

E. Mandatory Interim Milestones: EPA needs to determine interim milestones state programs need to meet which would show they are on track.

F. Financial Plan: states/local governments need to develop plans for financing the program.

G. Guidance: guidance is needed on BMPs and local ordinances. These would be generated at the federal level, and states could adapt/modify as needed.

H. "Default" system: local governments would take the lead with their programs, but there would be a built-in default system where the states or EPA would take over with more stringent controls if the locals fail to meet requirements.

I. Permit issuance: for high priority categories, could issue permits that allow flexibility or some alternative mechanism at state's option. Permits might be just for high priority categories; would include site design performance standards.

J. Phasing: there would be a schedule for issuing permits to key municipalities: high priority to low (e.g. coordinate by watershed); high flexibility to "getting tough" with recalcitrant localities. These would be based on inspections, on-site reviews.

K. Monitoring: this would be the difficult part of the program because of cost. Need is to be able to design something useful. The system might be "tiered" - highest to lowest priority; or "strategic" - focused only on gathering what we really need to know.

2. Sources to be targeted in Phase II.

The participants identified a number of specific unregulated pollutant sources that need to be targeted in Phase II of the storm water program. An approach recommended by some of the participants for controlling these sources is a "whole basin approach", which would focus attention and resources on activities impacting the water quality of a given watershed.

The group identified approximately 40 pollutant sources that they believe need to be included in Phase II of the storm water program. The sources identified include the following:

New Development/Redevelopment (commercial and residential)
Transportation Corridors
Dense Existing Development (commercial and residential)
Automotive Services
Federal facilities/military facilities
Feedlots (including dairy)
Failing septic systems
All incorporated places with less than 100,000
Non-urbanized watersheds yet to be determined
Parts of watersheds where land use is in a state of flux
Dry cleaning shops
Parking lots
Some forest operations
Nurseries/orchards
Recreational areas (e.g., stadiums, golf courses)
Landfills
Office parks
Grain elevators
Concrete cutting sites
Commercial pesticides
Landscaping industry
Car washes
Mobile washing units
Equipment maintenance
Boat yards
Tank farms
Shopping malls
Restaurants
Airports
Janitorial services
On-site solid waste (collection, hauling, transfer stations)
Atmospheric deposition
Cemeteries
Commercial strips
Wood stoves
Marine ports
Animal waste
Warehouses/storage facilities
Exterior building maintenance
Bridge maintenance

Members of the group suggested that rather than use the Phase I approach of including sources by category into the regulations, regulatory staff time and resources should be allocated on a water basin approach, i.e., target a watershed, identify impacting activities and their location within the watershed, and determine a set of criteria to deal with the problems impairing the watershed. This would allow limited resources to have maximum impact.

3. Source priorities.

After listing the range of sources that they felt should be included in the Phase II program, participants voted for what they considered to be the top priority sources, i.e. those sources that EPA should address immediately and diligently. The top sources selected are listed below, in order of decreasing number of votes received. All sources were selected by at least 50% of the participants. The sources identified as top priority for addressing in this order:

A. New Development/Redevelopment (commercial and residential)

B. Transportation Corridors

C. Dense Existing Development (commercial and residential)

D. Automotive Services

E. Federal facilities/military facilities

F. Feedlots (including dairy)

G. Failing septic systems

4. Lessons from a case study.

One participant presented an outline of the basic components of the Puget Sound Water Quality Management program. The program is a multifaceted approach toward the achievement of improved water quality which heavily emphasizes voluntary measures in its implementation strategy.

The program includes minimum BMP standards for all jurisdictions with additional water quality treatment BMPs, guidance and requirements for higher risk storm water dischargers. Key facets include: vigorous technical assistance, education, state financial support, education and support for storm water utility development, highway runoff regulations, a full nonpoint watershed management program, storm water operation and maintenance requirements, source controls, and local control and flexibility.

The program is being phased in over several years. It is a combination of mandatory requirements, technical guidance and voluntary compliance. There are specialized focus areas, such as shellfish protection districts and conservation districts. There is a coordination effort with individual and general permittees in the Puget Sound area.

The program views its strengths to be greater local flexibility and acceptance of requirements, a strong sense of teamwork between all levels, better water quality results, and better targeting and use of limited resources than if they were regulated by NPDES. They view the NPDES program as the "gorilla in the closet" that can be brought to bear if and when a source does not meet minimum standards and requirements.

5. Principles for Phase II.

Participants discussed the basic principles they believed should drive the Phase II program at the national level. For the program to be successful, it would require that the following pieces be put into place:

A. Require that people gather documentation of information regarding dischargers' activities and accomplishments and provide outsiders with that documentation;

B. Formally define gaps where additional information and understanding is needed. There needs to be an incentive to close these gaps;

C. Support (with encouragement and incentives) efforts that will close these gaps, and advance the state of the art and/or provide a technically sound basis for the programs' requirements;

D. Actively encourage a broad spectrum of understanding and involvement (the general public, community leaders, service groups, environmental groups) via educational programs and materials;

E. Strategically identify "good" guys and "bad" guys in the regulated community;

F. Provide clear guidance regarding programmatic and physical actions that are required/expected. Actively seek out evidence that people know <u>what</u> to do, and provide technical training to be sure that people know <u>how to do</u> what is required (technical transfer);

G. Require relevant/credible/useful monitoring only. Don't waste people's time/money/energy running data collection programs that yield bad or irrelevant data.

6. State suggestions of what EPA needs to consider in developing the Phase II program.

A sub-group of participants from state regulatory agencies met, and set forth a list of suggestions for EPA to consider in developing Phase II. The following recommendations were made:

A. EPA needs to provide states with the minimum program requirements they must achieve, and then allow states flexibility on how they will do it. The components must include:

- requirements/BMP standards for new development
- education/technical assistance
- control requirements for illicit connections/dumping
- developing state-specific priorities

B. EPA should require states to adopt regulations that specify program components that must be included;

C. To assure program funding, EPA needs to require that state and local governments set up funding mechanisms, e.g. storm water utilities, permit fees, etc.;

D. EPA needs to compile and disseminate technical information that would support programs, e.g. set up a national or regional clearinghouse of information on storm water plans being implemented, BMP-specific information and materials, etc.;

E. EPA needs to compile a national BMP manual that would assist members of the regulated community in determining and implementing appropriate BMPs to address their storm water problems. EPA needs to recognize, however, that BMP application will differ between regions, e.g. climatic differences will require different approaches;

F. EPA needs to require that states develop and implement education, technical assistance, and training programs; EPA also needs to hold the states responsible for effectiveness of these programs, and require permitting in the event that these measures do not work;

G. EPA needs to maintain the right to require permits in a reasonable amount of time (e.g. 2-3 years) if a state's program is not meeting federally determined requirements;

H. EPA needs to determine what short and long term goals they wish the storm water program to achieve.

7. Identification of problem areas and needs of the regulated community in dealing with the storm water program.

Participants were asked to identify what their "hot buttons" were, i.e. elements or considerations that EPA might include in the Phase II program which would cause major problems for them, or those which if not considered by EPA would create needs for the regulated community.

The list of "hot buttons" include the following:

A. Penalizing those who have already solved their problems by requiring permits.

B. Liability for water quality standards, sediment standards, and resource damage clean-up in the first round.

C. Failure to provide technical transfer - permittees need to know what to do and how to do it.

D. Failure to promulgate revised and simplified NPDES regulations that get around the complicated approval process.

E. Possible backlash from local governments if they are held responsible for instances of independent commercial activity that they cannot address or control when they don't know about it.

F. Lack of research on BMP effectiveness from a watershed perspective. There is inadequate federal/state money to look at BMPs because monitoring is so expensive.

G. Possibility of EPA not basing the program on permits (except in cases where the state can show that it can reach goals alternatively).

H. The inherent substantial risk of tremendous backlash that would affect people's livelihoods, i.e. failure to try to sell the program to regulators and public, including the NPDES permit process.

I. Prevention v. wetlands - determining how to prevent storm water problems while protecting wetlands.

J. Not addressing the roadblocks created by the regulations themselves. The system is so complicated, it now takes two generations for permits to get to goals.

K. Lack of federal monetary assistance. Some states may be reluctant to develop adequate programs without it.

L. Not getting rid of the acronyms in the regulatory language. No one understands what EPA is saying.

M. Concern that mainstream design is end-of-pipe treatment. This is not prevention! CZARA is on a better track.

N. Allowing states to cut monitoring activities first. They need to be encouraged to not eliminate that element disproportionately from their budget.

O. Need to figure out how to sell the program - to get through to OMB and top levels of state governments exactly what it is going to take to get the program into place.

P. Not identifying funding incentives and disincentives.

Q. Not giving praise for progress.

Additional Advice

Additional suggestions for development of the Phase II program were generated by the group during the two-day meeting. Included in those recommendations are the following:

1. **EPA needs to revisit and revise the terminology used in the regulations.**

    - the problems are often with the common words, e.g. runoff, storm water, nonpoint source, point source. EPA staff have attached certain meanings to words that are not conveyed to the regulated community, so there is inherent danger that people are not talking about the same thing. Words need to have clear and referenced meanings.

    - the enormous number of acronyms used by EPA creates significant comprehension problems for regulatees. The regulations need to be written with fewer acronyms, and all communications need to be sensitive to the level of use.

2. **EPA needs to clearly define the goals of the program.**

- all levels of feedback (focus group, survey, and meeting results) generated during The Rensselaerville Institute project have pointed out that the regulated community does not understand what EPA is trying to achieve with the storm water program. Assumption of what the goal is ranges from achievement of set water quality numerical limits to returning a water body to its original uses.

Confusion over the goals causes confusion for regulatees in terms of selecting the tools that need to be used to reach them. EPA needs to determine what the federal purpose is with regard to the storm water regulations given the reality of limitations of presently available methods and resources for preventing and treating storm water pollution.

3. **Citizen involvement can play an important role in achieving program goals. EPA, states and local governments need to promote citizen education and enforcement authority.**

Participants gave numerous examples of how citizens could play an active role in implementing and monitoring pollution reduction efforts. Given the limited resources of federal, state and local governments, voluntary citizen involvement can support successful program outcomes, including enforcement. Education of citizens at different levels, e.g. qualitative vs. quantitative monitoring, stream health vs. compliance monitoring, etc. would be needed. Guidance manuals can be developed to guide public education.

General Recommendations

The ten summary recommendations stated at the conclusion of the Executive Summary are here amplified to reflect the discussions and insights generated in this project. While not all persons involved agree with each observation and recommendation, these are advanced as having widespread support.

1. **It is possible and desirable to identify priority target areas for which there is widespread consensus concerning their contribution to water pollution.**

   These areas begin with new development and redevelopment--both residential and commercial. They also include transportation corridors, dense existing development and automotive services. Further, the priority of these target sources is relative to the watershed upon which they are impacting.

   Strategically, approaches that focus on a small number of priorities based on relative risk will show stronger results than one that initially targets a broad set of sources in Phase II. Also, it much more cost-effective to identify and pursue the "bad actors" (eg, those contributing toxicity as opposed to sediments or turbidity) as a priority, then get to those adding incremental pollution through routine activity.

2. **EPA needs to communicate more clearly and regularly with everyone impacted by the storm water regulations.**

The priority focus should be less on the amount of communication and more on different kinds of communication. Specifically, communications should be:

- more interactive--the examples of the focus groups and public meetings used in this project are often cited as productive formats for future citizen input;

- more localized to contexts--as in more regional workshops and fewer national ones. This means communications less inclined to reflect the national complexity of the program and more inclined toward addressing the specific information and guidance needs of the local person involved in a specific and delimited way. It also means less "canned" content and more consultative dialogue;

- less laden with acronyms and technical language that confuse and irritate many of the people who are the true "customers" of the program, and who are required to carry out the federal mandate. Along with this, more attention should be paid to finding and marketing simplicities rather than complexities.

3. **EPA could improve program effectiveness, efficiency and cost control in Phase II by "starting small".**

The concept of regional and even local prototypes was advanced by many people as a way of getting proposed new Phase II frameworks into the hands of users in prompt fashion to build and refine based on early use. This was generally seen as preferable to the comprehensive approach in which new programs are developed fully and then introduced comprehensively at a point when modification is difficult and expensive.

Related to prototypes is the case study--in which an analytical eye is turned to current programs that demonstrate one or more strategies or best practices for storm water implementation. An example is the Puget Sound model, with its focus on the tangible and cost-saving values of voluntary compliance by small businesses (a summary of this approach is contained in Volume 2).

The use of a small scale plays to the strength of regional differences as well as the reality that an equal stress on comprehensive large programs may so paralyze states and localities that nothing is done expeditiously.

4. **Selectivity in data collection and monitoring is essential.**

At present, some data collection frameworks consume tremendous time and money only to yield bad or useless data or murky or disputed conclusions. More attention should be paid as to what constitutes "good science" and activities that may show the appearance of effective activity but in reality be consuming scarce resources to no clear gain. This also relates to the adage, "what you measure is what you will get." While the tendency is to see monitoring and assessment as questions of methodology, they must first be viewed as questions of substance. What are we trying to measure and at what level of detail and accuracy?

Not all measuring and assessment need be arcane. In development projects, for example, the use of hay bales is known to contain overflows. No great study of cause or effect is needed. And if there is floating oil on a body of water, we can start by verifying that it is there--a useful step even if we do not "measure" its amount. At the same time, other kinds of assessment are meaningless without extensive (and expensive) levels of detail and analysis.

A related point is that documentation of discharger activity and accomplishment is as critical as scientific study of water conditions.

5. **More customer differentiation is also needed.**

At present the mind-set appears to be that one size fits all. While giving the appearance of equity, this concept actually creates strong inequalities. The same programs and regulations that befit a large corporation or municipality are simply not equitable for smaller enterprise and communities, for example. More broadly, some specific operations within a given source category contribute significant pollution; others contribute none. Some way to either make the initial process much less costly or to more quickly separate out those who do not need continuing attention must be found.

One form of general differentiation is between those who are causing a problem by clearly inappropriate activity (the "bad actors") and those contributing to storm water pollution by standard and at times inadvertent practice.

6. **While the ultimate goal is water quality standards, this is very difficult to achieve and/or to measure in the short term.**

While retaining water quality standards as the ultimate goal, EPA should be focusing on best management practices, and in particular those that reflect preventive and non-structural solutions. An example is stronger standards and technologies for storm water control in new residential and commercial construction. In many instances, the correlation is clear between the management practice and the consequences for cleaner water.

The codification and communication of best management practices applies not only to those targeted and controlled but to state and local actors implementing storm water programs. For example, a set of "carrots and sticks" known to promote voluntary compliance is just as critical to disseminate as a new approach to storm retention ponds in a sub-division.

While BMPs are set in place, interim milestones for water quality are also critical--and feasible--as a way of measuring progress. The transition from progress by practice to achievement by water quality measure must begin now.

7. **The most functional unit of both analysis and intervention is the watershed.** Most people in our samples for opinion and recommendation strongly suggested the watershed approach--not only on the macro level (e.g., Chesapeake Bay) but the micro-level as well. In particular, this means looking at stream quality issues beginning at the headwaters for early contributions and alterations. Most felt that functional differentiation of pollutant sources is not really meaningful in terms of either regulation or effective change at the watershed level.

8. **EPA's role is to offer technical support and direction more than program funding or even full guidelines for state and local implementation.** In particular, building useful data bases and collection methodologies not only on water quality but on practices to achieve it is critical. Also key are training and support programs and development of effective dissemination networks. In all EPA roles, the need is to recognize both regional differences and the need for a multi-faceted set of strategies, tools, approaches, solutions.

   Another EPA function is to focus on the connection between best management practices and long term consequences for water quality. While those who introduce them are in the best position to refine BMP's, they often do not have the tools to verify a correlation (let alone a causal connection) to water quality. This is an important EPA function.

9. **A collaborative approach to developing effective solutions is possible.** The interactive elements of this project are one reflection of the ability of those with strikingly different perspectives (ranging from strong environmental protection to a focus on economic development) to work cooperatively. If adversarial and polemical dynamics can be set aside, the gains are far greater.

   Collaboration must begin within EPA itself, where there is a tendency for those focussing on permits and "harder" tools of compliance and those focussing on education and "softer" elements of prevention to not fully connect with each other. In reality, there is a strong common theme from the need to see the storm water program as a way of enabling local communities and industries to change their behaviors to help the environment in ways that will directly benefit them as well as all other citizens.

1[illegible]. **Agriculture activities should be included more directly in the storm water program.**

In many regions, agriculture (which includes livestock as well as crops) is a primary contributor to surface water pollution. While the present NPDES program requires permitting of the <u>transport</u> of agricultural products, this brings intervention too late. The critical first steps of agricultural activities, e.g. soil preparation, growing, and harvesting, must be included.

Beyond this reality is the signal sent that for whatever set of reasons, some interests are exempt from a program in which they clearly belong.

Agency

EPA

Guidance Manual For The Preparation Of Part 2 Of The NPDES Permit Applications For Discharges From Municipal Separate Storm Sewer Systems

PB93-229821

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOAR
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FOREWORD

This manual provides detailed guidance on the development of Part 2 permit applications for municipal separate storm sewer systems. It provides technical assistance and support for all municipal separate storm sewer systems subject to regulatory requirements under the National Pollutant Discharge Elimination System (NPDES) program for storm water point source discharges. This manual also emphasizes the application of pollution prevention measures and implementation of Best Management Practices (BMPs) to reduce pollutant loadings and improve water quality.

The control of pollution from urban and industrial storm water discharges is critical in maintaining and improving the quality of the Nation's waters. Pollutants in storm water discharges from many sources are largely uncontrolled. The *National Water Quality Inventory, 1990 Report to Congress*, provides a general assessment of water quality based on biennial reports submitted by the States under Section 305(b) of the Clean Water Act (CWA). The report indicates that roughly one third of the impairment in assessed waters is due to storm water runoff.

This document was issued in support of Environmental Protection Agency (EPA) regulations and policy initiatives involving the development and implementation of a national storm water program. This document is Agency guidance only. It does not establish or affect legal rights or obligations. Agency decisions in any particular case will be made applying the laws and regulations on the basis of specific facts when permits are issued or regulations promulgated.

This document will be revised and expanded periodically to reflect additional guidance. Comments from users are welcomed. Send comments to U.S. EPA, Office of Wastewater Enforcement and Compliance, 401 M Street, SW, Mail Code EN-336, Washington, D.C. 20460.

Michael B. Cook,
Director
Office of Wastewater Enforcement
and Compliance

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INTRODUCTION

1.0 INTRODUCTION

1.1 OVERVIEW

Control of pollution from urban and industrial storm water discharges is an important factor in maintaining and improving the quality of the Nation's waters. To help improve the quality of storm water discharges, Congress passed the Water Quality Act (WQA) in 1987. The WQA added to the Clean Water Act (CWA) a provision [Section 402(p)] that directed the U.S. Environmental Protection Agency (EPA) to establish final regulations governing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program.

In response, EPA published regulations in the November 16, 1990, Federal Register (55 FR 47990) that established NPDES permit application requirements for storm water point source discharges. As part of these regulations, municipal separate storm sewer systems (MS4s) that serve populations greater than 250,000 ("large MS4s"), MS4s that serve populations between 100,000 and 250,000 ("medium MS4s"), and other MS4s identified by the permitting authority must be covered by NPDES permits. The regulations establish a two-part application process for these MS4s. In April 1991, EPA issued guidance on the preparation of Part 1 of the NPDES permit application for discharges from MS4s (EPA, 1991b). The present manual provides guidance on the preparation of Part 2 applications. The information in this manual should help municipalities focus their efforts on activities that meet the application requirements.

1.2 SUMMARY OF THE CLEAN WATER ACT REQUIREMENTS

Section 402 of the CWA prohibits the discharge of any pollutant to waters of the United States from a point source, unless that discharge is authorized by a NPDES permit. Efforts to improve water quality under the NPDES program have traditionally focused on reducing pollutants in discharges of industrial process wastewater and municipal sewage. As pollution control measures have been implemented for these discharges, it has become evident that diffuse sources of water pollution (those occurring over a wide area) are also major contributors to water quality degradation. Recent studies, including the Nationwide Urban Runoff Program (NURP) study (EPA, 1983), have shown that storm water runoff from urban and industrial areas typically contains the same general types of pollutants that are often found in wastewater in industrial discharges. Pollutants commonly found in storm water runoff include heavy metals, pesticides, herbicides, and synthetic organic compounds such as fuels, waste oils, solvents, lubricants, and grease. These compounds can have damaging effect on both human health and aquatic ecosystems. In addition to pollutants, the high volumes of storm water discharged from MS4s in areas of rapid urbanization have had significant impacts on aquatic ecosystems due to physical modifications such as bank erosion and widening of channels.

The statutory provisions governing discharges from MS4s are contained in CWA Section 402(p)(3)(B). In general, Congress provided that permits for discharges from MS4s:

- May be issued on either a system- or jurisdiction-wide basis;
- Shall effectively prohibit non-storm water discharges into the MS4; and
- Shall require controls to reduce the discharge of pollutants to the maximum extent practicable (MEP).

Under the storm water program, the initial round of NPDES permits will emphasize the use of Best Management Practices (BMPs) to reduce pollutant loadings from MS4s. These BMPs include pollution prevention measures, management practices, control techniques, and design and engineering practices. As with any discharger subject to the NPDES program, MS4s must meet technology-based requirements [in this case, the "maximum extent practicable" standard of Section 402(p)] as well as applicable water quality standards.

1.3 THE PERMIT APPLICATION PROCESS

The goal of the NPDES program for municipal storm water is the reduction and elimination of pollutants in storm water discharges from large and medium MS4s. The permit application process in 40 CFR 122.26(d) is designed to meet this goal by developing site-specific NPDES permits containing storm water management programs for individual MS4s. Site-specific permitting is crucial given the differing nature of discharges from MS4s in different parts of the country and the varying impacts of these discharges on receiving waters. To facilitate this process, the regulations specify a two-part permit application.

Part 1 of the permit application initiates the process through which municipalities began to identify sources of pollutants to the municipal storm sewer system. Part 1 also requires municipalities to propose strategies to characterize storm water discharges from their municipal separate storm sewer systems. *Guidance for the Preparation of Part 1 of The NPDES Permit Applications for Discharges From Municipal Separate Storm Sewer Systems* was issued in April 1991, and is available through EPA's Storm Water Hotline [(703) 821-4823].

The present manual describes how to meet the Part 2 permit application requirements for storm water discharges from large and medium MS4s. Part 2 of the permit application builds upon the foundation established in Part 1 and provides for the development of comprehensive storm water management programs. Part 2 requires particular information that MS4s must have developed to have an effective storm water control plan. However, each applicant is given flexibility on how to present and organize this information in a way which best suits the MS4's needs and is most consistent with its overall storm water management strategy. This guidance presents examples which illustrate some alternative ways to present information that will fulfill the Part 2 permit application requirements.

1.4 WHO MUST SUBMIT A PART 2 APPLICATION

Municipalities, incorporated places, and counties with unincorporated urban areas that own or operate a large or medium MS4 that discharges to waters of the United States are required to obtain a NPDES storm water permit. In addition, small MS4s (less than 100,000) that are owned or operated by a municipality other than those identified in the NPDES regulation can be designated by the permitting authority as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers.

Under EPA's definition of MS4, "large" MS4s serve populations greater than 250,000, and "medium" MS4s serve populations of at least 100,000, but less than 250,000. Population is determined by the most recent Decennial Census by the Bureau of the Census. A list of large and medium municipalities identified in the November 16, 1990, rule is contained in Exhibit 1-1, in which population was based on the 1980 Census. **After the publication of the November 16, 1990, rule, the Bureau of the Census released data for 1990, and, as a result, some additional municipalities may be required to submit applications, while others may fall below 100,000. These changes are not reflected in Exhibit 1-1.**

Exhibit 1-1: Large and Medium MS4s (Based on 1980 Census Data)

Municipalities, Counties, and Incorporated Areas With Populations greater than 250,000 which Must Submit NPDES Storm Water Applications.

State	Entity
Alabama	Birmingham
Arizona	Phoenix
	Tucson
California	Long Beach
	Los Angeles
	Los Angeles County
	Oakland
	Sacramento
	Sacramento County
	San Diego
	San Diego County
	San Francisco
	San Jose
Colorado	Denver
Delaware	New Castle County
District of Columbia	
Florida	Dade County
	Jacksonville
	Miami
	Tampa
Georgia	Atlanta
	DeKalb County
Hawaii	Honolulu County
Illinois	Chicago
Indiana	Indianapolis
Kansas	Wichita
Kentucky	Louisville
Louisiana	New Orleans
Maryland	Anne Arundel County
	Baltimore County
	Baltimore
	Montgomery County
	Prince George's County
Massachusetts	Boston
Michigan	Detroit
Minnesota	Minneapolis
	St. Paul
Missouri	Kansas City
	St. Louis
Nebraska	Omaha
New Jersey	Newark
New Mexico	Albuquerque
New York	Buffalo
	Bronx Borough
	Brooklyn Borough
	Manhattan Borough
	Queens Borough
	Staten Island Borough
North Carolina	Charlotte
Ohio	Cincinnati
	Cleveland
	Columbus
	Toledo
Oklahoma	Oklahoma City
	Tulsa
Oregon	Portland
Pennsylvania	Philadelphia
	Pittsburgh
Tennessee	Memphis
	Nashville/Davidson
Texas	Austin
	Dallas
	El Paso
	Fort Worth
	Harris County
	Houston
	San Antonio
Utah	Salt Lake County
Virginia	Fairfax County
	Norfolk
	Virginia Beach
Washington	King County
	Seattle
Wisconsin	Milwaukee

Municipalities, Counties, and Incorporated Areas with Populations between 100,000 and 250,000 which Must Submit NPDES Storm Water Applications.

State	Entity
Alabama	Huntsville
	Jefferson County
	Mobile
	Montgomery
Alaska	Anchorage
Arizona	Mesa
	Pima County
	Tempe
Arkansas	Little Rock
California	Alameda County
	Anaheim
	Bakersfield
	Berkeley
	Concord
	Contra Costa County
	Fremont
	Fresno
	Fullerton
	Garden Grove
	Glendale
	Huntington Beach
	Kern County
	Modesto
California, cont.	Orange County
	Oxnard
	Pasadena
	Riverside
	Riverside County
	San Bernardino
	San Bernardino County
	Santa Ana
	Stockton
	Sunnyvale
	Torrance
Colorado	Aurora
	Colorado Springs
	Lakewood
	Pueblo
Connecticut	Bridgeport
	Hartford
	New Haven
	Stamford
	Waterbury
Florida	Broward County
	Escambia County
	Fort Lauderdale
	Hileah
	Hillsborough County
	Hollywood
	Orange County
	Orlando
	Palm Beach County
	Pinellas County
	Polk County
	Sarasota County
	St. Petersburg
Georgia	Clayton County
	Cobb County
	Columbus
	Macon
	Richmond County
	Savannah
Idaho	Boise City
Illinois	Peoria
	Rockford
Indiana	Evansville
	Fort Wayne
	Gary
	South Bend
Iowa	Cedar Rapids
	Davenport
	Des Moines
Kansas	Kansas City
	Topeka
Kentucky	Jefferson County
	Lexington-Fayette
Louisiana	Baton Rouge
	Jefferson Parish
	Shreveport

(continued)

Exhibit 1-1: Large and Medium MS4s (cont.)
(Based on 1980 Census Data)

Massachusetts	Springfield	North Carolina	Durham	Texas, cont'd	Corpus Christi
	Worcester		Greensboro		Garland
Michigan	Ann Arbor		Raleigh		Irving
	Flint		Winston-Salem		Lubbock
	Grand Rapids		Cumberland County		Pasadena
	Lansing	Ohio	Akron		Waco
	Livonia		Dayton	Utah	Salt Lake City
	Sterling Heights		Youngstown	Virginia	Alexandria
	Warren	Oregon	Eugene		Arlington County
Mississippi	Jackson		Multnomah County		Chesapeake
Missouri	Independence		Washington County		Chesterfield County
	Springfield	Pennsylvania	Allentown		Hampton
Nebraska	Lincoln		Erie		Henrico County
Nevada	Clark County	Rhode Island	Providence		Newport News
	Las Vegas	South Carolina	Columbia		Portsmouth
	Reno		Greenville County		Richmond
New Jersey	Elizabeth		Richland County		Roanoke
	Jersey City	Tennessee	Chattanooga	Washington	Snohomish County
	Paterson		Knoxville		Spokane
New York	Albany	Texas	Amarillo		Pierce County
	Rochester		Arlington		Tacoma
	Syracuse		Beaumont	Wisconsin	Madison
	Yonkers				

Source: 55 FR 48073, November 16, 1990.

The definition of MS4 excludes those conveyances that are designed to discharge storm water runoff combined with municipal sanitary sewers ("combined sewer systems"). Therefore, municipalities that own or operate combined sewer systems may petition to have their population, based on Bureau of the Census figures, reduced by the number of people served by the combined sewer system. If the total population served by the separate storm sewer system alone is less than 100,000, the municipality may be eligible for an exemption from NPDES storm water permit requirements. Municipalities should contact their permitting authority for additional information. **Exhibit 1-1 does not reflect any modifications in the application requirements for cities with combined sewer systems.**

1.5 SUBMITTING THE PART 2 APPLICATION

Completed Part 2 applications should be submitted to the appropriate permitting authority listed in Exhibit 1-2. For municipalities in States with authorized NPDES programs, the permitting authority is the State office listed in Exhibit 1-2. Because some of these States may have application requirements in addition to EPA's, municipalities in States with authorized NPDES programs should contact their States for guidance. For municipalities in States without approved NPDES programs, the permitting authority is the EPA Regional Office listed in Exhibit 1-2.

Municipalities with populations greater than 250,000 (large MS4s) were to submit their Part 2 applications by November 16, 1992. Municipalities with populations greater than 100,000, but less than 250,000 (medium MS4s), must submit Part 2 applications by May 17, 1993. Inquiries regarding Part 2 applications or the permitting process should be directed to the appropriate permitting authority.

Exhibit 1-2: NPDES Storm Water Program Permitting Authorities

State	Permit Auth.	Contact
Alabama	State	Aubrey White Water Division 1751 Dickinson Dr. Montgomery, AL 36130 (205) 271-7811
Alaska	EPA	Steve Bubnick U.S. EPA Region 10 WD-134 1200 6th Ave. Seattle, WA 98101 (206) 553-8399
Arizona	EPA	Eugene Bromley U.S. EPA Region 9 W-5-1 75 Hawthorne St. San Francisco, CA 94105 (415) 744-1906
Arkansas	State	Mark Bradley Permitting Section Chief 8001 National Dr. P.O. Box 8913 Little Rock, AR 72219-8913
California	State	Archie Matthews Div. of Water Qual. Control Dept. of State Water Res. Bd. Mail Code G8 901 P Street Sacramento, CA 95814 (916) 657-0525
Colorado	State	Patricia Nelson Dept. of Health Water Quality Control Div. WPCD-PE-B2 4300 Cherry Drive South Denver, CO 80222-1530 (303) 692-3590
Connect-icut	State	Permit Coordinator Dept. of Envir. Protection Water Management Bureau 165 Capitol Ave. Hartford, CT 06106 (203) 566-7167
Delaware	State	Chuck Schadel Dept. of Natural Resources Surface Water Management 89 Kings Hwy., P.O. Box 1401 Dover, DE 19903 (302) 739-5731
District of Columbia	EPA	Kevin Magerr U.S. EPA Region 3 3WM53 841 Chestnut Bldg. Philadelphia, PA 19107 (215) 597-1651
Florida	EPA	Chris Thomas U.S. EPA Region 4 4WM-FP 345 Courtland St. N.E. Atlanta, GA 30365 (404) 347-2391
Georgia	State	Allen Hallum Municipal Permitting Prog. Ga. Env. Protection Div. 4244 International Pkwy. Suite 110 Atlanta, GA 30354 (404) 362-2680
Hawaii	State	Steve Chang Dept. of Health Clean Water Branch Five Water Front Plaza #500 Ala Moana Blvd. Honolulu, HI 96813 (808) 586-4309
Idaho	EPA	Steve Bubnick U.S. EPA Region 10 WD-134 1200 6th Avenue Seattle, WA 98101 (206) 553-8399
Illinois	State	Sue Epperson EPA Water Poll. Control Permits Section #15 P.O. Box 19276 Springfield, IL 62794-9276 (217) 782-0610
Indiana	State	Catherine Hess Dept. of Env. Mgmt. NPDES Permits Group Room #718 105 S. Meridian St. P.O. Box 6015 Indianapolis, IN 46206-6015 (317) 232-8704

(Continued)

Exhibit 1-2: NPDES Storm Water Program Permitting Authorities (cont.)

State	Permit Auth.	Contact
Iowa	State	Monica Wnuck Dept. of Natural Resources Wallace State Building 900 E. Grand Street Des Moines, IA 50319-0034 (515) 281-7017
Kansas	State	Don Carlson Dept. of Health and Env. Bureau of Water Ind. or Mun. Progs. Section Forbes Field, Building 740 Topeka, KS 66620 (913) 296-5555
Kentucky	State	Douglas Allgeier Dept. of Env. Protection Water Division 14 Reilly Road Frankfort, KY 40601 (502) 564-3410
Louisiana	EPA	Brent Larsen U.S. EPA Region 6 6W-PM 1455 Ross Ave. Dallas, TX 75202 (214) 655-7175
Maine	EPA	Shelley Puleo U.S. EPA Region 1 JFK Building/WCP Boston, MA 02203 (617) 565-3525
Maryland	State	Brian Clevenger MD Dept. of Environment Sed. & Storm Water Admin. 2500 Broening Hwy. Baltimore, MD 21224 (410) 631-3545
Mass-achusetts	EPA	Shelley Puleo U.S. EPA Region 1 WCP JFK Building Boston, MA 02203 (617) 565-3525
Michigan	State	Gary Boersen Dept. of Natural Resources Surf. Wtr. Qual. Div.-Permits P.O. Box 30028 Lansing, MI 48909 (517) 373-1982
Minnesota	State	Scott Thompson Pollution Control Agency 520 Lafayette Rd. St. Paul, MN 55155-3898 (612) 296-7203
Miss-issippi	State	Louis Lavalee Dept. of Env. Quality Office of Pollution Control Ind. Wastewater Branch P.O. Box 10385 Jackson, MS 39289-0385 (601) 961-5074
Missouri	State	Karl Fett Dept. of Natural Resources Water Poll. Control Program 205 Jefferson St. P.O. Box 176 Jefferson City, MO 65102 (314) 526-2928
Montana	State	Fred Shewman Water Quality Bureau Cogswell Building Helena, MT 59620 (406) 444-2406
Nebraska	State	Clark Smith Environmental Quality P.O. Box 98922 Lincoln, NE 68509 (402) 471-4239
Nevada	State	Rob Saunders Conserv. & Natural Res. Environmental Protection 333 W. Nye Lane Carson City, NV 89710 (702) 687-5870
New Hampshire	EPA	Shelley Puleo U.S. EPA Region 1 WCP JFK Building Boston, MA 02203 (617) 565-3525
New Jersey	State	Barry Chalofsky NJ DEPE Office of Regulatory Policy CN423 Trenton, NJ 08625-0423 (609) 633-7021

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Exhibit 1-2: NPDES Storm Water Program Permitting Authorities (cont.)

State	Permit Auth.	Contact
New Mexico	EPA	Brent Larsen U.S. EPA Region 6 6W-PM 1445 Ross Ave. Dallas, TX 75202 (214) 655-7175
New York	State	Ken Stevens Wastewater Facilities Design NY State Dept. of Env. Cons. 50 Wolf Road Albany, NY 12233 (518) 457-1157
North Carolina	State	Colleen Sullins Environmental Management Water Permits & Eng. P.O. Box 29535 Raleigh, NC 27626-0535 (919) 733-5083
North Dakota	State	Shelia McClenathan Dept. of Health Water Quality Div. 1200 Missouri Ave. P.O. Box 5520 Bismarck, ND 585202-5520 (701) 221-5210
Ohio	State	John Morrison OEPA Water Pollution Control 1800 Watermark P.O. Box 1049 Columbus, OH 43266 (614) 644-2017
Oklahoma	EPA	Brent Larsen U.S. EPA Region 6 6W-PM 1445 Ross Avenue Dallas, TX 75202 (214) 655-7175
		Ted Williamson Discharge Permits Division Oklahoma Dept. of Health 1000 N.E. 10th Oklahoma City, OK 73117
Oregon	State	Ranei Nomura DEQ-Water Quality 811 SW 6th Ave. Portland, OR 97204 (503) 229-5256
Pennsylvania	State	R.B. Patel Environmental Resources Water Quality Management P.O. Box 2063 Harrisburg, PA 17120 (717) 787-8184
Puerto Rico	EPA	Jose Rivera U.S. EPA Region 2 Wtr. Permits & Compl. Br. 26 Federal Plaza, Room 845 New York, NY 10278 (212) 264-2911
Rhode Island	State	Peter Duhamel Division of Water Resources 291 Promenade St. Providence, RI 02908 (401) 277-6519
South Carolina	State	Arturo Ovalles DHEC Industry and Agriculture Wastewater Division 2600 Bull St. Columbia, SC 29201 (803) 734-5241
South Dakota	EPA	Vern Berry U.S. EPA Region 8 8-WM-C Suite 500 999 18th St. Denver, CO 80202-2466 (303) 293-1630
Tennessee	State	Robert Haley Dept. of Env. Wtr. Poll. Ctrl. 401 Church St. 6th Floor L & C Annex Nashville, TN 37243-1534 (615) 532-0625
Texas	EPA	Brent Larsen U.S. EPA Region 6 6W-PM 1445 Ross Ave. Dallas, TX 37243-1534
Utah	State	Harry Campbell Div. of Water Qual. P.O. Box 144870 Salt Lake City, UT 84114-4870 (801) 538-6146

(Continued)

Exhibit 1-2: NPDES Storm Water Program Permitting Authorities (cont.)

State	Permit Auth.	Contact
Vermont	State	Brian Kooker Env. Conserv. Permits Compliance & Protection 103 S. Main St. Annex Building Waterbury, VT 05671-0405 (802) 244-5674
Virgin Islands	State	Marc Pacifico Dept. of Planning & Nat. Resources Div. of Env. Protection 1118 Watergut Project Box 1118 Christiansted St. Croix, VI 00820-5065 (809) 773-0565
Virginia	State	Burton Tuxford VA Water Control Board 4900 Cox Road Glen Allen, VA 23060 (804) 527-5000
Washington	State	Ed O'Brien Dept. of Ecology Industrial Storm Water Unit Water Quality Div. P.O. Box 47696 Olympia, WA 98504-7696 (206) 438-7614
West Virginia	State	Jerry Ray Office of Water Resources 1201 Greenbriar St. Charleston, WV 25311-1088 (304) 558-0375
Wisconsin	State	Anne Manuel Dept. of Natural Resources Wastewater Management P.O. Box 7921 Madison, WI 53707 (608) 267-7694
Wyoming	State	John Wagner Dept. of Envir. Quality Herschler Building 4th Floor Cheyenne, WY 82002 (307) 777-7082

Source: Poll of Regional and State offices.

1.6 USE OF INFORMATION IN PART 1 AND PART 2 APPLICATIONS

The information submitted in the Part 1 and Part 2 permit applications provides applicants with a starting point for developing comprehensive storm water management programs. For example, the field screening data submitted with the Part 1 application provides a basis for a program to control illicit discharges. Also, the application information may assist in prioritizing controls and in long-term tracking of program effectiveness.

Permitting authorities will use the information from each municipality's Part 1 and 2 applications as the basis for establishing conditions in that municipality's NPDES storm water permit. For example, if a municipality submits a satisfactory application, all or part of its proposed storm water management program is likely to become an integral part of its permit.

1.7 ORGANIZATION OF THIS MANUAL

Chapter 1, *Introduction*, provides a brief overview of the Part 2 permit application process. It discusses who must submit a Part 2 application and how the information in the applications will be used. It also contains a summary of the statutory and regulatory basis for the NPDES storm water program.

Chapter 2, *The Part 2 Application*, describes the statutory and regulatory requirements of municipal NPDES storm water permit applications in more detail. Chapter 2 outlines the specific requirements of the Part 1 and Part 2 applications, explains how Part 2 builds on the Part 1 application, and describes the interconnection among the various components of the Part 2 application.

Chapter 3, *Adequate Legal Authority*, describes how municipalities must demonstrate that they have adequate legal authority to carry out the program requirements [§122.26(d)(2)(i)].

Chapter 4, *Source Identification*, provides guidance on identifying major outfalls and inventorying dischargers to the MS4 [§122.26(d)(2)(ii)].

Chapter 5, *Discharge Characterization*, provides guidance for submitting quantitative data on the MS4 and developing a proposed monitoring program [§122.26(d)(2)(iii)].

Chapter 6, *Proposed Management Program*, describes the steps municipalities must take when they develop site-specific storm water management programs [§122.26(d)(2)(iv)]. These plans are the heart of the municipal permit application, and the permitting authority will probably incorporate all or part of the municipality's proposed management program into their NPDES storm water permit. In their proposed management programs, municipalities must describe management practices, control techniques and systems, design and engineering methods, and other provisions that are aimed at reducing the discharge of pollutants to the "maximum extent practicable."

Chapter 7, *Assessment of Controls*, explains how a municipality can assess the effectiveness of its storm water management program and target priorities through the use of direct and indirect measures [§122.26(d)(2)(v)].

Chapter 8, *Fiscal Analysis*, provides guidance on estimating necessary capital and operation and maintenance expenditures, and financing these expenditures [§122.26(d)(2)(vi)].

1.8 OTHER GUIDANCE AVAILABLE

Municipalities should use this guidance document together with the Part 1 guidance (EPA, 1991b). Exhibit 1-3 lists other sources of guidance available from EPA's Storm Water Hotline [(703) 821-4823]. In addition, applicants may wish to obtain further information from the documents identified in the bibliography at the end of this guidance (Appendix A).

Exhibit 1-3
Documents Available from the EPA Storm Water Hotline*
[(703) 821-4823]

November 16, 1990, Federal Register - 55 FR 47990 National Pollutant Discharge Elimination System (NPDES) Permit Application Requirements for Storm Water Discharges - Final Rule

March 21, 1991, Federal Register - 56 FR 12098 Application Deadline for Group Applications Final Rule; Application Deadline for Individual Applications - Proposed Rule

August 16, 1991, Federal Register - 56 FR 40948 NPDES General Permits and Reporting Requirements for Storm Water Discharges Associated with Industrial Activity - Proposed Rule

November 5, 1991, Federal Register - 56 FR 50548 Application Deadlines; Final Rule and Proposed Rule

April 2, 1992, Federal Register - 57 FR 11394 Application Deadlines, General Permit Requirements and Reporting Requirements, Final Rule

Summary of November 16, 1990, Storm Water Application Rule

Summary of August 16, 1991, Proposed Storm Water Implementation Rule

August 16, 1991, Proposed Storm Water Implementation Rule Package Fact Sheet

April 2, 1992, Storm Water Program Rule Fact Sheet

Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity (EPA 505/8-91-002, April 1991)

Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges From Municipal Separate Storm Water Systems (EPA 505/8-91-003A, April 1991)

Typical Values of Annual Storm Events Statistics for Rain Zones of the United States ("Urban Targeting and BMP Selection", EPA Region V, November 1990)

List of EPCRA (SARA Title III) Section 313 Water Priority Chemicals (Draft)

List of State and EPA Regional Storm Water Contacts

State NPDES Program Status

Question and Answer Document

List of Reportable Quantities for Hazardous Substances Under CERCLA

NPDES Storm Water Sampling Guidance Document (EPA 833-B-92-001, July 1992)

(Continued)

Exhibit 1-3
Documents Available from the Storm Water Hotline (cont.)

September 9, 1992, Federal Register - 57 FR 41176 Final NPDES General Permits for Storm Water Discharges from Construction Sites - Notice
September 9, 1992, Federal Register - 57 FR 41236 Final NPDES General Permits for Storm Water Discharges Associated with Industrial Activity - Notice
September 9, 1992 Federal Register - 57 FR 41344 National Pollutant Discharge Elimination System, Request for Comment on Alternative Approaches for Phase II Storm Water Program - Proposed Rule

* The following documents are available from the National Technical Information Service (NTIS): (1) *Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices* (EPA 832-R-92-006, September 1992); (2) *Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices* (EPA 832-R-92-005, September 1992).

CHAPTER 2
THE PART 2 APPLICATION

2.0 THE PART 2 APPLICATION

2.1 BACKGROUND

The NPDES permit application requirements for MS4s [40 CFR 122.26(d)] establish a two-part application designed to meet the goal of developing comprehensive site-specific storm water quality management programs for MS4s.

The purpose of the two-part application process is to develop information, in a reasonable time frame, that will build successful storm water management programs and allow permitting authorities to make informed decisions about permit conditions. The application process is designed to focus the efforts of municipalities in two areas: prohibiting non-storm water discharges into storm sewers, and implementing controls that reduce the discharge of pollutants from MS4s to the maximum extent practicable.

Part 1 of the application requires information on existing programs and legal authority. In addition, Part 1 requires the results from field screening of major outfalls to detect illicit connections. The **Part 2** application requirements are intended to build upon the information submitted with the Part 1 application. Each part has virtually the same major areas of concern, but the Part 2 application requires a greater level of detail. Part 2 of the permit application requires a demonstration of adequate legal authority, additional information on pollutant sources and outfalls, a limited amount of representative quantitative sampling data, a proposed monitoring program, a proposed storm water management program, an estimate of the effectiveness of storm water controls, and a fiscal analysis. The requirements for the Part 1 and Part 2 applications are summarized briefly in Exhibit 2-1, and described in more detail in Section 2.2. The storm water regulations underlying this guidance can be found in Appendix B.

Before applicants proceed with the detailed development of their permit applications, they should recognize the fundamental requirements:

- Who or what are the primary contributors of pollutants in storm water discharges from MS4s?
- Where are these sources of pollutants located in relation to receiving water resources?
- What is the magnitude of these pollutant sources and their potential impact on receiving waters?
- How does the municipality plan to reduce or eliminate the contribution of pollutants in storm water discharges or prevent the damaging influences of these discharges?
- Why did the municipality select the activities or best management practices (BMPs) it proposes?
- When will the municipality implement its proposed program?
- How will the applicant assess the effectiveness of the program? What criteria or measures will apply?
- How will the municipality fund proposed program activities?

Wherever appropriate, the applicant must also show that it has adequate legal authority to implement, enforce, or mandate compliance with applicable ordinances, statutes, contracts, or other similar vehicles as required by the storm water regulation.

Exhibit 2-1: Part 1 and Part 2 Storm Water Application Requirements.

Adequate Legal Authority

Part 1

- Identify existing ordinances that control storm water discharges to the MS4.
- Determine gaps in legal authority and develop schedule.

Part 2

- **Demonstrate that legal authority has been obtained to control industrial discharges, illicit discharges, dumping, and the contribution of pollutants from coapplicants.**
- **Show that legal authorities are enforceable.**

Source Identification

Part 1

- Describe historical use of legal controls.
- Identify major outfalls and industrial contributors to the MS4.
- Provide topographic map.

Part 2

- **Identify additional major outfalls.**
- **Identify additional industries.**
- **Organize industrial inventory by watershed.**

Charactization Data

Part 1

- Provide rain and snowfall data. List receiving water bodies, and describe water quality impacts.
- Provide results of field screening analysis, and propose representative outfalls for sampling.

Part 2

- **Provide results of sampling.**
- **Estimate annual and seasonal pollutant loadings and event mean concentrations.**
- **Propose monitoring program.**

Proposed Management Program

Part 1

- Identify existing storm water management activities.

Part 2

- **Identify commercial and residential, construction, and industrial activities to be addressed in the storm water program.**
- **Develop appropriate control measures for commercial and residential, construction, and industrial activities.**
- **Design a program to prohibit illicit discharges.**

Assessment of Controls

Part 2

- **Estimate expected reduction in pollutant loadings.**
- **Describe any known impacts of storm water controls on ground water.**

Fiscal Analysis

Part 1

- Describe budget for existing storm water programs and resources available to complete Part 2.

Part 2

- **Estimate capital and operating costs necessary for the storm water management program.**
- **List available sources of funding and legal restrictions on these sources.**

These questions (described above) that an applicant must address follow a natural progression or development. For example, before applicants can identify how they will reduce the contribution of pollutants in storm water discharges (the fourth bullet point above), they must identify pollutant sources and estimate the magnitude of pollutant loads (bullet points 1-3 above).

2.2 PART 1 APPLICATIONS

Sections 2.2.1 and 2.2.2 provide overviews of the regulatory requirements of §122.26(d). Section 2.2.3 describes the relationship among the various application provisions.

2.2.1 Overview of the Part 1 Application

Part 1 applications consist of the following six elements:

- **General information.** The applicant's name, address, telephone number of contact person, ownership status and status as a State or local government entity.

- **Legal authority.** A description of existing legal authority to control discharges to the MS4, and if this authority does not meet the required criteria, a list of additional authority needed and a schedule and commitment to seek such authority.

- **Source identification.** A description of the historic use of ordinances, guidance, or other controls that limit non-storm water discharges to any publicly owned treatment works (POTW), and a topographic map covering an area one mile beyond the service boundaries of the MS4 showing:

  - the location of known municipal sewer system outfalls;
  - a description of all land use activities;
  - the location and activities of landfills;
  - the location and permit number of any known discharge to the MS4;
  - the location of major structural controls for storm water discharges (such as retention basins, or major infiltration devices); and
  - identification of publicly owned parks, recreational areas, and other open lands.

- **Discharge characterization.** A summary of the types and characteristics of storm water discharges, including:

  - monthly mean rain and snowfall estimates and the average number of storm events per month;
  - existing quantitative data describing the volume and quality of discharges from the MS4, including a description of the outfalls and sampling methods used;
  - a list of "downstream" water bodies receiving discharge from the MS4, and a description of the impact of outfall upon them;
  - the results of field screening analysis for illicit discharges at either selected field screening points or major outfalls covered in the permit application; and
  - a proposed characterization plan for conducting sampling and obtaining the quantitative data necessary to complete Part 2 of the application.

- **Management programs.** A description of existing management programs to control pollutants from the municipal separate storm sewer system. For example, what procedures are in place to control pollution from construction activities, and how do they work? What is the program (such as investigation procedures and how they operate) for identifying illicit connections to the municipal storm sewer system?

- **Fiscal resources.** A presentation of the municipality's budget for existing storm water programs and for completing Part 2 of the permit application.

2.2.2 Overview of the Part 2 Application

The Part 2 application must include the following elements:

- **Adequate legal authority.** A demonstration that the municipality can operate according to the legal authority established by ordinance, statute, or series of contracts. The municipality also must demonstrate that its authority is enforceable. A discussion of how adequate legal authority may be demonstrated appears in Chapter 3 of this guidance.

- **Source identification.** An inventory, organized by watershed, of the facilities that may discharge storm water associated with industrial activity to the MS4. The applicant also must identify the location of any major outfall that discharges to waters of the United States that was not reported in Part 1. A discussion of the information to be submitted for each such facility in the inventory appears in Chapter 4 of this guidance.

- **Characterization data.** Sampling results for 5-10 outfalls designated by the permitting authority, estimates of cumulative annual pollutant loadings and event mean concentrations, and a proposed schedule to submit estimates of seasonal pollutant loadings and event mean concentrations for each major outfall identified in the source identification sections of Part 1 and 2. The *Characterization Data* provision of the Part 2 application also requires the development of an on-going monitoring program covering the term of the permit. Procedures for meeting the requirements of this section appear in Chapter 5.

- **Proposed management program.** A program that shows the municipality's comprehensive planning process for the reduction and control of pollutants, the staff and equipment available to implement the program, and a full description of how controls will be implemented to reduce pollutants from all sources of storm water. Municipalities must also describe how the program will be implemented and maintained. The Part 2 requirements for a proposed management program are described in Chapter 6.

- **Assessment of controls.** An estimate of the projected effectiveness of the municipal storm water management program, and an identification of the known impacts of storm water controls on ground water. The assessment of controls is discussed in Chapter 7.

- **Fiscal analysis.** A fiscal analysis of the capital and operation and maintenance expenditures needed to accomplish the activities (including implementation) required by the characterization data and proposed management program sections of the Part 2 application. This fiscal analysis must include projected expenses for each fiscal year of the permit term. A discussion of the fiscal analysis is included in Chapter 8.

2.2.3 Relationship Among Application Requirements

The required elements of the Part 2 application are related to each other. As a result, this guidance addresses how the application elements are related, and how information gathered for one requirement will assist the applicant in meeting other requirements. For example, the information gathered for the *Industrial Source Identification* provision of the Part 2 application will assist the municipality in:

- Targeting monitoring goals to potential pollutant sources, which may include selecting monitoring locations and chemical specific sampling frequencies (a requirement of the *Characterization Data* provision);
- Identifying illicit discharges (a requirement of the *Proposed Management Program's* illicit connection provision);
- Identifying facilities with the greatest potential for degrading receiving water quality (a requirement of the *Proposed Management Program's* industrial program provision); and
- Targeting sites that handle, store, or transport toxic or hazardous materials for on-site inspections (another requirement of the *Proposed Management Program's* industrial program provision).

As another example, the information that the applicant must prepare for the *Characterization Data* provision (e.g., the results of the sampling requirement and the estimated event mean concentrations and annual pollutant loads) may help the municipality:

- Evaluate the contribution of pollutants in storm water discharges from individual sources and determine which sources may require inspections or controls (a requirement of the *Proposed Management Program's* industrial program provision);
- Predict the impact of storm water discharges on receiving waters known to be impacted. (In the *Proposed Management Program*, additional controls may be warranted for construction sites or other industrial activities that discharge to these waters); and
- Determine what BMPs may be appropriate for given areas (another requirement of the *Proposed Management Program*).

Exhibit 2-2 summarizes some of these key interrelationships, although many other interrelationships exist. A more detailed discussion of specific information requirements and interrelationships among provisions is provided in subsequent chapters. As municipalities prepare their permit applications, they should coordinate all program requirements.

Exhibit 2-2
Examples of Relationship Among Part 2 Requirements

					Fiscal Analysis
				Assessment of Controls	Cost/benefit analysis identifies the most cost-effective BMPs.
			Proposed Management Program	Estimates of reductions in pollutant loadings predicts impact of storm water management activities	Fiscal analysis considers costs of controls, maintenance, and capital improvements. Management program may include feasibility analyses that consider cost.
		Characterization Data	Annual pollutant loads help prioritize areas for BMPS. On-going monitoring indicates success of BMPs and need to re-prioritize.	On-going monitoring program verifies program effectiveness. Instream monitoring verifies biological recovery.	Fiscal analysis considers cost of on-going monitoring
	Source Identification	Land use information and organization of industry by watershed defines representative sampling points.	Inventory of industrial users helps the city target facilities for inspections and control measures.	Estimates of pollutant load reductions depend on land use.	Industrial inventory identifies potential sources of storm water utility fees.
Adequate Legal Authority	Some sources or outfalls may be outside a city's jurisdiction. Interjurisdictional agreements may be necessary.	Authority to require sampling and obtain information for industries and dischargers outside of the MS4's jurisdiction at sampling points.	Legal authority needed to implement BMPS, control and inspect industry, and prohibit dumping and illicit discharge.	Need information gathering and inspection authority where it is necessary to inspect, monitor, and enter the facility or the site.	Legal authority is required for some financing plans, such as a storm water utility.

2.3 ADDITIONAL FACTORS TO BE CONSIDERED IN DEVELOPING THE PART 2 APPLICATION

As discussed in the previous section, the various provisions of the Part 2 application process are interconnected.

All municipalities covered by §122.26(d) must submit a Part 2 permit application that meets the requirements of the storm water permit application regulations. However, each MS4 is unique, and each Part 2 submission will be different. Municipal separate storm sewer systems differ in many ways, including population served, geologic and climatologic settings, density of development, and form of government. These underlying factors make each applicant unique.

The major factors that applicants should consider are:

- Population and projected growth rate;
- Zoning and existing land use patterns;
- Nature of watershed and receiving waters;
- Climatic conditions, soil types, and watershed delineations;
- Existing municipal functions and municipal lands;
- Other environmental impacts;
- Public involvement; and
- Intergovernmental coordination.

In addition, municipalities must implement their storm water management programs in a manner that is consistent with other applicable Federal, State, and local environmental laws.

<u>Population and Projected Growth Rates</u>

Some storm water BMPs are more appropriate for densely developed areas, while other methods may be more useful in developing areas. Consequently, defining current population densities and projecting future areas of population growth provides the basic information that can assist in the evaluation and prioritization of appropriate storm water control strategies.

<u>Zoning and Existing Land Use Patterns</u>

Through ordinances, permits, or contracts, municipalities may mandate storm water controls for new residential, commercial, or industrial developments in order to improve or assure maintenance of the quality of receiving waters at or near pre-development levels. The Nationwide Urban Runoff Program (NURP) study (EPA, 1983), pointed out that some of the best opportunities for implementing cost effective measures to prevent or reduce pollutants in storm water occur during new development. These measures may include structural controls, such as storm water detention basins or constructed storm water wetlands, or nonstructural alternatives such as cluster development and buffer zones. Sections 122.26(d)(1)(iii)(B)(2) and 122.26(d)(2)(ii) require the municipality to establish comprehensive management plans for new development (see Chapter 6).

<u>Nature of Watershed and Receiving Waters</u>

The types of storm water controls appropriate for a MS4 depend on the nature of the watershed and the receiving waters. This includes geologic and hydrologic features such as slope drainage patterns and stream size. For example, roadside swales may not be practical in areas with steep terrain, but can be very useful in flat areas. In addition, structural BMPs or other management measures that control the volume and timing of release are appropriate where uncontrolled storm water may cause physical impacts to receiving waters (especially small streams, rivers, and wetlands).

Information on the watershed and the receiving waters is required in the Part 1 permit application [§122.26(d)(1)(iv)(C)]. In Part 1, applicants are required to list water bodies that receive discharges from the MS4. The list of water bodies includes downstream segments, lakes, and estuaries where pollutants from the system discharges may accumulate and result in non-attainment of State water quality standards. Part 1 also requires a description of known water quality impacts. Applicants must include a discussion of water bodies that were cited in:

- State reports required by CWA Sections 305(b), 304(l), and 314(a);
- The State Nonpoint Source Report; and
- Other reports identifying sensitive watersheds.

Part 1 applicants should also include in this discussion a description of impacts caused by dissolved oxygen depression, bioaccumulation of toxics, excessive sedimentation, hydrologic modification, habitat destruction, etc.

Municipalities are expected to give priority consideration to those classes of pollutant sources that contribute significant loadings or pose a significant impact on receiving waters. Applicants must consider control methods that address storm water discharges from commercial and residential areas; illicit discharges and illegal disposal; storm water discharges from industrial areas; and storm water runoff from construction sites. Municipalities' permits will differ substantially in the emphasis placed on controlling various sources of pollutants in discharges from the MS4. Permits for older municipalities may emphasize control of cross-connections, while permits for municipalities with large areas of new development may emphasize the installation of permanent structural controls during construction.

The Part 2 storm water permit application requires descriptions of management programs to address sources of pollutants discharged to separate storm sewer systems. For management strategies to be effective, municipalities must give prior consideration to the nature (e.g., physical and biological parameters) and the designated uses of receiving waters such as streams, tributaries, and natural wetlands. For example, a storm water management program for a newly developing area with an existing shallow, slow-moving stream could include provisions to ensure that the post-development peak discharge flow rate for the stream is held to a certain percentage of its historical or pre-development peak discharge flow rate.

<u>Climatic Conditions, Soil Types, and Watershed Delineations</u>

Seasonal variations in precipitation can have a significant impact on storm water quality. For example, extended dry seasons in areas such as the southwestern United States result in pollutant loads distinctly higher than in other parts of the country during the first several storms of the wet season. Areas with more frequent rain and snowfall throughout the year may have more storm water discharges, but the discharges may have consistently lower pollutant concentrations than those in the Southwest. In addition, areas with significant snowfall may experience a peak in storm water discharge volume and pollutant concentration during the spring thaw.

Natural soil conditions affect the potential for storm water to recharge ground water. Porosity and permeability are properties of the soil that govern the size and number of the interstitial spaces through which water may flow. Compaction (e.g., compression of the soil by heavy machinery) will reduce the amount of void space in the soil and thereby reduce the amount of rainfall that infiltrates through the soil to ground water. Natural soil conditions are very important when siting structures designed for storm water infiltration. In addition, identifying such sites must take into consideration potential ground water impacts that may result whenever infiltration is part of the storm water management program.

Existing Municipal Functions and Municipal Lands

The Part 2 application affords municipalities the opportunity to discuss alternatives in the *Proposed Storm Water Management Program*. When considering the wide range of municipal functions, applicants need to establish which agencies will be responsible for implementing each portion of a storm water management program. (This could be outlined in the *Adequate Legal Authority* chapter of the Part 2 application, as discussed in Chapter 3 of this guidance.) Many of these agencies, will have primary missions other than dealing with storm water or water quality. Expansion of the established charter of an agency to include an element of storm water control may require legislative action, moderately expanding the scope of other municipal agencies' missions to include storm water concerns can be much more cost effective than the initiation of entirely new programs.

Applicants should identify existing municipal functions that impact the quality of storm water discharges. These functions may include snow removal activities such as road deicing, vehicle maintenance operations, and herbicide, pesticide, and fertilizer application to public lands. Municipalities can modify these activities to improve storm water quality through oversight of future land development, modifications to flood management structures, changes in materials used or in material handling or application practices, maintenance of roads, and installation of structures such as retention basins.

The municipal agency (or agencies) responsible for storm water runoff control should also consider the extent to which municipal lands and activities contribute pollutants to runoff. The same BMPs recommended for private lands may also be incorporated into the development and maintenance of a municipality's own lands and activities. For example, reduced use of pesticides and fertilizers on park land and open spaces usually decreases the contribution of these contaminants to storm water runoff. Implementing BMPs on municipal lands also shows the municipality's commitment to an effective storm water management program. BMPs are discussed in greater detail in Section 6.4 of this guidance.

Other Environmental Impacts

Municipalities should consider those activities that can directly or indirectly alter the natural hydrograph of a stream and potentially degrade an otherwise stable aquatic habitat. These factors are particularly important when considering impacts to wetlands, riparian areas, ground water, small rivers, and streams. In addition, the installation of detention or rapid infiltration ponds may have negative impacts on ground water. The installation of culverts or concrete drainage channels and other such structures typically increases the volume and velocity of runoff, which can lead to increased erosion, siltation, and sedimentation in receiving waters. Therefore, installation of these structures can contribute to the degradation of a neighboring habitat.

Public Involvement

Municipal applicants must ensure that they provide adequate public education and ample opportunities for public participation. Public participation should focus on spreading awareness of program objectives and components. Education and public involvement programs must be defined as part of the *Proposed Storm Water Management Program* [§122.26(d)(2)(iv)]. Generally, the public should be involved as early as possible in storm water management initiatives.

Conflict and confusion can be minimized if the program includes a schedule for initial public contact and milestones for public involvement throughout the development and implementation phases. Public education programs are expected to target specific audiences, including those regulated or affected by the storm water management program (e.g., developers, building contractors, and industrial operators) and those that can assist with program implementation (e.g., volunteers and citizens). For example, one large municipal applicant (Seattle) described an existing public participation program in its Part 1 Application submission. Elements of this program may be instructive to municipalities completing Part 2 of the application because it has generic components that are likely to be applicable to other large (and perhaps medium) municipalities. Excerpts from Seattle's public involvement program are provided in Exhibit 2-3 for reference.

Elements of this municipality's program that are particularly important to consider include of the role of an advisory and outreach group and its relationship to the entire process. Effective public participation programs clearly identify the role of the public.

The potential exists for a considerable range in the level of participation the public may actually have in the decision-making process. Generally, the municipal authority is going to make the decisions. However, the authority can choose to use the "participation" process to simply inform the public of decisions, or to allow the views of the public to be registered prior to decision milestones. In other cases, although uncommon, the public may have an actual voice or vote in making decisions.

The timing and frequency of meetings and the duration of the groups established for public participation will usually be dictated by the nature of the issues being addressed. For example, an ad hoc group established to address a single issue may discover that the issue cannot be effectively addressed without consideration of a broader range of issues that the municipality may also be considering. In this instance it may be appropriate for the group to expand its scope, hold regular meetings, and actively participate in the authority's decision making process. Therefore, applicants should outline in their Part 2 applications how such coordination will be accomplished.

<u>Intergovernmental Coordination</u>

If a number of municipal entities (e.g., multiple cities or a city and a county) are participating in the permit application process as coapplicants, various mechanisms can be used to improve intergovernmental coordination to ensure that the roles and responsibilities of each entity are well defined. Each entity must fulfill its responsibilities to implement applicable program measures. Examples of some of the appropriate coordination techniques and their benefits include:

- **Memoranda of agreement (MOA).** MOAs can define specific municipal roles, responsibilities, and points of coordination that help minimize duplication of effort and ensure accountability;

- **Cross-training of staff.** This allows for the identification of gaps in staffing (e.g., neglected areas of responsibility or insufficient staff levels) as well as providing the benefits of increased versatility and opportunities for learning from others;

- **Interagency advisory committees.** Their objective is to arm decision makers with a comprehensive understanding of the implications of proposed activities or decisions; and

- **Regularly scheduled intermunicipal staff meetings.** These can facilitate an open and thorough exchange of information and solidify new lines of communication.

Exhibit 2-3
Excerpts from a Public Involvement Program

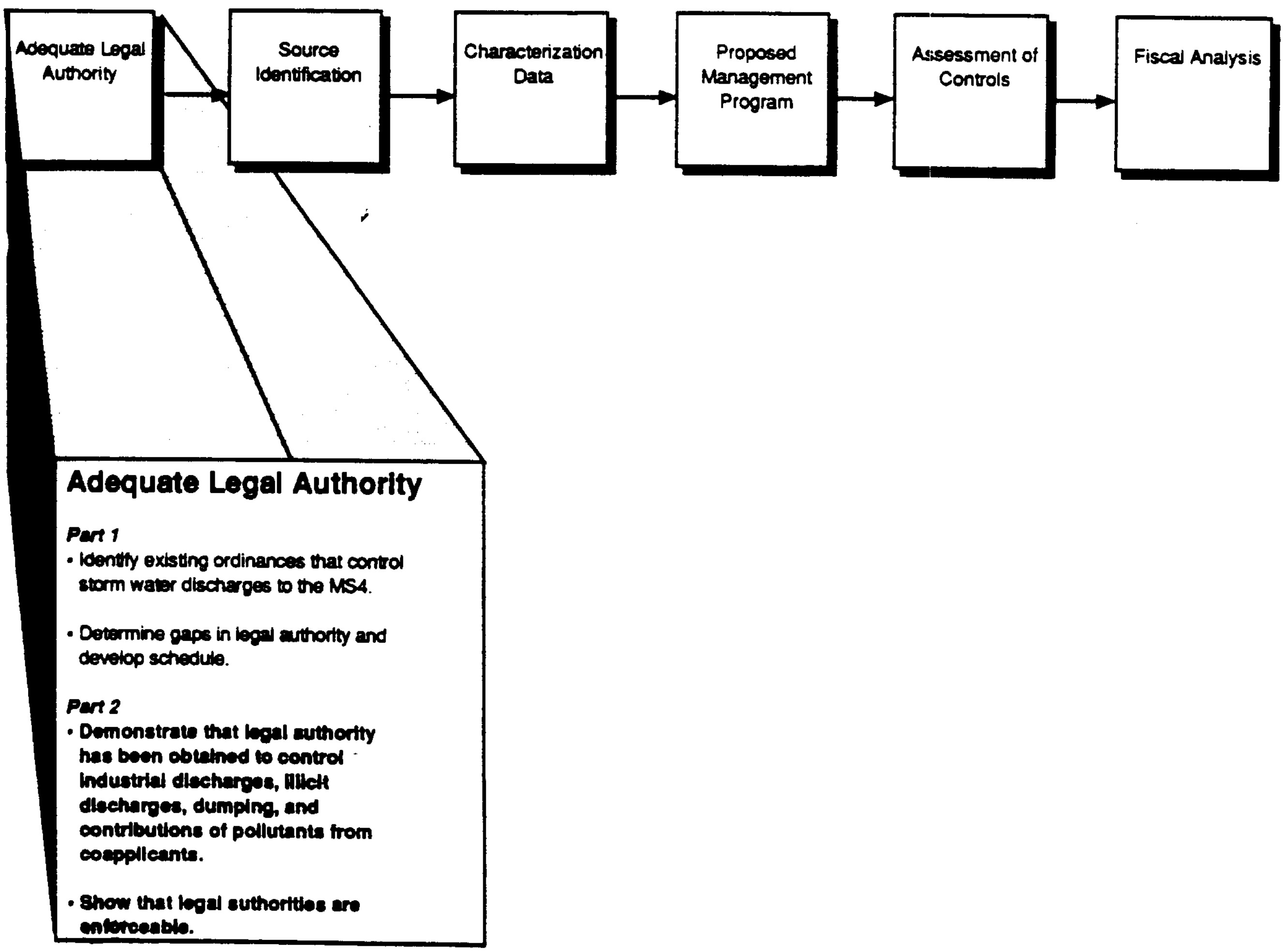
The public involvement program [of the City of Seattle] has been designed to assist in developing an acceptable city-wide plan for addressing drainage and water quality problems. Acceptable is defined as a plan that is both technically sound and sensitive to the needs and interests of the citizens. The involvement program has two major elements: a Citizen Advisory Committee (CAC) and a community outreach effort. The initial role of the CAC was to provide guidance to City staff and consultants preparing various sections of a Comprehensive Drainage Plan. Until the adoption of the Comprehensive Drainage Plan by the City Council, the CAC provided direction on drainage policy issues, assisted with the public review of the draft plan and environmental impact statement (EIS), and helped coordinate comments sent to the city from the public during the review period. Following council adoption of the plan, the CAC was reconstituted into a Drainage and Wastewater Advisory Committee which serves as an on-going sounding board to the Drainage and Wastewater Utility, the mayor, and the City Council on both sewer and drainage matters.

The community outreach effort was established for two purposes. The first was to ensure adequate public review and support of the Comprehensive Drainage Plan and EIS. Comments received during the review were used by the Drainage and Wastewater Utility, the mayor, and the City Council in making decisions about the Drainage Plan and the City's on-going drainage program. The second purpose was to begin educating residents and business people about the importance of their role in solving flooding, landslide, and water quality problems throughout the city. This community outreach/education role remains an on-going effort of the Drainage and Wastewater Utility.

Source: City of Seattle, *NPDES Storm Water Permit Application, Part 1*, City of Seattle, November 1991: 37.

Single municipalities with separate governing functions may face the same challenges as coapplicants when they prepare their Part 2 applications. Many of the same coordination steps may be necessary within a single municipal jurisdiction. The need for *intra*governmental coordination may be most crucial in large municipalities that have functions that impact storm water quality spread throughout the organizational structure of the municipality. For example, a planning department may be in charge of implementing a stream buffer policy, while a public works department may plan, site, and construct storm water BMPs. Still other agencies may be responsible for implementing erosion and sediment control requirements, and permitting and inspection functions. Storm water-related responsibilities within governmental organizations may be allocated in this manner due to the relatively recent emergence of storm water quality as an important issue. Nonetheless, effective coordination within the government of a single municipality may be as critical to the success of the storm water management program as is intergovernmental coordination for coapplicants. Therefore, applicants should outline in their Part 2 applications how such coordination will be accomplished.

CHAPTER 3
ADEQUATE LEGAL AUTHORITY



3.0 ADEQUATE LEGAL AUTHORITY

3.1 BACKGROUND

A crucial requirement of the NPDES storm water regulation is that a municipality must demonstrate that it has adequate legal authority to control the contribution of pollutants in storm water discharged to its MS4. This guidance manual and the storm water program emphasize development and implementation of storm water management programs as described in Chapter 6. In order to have an effective municipal storm water management program, a municipality must have adequate legal authority to control the contribution of pollutants discharged to the MS4.

Part 1 of the permit application requires applicants to describe their existing legal authority to control the discharge of pollutants from MS4s and evaluate the adequacy of these ordinances. Where existing ordinances were lacking, a proposed schedule to obtain the necessary authority was included with the Part 1 application. In Part 2 of the application, municipal applicants must demonstrate that they now possess adequate legal authority to:

- Control construction site and other industrial discharges to the MS4;
- Prohibit illicit discharges and control spills and dumping;
- Control potential sources of pollutants from discharges to or from coapplicants' MS4s, or MS4s that are interconnected or shared with other entities;
- Require compliance with all regulations and statutes; and
- Carry out inspection, surveillance, and monitoring procedures.

Section 3.2 reviews each of these regulatory requirements. Section 3.3 describes specific procedures a municipality may use to demonstrate adequate legal authority.

3.2 SUMMARY OF REGULATORY REQUIREMENTS

3.2.1 Control Construction Site and Other Industrial Discharges to the MS4.

> **§122.26(d)(2)(i)(A).** [The applicant must demonstrate that it can control] through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity.

The municipality, as a permittee, is responsible for compliance with its permit and must have the authority to implement the conditions in its permit. To comply with its permit, a municipality must have the authority to hold dischargers accountable for their contributions to separate storm sewers.

"Control," in this context, means not only to require disclosure of information, but also to limit, discourage, or terminate a storm water discharge to the MS4. For example, construction sites (of 5 or more acres) and other industrial activities that discharge storm water through MS4s are required to obtain individual NPDES permits or coverage under general NPDES permits from EPA or an authorized NPDES State. These permits require compliance with applicable Federal and State regulations. However, a municipality, to satisfy its permit conditions, may need to impose additional requirements on discharges from permitted industrial facilities, as well as discharges from industrial facilities and construction sites not required to obtain permits. Therefore, a municipality should develop a mechanism to assure that all industrial facilities and constructions sites that discharge to the MS4 know their obligation to comply with the applicable terms of the municipality's storm water ordinances.

3.2.2 Prohibit Illicit Discharges and Control Spills and Dumping

> §122.26(d)(2)(i)(B). [The applicant must demonstrate that it can prohibit] through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer.
>
> §122.26(d)(2)(i)(C) [The applicant must demonstrate that it can control] through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water.

To demonstrate that it possesses adequate legal authority to control storm water discharges, a municipality must be able to effectively prohibit illicit discharges and illegal dumping. An illicit discharge is "any discharge that is not composed entirely of storm water except discharges pursuant to a NPDES permit . . . and discharges resulting from fire fighting activities" [40 CFR 122.26(b)(2)].

3.2.3 Control Contributions of Coapplicants

> §122.26(d)(2)(i)(D). [The applicant must demonstrate that it can control] through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system.

An operator of a MS4 may participate in an application with one or more other operators, or may submit an individual application for the separate storm sewer it operates. As indicated in the box above, the operator of a discharge from a large or medium MS4 may submit, through the use of interjurisdictional agreements, a system-wide permit application. The system-wide application can accommodate existing storm water programs, on a watershed basis, as well as programs which must take into account regional differences in climate, geography, and political institutions. Such an application should cover issues of liability, financial contributions, access to records, enforcement responsibilities, and any other applicable areas of mutual concern.

When two or more municipalities submit a joint application, each coapplicant must demonstrate that it individually possesses adequate legal authority over the entire municipal system it operates or owns. A coapplicant need not fulfill every component of legal authority specified in the regulations, as long as the combined legal authority of all coapplicants satisfies the regulatory criteria for every segment of the MS4 (including authority over all sources that discharge to the MS4).

As coapplicants, for example, a county and a flood control district within that county may together possess adequate legal authority. The flood control district may have legal authority to build, operate, and maintain structures associated with major drainage channels within the county. The county itself may have legal authority to control pollutants in discharges from privately owned lands to the MS4s and legal authority to build, operate, and maintain structures associated with minor drainage channels that tie into major drainage channels. In this situation, the combined legal authority of the coapplicants may be adequate for the system, provided that the only discharge to major drainage channels comes from the county's separate storm sewer system. As another example, a department of transportation or flood control district with no land use authority could be a co-permittee with a city that does possess land use authority over the entire jurisdiction.

Coapplicants also may use interjurisdictional agreements to show adequate legal authority and to ensure planning, coordination, and the sharing of the resource burden of permit compliance. When more than one entity is submitting an application for a MS4 (either as coapplicants or as individual applicants for different parts of a system), the role of each party must be well defined. Each applicant or coapplicant must show the ability to fulfill its responsibilities, including legal authority for the separate storm sewers it owns or operates.

Applicants and coapplicants may use the procedures outlined in Section 3.3 to demonstrate adequate legal authority in their Part 2 permit applications. These procedures are guidelines, however, and are not intended to be the only possible approaches that applicants may follow.

3.2.4 Require Compliance with all Regulations and Statutes

To meet the requirements of §122.26(d)(2)(i)(E), the applicant must show that it has adequate authority to enforce its ordinances.

> **§122.26(d)(2)(i)(E).** [The applicant must demonstrate that it can require] compliance with conditions in ordinances, permits, contracts or orders.

One acceptable way to support a declaration of adequate legal authority, including the ability to enforce appropriate ordinances, is for the municipality to provide a certification from the Municipal General Counsel or equivalent. The certification should state that the applicant has the legal authority to apply and enforce the requirements of §122.26(d)(2)(i)(A)-(F) in State or local courts. The certification would, therefore, cite specific ordinances and the reasons why they are enforceable. The statement should discuss what the municipality can do to ensure full compliance with §122.26(d)(2)(i).

In a Part 2 application, through a statement from the Municipal General Counsel or through some other method, a municipality should identify the administrative and legal procedures available to mandate compliance with appropriate ordinances, and, therefore, with permit conditions. Applications should contain descriptions of how ordinances are implemented and appealed. In particular, a municipality should indicate if it can issue administrative orders and injunctions or if it must go through the court system for enforcement actions.

3.2.5 Carry Out Inspection, Surveillance, and Monitoring Procedures

In their Part 2 applications, municipalities must propose programs to control the contributions of pollutants from industrial facilities and prohibit illicit discharges. For both of these activities, municipalities must have the legal authority to carry out inspection, surveillance, and monitoring procedures necessary to determine compliance.

> **§122.26(d)(2)(i)(F).** [The applicant must demonstrate that it can carry] out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

To meet this requirement, municipalities may wish to consider establishing ordinances that require industrial facilities to perform inspections and report the results to the city. In many municipalities, these facilities may perform similar inspections under a pretreatment program. In their Part 2 applications, municipalities should provide documentation of their authority to enter, sample, inspect, review, and copy records, etc., as well as demonstrate their authority to require regular reports.

3.3 PROCEDURES FOR DEMONSTRATING ADEQUATE LEGAL AUTHORITY

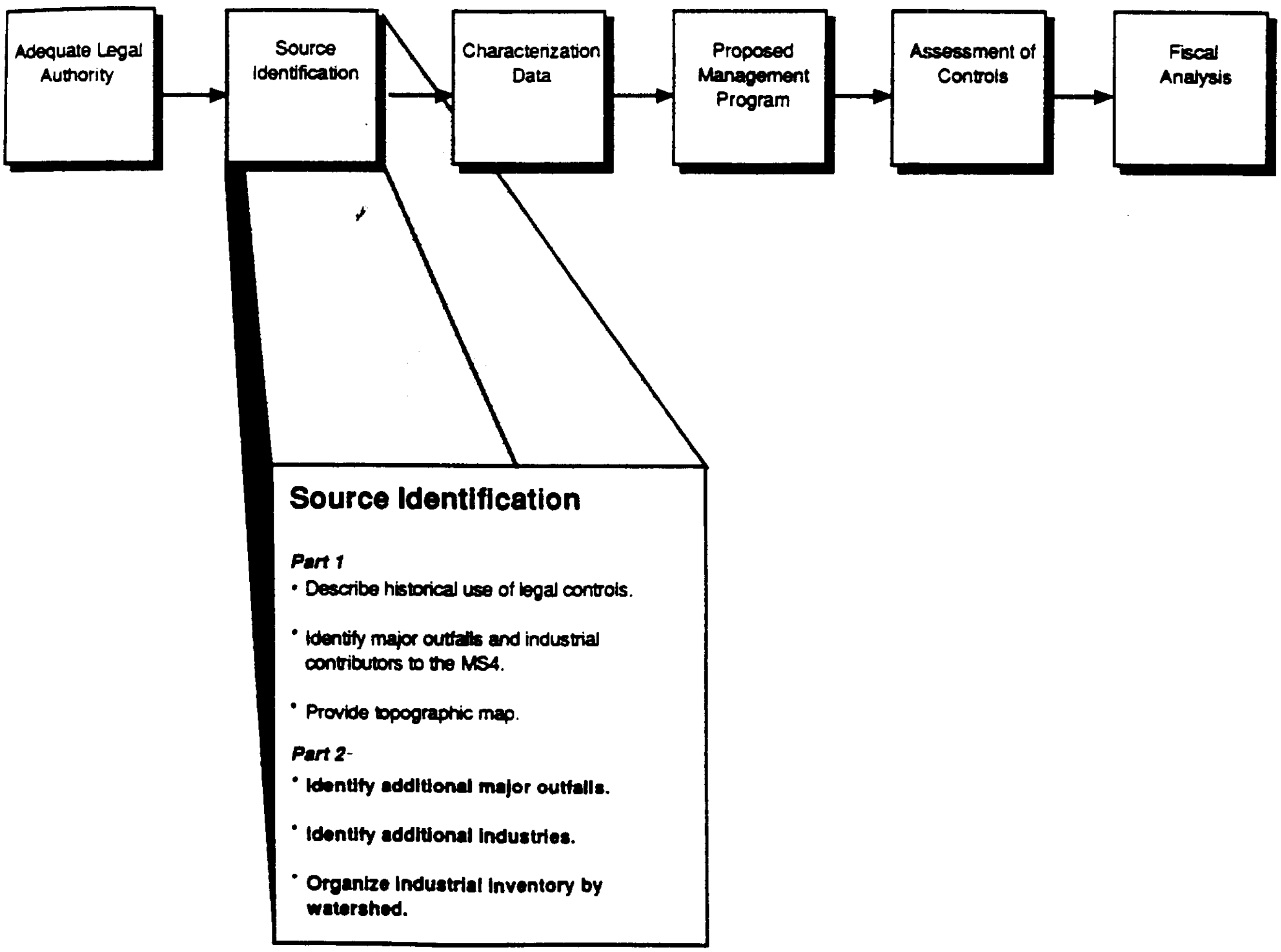
The Part 2 application requires the applicant or coapplicants to cite and describe specific ordinances currently in effect and demonstrate that the jurisdiction for these ordinances covers the entire area served by the MS4. In addition, the applicant may elect to discuss specific changes in ordinances passed since the submission of the Part 1 permit application to illustrate how legal authority has evolved to meet the regulatory requirements in §122.26(d)(2)(i). One method by which an applicant can partially demonstrate that it has adequate legal authority is to develop a matrix that compares, in a side-by-side format, the regulatory requirements in §122.26(d)(2)(i)(A)-(F) and the municipality's legal authority. Once completed, the matrix would indicate whether an adequate legal framework exists to address all key regulatory requirements identified in §122.26(d)(2)(i)(A)-(F). Furthermore, the matrix could also illustrate where the authority to mandate compliance is vested.

In order to support an assertion of adequate legal authority, applicants should include the complete text of the applicable portions of the ordinances or other such provisions in the application. The applicant should also provide a specific explanation of why and how the language of a particular ordinance or other authority meets Federal regulatory requirements. The application should indicate to whom the ordinance applies and how it will operate to control, prevent, or stop discharges that violate permit conditions. For example, the municipality may describe and provide an excerpt from a city ordinance that prohibits non-storm water discharges to the MS4.

Appendix C illustrates one way to detail the existence of ordinances that establish the legal authority required in §122.26(d)(2)(i). A narrative discussion of the historical use of these ordinances to control pollutants in storm water discharges also may be included. The example in Appendix C shows what the applicant may do to satisfy §122.26(d)(2)(i).

Substantial effort should be devoted to obtaining the necessary legal authority before the Part 2 application is submitted. However, some municipalities may find that the two-year application process does not allow enough time to secure adequate legal authority as described in this section. This may be due to the need for State statutory or legislative changes. In this instance, the Part 2 application must include a detailed description of what changes are needed and a schedule of when they will be accomplished. The schedule must include timetables for drafting proposed changes, public comment periods, and final authorizations.

CHAPTER 4
SOURCE IDENTIFICATION



4.0 SOURCE IDENTIFICATION

4.1 BACKGROUND

In Part 1 of the NPDES storm water permit application, applicants are required to identify the location of known major outfalls discharging to waters of the United States from MS4s. Applicants also are required to provide information and data on existing land use activities. The identification of outfalls and land use activities is the first step in the process of:

- Identifying the sources of pollutants in storm water runoff;
- Linking the sources of pollutants in runoff to specific water quality impacts and other impacts that may result in degradation of aquatic resources;
- Identifying those activities or physical factors that have the most significant impact on water quality;
- Defining control measures that yield improvements in storm water quality; and
- Developing methodologies by which engineers, urban planners, and managers can make long term decisions that not only provide for economic growth, but also have discernible environmental benefits through imposed storm water controls.

The source identification requirements in the Part 2 permit application reflect three basic steps. First, municipalities must **identify any major outfalls** that were not already identified in the Part 1 application. Second, applicants must **compile an inventory of industrial** activities that may discharge storm water to a MS4. Third and finally, applicants must **organize the inventory of industrial activities on a watershed basis.**

Organizing the inventory by watershed allows the municipality to focus on activities within discrete areas that may contribute pollutants in storm water discharges to waters of the United States. For example, combining outfall data with the industrial inventory organized by watershed may help the municipality to identify probable areas of illicit connections. This information will also be useful for municipalities when they develop specific strategies [e.g., best management practices (BMPs)] as part of their proposed storm water management programs. The following sections discuss regulatory requirements and procedures for completing the source identification section of the Part 2 permit application. Section 4.2 provides guidance on identifying major outfalls, Section 4.3 provides guidance on compiling an inventory of industrial dischargers, and Section 4.4 provides guidance on organizing the inventory of industrial discharges by watershed.

4.2 MAJOR OUTFALLS

The first portion of the Part 2 Source Identification provision states:

> **§122.26(d)(2)(ii).** *Source Identification.* [The applicant must provide the] location of any major outfall that discharges to waters of the United States that was not reported [in Part 1 of the application] . . . .

4.2.1 Definition of a Major Outfall

According to 40 CFR 122.26(b)(5), a major outfall is a MS4 outfall that discharges from a single pipe with an inside diameter of at least 36 inches. The term also includes discharges from a single conveyance other than a circular pipe serving a drainage area of more than 50 acres.

For those municipal separate storm sewer systems that receive storm water runoff from lands zoned for industrial activity, major outfalls also include outfalls that discharge from a single pipe with an inside diameter of 12 inches or more, or discharge from other than a circular pipe associated with a drainage area of 2 acres or more. This definition also applies to outfalls of drainage areas that have both industrial and non-industrial activity. For example, if a three acre drainage area is zoned half woodland and half industrial, the discharges from that area would still be considered a major outfall. Because the definition of major outfall includes consideration of drainage area, municipalities may need to consider conveyances such as ditches and swales when identifying major outfalls.

4.2.2 Identifying Major Outfalls

The first step in this section of the Part 2 application is the identification of major outfalls not identified in the Part 1 application [§122.26(d)(2)(ii), cited in box above]. When identifying these major outfalls, municipalities should build upon the approach used in the Part 1 application. One way to identify major outfalls is a **review of sewer system maps.** These maps can provide information on sewer system type (e.g., separate storm versus combined sewer), pipe size, and outfall location. However, depending upon the age of the sewer system maps, they may not provide complete information about newly developed areas or improvements to older areas. Often, **interviews with sewer system maintenance personnel** can provide information on the most recent changes to the sewer system. The municipality should also consider conducting field surveys (e.g., visual inspection of the banks of receiving waters) to locate major outfalls.

When submitting a Part 2 permit application, municipalities should include a brief description of how additional major outfalls were identified. This description is not intended to be a lengthy list of each sewer system employee interviewed, but rather an outline of the methods employed.

4.3 INVENTORY OF INDUSTRIAL DISCHARGERS

The second step in this portion of the Part 2 application is assembling an inventory of industrial storm water dischargers.

> **§122.26(d)(2)(ii).** *Source Identification. . . .* Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity.

This section describes how municipalities may develop the inventory of industrial facilities. Section 4.4, below, provides guidance on organizing these facilities by watershed.

4.3.1 Facilities that must be Included in the Inventory

As stated above, applicants must provide an inventory of each facility that may discharge to the MS4 storm water associated with industrial activity. Industrial storm water dischargers that must be included in this inventory fall into 11 classes of industrial activities as defined in the November 1990

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regulations. Six of these classes were defined in a narrative format and five were defined by Standard Industrial Classification (SIC) codes. Specific categories of industries are identified in §122.26(b)(14)(i)-(xi). Exhibit 4-1 provides a list of the SIC codes and industry categories cited in the regulatory definition.

4.3.2 Identifying the Industrial Facilities

As a first step in developing a comprehensive industrial storm water inventory, the applicant must review **facility notifications**. Industrial facilities were required to notify municipalities by May 15, 1991, of their intent to discharge storm water to the municipal storm sewer system [§122.26(a)(vi)(4)]. Each facility should have submitted to the municipality information including facility name, facility location, and facility type (such as SIC code or other industry categorization).

In addition, municipalities should explore other sources of information on industrial facilities to help identify gaps in inventory. One specific source of information a municipality should review is **facility information submitted under other programs**. For example, SIC codes are often required for air pollution permit applications, hazardous materials management permits, pretreatment program applications, building permits, business licenses, or local tax rolls. A municipality may take the list of SIC codes provided in Exhibit 4-1 and compare it with existing information on SIC codes or industrial categories which has been submitted by industrial facilities under other programs.

Under 40 CFR 122.28, facilities that discharge storm water associated with industrial activity must submit an individual permit application, participate in a storm water group permit application, or file a **Notice of Intent (NOI)** to be covered by a general permit. These applications and NOIs are another source of information on industrial dischargers. For existing facilities, applications or NOIs were to be submitted by October 1, 1992; for new facilities, they must be submitted prior to the commencement of industrial activity. However, in the Intermodel Surface Transportation Efficiency Act of 1991, Congress provided that permit application requirements be reserved for industrial activities owned or operated by municipalities with a population of less than 100,000, with the exception of airports, power plants, and uncontrolled sanitary landfills. If EPA is the permitting authority in a State, applications and NOIs should be submitted to EPA; if a State has NPDES authority, they should be submitted to the State. Section 308 of the CWA provides the legal authority for any individual (including a municipality) to obtain information from the NPDES permitting authority. A municipality may be able to obtain a list of the facilities in its jurisdiction that have applied for coverage under a general or individual permit or that have applied for coverage as a member of a group.

Additional sources of information on industrial facilities may include **zoning maps** showing industrial parks, manufacturing and industrial listings in **telephone books, trade association listings, pretreatment industrial waste surveys, the Chamber of Commerce Manufacturing Directory, and Dunn and Bradstreet**.

In the Part 2 application, a municipality should provide a brief description of the sources it reviewed in identifying the industrial dischargers. As part of the proposed storm water management program, which is described in Chapter 6, municipalities should describe a plan for collecting new or updated information on industrial dischargers throughout the life of the permit.

Exhibit 4-1
Industry Categories Cited in the Definition of Storm Water Associated with Industrial Activity

1. Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category 11 below.

2. Facilities described by SIC 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, 373.*

3. Facilities described by SIC 10 through 14 (mineral industry), including:

   - active or inactive mining operations, except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(1) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990; and

   - oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, by-products, or waste products located on the site of such operations.

4. Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of RCRA.

5. Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under Subtitle D of RCRA.

6. Facilities involved in the recycling of materials (metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards) including but not limited to SIC 5015 and 5093.

7. Steam electric power generating facilities, including coal handling sites.

8. Transportation facilities described by SIC 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171, which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under 1 - 7 or 9 - 11 are associated with industrial activity.

(Continued)

Exhibit 4-1 (continued)

9. Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that is located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not located within the facility, or areas that are in compliance with Section 405 of the CWA.

10. Construction activity including clearing, grading, and excavation activities except operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale.**

11. Facilities described by SIC 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories 2 - 10).*

Source: 55 FR 48065, November 16, 1990.

*Please note the SIC 285 is covered under Category 11. Also note that for the industries identified in Category 11, the term includes only storm water discharges from all areas (except access roads and rail lines) where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water.

**On June 4, 1992, the United States Court of Appeals for the Ninth Circuit found that EPA's rationale for exempting construction sites of less than five acres and certain uncontaminated storm water discharges from Category 11 light industrial facilities from Phase I of the storm water program to be invalid and has remanded these exemptions for further proceedings (see *Natural Resources Defense Council* v. *EPA* No. 91-70176).

4.4 ORGANIZING THE INDUSTRIAL INVENTORY BY WATERSHED

Once the industrial inventory is complete, the applicant must organize the inventory by watershed, or drainage area. The main objective of this requirement is to associate discrete discharges with specific watersheds, which may help the municipality identify relationships between pollutant sources and receiving water quality problems. To help organize the industrial inventory by watershed, municipalities should consider the long-term benefits of using automated database systems to help organize and update information on:

- Locations of major outfalls or system modifications;
- Land use designations and composition;
- Dischargers of storm water associated with industrial activity;
- Other NPDES permit holders;
- Location/inventory of structural controls; and
- Locations of illicit connections.

This information can help satisfy the requirement that discharges of storm water associated with industrial activity be organized by watershed. Using an automated database system or the map submitted in the Part 1 application may be helpful in satisfying this requirement. However, the regulations do not require Part 2 applicants to use a particular database or submit certain information, and municipalities may elect to use other methods.

The following procedure is provided as an example of one way to organize industrial dischargers by watershed:

1. Create a transparent overlay of tax maps covering the entire area served by the MS4.

2. Indicate on the maps the location of each industrial activity according to its address with an appropriate symbol or code.

3. Produce an overlay of existing watersheds from a topographical map, for example, United States Geological Survey (USGS) maps, covering the area that the MS4 supports. Previously performed hydrological surveys may be helpful in delineating the boundaries of existing watersheds. Municipalities may elect to sub-divide existing watersheds into smaller units if this will assist in management planning.

4. Align the tax map and watershed overlay so that industrial activity locations can be transposed to the watershed overlay.

A number of PC-based tools can be used to organize information on facilities and outfalls. For example, computer-aided design (CAD) packages, in conjunction with third-party software packages, are specifically designed to present information on separate transparent layers that can be "turned off and on" when necessary. One layer could contain information on watershed topography and another could contain the locations of industrial storm water dischargers. Additional layers might contain information on the layout of the municipal system, locations of structural source controls and outfalls, and land-use patterns (both present and future).

A CAD-based system can be useful, not only in presenting information easily and graphically, but also in its ability to transfer spatial data, such as XYZ coordinates, to commonly available PC-based database applications. This spatial data can be merged with other databases containing more generic information including facility name, address, and SIC codes. However, one potential drawback to CAD systems is that most of them cannot store "real-world" (e.g., latitude-longitude) coordinates and are not generally designed for spatial analyses.

Information stored in a CAD format may also be input into a Geographic Information System (GIS). With some conversion, the CAD system coordinates may be transformed into the "real-world" coordinates typically employed by GIS. GIS are integrated database management systems designed for the input, storage, retrieval, analysis, output, and display of geographically or spatially indexed data.

The key attribute of GIS is the relational database capabilities that make these systems powerful tools for conducting spatial analyses. Using GIS, a municipality could overlay several layers of data and derive new information from this existing information. For example, using GIS, an applicant could overlay a map showing the 100-year flood plain with a map showing locations of industrial facilities. The GIS could then calculate the amount of industrial area within the 100-year flood plain and plot this data on a new overlay. This type of spatial analysis might be a powerful tool in the design of the municipality's storm water management program.

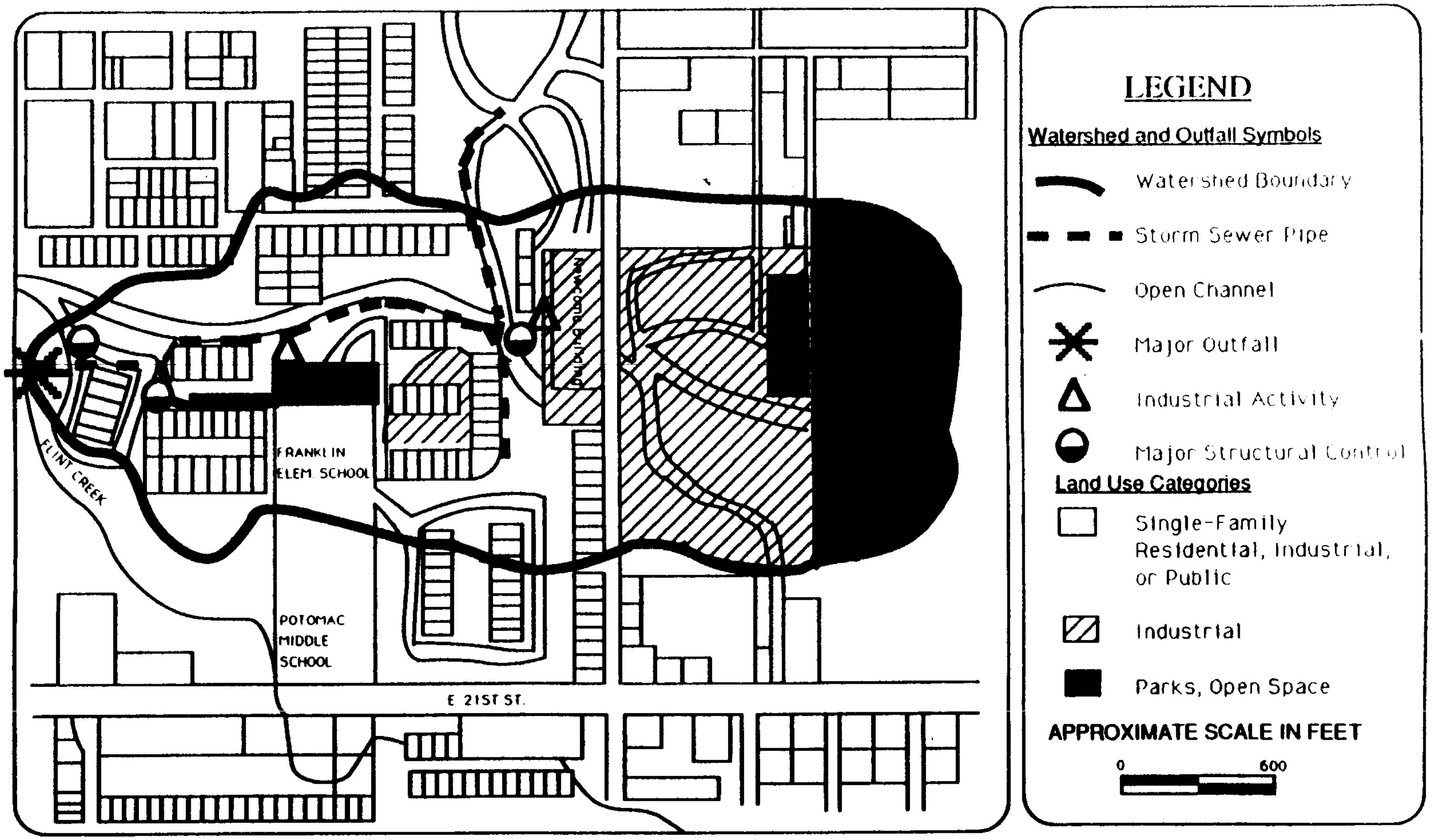
Another benefit of GIS is the ability for common data to be shared efficiently among several agencies. For example, the flood management agency, department of transportation, and storm water control agency could all contribute data to and use analyses from the same GIS. On the other hand, one potential drawback to GIS is their relatively high cost. Often, developing accurate, appropriate base maps is one of the most resource intensive parts of the system.

The techniques presented in this section to organize industrial dischargers by watershed are not the only methods that the applicant can use. For example, municipalities may elect to present the information in tabular form. Using a CAD, GIS, or other automated system is entirely up to the municipality. There is no requirement that municipalities use these systems in the development of either the Part 1 or Part 2 NPDES permit applications. Each applicant will have to examine its existing resources (including computer systems, personnel, and budget) and projected needs before deciding which method will be the most efficient and most useful in the long term.

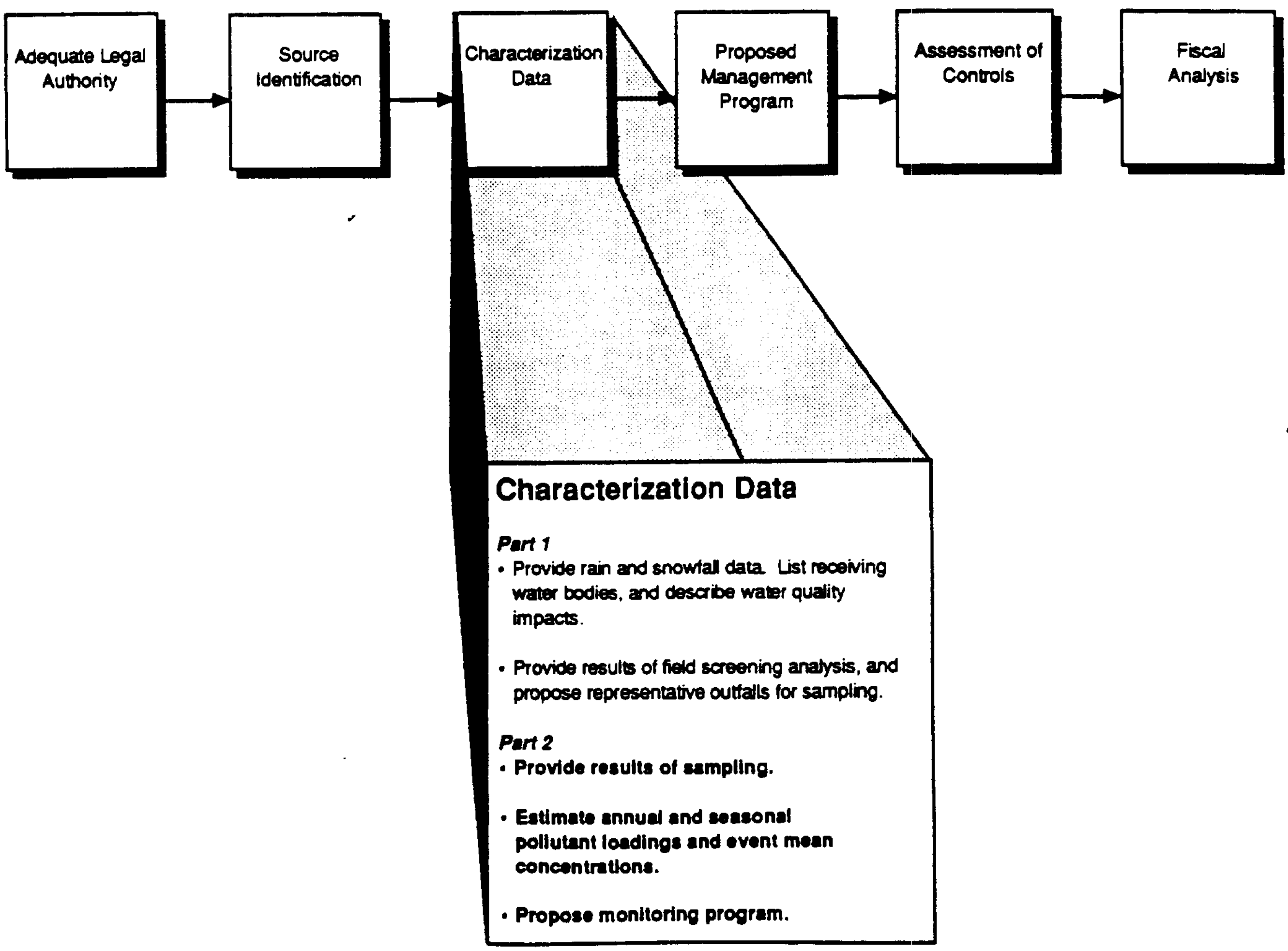
A discussion of maintaining and/or updating the industrial inventory is provided in Section 6.3.3.2 of this guidance.

Exhibit 4-2 illustrates an example of the procedure discussed in Sections 4.3 and 4.4.

Exhibit 4-2
Example of a Map Organizing Industry by Watershed



CHAPTER 5
CHARACTERIZATION DATA



5.0 CHARACTERIZATION DATA

5.1 BACKGROUND

5.1.1 Objective of this Section

This section addresses the requirements for reporting the physical and chemical characteristics of municipal storm water runoff as specified by 40 CFR 122.26(d)(2)(iii). These requirements describe the minimum quantitative and descriptive data necessary to begin characterizing storm water discharges.

The applicant is encouraged to provide additional information, if available, which may provide a basis for a more effective storm water management program. The additional information may also help the permitting authority make more informed decisions regarding the specifications of the permit to be issued.

The NPDES permit application regulations require the applicant to identify all major outfalls that are part of the MS4 [§122.26(d)(1)(iii) and 126(d)(2)(ii)]. Part 1 requires the municipality to propose a sampling plan that identifies 5-10 outfalls that would be appropriate for representative data collection under Part 2 of the application [§122.26(d)(1)(iv)(E)]. The next step is to collect and analyze samples from these outfalls (or others designated by the permitting authority) for a variety of pollutant parameters from 3 representative storm events.

5.1.2 Potential Impacts of Storm Water Runoff

The Nationwide Urban Runoff Program (NURP) study showed that discharges from MS4s contribute to the degradation of water quality in the Nation's waters (EPA, 1983). The NURP study also concluded that the effects of urban runoff on receiving water quality are very site specific. The effects depend on the types, size, and hydrology of the water body, the designated beneficial use, the pollutants which affect that use, the urban runoff quality characteristics, and the amounts of urban runoff dictated by local rainfall patterns and land use. *The National Water Quality Inventory, 1990 Report to Congress* as required by Section 305(b) of the Clean Water Act, stated that one-third of the impairment in assessed waters is due to storm water runoff (EPA, 1990d).

<u>Quantity Impacts</u>

Urbanization often increases the quantity and reduces the quality of storm water runoff. For example, vegetated or forested areas with pervious surfaces are often replaced with impervious surfaces (e.g., concrete and asphalt) that prevent or minimize the amount of rainfall available for ground water recharge. This increases the volume and velocity of storm water runoff.

Vegetated areas play a crucial role in ground water recharge and in the maintenance of stream baseflow. This is especially true during extended dry periods, when ground water is often the only source that preserves stream baseflow. In highly urbanized areas, ground water recharge may be so severely reduced that ground water flow to perennial streams during dry periods is not sufficient. Further, the natural hydrology of a watershed is often altered by urbanization, because developing areas often provide drainage appurtenances that rapidly conduct storm water runoff away from these areas. Such drainage may also affect the geometry of natural streams, especially where natural streams have been modified through the installation of man-made channels. Ultimately, reduced perviousness due to urbanization increases the magnitude and the frequency of localized flooding which can have the long term effect of substantially increasing the width of natural streams through erosion and scouring.

Increases in peak discharge velocity and runoff volume can also result in substantial erosion of natural streambanks and the washout of benthic habitats. Since streambeds often consist of unconsolidated silt and sediment, they may be stripped away substantially by excessive discharge velocities. Increased discharge velocities can also lead to undercutting and destabilization of streambanks, which may cause erosion that extends beyond the natural boundary of the streambank.

Further, silt and sediment can increase the turbidity of the receiving water, thus interfering with the growth of aquatic plants which depend on photosynthesis. Increased turbidity can also interfere with aquatic feeding, eliminate spawning areas for fish, and cause abrasion and clogging of fish gills. Also, because silt and sediment may remain in the watershed, they can blanket benthic habitats and severely reduce streamflow capacity.

In the presence of excessive volumes of storm water runoff and discharge velocities, the net impact on receiving waters can be almost indistinguishable from impacts commonly associated with the discharge of toxics (e.g., increased mortality, reduced biodiversity, and reduced reproduction).

Deposition and Resuspension of Toxicants

Research is currently on-going to examine the impact of the deposition and resuspension of toxicants as a result of wet weather events. Questions about the survivability of benthic habitats when exposed to toxicants in deposited sediments still remain. The impact of resuspended toxicants from the sediments is not well known since toxics are often bound to sediment particles that may reduce the concentrations available for biological uptake and subsequent bioaccumulation. The applicant should also be aware that different metal contaminants in sediments can exhibit different solubilities. Under varying conditions of pH and temperatures, metals deposited in sediment can become soluble again and be reintroduced into the water column.

Excessive Bacterial Levels

The NURP study final report concluded that "coliform bacteria are present at high levels in urban runoff and can be expected to exceed EPA water quality criteria during and immediately after storm events." This is of significant concern, particularly in swimming and shellfish areas.

Dissolved Oxygen Depression

The presence of oxygen-consuming pollutants in receiving waters can lead to severe dissolved oxygen depression. Factors that can cause dissolved oxygen depression include the resuspension of biodegradable organic material (which can occur in the presence of high flow velocities) or the discharge of organic pollutants in storm water discharges. The NURP study demonstrated that storm water discharges exhibit biochemical oxygen demand (BOD) levels in excess of levels commonly associated with secondary treated effluent from publicly owned treatment works (POTWs). Severe dissolved oxygen depression could contribute to fish kills, which are one of the most readily observable impacts of pollution on receiving waters.

Eutrophication

Eutrophication, or the aging of a water body, can be accelerated by excessive nutrient loadings from storm water. Advanced stages of eutrophication are often associated with substantial variations in dissolved oxygen concentration. Nutrients of concern are nitrogen and phosphorus. Phosphorus is typically the growth-limiting nutrient for plants in fresh water systems. Storm water discharges routinely contain excess concentrations of these nutrients, which can lead to excessive algal growth, commonly referred to as algal blooms. Excessive concentrations of algae can cause odor and taste problems in drinking water and can result in aesthetically unpleasant environments. In addition, the eventual decomposition of large concentrations of algae can depress dissolved oxygen in the water body to levels where fish kills occur. In nature, the process of eutrophication occurs over a substantial period of time; however, storm water discharges can rapidly accelerate this process.

Exceedance of Chronic Toxicity Criterion

Long-term exposure to toxics in excess of chronic toxicity criteria can cause sublethal effects on aquatic life. Indicators of chronic toxicity include reduced fertility, reproduction, and growth rates and a decline in the diversity of aquatic organisms. The NURP study clearly indicated that storm water discharges contain concentrations of trace metals, such as lead, cadmium, zinc, and copper in amounts that exceed the chronic toxicity criteria. Prolonged exposure to chronic concentration levels of toxics can also be lethal to aquatic organisms, primarily from the bioaccumulation of toxics within the cell tissue of the organism over a extended period of time.

Thermal Impacts

The temperature of storm water runoff may become significantly elevated via conductive and convective heat transfer with impervious, man-made surfaces. In the case of contact with impervious surfaces, the resulting temperature elevation of storm water runoff can be substantial. For example, the surface temperature of parking lots during summer months may exceed 100 degrees Fahrenheit. Consequently, storm water runoff from these parking lots will be elevated in temperature. Many aquatic organisms are extremely sensitive to changes in water temperature. Increased water temperature also reduces dissolved oxygen in streams, rivers, lakes, and wetlands. Therefore, significant discharges of storm water at elevated temperatures can, over the long term, lead to the alteration of aquatic populations.

5.1.3 Use of the Characterization Data

The NURP study analyzed storm water discharge from 28 sites representing 12 major river basins of the United States. NURP detected 77 EPA priority pollutants present in the storm water discharges sampled, including samples with concentrations that exceeded water quality criteria for certain pollutants. Those pollutants detected in at least 10 percent of the samples studied in NURP are identified in Exhibit 5-1.

The data gathered for storm water discharge characterization can be used to create a baseline measurement of pollutant concentration and loadings. The data also can be used to evaluate the effectiveness of best management practices (BMPs) as well as help identify storm water control priorities. In addition, it can be used to help identify the sources of pollutants in storm water runoff, to help establish an effective monitoring program for the life of the permit, and to help predict the impact of storm water runoff on receiving waters that are known to be impaired.

5.1.4 Storm Water Sampling and Analysis Procedures

The regulation requires that the process of collecting quantitative data for storm water characterization follow certain guidelines.

> **§122.26(d)(2)(iii)** ***Characterization data.*** When "quantitative data" for a pollutant are required under paragraph (d)(1)(iii)(A)(3) of this paragraph, the applicant must collect a sample of effluent in accordance with 40 CFR 122.21(g)(7) and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method.

Exhibit 5-1. Priority Pollutants Detected in at Least 10% of NURP Samples.

PARAMETERS	FREQUENCY OF DETECTION (%)
Metals and Inorganics:	
Antimony	13
Arsenic	52
Beryllium	12
Cadmium	48
Chromium	58
Copper	91
Cyanides	23
Lead	94
Nickel	43
Selenium	11
Zinc	94
Pesticides:	
Alpha-hexachlorocyclohexane (alpha-BHC)	20
Alpha-endosulfan	19
Chlordane	17
Lindane (gamma-BHC)	15
Halogenated aliphatics:	
Methane, dichloro-	11
Phenols and cresols:	
Phenol	14
Phenol, pentachloro-	19
Phenol, 4-nitro	10
Phthalate esters:	
Phthalate, bis(2-ethylhexyl)	22
Polycyclic aromatic hydrocarbons:	
Chrysene	10
Fluoranthene	16
Phenanthrene	12
Pyrene	15

Source: U.S. Environmental Protection Agency, *Results of the Nationwide Urban Runoff Program*, EPA Planning Division (National Technical Information Service (NTIS) Accession No. PB84-8552). December 1983.

The data collection procedures must follow the guidelines for storm water sampling outlined in §122.21(g)(7), *Effluent Characteristics*. This portion of the NPDES regulation describes the conditions under which a storm water discharge will be sampled, and which collection procedure (grab sample versus flow-weighted composite sample) is required for the water quality parameter being analyzed. These guidelines are discussed in more detail in Sections 5.3.2 and 5.3.4 of this guidance manual. In addition, EPA has available a *Storm Water Sampling Guidance Document* that describes in detail the methods used for storm water discharge sampling (EPA, 1992a).

The methods for the chemical analyses of storm water discharge samples must be conducted in accordance with 40 CFR Part 136, *Guidelines for Establishing Test Procedures for the Analysis of Pollutants*. These guidelines refer the applicant to EPA-approved methods and cite the source of the approved methods (e.g., Standard Methods for, the Examination of Water and Wastewater, ASTM methods, etc.). Note that alternative methods (i.e., those not included in Part 136) may be used under certain circumstances (see Section 5.3.4) as described in 40 CFR Part 136, and reiterated in the Characterization Data section of Part 2 of the storm water discharge NPDES permit.

The specific constituent pollutants and water quality parameters that must be analyzed in the storm water samples are presented in Section 5.3.4.

5.2 SUMMARY OF REGULATORY REQUIREMENTS

The following is a summary of the characterization data requirements for the Part 2 application:

- Quantitative data on physical and chemical characteristics of the discharge taken from at least 5 to 10 representative outfalls chosen by the permitting authority (Section 5.3);
- Estimates of both the annual pollutant load and event mean concentration of the cumulative discharges from all municipal outfalls during a storm event (Section 5.4);
- A proposed schedule to provide estimates for each major outfall of the seasonal pollutant load and the event mean concentration for constituents detected in required sampling (Section 5.5); and
- A proposed monitoring program for the life of the permit that meets specific requirements established in the regulations (Section 5.6).

5.3 QUANTITATIVE AND QUALITATIVE DATA REQUIREMENTS

5.3.1 Selection of Representative Sampling Sites

In the Part 1 application, the municipality is required to describe a plan for obtaining characterization data [§122.26(d)(1)(iv)(E)]. The plan should reflect the requirements of §122.26(d)(2)(iii).

Different types and intensities of land use activities influence, in part, the types of pollutants and the pollutant concentrations in municipal storm water runoff. Therefore, Part 1 of the permit application [§122.26(d)(1)(iii)(B)(2)] requires the applicant to describe the land use activity within the area to be covered by the permit. In Part 1, the applicant also must select a subset of all the major outfalls (see Section 4.2.1 for definition of major outfall) identified that represented surface runoff discharge of the various land use activities described. In some cases, a municipality preparing a Part 2 application may want to supplement its sampling program by collecting and analyzing samples from major outfalls that were not identified in the Part 1 application or designated by the permitting authority. This additional sampling may provide the

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municipality with data that better characterizes its MS4 discharges.

5.3.2 Criteria for Storm Water Discharge Sampling

Land use activities are not the only factors that affect the pollutant composition of storm water runoff. Storm water composition also varies according to the nature of the storm event (e.g., duration, volume), and the composition may vary throughout the duration of a single storm event (i.e., the initial discharge, or "first flush," tends to have higher pollutant loads). In order to obtain data that represents an "average" storm event, EPA requires samples from three separate storm events to characterize the surface water runoff; however, the permitting authority may allow exemptions.

> **§122.26(d)(2)(iii)(A)(*1*)** For each outfall or field screening point designated under this subparagraph, samples shall be collected of storm water discharges from three storm events occurring at least one month apart in accordance with the requirements at §122.21(g)(7) (the Director may allow exemptions to sampling three storm events when climatic conditions create good cause for such exemptions);

The criteria for sampling storm water discharge are detailed in §122.21(g)(7), *Effluent Characterization*. EPA's *Storm Water Sampling Guidance Document* addresses these criteria. For the purpose of this discussion, a brief synopsis of these criteria follows:

- For each outfall or field screening point selected, samples must be collected from three separate storm events.
- The three storm events must be at least one month apart.
- Each sampled storm event must have a rainfall of at least 0.1 inch in the drainage area.
- There must be no storm event in excess of 0.1 inch in the drainage area for at least 72 hours prior to the sampled storm event.
- The rainfall event should not vary by plus or minus 50 percent from the average or median per storm volume and duration for the region.

EPA understands that climatic conditions may make it difficult for some municipalities to sample storm events meeting these criteria. For example, storm events may be so infrequent in arid and semi-arid areas that sufficient samples cannot be obtained by the application deadline. In other areas, storms may be so frequent that it may not be possible to wait the required 72 hours between storm events. In such cases, the applicant should confer with the permitting authority in advance. In instances where representative storm events do not occur prior to the application due date, the municipality should submit its application with as much information as possible. It should include an explanation [certified by a principal executive officer or ranking elected official in accordance with §122.22(a)(3)] as to why sampling data were unavailable.

The municipality may need to perform some initial research and calculation to meet the requirements listed above. In order to determine what constitutes an average storm event for the area, the applicant should contact the National Weather Service or National Oceanographic and Atmospheric Administration's National Climate Center. Weather data is also available commercially and from airports. The applicant may also refer to the information provided in the *Storm Water Sampling Guidance Document*.

5.3.3 Narrative Description of Storm Event

> **§122.26(d)(2)(iii)(A)(2)** A narrative description shall be provided of the date and duration of the storm event(s) sampled, rainfall estimates of the storm event which generated the sampled discharge and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event;

Under §122.26(d)(2)(iii)(A)(2), the municipality must provide a narrative description of each storm that produced the discharge to be chemically and physically characterized. Such a narrative description must include:

- The date and duration of the rainfall event that produced the discharge sampled. Measurements describing the peak intensity of the storm, if available, should also be reported;

- The amount of rainfall. Rainfall conditions may vary significantly across large drainage areas, so rainfall characteristics should be spatially averaged over the drainage area, if possible. If more than one rain gauge is used, averages should be reported. Rain gauges operated near the drainage area by the National Weather Service may be used, or the discharger may collect this information;

- The time elapsed since the last rainfall event greater than 0.1 inches. Historical rainfall data from rainfall gauges can be used to provide this information. If a gauge records only daily data, municipal field personnel could be asked to provide information on times during the day a rainfall event began or ended.

5.3.4 Chemicals/Water Quality Parameters to be Measured

The storm water discharge samples must be analyzed for a number of pollutant parameters.

> **§122.26(d)(2)(iii)(A)(3)** For samples collected and described under paragraphs (d)(2)(iii)(A)(1) and (A)(2) of this section, quantitative data shall be provided for: the organic pollutants listed in Table II; the pollutants listed in Table III (toxic metals, cyanide, and total phenols) of appendix D of 40 CFR part 122, and for the following pollutants:
>
> Total suspended solids (TSS)
> Total dissolved solids (TDS)
> COD
> BOD_5
> Oil and grease
> Fecal coliform
> Fecal streptococcus
> Ph
> Total Kjeldahl nitrogen
> Nitrate plus nitrite
> Dissolved phosphorus
> Total ammonia plus organic nitrogen
> Total phosphorus
>
> *[Note that total kjeldahl nitrogen is actually a substitute for total ammonia plus organic nitrogen.]*

The complete list of chemicals is provided in Exhibits 5-2, 5-3, and 5-4. Exhibits 5-2 and 5-3 are derived from 40 CFR Part 122, Appendix D, Tables II and III, respectively. Exhibit 5-4 comes from the text of the regulation (see box above). The EPA-approved analysis procedure for the pollutants in Exhibits 5-2 and 5-3 can be found in 40 CFR Part 136. If a municipality is seeking approval to use an alternative method of analysis, then a request should be made according to procedures outlined in 40 CFR 136.4.

Exhibit 5-2: Pollutants Listed in Table II in Appendix D of 40 CFR Part 122

Pollutant		Pollutant	
Volatiles		**Acid Compounds**	
Acrolein	1,2-Dichloropropane	2-Chlorophenol	
Acrylonitrile	1,3-Dichloropropylene	2,4-Dichlorophenol	
Benzene	Ethylbenzene	2,4-Dimethylphenol	
Bromoform	Methyl bromide	4,6-Dinitro-o-cresol	
Carbon tetrachloride	Methyl chloride	2,4-Dinitrophenol	
Chlorobenzene	Methylene chloride	2-Nitrophenol	
Chlorodibromomethane	1,1,2,2-Tetrachloroethane	4-Nitrophenol	
Chloroethane	Tetrachloroethylene	p-Chloro-m-cresol	
2-Chloroethlyvinyl ether	Toluene	Pentachlorophenol	
Chloroform	1,2-trans-Dichloroethylene	Phenol	
Dichlorobromomethane	1,1,1-Trichloroethane	2,4,6-Trichlorophenol	
1,1-Dichloroethane	1,1,2-Trichloroethane		
1,2-Dichloroethane	Trichloroethylene		
1,1-Dichloroethylene	Vinyl chloride		
Base/Neutral		**Pesticides**	
Acenaphthene	Diethyl phthalate	Aldrin	Endrin
Acenaphthylene	Dimethyl phthalate	Alpha-BHC	Endrin aldehyde
Anthracene	Di-n-butyl phthalate	Beta-BHC	Heptachlor
Benzidine	2,4-Dinitrotoluene	Gamma-BHC	Heptachlor epoxide
Benzo(a)anthracene	2,6-dinitrotoluene	Delta-BHC	PCB-1242
Benzo(a)pyrene	Di-n-octyl phthalate	Chlordane	PCB-1254
3,4-benzofluoranthene	1,2-diphenylhydrazine (as azobenzene)	4,4'-DDT	PCB-1221
Benzo(ghi)perylene	Fluoranthene	4,4'-DDE	PCB-1232
Benzo(k)fluoranthene	Fluorene	4,4'-DDD	PCB-1248
Bis(2-chloroethoxy)methane	Hexachlorobenzene	Dieldrin	PCB-1260
Bis(2-chloroethyl)ether	Hexachlorobutadiene	Alpha-endosulfan	PCB 1016
Bis(2-chloroisopropyl)ether	Hexachlorocyclopentadiene	Beta-endosulfan	Toxaphene
Bis(2-ethylhexyl)phthalate	Hexachloroethane	Endosulfan sulfate	
4-bromophenyl phenyl ether	Indeno(1,2,3-cd)pyrene		
Butylbenzyl phthalate	Isophorone		
2-Chloronaphthalene	Naphthalene		
4-Chlorophenyl phenyl ether	Nitrobenzene		
Chrysene	N-nitrosodimethylamine		
Dibenzo(a,h)anthracene	N-nitrosodi-n-propylamine		
1,2-Dichlorobenzene	N-nitrosodiphenylamine		
1,3-Dichlorobenzene	Phenanthrene		
1,4-Dichlorobenzene	Pyrene		
3,3'-Dichlorobenzidine	1,2,4-trichlorobenzene		

Source: 40 CFR Part 122, Appendix D

Exhibit 5-3: Pollutants Listed in Table III in Appendix D of 40 CFR Part 122

Pollutant	Pollutant	Pollutant
Antimony, total Arsenic, total Beryllium, total Cadmium, total Chromium, total	Copper, total Lead, total Mercury, total Nickel, total Selenium, total	Silver, total Thallium, total Zinc, total Cyanide, total Phenols, total

Source: 40 CFR Part 122, Appendix D

Exhibit 5-4. Conventional Pollutants Listed in Section 122.26(d)(2)(iii)(A)(3)

Pollutant	Pollutant
Total suspended solids (TSS) Total dissolved solids (TDS) COD BOD_5 Oil and grease Fecal coliform Fecal streptococcus	pH Total Kjeldahl nitrogen (TKN)* Nitrate plus nitrite Dissolved phosphorus Total ammonia plus organic nitrogen Total phosphorus

* Total ammonia plus organic nitrogen is interchangeable with TKN.

Source: 40 CFR 122.26(d)(2)(iii)(A)(3)

Section 122.21(g)(7) specifies that certain pollutant parameters will be analyzed on grab samples taken from the outfall, whereas the remainder of the pollutant parameters require that composite samples be taken from the outfall. These types of sampling procedures are differentiated as follows:

Grab samples: discrete, individual samples taken within a short period of time (usually less than 15 minutes). Analysis of grab samples characterizes the quality of a storm water discharge at a given time of the discharge. The following measurements must be made from grab samples:

- pH
- Temperature
- Cyanide
- Total phenols
- Residual chlorine
- Oil and grease
- Fecal coliform
- Fecal streptococcus

Note that measurements of temperature and pH must be taken in the field to avoid time-dependent changes that may occur between sampling time and actual analyses.

Flow-weighted composite samples: single unit volumes composed of a mixture of samples collected proportional to flow throughout the entire runoff event or at least for the first three hours of the storm water event, if it lasts more than three hours. The flow-weighted composite sample must consist of at least three discrete aliquots per hour from the storm water discharge, or a continuous sampler may be used.

All parameters (see Exhibits 5-2, 5-3, 5-4) not listed under the description of grab samples above must be analyzed from flow-weighted composite samples. Details on taking flow-weighted composite samples may be found in the EPA *Storm Water Sampling Guidance Document*.

5.3.5 Additional Quantitative Data

Section 122.26(d)(2)(iii)(A) concludes with a provision that allows the permitting authority to request additional quantitative data if necessary to determine permit conditions.

> **§122.26 (d)(2)(iii)(A)(4)** Additional limited quantitative data required by the Director for determining permit conditions (the Director may require that quantitative data shall be provided for additional parameters, and may establish sampling conditions such as the location, season of sample collection, form of precipitation (snow melt, rainfall) and other parameters necessary to insure representativeness);

To ensure the storm water discharge system is accurately represented, the permitting authority may require that quantitative data include additional parameters and may establish specific sampling conditions, such as:

- Location where the sample is taken;
- Season of sample collection;
- Form of precipitation (snowmelt, rainfall);
- Evidence of impact to aquatic ecosystems; or
- Other parameters necessary to ensure the system is accurately characterized.

The data generated from the qualitative and quantitative analyses described under §122.26 (d)(2)(iii)(A) will be used to calculate the annual pollutant loads and event mean concentrations for each pollutant as described in subsequent parts of this section. Estimates of annual pollutant loads and event mean concentrations would then be used to assist in establishing storm water management priorities and selecting BMPs.

5.4 ESTIMATION OF SYSTEM-WIDE EVENT MEAN CONCENTRATIONS AND ANNUAL POLLUTANT LOADS

The applicant must submit estimates of the event mean concentration and annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls.

> **§122.26(d)(2)(iii)(B)** Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under §122.21(g)(7)) for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

Estimates of annual pollutant loads will be somewhat imprecise; however, municipalities should exercise best professional judgement in deriving these estimates. A description of what assumptions were made to derive pollutant loadings must be included.

Under §122.26(d)(2)(iii)(B) (see box above) applicants must provide the following:

- Estimates for the event mean concentration for pollutants listed in Exhibit 5-5 below, which can be used to estimate the annual pollutant load associated with all municipal outfalls identified under §122.26(d)(1)(iii) and (d)(2)(ii);

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- A description of the procedures for estimating constituent loads and concentrations; and
- Details on data analysis, models used, and calculation methods.

Data sources and procedures that municipal applicants may use to estimate event mean concentrations and annual pollutant loads of the cumulative discharges are discussed below.

The primary purpose for estimating annual pollutant loads and event mean concentrations is to assign priorities for implementing BMPs. Municipalities should consider the magnitude of individual pollutant loadings when assigning priorities to resources to reduce these loadings. The areas receiving the highest priority for implementation of BMPs will be those portions of the MS4 that appear to contribute the largest load of pollutants to the system. Therefore, it is the relative value of these calculations that is of importance within this regulation, not the absolute value.

Over time the accuracy of the available methods to calculate loads and concentrations will improve and the use of these estimates may assume a larger role in determining permit conditions and estimating the success of the comprehensive municipal storm water management program. The emphasis for now, however, is on the application of the most practicable methods to reasonably estimate annual loads and event mean concentrations.

5.4.1 Data Sources

The Part 1 application requires municipalities to submit all existing storm water sampling data, along with all relevant water quality data, sediment data, fish tissue or other biosurvey data taken over the past 10 years. All historical data must accompanied by a narrative description of the watershed served by the outfall from which the data are obtained, a description of the sampling and quality control program, and the monitoring location of the receiving water.

To estimate an annual pollutant load for a given pollutant, a value must be derived for the average concentration, or event mean concentration, of that pollutant. To derive this value, applicants may use either site-specific data, or data from a national or regional study, such as NURP.

Municipalities with adequate historical data may choose to use these data to estimate annual pollutant loads in the Part 2 application. However, many applicants may not have enough site-specific data to develop valid estimates. These applicants may choose to use generic data (e.g., from regional and national studies), such as the data provided in the NURP study. The NURP study's estimated range of detected concentration for specific pollutants is summarized in Exhibit 5-6.

Exhibit 5-5: Pollutants for which Event Mean Concentrations and Annual Pollutant Loads Must be Calculated

Pollutant	Pollutant
BOD$_5$	Total phosphorus
COD	Dissolved phosphorus
TSS	Cadmium
Dissolved solids	Copper
Total nitrogen	Lead
Total ammonia plus organic nitrogen	Zinc

Source: 40 CFR 122.26(d)(2)(iii)(B) (55 FR 48070, November 16, 1990)

Exhibit 5-6. NURP Study Range of Detected Concentration for Specific Pollutants

Parameter	Concentrations µg/L
Metals and inorganics:	
Antimony	2.6 - 23
Arsenic	1 - 50.5
Beryllium	1 - 49
Cadmium	1 - 14
Chromium	1 - 90
Copper	1 - 100
Cyanides	2 - 300
Lead	4 - 23,000
Nickel	1 - 182
Selenium	0.2 - 0.8
Zinc	10 - 2400
Pesticides:	
Alpha-hexachlorocyclohexane (alpha-BHC)	0.027 - 0.10
Alpha-endosulfan	0.008 - 0.20
Chlordane	n/a
Lindane (gamma-BHC)	0.007 - 0.1
Halogenated aliphatics:	
Methane, dichloro-	5 - 14.5
Phenols and cresols:	
Phenol	1 - 13
Phenol, pentachloro-	1 - 115
Phenol, 4-nitro	1 - 37
Phthalate esters:	
Phthalate, bis(2-ethylhexyl)	4 - 62
Polycyclic aromatic hydrocarbons:	
Chrysene	0.6 - 10
Fluoranthene	0.3 - 2
Phenanthrene	0.3 - 10
Pyrene	0.3 - 16

Source: U.S. Environmental Protection Agency, *Results of the Nationwide Urban Runoff Program*, EPA Planning Division (National Technical Information Service (NTIS) Accession No. PB84-8552). December 1983.

The applicant should be aware of limitations associated with data from national and regional studies before deciding on methods to estimate pollutant loadings. In some cases, it may be more appropriate to use any available site-specific data rather than data from national or regional studies. For example, the NURP study did not collect pollutant concentration data from industrial areas. In this instance, even limited site specific concentration data from industrial areas may be more meaningful.

EPA encourages applicants to seek data from a variety of sources to better characterize the quality of their storm water discharges. Regardless of the data source, a description of the procedures for estimating constituent loads and concentrations, including any modeling, data analysis, and calculation methods, must be included.

There will be a degree of uncertainty associated with estimating pollutant loadings in the Part 2 application. The requirement to calculate pollutant loadings and concentrations is intended to be a planning and screening effort to assign program priorities, and not necessarily to determine absolute values.

5.4.2 Event Mean Concentrations

Event mean concentrations (C_i in Equation 1 on page 5-16) are determined from analyses of flow-weighted composite samples collected from each of the designated field screening points. Section 2.2.4 of the *Storm Water Sampling Guidance Document* describes procedures for collecting flow-weighted composite samples (EPA, 1992a). Concentration values must be reported in the applicant's Part 2 Permit Application for each representative storm event sampled. The applicant should report the average of these results as the event mean concentration for each parameter measured. Municipalities are encouraged to present data in a tabular format. However, the applicant has flexibility to present the data in other ways, provided the data is clearly presented.

As stated previously, applicants must sample storm events for at least three hours, or for the entire storm event if it lasts less than three hours. If a storm event lasts more than three hours, the applicant may choose among three approaches for calculating the event mean concentration of the storm. First, the applicant may report the event mean concentration for the first three hours of the event (or longer, if the applicant monitored more than three hours). Second, if the applicant has data available on the correlation between flow and concentration which allows it to be more specific about the event mean concentration, an estimation technique may be used to derive the event mean concentration. If the applicant uses such an estimation technique, the methodology must be explained. Third and finally, the applicant may monitor the entire storm event and report the actual event mean concentration.

Whichever approach the applicant uses, the same method should be used to derive event mean concentrations in the future. This will assist the applicant in identifying meaningful trends in changes in event mean concentrations over time.

5.4.3 Annual Pollutant Loadings

Municipalities may choose from a variety of acceptable procedures for estimating the annual pollutant loads of the cumulative discharge. This guidance contains an example of calculating the annual pollutant loads using the "simple method," which is adapted from Schueler (1987). The guidance also discusses some dynamic models that applicants may wish to employ.

Regardless of which method applicants choose, they must describe and document the specific technique used. The description should include (but is not limited to) the key equations used to calculate reported values, such as:

- Assumptions for selecting site-specific parameters (e.g., runoff coefficients);

- References to any source documentation (e.g., previously completed studies or reference textbooks); and

- Justification for any assumed parameter values.

The Simple Method

The following method of computing pollutant loadings is referred to as the "simple method" and is adapted from Schueler (1987). For purposes of satisfying Part 2 application requirements, the simple method provides a quick and reasonable estimate of pollutant loadings with a minimal amount of data required. Although the regulations require a system wide (cumulative) annual pollutant load calculation for each of the pollutants listed in Exhibit 5-5 (above), the single pollutant load values provide limited insights into potential problem areas and what BMPs might yield the best results. Consequently, the municipality may want to consider using the simple method to estimate "individual" pollutant loadings from drainage areas. The individual pollutant loadings can be aggregated to derive a cumulative annual pollutant loading for the entire MS4. In the procedure below, for example, Step 1 computes the annual loading for each outfall of the MS4. Then in Step 2, the resulting pollutant loadings are summed to derive annual pollutant loads on a per-watershed basis. In Step 3, the annual pollutants loads for each watershed are summed to derive a system-wide annual pollutant load.

As stated above, this procedure is only one example of how a municipality could calculate a system-wide annual pollutant load. Estimates of annual pollutant loads for individual outfalls, watersheds, or other discrete areas are not specifically required by the regulations. However, municipalities will find such estimates helpful in making relative comparisons among different areas of the MS4. Ultimately, these estimates could assist the municipality with selecting BMPs and assigning priorities to potential problem areas.

Step 1: Use the Simple Method to Calculate Annual Pollutant Loads on a Per-Outfall Basis

The first step in this example is to calculate annual pollutant loads for individual outfalls. However, the applicant may choose to begin by calculating annual pollutant loads for each watershed or other discrete area. As stated above, this example uses the simple method, which is given by the following equation:

EQUATION 1:

$$L_i = \left[\frac{(P)(CF)(Rv_i)}{12}\right](C_i)(A_i)(2.72)$$

where:
- L_i = Annual pollutant load (lb/outfall/yr)
- P = Annual precipitation (in/yr)
- CF = Correction factor that adjusts for storms where no runoff occurs (a value of 0.9 is typically used)
- Rv_i = Weighted-average runoff coefficient for the area served by the outfall (the calculation of runoff coefficients is discussed below)
- C_i = Event mean concentration of pollutant (mg/L)
- A_i = Catchment area (acres)

The numbers 12 and 2.72 are conversion factors that account for unit conversions.

Each of the parameters in Equation 1 is defined below:

- **Annual pollutant load** is the total amount of a specific pollutant discharged in pounds per time period (in this case, per year) for the particular segment of the MS4 being modeled (in this case for each outfall). Pollutant loads may also be expressed for alternative time periods, or on a system-wide or watershed basis.

- **Annual precipitation** is the total inches of rainfall occurring in a single year plus the contribution of snowmelt. Estimates of the annual rainfall can be based on the rainfall data provided in Part 1 of the application.

- **Correction factor** is an adjustment factor for the number of storm events that do not actually produce any runoff (i.e., the percentage of storm events that have a total accumulation greater than a specific threshold value). This value will vary by region. Without this adjustment factor, the municipality would be assuming that all storm events produce runoff, which may or may not be the case. A typical value for this correction factor is 0.9 (90%). However, this value can vary between climatic regions. Municipalities should review historical rainfall data to estimate the percentage of storm events that produce runoff versus the number of storm events per year.

- **Weighted-average runoff coefficient** is a relative measure of imperviousness or the percentage of rainfall that becomes surface runoff. Runoff coefficients are a function of the type of surface, intensity of the rainfall, the degree of soil saturation and storativity (storage capacity) of the soil. To deterimine runoff coefficients, the municipality may use Equations 2 or 3 (which follow). Alternatively, the municipality may use actual field measurements, relevant hydrologic studies, average values published in civil engineering reference manuals, or default values provided in Exhibit 3-12 of EPA's *NPDES Storm Water Sampling Guidance Document*.

- **Event mean concentration of pollutant** is the event mean concentration value for the specific pollutant determined from the analysis of flow-weighted composite samples. Equation 1 requires a value for each pollutant concentration. As discussed previously, the applicant may use site-specific concentration data (e.g., storm water sampling data) or generic (e.g., NURP) data to derive event mean concentrations. In other words, the applicant should use best professional judgement to decide which of the following concentration values to use:

  - a mean concentration value from the NURP study;

    OR

  - an average of all event mean concentrations from all samples over three representative storm events;

    OR

  - an event mean concentration attributable to a specific land use activity.

  The applicant will have to consider the extent of the variability of the data when selecting an appropriate concentration value. NURP or other regional studies used to estimate pollutant concentrations can be compared to existing site-specific data in order to assess the uncertainty associated with generic approaches.

- **Catchment area** is the size of the drainage area for the particular segment of the MS4 being modeled (in this case, the outfall drainage area). Areas that are served by combined sewers or that are not otherwise served by the MS4 should not be included.

Weighted-average runoff coefficient. Runoff coefficients can be based on flow measurements or estimated from land use characteristics. In order to determine an average runoff coefficient for an area with a diversity of land use activities, the following equation should be used to estimate a weighted-average runoff coefficient:

EQUATION 2

$$Rv_i = \frac{(\sum A_t R_v)}{\sum A_i}$$

where: Rv_t = Weighted-average runoff coefficient
A_t = Catchment area (acres)
R_v = Catchment runoff coefficient

As an alternative to Equation 2, Equation 3 can be used to estimate weighted-average runoff coefficients from percent imperviousness data (Shelley, 1986):

EQUATION 3

$$Rv_i = 0.05 + 0.009 * I$$

where: Rv_t = Weighted-average runoff coefficient
I = Percent imperviousness

The percent imperviousness can be estimated from land use data. Residential land can be assumed to be 24% impervious; commercial land 75% impervious; industrial land 55% impervious; and open space 15% impervious. The percent imperviousness of residential land was estimated from the following empirical equation of NURP and USGS data, which relates population density to percent imperviousness:

EQUATION 4

$$I = 9 * D^{0.5}$$

where: I = Percent imperviousness
D = Population density (persons/acre)

Similar to Equation 1, individual parameters for Equations 2, 3, and 4 can be used on a system-wide basis, or modified to reflect more realistic conditions within smaller or discrete segments (e.g., individual watersheds or outfalls).

Step 2. Use the Per-Outfall Annual Pollutant Loads to Calculate Per-Watershed Annual Pollutant Loads

If the simple method is used to compute the annual loading on a per-outfall basis, Equation 5 may be used to estimate annual pollutant loadings on a per watershed basis. The approach of computing pollutant loadings on a watershed basis is used by some counties where larger watersheds are segregated into smaller watersheds or drainage areas on the basis of similar land use designations. One county uses this method in conjunction with forecasts of future development within the county to develop preliminary estimates of future pollutant loadings. This approach minimizes the possibility of computing an annual pollutant loading that is too conservative.

EQUATION 5

$$L_w = \sum L_i$$

where: L_w = Annual pollutant load for a particular watershed
$\sum L_t$ = Summation of individual annual pollutant loadings from all major outfalls within a specific watershed

Step 3: Use the Watershed-Based Annual Pollutant Loads to Calculate System-Wide Annual Pollutant Loads

To calculate the annual loadings system-wide, use the following equation:

EQUATION 6

$$L_n = \sum L_w$$

where: L_n = Annual pollutant load for an entire MS4

$\sum L_w$ = Summation of individual annual pollutant loadings from all watersheds within a municipal separate storm sewer system

Dynamic Models

In instances where a municipality has a significant amount of historical data for the drainage areas serviced by storm sewer outfalls, including historical precipitation data and receiving water concentration and flow data, the MS4 may elect to use dynamic models to derive pollutant loads and to analyze the effects of MS4 discharges on receiving waters.

Dynamic models are designed to calculate a complete probability distribution for the output being modeled. Therefore, dynamic models take into consideration the inherent variability of data associated with MS4 discharges, such as variations in concentration, flow rate, and runoff volume.

One benefit of using a dynamic model is that the calculation of a complete probability distribution allows the modeler to consider a multitude of "what-if" scenarios. For example, when sufficient historical data is available, the modeler could consider the benefits and risks associated with alternative BMP strategies.

Dynamic models have one additional benefit over steady-state models in that dynamic models determine the entire discharge concentration frequency distribution. Consequently, this would enable the modeler to examine the effects of storm water discharges on receiving water quality in terms of the frequency by which water quality standards may be exceeded. For purposes of computing pollutant loadings, a number of models are available including EPA's Stormwater Management Model (SWMM) and Hydrologic Simulation Program (HSPF); U.S. Army Corps of Engineers' Storage, Treatment, Overflow, Runoff Model (STORM); and Illinois State Water Survey's Model QILLUDAS (or Auto-QI).

Regardless of the method employed, the applicant must document how pollutant loadings are derived. Applicants must provide estimates of annual pollutant loads and event mean concentrations for each outfall with their Part 2 applications. However, some outfalls will need to be more completely characterized, and conditions will change after the permit is approved. This is one reason why, as described in Section 5.4, data collection will continue throughout the term of the permit. Estimates of the individual contribution of pollutant loadings for each watershed or major outfall will help the applicant select priorities for specific watersheds.

5.5 PROPOSED SCHEDULE FOR SEASONAL LOADS AND REPRESENTATIVE EVENT MEAN CONCENTRATIONS OF MAJOR OUTFALLS

> **§122.26(d)(2)(iii)(C)** A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(*1*) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section;

Seasonal pollutant loads are important because they are a more accurate representation of loadings that may occur during a short time interval. To further refine the annual pollutant load estimates, Part 2 requires the applicant to propose a schedule to estimate seasonal pollutant loadings and event mean concentrations for each major outfall.

The quality of the data available when the Part 2 application is prepared will affect the accuracy and usefulness of the initial estimates of pollutant loadings and average concentrations. These estimates can be improved as more site-specific data are collected during the term of the permit. A long-term site specific monitoring program will capture the variability in data that is essential to estimate more accurate pollutant loadings over time. Therefore, the impacts associated with these loadings can also be estimated with greater certainty. In addition, a site specific record collected over a longer time frame allows the effectiveness of the comprehensive municipal storm water management program to be evaluated.

Estimates must be submitted for any contaminant detected in any sample required under the Part 2 sampling effort [§122.26(d)(2)(iii)(B)]. Seasonal pollutant load estimates are required for any pollutants listed in Exhibits 5-2, 5-3, and 5-4 that were detected during the sampling procedure described in Section 5.3.4. Therefore, the analyses required for seasonal pollutant loads will potentially be more comprehensive than the analyses of annual pollutant loads. This results from the possibility that additional pollutants will be detected as part of the storm water characterization studies.

In some regions, precipitation patterns vary significantly from season to season, resulting in significantly different pollutant loadings throughout the year. In arid and semi-arid parts of the country, pollutants accumulate during dry spells, resulting in significantly higher pollutant concentrations in storm water discharges after extended dry weather. Because of the buildup of accumulated pollutants, pollutant concentrations in discharges from MS4s are typically highest during the "first flush," or initial discharge.

In other regions, pollutants that accumulate in snow may lead to high pollutant concentrations in runoff from the spring thaw. Therefore, using an annual average pollutant loading might disguise the impact of shock loadings (discharges that occur within a very short time period and which often exceed acute toxicity criteria) of certain pollutants. Numerous factors contribute to the total volume of snowmelt runoff including shortwave and longwave radiation, condensation or vaporization, convected heat transfer by wind, heat content of rain water, and conductive heat transfer from the ground. Therefore, for regions with significant snowfall, pollutant loading estimates need to be adjusted to account for the additional volume of runoff attributable to snowmelt.

Since snowmelt runoff can occur in either the presence or absence of a storm event, the computation of seasonal pollutant loadings becomes significantly more complex. The determination of total snowmelt runoff, however, is beyond the scope of this manual. Affected municipalities are encouraged to contact the U.S. Geological Survey or the Army Corps of Engineers for historical data on snowmelt runoff.

The effects of pollutant load can also vary by season. Nutrient pollutant loads from storm water discharges can promote algal blooms in receiving waters during the spring and summer, but they may be of little consequence during winter in surface waters with good flushing characteristics. Quantifying seasonal variations in pollutant loads may aid the development of more cost-effective storm water management programs.

Pollutant loads also may vary significantly from one outfall to another. Within a drainage area, the type of land use, the percent of surface that is impervious, and the extent of exposure of storm water to contaminants affect the pollutant load from an outfall. Procedures for estimating seasonal pollutant loadings must be proposed for major outfalls only.

Under §122.26(d)(2)(iii)(C) the regulation requires a schedule to provide estimates of:

- The seasonal pollutant load for each identified major outfall.
- The event mean concentration of a representative storm for any constituent detected in any sample required.

The following steps can be taken to develop a proposed schedule for estimating seasonal loadings at major outfalls:

1. Use historical or long-term hydrologic data to define seasons.
2. Describe the procedure to be used to estimate seasonal loads. This could be an adaption of the simple method or another mathematical model used for annual loads (e.g., instead of using a total annual rainfall accumulation, use an average rainfall accumulation associated with a specific season). If the simple method is used, the municipality could still use Equation 1. However, the amount of rainfall (P) would no longer be an annual value. Instead, it would be the amount of rainfall associated with a particular season defined by the municipality. In addition, the applicant may have to adjust the average runoff coefficient to reflect seasonal changes (e.g., frozen ground can behave like an impervious surface and substantially increase the amount of runoff). Lastly, substantial differences in the frequency and duration of seasonal storm events may increase or decrease the correction factor CF (e.g., during a dry season, the number of storms that actually produce runoff may be substantially lower than during a wet weather season).
3. Identify data elements that need to be refined. In cases where there is substantial seasonal variation, revised runoff coefficient values may be necessary. For example, during rainy seasons, ground surfaces are more saturated than during the dry season. As a result, the same amount of rainfall in the wet season will lead to a greater volume of storm water runoff than in the dry season.
4. Proposed procedures for collecting the appropriate data or otherwise improving estimates.
5. Provide an approximate time frame for data collection and submission of seasonal load estimates.

Proposed procedures for estimating seasonal pollutant loadings and event mean concentrations should explain when and how data used for the estimates will be obtained. The data can be based on site-specific information, or they can be obtained from municipal systems with similar characteristics (such as Regional NURP data).

5.6 COLLECTION OF REPRESENTATIVE DATA FOR PROPOSED MONITORING PROGRAM FOR THE TERM OF THE PERMIT

Under §122.26(d)(2)(iii)(D), applicants are given the opportunity to propose monitoring programs to be carried out during the term of the permit.

> **§122.26(d)(2)(iii)(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.**

Applicants should consider their specific needs and identify priorities for the proposed monitoring program. After receiving the Part 2 application, the permitting authority will review proposed monitoring programs and make appropriate adjustments when establishing permit conditions.

The applicant must propose a monitoring program for representative data collection for the term of the permit that describes:

- The location of outfalls or field screening points to be sampled (or the location of instream stations);
- Why the location is representative;
- The frequency of sampling;
- Parameters to be sampled; and
- A description of sampling equipment.

Municipalities must submit sampling data over the life of a permit so that changes in storm water quality can be assessed. Like initial sampling data, the data from an on-going monitoring program can be used by the municipality to allocate resources to achieve reduction in pollutants. The monitoring data will also serve as an environmental indicator of the success of the storm water management program. Many municipalities may require an extended period of time (possibly the entire permit term) and substantial data to definitively evaluate the effectiveness of a storm water management program. Therefore, a plan for data collection must be proposed by the municipality for the five-year term of the permit. During the permit term, the results of the monitoring program will be submitted in the municipality's annual report [§122.42(c)(4), discussed in Section 7.3 of this guidance].

5.6.1 Goals of a Monitoring Program

The first and most important step in developing a proposed monitoring program is to define the program's objectives as clearly as possible. Development of monitoring program goals should be closely coordinated with development of the proposed storm water management program. Applicants are required to propose monitoring programs as part of their proposed management programs to reduce pollutants from industrial site runoff. The monitoring plan is part of *Characterization Data* [§122.26(d)(2)(iii)]. The storm water management program is discussed in Section 6.

A comprehensive monitoring program should be designed to support specific goals, including:

- Characterizing discharges;
- Evaluating the source of specific pollutants;
- Evaluating the performance of specific source controls; and
- Identifying the full range of chemical, physical, and biological water quality impacts.

5.6.1.1 Characterizing Discharges

Monitoring pollutants in discharges from MS4s serves several purposes. Quantitative data on specific pollutants in storm water runoff can support estimates of annual and seasonal pollutant loadings and modelling efforts to identify the magnitude of water quality impacts. Over the long term, monitoring data may suggest that new outfalls should be selected for sampling. As municipalities gain experience in storm water sampling, they likely will target BMPs that achieve the greatest improvements in storm water quality.

5.6.1.2 Evaluating the Source(s) of Specific Pollutants

Some sources of storm water (e.g., industrial sources that must be covered by NPDES permits, highways with heavy traffic flows, and large parking lots) are expected to generate significantly higher concentrations of pollutants than typical urban runoff. Monitoring efforts to quantify sources of priority pollutants can provide support for resource allocations to address pollutant sources posing the greatest environmental risk. How proposed monitoring efforts will be structured to identify and quantify pollutant sources should be discussed in proposed storm water management programs.

The monitoring program may also include procedures to conduct dry-weather monitoring over the term of the permit to help detect illicit discharges and improper dumping. This can include recording visual observations and odors observed in dry weather flows.

5.6.1.3 Evaluating the Performance of Specific Controls

Pollutant removal efficiencies are fairly well known for certain structural BMPs. However, sampling may still be necessary to ensure that the BMP is meeting original design expectations. The expected pollutant removal efficiency for a structural control must take into account site-specific conditions. For example, an infiltration basin has a certain expected pollutant removal efficiency, but actual field efficiency is affected by subsurface soil conditions and the extent and frequency of maintenance.

The efficiency of a particular structural control will be affected by many factors, such as detention time. However, efforts to determine the efficiency of structural controls must include consideration of pollutant concentrations and flow volumes into and out of the control. The efficiency of nonstructural source controls can be characterized by comparing discharges at a given location before and after the control measures are implemented. Over time, sufficient monitoring data may be gathered to draw substantive conclusions about the effectiveness of certain BMPs. Alternatively, discharges from a sampling site with source controls can be compared with discharges from a similar site that lacks source controls. Efforts to monitor the effectiveness of controls should be closely coordinated with the assessment of control efficiencies discussed in Chapter 7.

5.6.1.4 Identifying the Full Range of Chemical, Physical, and Biological Water Quality Impacts

Characterizing the effect of storm water discharges on water quality is complicated by a number of factors. EPA recommends an integrated approach to assessing water quality impacts associated with discharges from MS4s. Monitoring procedures that help assess water quality impacts include:

- Discharge and receiving water monitoring to support water quality models and to identify hydraulic impacts of increased peak flows and to identify parameters of concern; and
- In-stream monitoring of water chemistry;
- Bioassessments and biosurveys; and
- Sediment sampling.

<u>Discharge and Receiving Water Monitoring to Support Water Quality Models</u>

As discussed above, when there is sufficient historical data available from monitoring, these data may be used as inputs to models that predict or validate the effects of pollutant loadings from MS4s on receiving water quality characteristics. In addition to monitoring data, data on receiving water quality characteristics are also necessary to calibrate a particular model.

Once the model has been calibrated to reflect site-specific conditions, future monitoring data could be used to validate long term reductions in pollutant loadings, the effectiveness of nonstructural BMPs, and/or pollutant removal efficiencies of existing structural controls.

The information gathered from this approach may also help define those BMPs that which appear to be the most effective. For example, in developing areas, monitoring data could eventually support future planning efforts that would seek to minimize the impact of future development on local receiving waters.

In-stream Monitoring

Using models to estimate pollutant concentrations in receiving waters can be inaccurate. In-stream monitoring can directly measure pollutant concentrations. General designs for in-stream monitoring are:

- **Monitoring above and below a set location.** This method is generally more useful for evaluating control effectiveness than documenting the severity of a diffuse source of pollutants.

- **Monitoring at different times.** Monitoring at different times and seasons can provide valuable information on seasonal variations in pollutant concentrations. Dry weather in-stream monitoring can be compared with in-stream monitoring during storm events.

- **Paired watersheds.** Evaluating similar water bodies can document management program improvements by controlling for meteorologic and hydrologic variability. This approach can also be used to compare receiving waters to background conditions associated with undeveloped watersheds.

Detailed guidance on applying these approaches is provided in the draft *Nonpoint Source Monitoring and Evaluation Guide*, February 26, 1988, Nonpoint Source Branch, U.S. EPA.

Bioassessments and Biosurveys

A biological assessment, or "bioassessment," is an evaluation of the biological condition of a water body using biological surveys and other direct measurements of resident biota in surface waters. A biological survey or "biosurvey," consists of collecting, processing, and analyzing representative portions of a resident aquatic community to determine the community structure and function. Biosurveys and bioassessments can be used directly to evaluate the overall biological integrity (structure and/or functional characteristics) of an aquatic community. Deviations from the biological integrity can be measured directly using biosurveys only when the impacted community is compared against a predetermined reference condition. Without the proper reference conditions, biosurveys may underestimate the extent of impairment.

Biosurveys are useful in that they can assess or detect the aggregate effect of impacts upon an aquatic community where discharges are multiple, complex, and variable, and where point, nonpoint, and storm water discharges are all affecting the biological condition of the receiving water. Because of this, biosurveys cannot measure the impacts of one particular discharge or effluent being discharged to receiving waters. Currently, biosurveys cannot be used as a predictive water quality assessment tools.

Biosurveys provide a useful monitor of both aggregate ecological impact and historical trends in the condition of an aquatic ecosystem. They can also detect impacts that other assessment methods may miss. More importantly, biosurveys can detect impacts caused by habitat degradation such as channelization, sedimentation, and historical contamination that disrupt the interactive balance of the components of the aquatic community.

Sediment Sampling

Pollutants, both organic and inorganic, associated with storm water discharges may become physically or chemically bound with sediment particles. Depending upon the size distribution of the sediment particles, a portion of the contaminated sediment particles will settle out of the water column. Consequently, the potential exists for a buildup of contaminated sediment over time. The effects of heavily contaminated sediments on both benthic habitat and water quality have been documented to the extent that EPA is developing sediment quality criteria (SQC) that will allow assessments of the toxicological effects of contaminated sediments on varying types of receiving waters.

The amount of sediment material found in storm water discharges suggests that applying sediment quality criteria could be a useful component of a monitoring program. For example, sediment quality criteria could be a valuable preventative tool to ensure that point source discharges of storm water do not cause or contribute to the contamination of sediments.

In addition, a MS4 could make comparisons of field measurements to sediment quality criteria as a means of providing an early warning of a potential problem. Consequently, an early warning could provide an opportunity to take corrective action to prevent further contamination. For long term planning, consideration could also be given to the feasibility of establishing target levels or goals that would ensure that point sources discharges of storm water do not contribute to sediment contamination.

5.6.2 Monitoring Procedures

Monitoring procedures will depend on the objectives of the monitoring effort. To a large extent, the type of receiving water will be an important factor in developing monitoring procedures and techniques. For example, grab samples may be appropriate for monitoring discharges from a retention pond, while composite samples may be appropriate for monitoring flows into the pond. The following information, at a minimum, should be included for each sampling site:

- The criteria for storm selection;
- Whether grab, composite, continuous, or other sampling techniques are to be used;
- The criteria on when to begin and end sample collection;
- The basis for selecting the time interval between sequentially collected samples;
- How seasonal factors affect the selection of monitoring frequencies;
- The method of estimating rates or volumes of flow passing the sampling point; and
- The analytical methods used for analyzing pollutant parameters and their detection limits.

Location of Monitoring Sites and Description of Drainage Basins

The selection of monitoring sites should depend on the goals of the monitoring program. Applicants should identify the location of each proposed monitoring site and the boundary of its drainage basin. They should describe the estimated size and land use characteristics of the drainage basin for each sampling location. The applicant also should explain why the sampling sites are representative or will otherwise provide information to support a monitoring program goal. Other monitoring sites can be selected to evaluate unique conditions in the drainage area that have significant or unusual potential for generating pollutants in storm water discharges.

Samples should be analyzed in accordance with the analytical methods approved under 40 CFR Part 136.

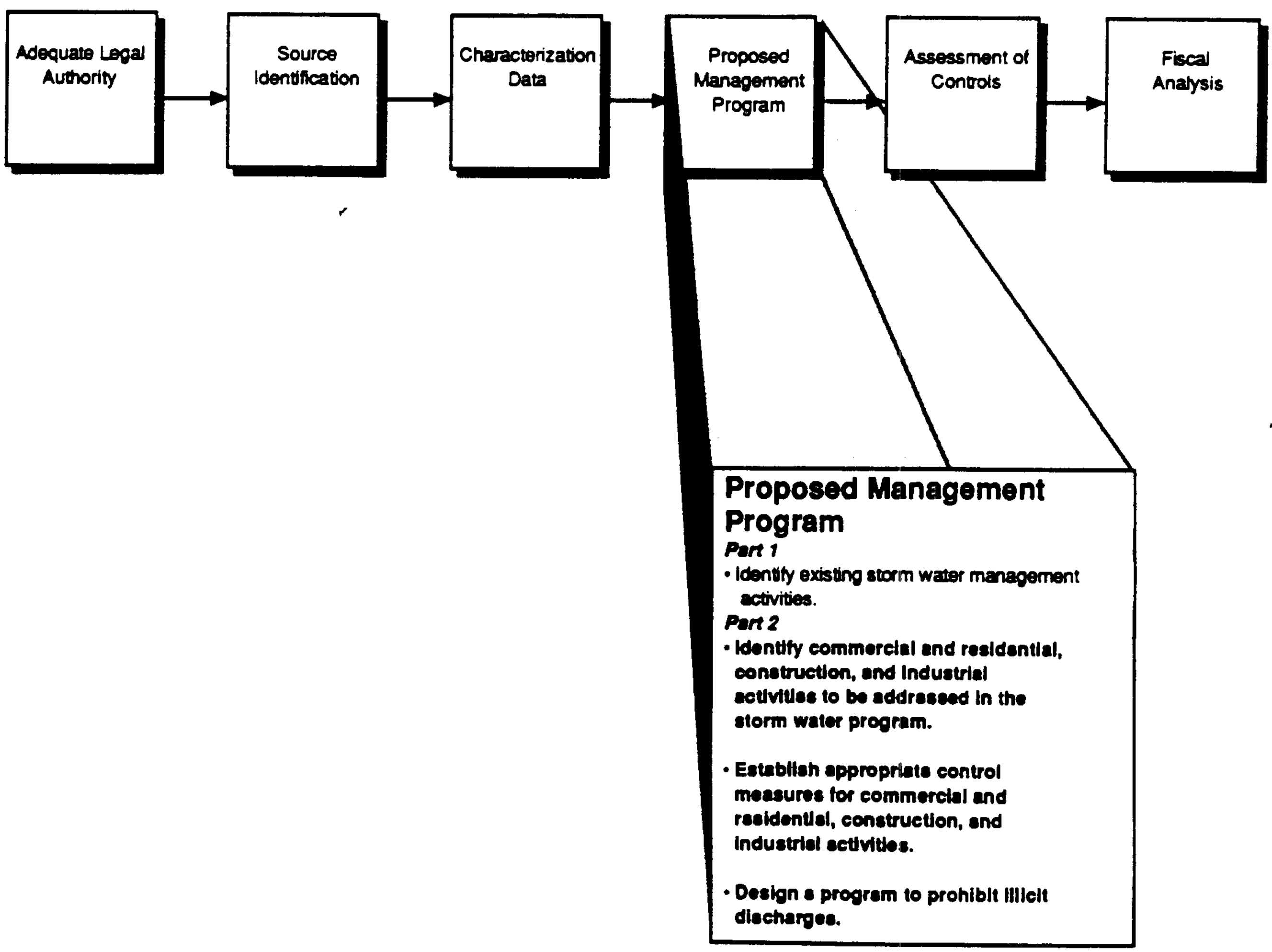
Parameters to be Analyzed

The applicant must list all parameters to be analyzed, which should depend on the objective of the sampling effort. For example, it may only be necessary to monitor several indicator parameters (such as TSS, settleable solids, nutrient, and a metal) to characterize the pollutant removal efficiency of a wet pond.

Sampling Equipment

The applicant must describe the equipment to be used in the proposed sampling program. Only the primary pieces of equipment need be identified. Descriptions can be made by reference to equipment supplied by a vendor or manufacturer if distinctive enough to be readily identified.

CHAPTER 6
PROPOSED MANAGEMENT PROGRAM



6.0 PROPOSED MANAGEMENT PROGRAM

6.1 BACKGROUND

Under the Part 2 application requirements, municipalities must propose site-specific storm water management programs. This is the most important aspect of the permit application. The Part 2 application requirements provide each MS4 with the flexibility to design a program that best suits its site-specific factors and priorities.

The regulations require the applicant to provide a description of the range of control measures considered for implementation during the term of the permit. Applicants must meet all the requirements of the Part 2 application regulation. However, flexibility in developing permit conditions is encouraged by allowing municipalities to emphasize the controls that best apply to their MS4. For example, a municipality that expects significant new development may focus more on requirements for new development and construction, while a municipality that does not expect significant new development may focus more on a program to prohibit illicit discharges or control industrial contributions. In any case, a satisfactory proposed management program will address: management practices; control techniques and systems; design and engineering methods; and other measures to ensure the reduction of pollutants to the "maximum extent practicable (MEP)."

If the municipality proposes a thorough and complete program, the permitting authority is likely to incorporate all or part of the proposed management program into the NPDES storm water permit written for that municipality. Therefore, the proposed programs provide municipalities with the opportunity to have substantial input into their NPDES permit conditions.

This section of the guidance manual describes the minimum information requirements for proposed storm water management programs. Examples of how the program elements should be addressed are provided. These examples illustrate minimum information requirements for the program elements, and occasions when municipalities may opt to go beyond minimum requirements in order to meet the MEP standard.

6.2 SUMMARY OF REGULATORY REQUIREMENTS

The municipality must develop and submit a proposed management program that covers the duration of the permit. The program must integrate the information and actions described in the Part 1 application and portions of the Part 2 application (see Chapters 3, 4, and 5 of this guidance). The regulatory requirements for the proposed management program are in 40 CFR 122.26(d)(2)(iv).

At a minimum, the proposed management program must include:

- A comprehensive planning process that involves both public participation and intergovernmental coordination;
- A description of management practices, control techniques, and system design and engineering methods to reduce the discharge of pollutants to the MEP; and
- A description of staff and equipment available to set up and assess the storm water management program.

Additional provisions under §122.26(d)(2)(iv)(A) require applicants to include:

- Programs to control storm water runoff from commercial and residential areas, construction sites, and industrial facilities (including waste handling sites), (Section 6.3);

- Identification of structural control measures to be included in these proposed programs, such as detention controls, infiltration controls, and filtration controls that the municipality plans to apply to the activities addressed in its storm water management program (Section 6.4); and

- Programs to detect and remove illicit discharges, and to control and prevent improper disposal into the MS4 of materials such as used oil or seepage from municipal sanitary sewers (Section 6.5).

6.3 PROGRAMS TO CONTROL STORM WATER RUNOFF FROM COMMERCIAL AND RESIDENTIAL AREAS, CONSTRUCTION SITES, AND INDUSTRIAL FACILITIES

A proposed management program must identify the activities or areas that require controls to reduce pollutants in storm water runoff. Specifically, a proposed management program must address storm water runoff from **commercial and residential areas** (Section 6.3.1), **construction sites** (Section 6.3.2), and **industrial facilities** (Section 6.3.3). Also, areas where illicit connections or illegal discharges may occur must be identified (Section 6.5).

In addition to the requirements of the proposed storm water management program, other provisions of the Part 1 and Part 2 applications require information that will help enable the municipality to focus on identifying activities and areas that may need control measures. Examples of these provisions include:

- Identification of sources [Part 1, §122.2(d)(1)(iii)(B)(3)-(4), and Part 2, §122.26(d)(2)(ii)];

- Identification of water bodies that may be adversely affected by storm water runoff [Part 1, §122.26(d)(1)(iv)(C)];

- Organization of sources by watershed [Part 2, §122.26(d)(2)(ii)];

- Description of land use activities [Part 1, §122.26(d)(1)(iii)(B)(2)];

- Results of field screening analysis [Part 1, §122.26(d)(1)(iv)(D)];

- Results of the sampling program [Part 2, §122.26(d)(2)(iii)(A)(3)];

- Estimates of annual pollutant loads and event mean concentrations, and schedules to submit seasonal pollutant loads and event mean concentrations [Part 2, §122.26(d)(2)(iii)(B) and (C)]; and

- Findings from an on-going monitoring program [Part 2, §122.26(d)(2)(iii)(D)].

6.3.1 Commercial and Residential Activities

Under §122.26(d)(2)(iv)(A), applicants must propose structural and source control measures to reduce pollutants from commercial and residential areas.

> **§122.26(d)(2)(iv)(A).** [The proposed management program must include a] description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls.

To ensure that proposed control measures are effective, the applicant should study how storm water runoff from pollutant sources affects the existing municipal system, how the proposed control measures will enhance the existing system, and what impact the proposed measures will have on receiving waters. The control measures should recognize and emphasize the interaction between pollutant sources and the physical attributes of the municipal system and receiving waters.

Specific commercial and residential activities that must be addressed include maintenance activities and a maintenance schedule for structural controls to reduce pollutants in storm water runoff. This provision is discussed in Section 6.4.2. Other activities to be addressed include:

- Post-construction controls to reduce pollutants in discharges to MS4s resulting from new development and significant redevelopment (Section 6.3.1.1);
- Practices for maintaining and operating public streets, roads, and highways that will reduce the impact on receiving waters from storm water runoff discharges (Section 6.3.1.2);
- Procedures to assure that the impacts on receiving waters from flood management projects are assessed, and that existing structural control devices have been evaluated to determine if retrofit controls are feasible (Section 6.3.1.3);
- A program to monitor pollutants in runoff from operating or closed municipal landfills that identifies priorities and procedures for inspections and establishing and implementing control measures (Section 6.3.1.4); and
- A program to reduce to the maximum extent practicable, pollutants in storm water runoff associated with the application of pesticides, herbicides, and fertilizer (Section 6.3.1.5).

To reduce pollutants in storm water runoff from commercial and residential activities, a proposed management program might include the use of infiltration devices, detention and retention basins, vegetated swales, water quality inlets (which may include oil and water or oil/grit separators), screens, channel stabilization/riparian habitat enhancement efforts, wetland restoration and preservation projects, as well as various source control strategies and other nonstructural control measures.

6.3.1.1 New Development and Significant Redevelopment

Summary of Regulatory Requirement

New development or redevelopment often increases impervious land surfaces, which usually leads to increased pollutant levels in storm water runoff. Chemical and thermal changes in storm water runoff are commonly associated with new development and can adversely affect the quality of receiving waters. In addition, urbanization results in an increase in the volume of storm water discharges.

The Nationwide Urban Runoff Program (NURP) study (EPA, 1983) and more recent investigations indicate that controlling the contribution of pollutants in storm water discharges at the onset of land development is the most cost-effective approach to storm water quality management. Mitigating problems caused by pollutants after they have entered a MS4 is often more expensive and less efficient than preventing or reducing the discharge of pollutants at the source. Therefore, a satisfactory proposed management program will propose structural and nonstructural measures to reduce pollutants in storm water discharges from areas of new development and redevelopment. Examples of such measures are discussed below.

> **§122.26(d)(2)(iv)(A)(2).** [The applicant must include a] description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed.

Provisions under §122.26(d)(2)(iv)(A)(2) focus on the reduction of pollutants in storm water runoff **after** construction in areas where new development or redevelopment is completed. Controls that are required **during** construction are discussed in Section 6.3.2 of this guidance.

Post-Construction Controls

Proposed storm water management programs should include planning procedures for both during and after construction to implement control measures to ensure that pollution is reduced to the maximum extent practicable in areas of new development and redevelopment. Design criteria and performance standards may be used to assist in meeting this objective.

Further, storm water management program goals should be reviewed during planning processes that guide development to appropriate locations and steer intensive land uses away from sensitive environmental areas. A municipality may, for example, include provisions in the planning process that ensure that all new development in targeted areas or zones provides for a certain percentage of undisturbed area to assist in preserving post-development runoff quality and velocity as similar as possible to pre-development conditions. In its Part 2 application, a municipality should describe how it plans to implement the proposed standards (e.g., through an ordinance requiring approval of storm water management programs, a review and approval process, and adequate enforcement).

The proposed storm water management program should identify and include **planning procedures and control measures** that will be used in the municipality.

Planning Procedures

Comprehensive planning procedures typically involve incorporation of land use goals and objectives into a plan document or a plan map. These plans are often called Master Plans, Comprehensive Land Use Plans, or Comprehensive Zoning Plans.

Comprehensive or master plans are often non-binding. They provide support and direction to local officials that have the authority to make land use decisions.

While applicants do not need to submit a complete comprehensive or master plan with the Part 2 application, they should detail the planning process employed by the municipality. They must thoroughly describe how the municipality's comprehensive plan is compatible with the storm water regulations. The description should clearly:

- Identify management objectives for streams, wetlands, and other receiving waters;

- Identify areas where urban development is likely to occur and areas that are sensitive to the effects of urbanization. Consideration should be given to receiving waters, topography, soil types, ground water uses and potential impacts, and other relevant factors;

- Describe standards such as design criteria and performance standards for storm water controls for new developments, such as buffer zones, open space preservation, erosion and sediment controls, etc.;

- Describe other measures to minimize the effects of new development on storm water quality (these may include local code and ordinance requirements); and
- Identify or discuss the site development review process for the evaluation and approval of storm drainage or storm water management programs. Requirements in drainage or storm water management programs can be coordinated with review of other related plans such as those for site grading or landscaping.

There will be great variation among municipalities in their sophistication of land use planning. If the municipality has recently updated its land use plan, it may detail storm water quality issues. In other instances, there may be no policy to include storm water quality considerations in land use decisions. In such cases, the applicant must describe how consideration of those activities that affect storm water quality are to be incorporated into the municipality's comprehensive or master plan and its approval process for construction projects.

<u>Control Measures</u>

Most traditional storm water control measures focus on efficient collection and conveyance of storm water runoff to an offsite location. This approach can increase downstream property damage due to increased storm water runoff quantity and flow velocity. Corrective action often involves expensive public works projects, such as enlarging and reinforcing channels or constructing swales to provide an adequate outfall from affected or damaged areas. The traditional approach has typically involved downstream channel stabilization projects. However, these projects may also result in increased storm water runoff quantity and flow velocity.

Some recent approaches to storm water management include preserving the natural features of a watershed by maintaining vegetative cover and establishing buffer zones and open space or green areas. The benefit of employing this approach is the protection afforded to riparian areas and wetlands, as well as the preservation of a stable watershed. One additional benefit from this approach includes maintaining ground water recharge through infiltration. These approaches to storm water management minimize the impact of erosion, flooding, and other damage to natural drainage features such as streams, wetlands, and lakes. Preservation of natural habitat can be achieved through effective storm water quality control measures. More recent approaches use storm water to:

- Recharge ground water sources with runoff from impervious areas;
- Preserve baseflows of surface water bodies;
- Augment water supplies used for street cleaning and other municipal functions, such as watering public lawns;
- Increase recreational opportunities including swimming, fishing, and boating; and
- Sometimes, augment drinking water supplies if it is treated and in compliance with all applicable drinking water standards.

The municipality should consider storm water controls and structural concerns in planning, zoning, and site or subdivision plan approval. An example of effective structural control is described in Exhibit 6-1. Non-structural control measures are highly recommended for new development. They can be included during the planning, site-selection, and development stages. Examples of non-structural controls include street sweeping, buffer strip preservation, and public education.

Exhibit 6-1
Storm Water Programs in Delaware and Florida

Delaware requirements for on-site measures include water quality ponds with permanent pools. Ponds must be designed to release the equivalent volume of runoff from the first 1/2 inch of runoff from the site over a 24-hour period and have a storage volume designed to accommodate at least 1/2 inch of runoff from the site. Water quality ponds without permanent pools may also be used in Delaware's program. These pools are to be designed to release the first inch of runoff from the site over a 24-hour period.

Developers are instructed to consider infiltration practices only after ponds are eliminated for engineering or hardship reasons. Infiltration structures must be designed to accept at least the first inch of runoff from all streets, roadways, and parking lots. Other practices may be acceptable if they meet the equivalent removal efficiency of 80 percent for suspended solids. More stringent requirements may be established on a case-by-case basis.

The 80 percent removal efficiency for suspended solids that Delaware requires takes into account pollutant settling. The 24-hour detention period allows for substantial settling where most of the pollutant removal occurs. In addition, the requirement that the first inch of runoff be released over a period of no less than 24 hours reduces downstream erosion.

Source: Schueler, 1987.

For significant redevelopment, municipalities can incorporate both structural and nonstructural storm water controls. However, there are generally far more constraints and limitations on the control opportunities available at redevelopment sites. One of the primary constraints is the availability of sufficient open area to accommodate structural controls such as detention ponds. In instances where redevelopment is occurring in densely urbanized areas, storm water runoff volumes may be so large that sufficient storage capacity can not be provided without further compounding problems associated with siting and retrofitting existing storm water conveyance systems. In such cases, the municipality should consider nonstructural control measures such as traffic flow control, the use of porous construction materials for roads and parking lots, revisions to street sweeping or deicing policies, or public education programs.

6.3.1.2 Public Streets, Roads, and Highways

Summary of Regulatory Requirement

Public streets, roads, and highways can be significant sources of pollutants in discharges from MS4s. Therefore, proposed management programs must include a description of practices for operation and maintenance of public streets, roads, and highways, and procedures for reducing the impact of runoff from these areas on receiving waters.

§122.26(d)(2)(iv)(A)(3). [The application must include a] description of practices for operating and maintaining public streets, roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities.

Road maintenance practices, especially **snow management** and **road repair**, and **traffic** are significant sources of pollutants in storm water discharges. Measures to reduce the pollutants in storm water runoff from these sources should be addressed in the proposed management program.

Snow Management

Deicing salts are the main source of pollutants in runoff of urban snowmelt. Municipalities can reduce these pollutants by calibrating equipment, educating equipment operators, using alternative deicing materials, and properly storing deicing materials. As alternatives to deicing salts, the Federal Highway Administration is considering many materials that may be less polluting. However, most of these deicers contain sodium or chloride ions that are harmful to roadside trees, shrubs, and soils. One deicer, calcium magnesium acetate (CMA) may be the best option for environmentally sensitive areas (Chollar, 1990). In salt storage facilities, salt piles should be completely covered, storage and handling areas should have impervious surfaces, and contaminated runoff should be contained.

Road Repair

Road maintenance and repair activities may contribute pollutants through erosion caused by the elimination of stabilizing vegetation from roadside shoulders and ditches. Maintenance crews can decrease the potential for erosion by disturbing only the area under repair. Graded areas should also be limited in size so that repairs can be completed the same day and graded areas stabilized by the end of the workday. Other measures to reduce pollutants in storm water include scheduling potential pollutant-causing repair work during dry seasons, when possible.

Municipal equipment yards and maintenance shops that support road maintenance activities can also be significant sources of pollutants. Therefore, municipalities should consider instituting procedures that address spill prevention, material management practices, and good housekeeping.

Traffic

Oil and grease and metals from traffic are the pollutants of most concern with respect to aquatic toxicity and their ability to "wash off" roadways and enter a MS4.

In almost all instances, the pollutant concentrations in initial storm water discharge from heavily travelled streets is significant. When the initial runoff reaches the velocity needed to entrain particulates, highly soluble pollutants that have accumulated between storms are transported to the storm sewer system. Therefore, shortly after a storm event begins, the pollutant loading in the initial flow to a MS4 is often the greatest.

Pollutants from traffic can be minimized by using **nonstructural controls** (e.g., traffic reduction and improved traffic management), **structural controls** (e.g., traditional and innovative BMPs), and **changing maintenance activities**. Traditional structural controls to reduce pollutants in road runoff include vegetated swales, infiltration devices and detention/retention basins. Highways often afford opportunities for using structural controls such as detention basins on entrance or exit ramps and upstream or downstream of culvert crossings (Steward, 1992). Smaller roads may also have low-cost structural control opportunities available at culvert crossings such as vegetated swales. Many structural controls can also be placed on public or private land that is outside the right-of-way, but still may be proximate enough to capture road runoff. Any time controls are placed at culvert crossings, potential wetland impacts and instream treatment issues need to be considered.

Maintenance activities that can reduce pollutants in storm water discharges include catch basin cleaning, litter control, and targeted street sweeping. For municipalities that have developed transportation plans under the Clean Air Act, applicants should describe how they will review the plan, and amend it where appropriate, to address water quality concerns. Potential locations for installing new structural controls to reduce pollutants from road and highway runoff should be identified by applicants.

6.3.1.3 Flood Management Projects

Summary of Regulatory Requirement

The traditional focus of storm water management in many communities has been water quantity (i.e., flood) control. The proposed management program must demonstrate that flood management projects take into account the effects on the water quality of receiving water bodies, and the program must discuss whether existing structural flood control devices can be retrofitted to control water quality.

> §122.26(d)(2)(iv)(A)(4). [The application must include a] description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible.

Opportunities for pollutant reduction should be considered when determining specific controls to be proposed as the MEP standard in the storm water management program.

Control Measures

Storm water management devices and structures that focus solely on water quantity are usually not designed to remove pollutants, and may sometimes harm aquatic habitat and aesthetic values. For example, channels that are completely lined with concrete typically do not provide for aquatic habitat and tend to increase potentially erosive velocities and elevate ambient water temperatures, resulting in downstream channel enlargement and increased pollutant loadings. However, this condition can be mitigated through alternative stabilization methods.

Channel management measures that can enhance streams and their ecological values include corridor preservation, biological bank treatment, and, where necessary, geomorphic restoration (Ferguson, 1991). The municipality may also install structural devices to dampen the hydraulic energy of the flow and minimize downstream erosion. As another example, willow saplings could be planted between rip-rap, timbers, and other stabilization structures that are anchored into terraces on the side of the streambank.

Flood-control projects can be built or subsequently modified to address water quantity and water quality concerns. Sometimes existing flood control structures can be retrofitted to provide water quality benefits as well as water quantity control (EPA, 1989b). Basin retrofits are a common example. For such a retrofit, dry flood control or detention basins can be converted to wet basins by modifying outlet orifices. Additional storage can be obtained by raising the elevation of the basin embankment.

Dry retention basins, or extended dry or wet retention basins can be used to improve water quality. Dry retention basins are not as efficient or as effective in improving water quality as extended dry or wet retention basins, but dry retention basins are generally less costly to design and maintain. The decision to use dry retention or extended dry or wet retention basins should consider all these factors.

Optimally, such measures should be considered in the planning process (discussed previously). However, they can also be implemented later in the land development process (e.g., site review or public facilities requirements stage).

If a flood control authority is responsible for a portion of the MS4, the applicant should take the lead in coordinating efforts to incorporate pollutant reduction considerations in flood control projects. EPA recommends the use of Memoranda of Agreement and Memoranda of Understanding to clarify roles and responsibilities between two or more political entities.

6.3.1.4 Municipal Waste Facilities

Applicants must describe programs that identify measures to monitor and reduce pollutants in storm water discharges from facilities that handle municipal waste, including sewage sludge.

> **§122.26(d)(2)(iv)(A)(5).** [The application must include a] description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges.

The first step is to identify facilities that handle municipal waste and summarize their operations. The types of facilities that should be included are:

- Active or closed municipal waste landfills;
- Publicly owned treatment works, including water and wastewater treatment plants;
- Incinerators;
- Municipal solid waste transfer facilities;
- Land application sites;
- Uncontrolled sanitary landfills;
- Maintenance and storage yards for waste transportation fleets and equipment;
- Sites for disposing or treating sludge from municipal treatment works; and
- Other treatment, storage, or disposal facilities for municipal waste.

Applicants may combine this part of the proposed management program with the program established under §122.26(d)(2)(iv)(C), which sets standards for monitoring and controlling pollutants from similar types of solid waste facilities (e.g., those with hazardous wastes, or subject to the requirements of SARA Title III—Section 313 of the Emergency Protection and Community Right-to-Know Act). Monitoring should include all the parameters listed in §122.26(d)(2)(iv)(C) and any additional parameters listed in an effluent guideline. Procedures to evaluate, inspect, monitor, and establish control measures for municipal waste sites over the term of the NPDES permit should be described. For example, after one year of monitoring each waste handling facility category listed above, the municipality may have collected enough data to decide which facilities or types of facilities should receive a higher priority for pollutant reduction. More attention could then be focused on the high-priority sites.

6.3.1.5 Pesticides, Herbicides, and Fertilizers

The proposed management program must include a description of procedures to reduce the contribution of pollutants associated with pesticides, herbicides, and fertilizers discharged to the MS4.

> §122.26(d)(2)(iv)(A)(6). [The application must include a] description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

The proposed program should include educational measures for the public and commercial applicators, and should include integrated pest management measures that rely on non-chemical solutions to pest control. The program should also describe how educational materials will be developed and distributed. Applicants are encouraged to consider providing information for the collection and proper disposal of, unused pesticides, herbicides, and fertilizers, or to establish their own program. An effective and safe program would include:

- Development of an inventory of products that may be accepted under the program, and collection of the Material Safety Data Sheets (MSDSs) for these products;
- Identification of transportation, storage, and disposal requirements;
- A shelf-life program to dispose of expired products;
- Applicator training or certification (the pretreatment program may be helpful as a source of industry-specific information or as a model approach for obtaining and tracking information on chemical applicators and distributors); and
- Safety training.

Any certification/training program for the collection and disposal of pesticides, herbicides, and fertilizers must be in compliance with Federal, State, and local laws such as the Resource Conservation and Recovery Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Department of Transportation's hazardous materials regulations; and State and local ordinances.

In addition, applicants must include a discussion of controls for the application of pesticides, herbicides, and fertilizers in public-rights-of-way and at municipal facilities. Planting low-maintenance vegetation, such as perennial ground covers, reduces pesticide and herbicide use. Native vegetation is often preferable because there is less need to apply fertilizers and herbicides, and to perform other forms of maintenance, such as mowing (Horner, 1988).

If herbicides are used, a herbicide-use plan must be proposed as part of the storm water management program. The plan might include:

- A list of selected herbicides and their specific uses;
- Information about the formulations of various products, including how to recognize the chemical constituents from the label, and directions and precautions for applicators that explain if products should be diluted, mixed, or only used alone;
- Application methods and estimated quantities to be used;
- Equipment use and maintenance;
- Training in safe use, storage, and disposal of pesticides (safety requirements for individual products are listed on the products' MSDSs);
- Inspection and monitoring procedures; and

- Recordkeeping and public notice procedures.

6.3.2 Construction Sites

As specified in §122.26(d)(2)(iv)(D), applicants must describe proposed regulatory programs to reduce pollutants in storm water runoff from construction sites to the MS4.

> **§122.26(d)(2)(iv)(D).** [The application must include a] description of a program to implement and maintain structural and nonstructural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system.

This part of the proposed management program must address:

- Implementation of BMPs;
- Procedures for reviewing site plans to ensure that they are consistent with local sediment and erosion control plans;
- Inspection of construction sites; and
- Enforcement measures and educational activities for construction site developers and operators.

EPA encourages municipalities to (1) coordinate requirements to reduce pollutants in construction site runoff with management programs to reduce pollutants from new development, and (2) maintain, to the degree possible, pre-construction hydrologic conditions (Section 6.3.1.1). Applicants are encouraged to describe these two proposed management program components together. Implementation of this program component will rely on the establishment and maintenance of both structural and nonstructural BMPs. This requirement extends to all construction activity within the municipality.

All construction sites, regardless of size, must be addressed by the municipality. To begin to identify these sites, the applicant should obtain lists of construction site operators that are covered by general or individual storm water NPDES permits from the NPDES permitting authority. However, construction sites not covered by a storm water discharge permit also need to be addressed by the municipality. The best way to identify these construction sites and implement an effective BMP program to reduce pollutants in their runoff is through the site planning process (see Section 6.3.2.1).

The BMPs envisioned for construction site runoff are generally well established technologies and practices. They rely predominantly on erosion and sediment controls and other measures applicable to construction sites (e.g., control of solid wastes, and prohibitions on discharging concrete truck washing runoff into storm drains). The technologies proposed should be referenced, and a description of when and how the controls will be used should be included. Municipality-specific technical guidance for construction site operators, such as handbooks and inspection checklists, are examples of suitable reference sources. If an applicant chooses to develop such handbooks and checklists, they should be referenced and described in the application.

The major requirements of this program component include:

- Site planning that considers the potential impacts on water quality;
- Nonstructural and structural best management practices;
- Procedures that consider physical site characteristics when identifying priorities for inspection and enforcement; and
- Educational and training measures for construction site operators.

Each of these requirements, and the reasons that they are important elements of a proposed storm water management program, is described in more detail below.

6.3.2.1 Site Planning

Sediment runoff rates from construction sites are typically 10 to 20 times greater than those of agricultural lands, and 1,000 to 2,000 times those of forest lands. Over a short period, construction sites can contribute more sediment to streams than had been deposited over several decades. Runoff from construction sites can also include other pollutants such as phosphorus and nitrogen from fertilizer, pesticides, petroleum derivatives, construction chemicals, and solid wastes.

To address these problems, the proposed management program should describe procedures for site planning that consider potential water quality impacts.

> **§122.26(d)(2)(iv)(D)(*1*).** [The program for construction sites must include a] description of procedures for site planning which incorporate consideration of potential water quality impacts.

The objective is for the municipality and the developer to address storm water discharges from construction activity early in the project design process so that potential water quality impacts can be eliminated or minimized and consequences to the aquatic environment assessed. Nonstructural approaches to minimize the generation of runoff from the construction site will also need to be considered. These measures may include phasing development to coincide with seasonal dry periods, minimizing areas that are cleared and graded to only the portion of the site that is necessary for construction, exposing areas for the briefest period possible, and stabilizing and reseeding disturbed areas rapidly after construction activity is completed.

It is often easier and more effective to incorporate storm water quality controls during the site plan review process or earlier. The process typically culminates with the developer of the construction site submitting detailed engineering plans to the municipality for review and approval.

Upon completion of the site plan review stage, the developer and the municipality have invested considerable time and money into the project. If storm water quality issues are considered only after significant detailed engineering has gone into the project, municipal site reviewers may only address minor drainage issues. In recent years, however, many municipalities have developed separate teams of site inspectors to implement erosion and sediment control measures in the field. In these municipalities, site inspectors should be part of the site review team (if they are not already) in order to incorporate their expertise on the appropriate erosion and sediment controls for the given circumstances.

The above discussion reinforces the importance of site planning, as described in the section on site planning for new development (Section 6.3.1). In general, the sooner planners consider storm water quality issues, the better the opportunity for efficient and effective pollutant reduction. In some cases storm water issues should be considered in the conceptual stage of planning (e.g., as a planning or zoning function).

Some municipalities include a final step in the planning process that requires a developer to provide a far greater level of design detail than earlier conceptual design approvals. This step may be required as a condition of the final approval for certain zoning categories. Municipalities with such a step in the development process can consider potential storm water quality issues in detail at this stage. Municipalities that do not currently require such detailed plans should consider adopting this procedure as part of their storm water management program.

6.3.2.2 Nonstructural and Structural BMPs for Construction Activities

This component of the proposed management program should describe requirements for nonstructural and structural BMPs that operators of construction activities that discharge to MS4s must meet.

> §122.26(d)(2)(iv)(D)(2). [The program for construction sites must include a] description of requirements for nonstructural and structural best management practices.

As indicated above, applicants must propose site review and approval procedures that address sediment and erosion controls, storm water management, and other appropriate measures. Approvals should be clearly tied to commitments to implement structural and nonstructural BMPs during the construction process. Appropriate structural and nonstructural control requirements will vary by project. Project type, size, and duration, as well as soil composition, site slope, and proximity to sensitive receiving waters will determine the appropriate structural and nonstructural BMPs. Municipalities should acquire the authority to require operators to install and maintain applicable erosion and sediment control plans. Exhibit 6-2 summarizes common construction-site BMPs.

A description of the local erosion and sediment control law or ordinance is needed to satisfy this program requirement. The description should include information that links the enforcement of the law or ordinance to the legal authority of the applicant, as discussed in Section 3 of this manual.

While many municipalities have erosion and sediment control ordinances in place, their effectiveness is often limited because they are not adequately implemented and enforced. Examples include silt fencing that is not maintained, or excavated soils that are placed directly on top of the silt fencing. Therefore, construction sites covered under NPDES permit regulations must indicate whether they are in compliance with State and local sediment and erosion control plans. Site inspections are expected to be the primary enforcement mechanism by which erosion and sediment controls are maintained.

To ensure that developers are in compliance with erosion and sediment control plans, applicants may wish to consider expanding the use of performance bonds. This approach might depart from a traditional site bonding approach. For example, the size of bonds could be based on the amount of earth disturbed, the slope of the site, changes in grades, soil type, proximity to surface waters, sensitivity of surrounding area, and other relevant factors. In addition, the bond could clearly specify the storm water quality controls that must be included in the development. Appropriate maintenance and site cleanup could be tied to the bond-release process.

6.3.2.3 Site Inspections and Enforcement of Controls For Construction Sites

Storm water BMPs associated with construction activities are highly susceptible to damage due to the intensity of activities commonly associated with construction. Consequently, inspections are crucial to the effective operation of storm water BMPs. Therefore, the proposed management program should describe construction site inspection and enforcement procedures. The procedures should be flexible so that they can be tailored to specific construction activities and physical characteristics of the construction site.

> §122.26(d)(2)(iv)(D)(3). [The program for construction sites must include a] description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality.

Exhibit 6-2
Construction Site Controls and Their Applicability

Control Type	Slope Protection	Waterway Protection	Surface Drainage	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Non-structural (cover)							
temporary seeding	●		●		●	●	●
mulching & matting	●				●	●	
plastic covering	●					●	
retain natural vegetation	●	●	●	●	●	●	●
buffer zones	●	●	●	●	●	●	●
seeding & planting	●				●	●	
sodding	●		●		●	●	●
topsoiling					●	●	
Structural-erosion control							
gravel entry/truck wash			●		●		
road stabilization			●				
dust control							
pipe slope drains					●	●	●
subsurface drains	●						
surface roughening	●				●		
gradient terraces	●					●	
bioengineered slopes	●					●	
level spreader			●				
interceptor dikes/swales	●					●	●
check dams			●				●
outlet protection		●	●				
riprap	●	●	●				
vegetative streambank stabilization		●					
bioengineered streambank stabilization		●					
structural streambank stabilization		●					
Structural-sediment retention							
filter fence		●		●			●
gravel filter berm	●	●			●		●
storm drain inlet protection	●			●			●
sediment trap or sump		●	●		●	●	●
sediment pond or basin		●	●	●	●	●	●

Source: Modified from WDOE, *Public Review Draft - Stormwater Management Manual for the Puget Sound Basin*, Washington State Department of Ecology, Publication #90-73. June 1991.

Effective inspection and enforcement requires adequate staff, systematic inspection procedures, penalties to deter infractions, and intervention by the municipal authority to correct violations. Enforcement mechanisms, such as the ability to require additional storm water controls, administrative penalties (e.g., stop work orders) and injunctive relief (via citizen suits) also must be described. In addition, the applicant should describe who has the authority to require compliance.

Proposed procedures for inspecting construction sites may include minimum frequencies and an inspector's checklist. For example, the State of Delaware requires a minimum of one inspection every two weeks for sites over 50,000 square feet.

The proposed program should also specify the minimum number of inspectors that will be employed during the permit term and how they will be trained. For example, some erosion and sediment control programs require that certified private inspectors be used. In such case, procedures for inspector training and certification must also be described.

In formulating procedures to identify priorities for inspecting sites and enforcing control measures, applicants are encouraged to begin early in the process (i.e., at the site planning stage, as discussed previously) and continue throughout all ground disturbing activities. Once the nature of the construction activity has been established or perhaps modified during the site plan review process, the physical site constraints can be evaluated so that effective controls can be implemented.

For example, if the controls specified in the site plan prove to be ineffective, or if changes occur that were not anticipated during the planning process, site inspection and enforcement mechanisms can be required to mitigate the potential for pollutants to enter a downstream MS4. In this instance, a perimeter barrier, such as a temporary diversion dike, could be used to divert the concentrated runoff to a pipe slope drain terminating with a level spreader. The spreader would dissipate the erosive velocity of the runoff and release it into an undisturbed area beyond the limits of the clearing and grading at the toe of the slope.

The proximity and sensitivity of the receiving water to which the construction site discharges is an important consideration. For construction sites that discharge to receiving waters that do not support their designated use or other waters of special concern, additional construction site controls are probably warranted and should be strongly considered. These receiving waters are identified in the Part 1 municipal NPDES storm water permit application [§122.26(d)(1)(i)(C)].

6.3.2.4 Educational Measures for Construction Site Operators

Construction site operators often need training and education about the sources, control, and impacts of pollutants in runoff from construction sites (see Virginia, 1988). Therefore, applicants must describe examples of informational materials and activities to be used in education programs.

> **§122.26(d)(2)(iv)(D)(4).** [The program for construction sites must include a] description of appropriate educational and training measures for construction site operators.

Implementation and enforcement of erosion and sediment controls have historically been major problems even with many programs that may be otherwise exemplary. Therefore, technical information on how to incorporate storm water management with erosion and sediment control and other BMP training courses are recommended for municipal employees and construction site operators. Training on the available alternatives will help operators recognize and correct problems promptly. Tools for such training include videos, workshops, seminars, and demonstrations or field trips.

An acceptable program must include a training program, which should be supplemented by a certification program for all construction site operators (contractors and developers), plan reviewers, and inspectors that work on sites that discharge to a MS4. For example, one NPDES State has a certification program based on adequate training and minimum-competency level testing of all private individuals involved in the preparation and implementation of erosion and sediment control plans.

6.3.3 Program to Control Pollutants in Storm Water Discharges from Waste Handling Sites and from Industrial Facilities

> §122.26(d)(2)(iv)(C). [The application must include a] description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system.

The storm water regulations envision that NPDES permitting authorities and municipal operators will cooperate to develop programs to monitor and control pollutants in storm water discharges to municipal systems from various sites that handle waste and certain industrial facilities.

Operators responsible for storm water discharges associated with industrial activity must obtain NPDES permits from EPA or an authorized NPDES State. These industrial storm water permits will establish requirements such as controls, practices, and monitoring for storm water discharges from the industrial facilities to the MS4. The industrial storm water permits will also provide a basis for enforcement actions directly against the industrial owner or operator.

NPDES permits for MS4s will establish responsibilities for municipal system operators to control pollutants from industrial storm water discharged through their system. Proposed storm water management programs must address the reduction of pollutants in storm water discharges from municipal landfills; hazardous waste treatment, storage and disposal facilities; facilities subject to SARA Title III; and other priority industrial facilities, as determined by the applicant. Municipalities should consider the information gathered for the Part 1 application and other parts of the Part 2 application (particularly the Source Identification and Characterization Data components) when prioritizing storm water discharges from these sites. In addition, Appendix B contains a list of pollutants commonly associated with various industries.

In the Part 2 application, the Source Identification component (see Section 4 of this guidance manual) requires the applicant to provide an inventory of pollutant sources, organized by watershed. This inventory identifies and describes the products and services of each industrial facility that may discharge storm water to the MS4. The *Source Identification* component suggests applicants use standard industrial classification (SIC) codes for this description. EPA strongly recommends this information be used to identify priority waste handling sites and industrial facilities. A similar technique could be developed for sites that do not meet the regulatory definition of "storm water discharge associated with industrial activity" (i.e. not included in the *Source Identification* and *Discharge Characterization* components), but are identified as a high priority under the proposed management program. Applicants can obtain information on how SIC codes are used to describe the industrial facilities located within their jurisdictions from their NPDES permitting authority.

Characterization data should also be evaluated. Applicants should analyze quantitative data from representative outfalls to establish a monitoring and control program.

An integral part of this requirement is the adequacy of the applicant's legal authority. If a municipality believes that a discharge of storm water associated with industrial activity violates the industrial facility's NPDES permit limits, but the municipality does not have authority over the discharge, the municipality should contact the NPDES permitting authority for appropriate action. Examples of possible actions by the NPDES permitting authority are:

- For a facility that already has a NPDES individual permit, the permit may be reopened and further controls imposed;

- For a facility covered by a NPDES general permit, an individual site-specific permit application may be required; or

- For a facility not covered by a NPDES storm water permit, a permit may be required.

The municipality is ultimately responsible for discharges from their MS4. Consequently, the proposed storm water management program should describe how the municipality will help EPA and authorized NPDES States:

- Identify priority industries discharging to their systems;

- Review and evaluate storm water pollution prevention plans and other procedures that industrial facilities must develop under general or individual permits;

- Establish and implement BMPs to reduce pollutants from these industrial facilities (or require industry to implement them); and

- Inspect and monitor industrial facilities to verify that the industries discharging storm water to the municipal systems are in compliance with their NPDES storm water permit, if required.

6.3.3.1 Identifying Priorities

Proposed management programs must clearly identify priority industrial facilities.

> **§122.26(d)(2)(iv)(C)(*1*).** [The applicant must] identify priorities and procedures for inspections and establishing and implementing control measures for such discharges.

This section discusses how applicants might identify priority facilities. Section 6.3.3.2 discusses how municipalities might develop procedures for inspections and implementation of control measures.

At a minimum, priority facilities include:

- Operating and closed municipal landfills;

- Hazardous waste treatment, disposal or recovery facilities; and

- Facilities subject to SARA Title III.

Municipalities must identify these and other priority industrial facilities and describe the criteria used to identify them. For example, information from the Toxics Release Inventory is one source a municipality could use to identify industrial facilities subject to SARA Title III. Other sources may include CWA Section 205 or 208 use-attainability studies, other studies that indicate a site-specific beneficial use impairment immediately downstream of a storm water outfall, or records of industrial pretreatment programs or other permit programs that identify facilities that may be the source of a use impairment or a major contribution of pollutants. The program should also describe procedures for modifying the inventory of priority industries based on additional evaluation that occurs throughout the permit term.

Applicants may initially focus their implementation efforts on known pollution sources. The municipality may have previously identified these sources, or they may be identified through existing information compiled during the permit application process. However, the initial management program implementation strategy should be based on information gathered while completing the *Adequate Legal Authority, Source Identification*, and *Discharge Characterization* sections of the permit application (See Chapters 3, 4, and 5, respectively.)

During the term of the permit, as additional information becomes available, the municipality should target and set priorities for other program elements that emerge. For example, if the municipality has incomplete characterization data about waste handling sites identified in this program component because the inventory of dischargers to the MS4 has not been completed, the municipality could propose to direct monitoring programs to those areas. Upon acquiring sufficient characterization data, the priority of the sites discharging to these portions of the MS4 can be either determined or modified.

As noted above, when identifying priority sites, applicants must consider all the facilities listed in §122.26(d)(2)(iv)(C)(*1*). When municipalities develop criteria for identifying additional priority industrial facilities, they are advised to consider, at a minimum:

- The type of industrial activity (SIC codes can help characterize the type of industrial activity);
- The use and management of chemicals or raw products at the facility and the likelihood that storm water discharge from the site will be contaminated; and
- The size and location of the facility in relation to sensitive watersheds.

6.3.3.2 Developing Procedures

This program component should describe the specific steps that the municipality will take if it identifies a waste handling site or priority industrial facility when preparing the Part 2 application or during the permit term [§122.26(d)(2)(iv)(C)(*1*), printed in the box above]. The proposed management program must include procedures for inspecting priority industrial sites. The results of inspection may be used as a basis for requiring storm water management controls and enhanced pollution prevention measures. It should also establish an inspection schedule for each priority facility at the time it is identified.

Applicants may want to consider establishing prior notification procedures. The applicant will need to evaluate the legal authority it has over priority facilities to determine if prior notification is required. This is another example of how EPA expects the different components of the application process to be linked. In this instance, the Adequate Legal Authority section is tied directly to the prior notification procedure of the inspection and evaluation component of the proposed management plan.

Applicants also should consider developing inspection documents such as standard forms or checklists for recording observations. Forms and checklists can be used to identify high risk areas of priority facilities and to make comparisons among sites. When characterization data or baseline estimates are factored into the evaluation process, the effectiveness of pollution prevention activities at a particular site could be quantified and compared to similar sites. Other procedures that applicants should describe to effectively incorporate inspections as well as establish and implement control measures for these types of discharges can be derived from monitoring data.

Applicants also should describe a procedure for conducting follow-up inspections, where necessary, as part of this program component. For example, follow-up inspections might be needed to verify the installation of a specific control or implementation of a practice specified in a negotiated agreement between the municipality and the industrial site. A system-wide approach to establishing priorities for inspection procedures is recommended. The system-wide approach should begin with the evaluation of existing information, followed by the identification and evaluation of new information during the permit term. Therefore, applicants should link these procedures with information from the *Source Identification* and *Discharge Characterization* components.

6.3.3.3 Establishing and Implementing Controls

A municipality must consider if it should place more stringent controls on discharges associated with industrial activity than are required in an industrial facility's existing NPDES storm water permit [§122.26(d)(2)(iv)(C)(*1*), printed in box above]. Usually, the municipality will not need to impose controls beyond those required in the industrial facility's NPDES storm water permit (for more information on appropriate controls, refer to *Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices*, EPA 832-R-92-006, September, 1992).

However, nothing in the Federal regulations would prohibit the municipality from requiring additional controls beyond the permit requirements for industrial activities. For this reason, EPA recommends that municipal applicants incorporate a provision in the proposed storm water management program that allows the municipality to require priority industrial facilities to implement the controls necessary for the municipality to meet its permit responsibilities.

Finally, the applicant should suggest procedures for requiring pollutant control measures in runoff from priority industrial facilities. Applicants should provide information to the industrial facilities that discharge to the MS4s and industry-specific guidance on appropriate control measures that industries discharging to their systems should follow (WDOE, 1991).

Priority industrial facilities should focus on controlling activities such as the use, storage, and handling of toxic chemicals. Standard methods for implementing control measures at different types of facilities should be described. To facilitate this, municipalities should obtain copies of the pollution prevention plans developed by industrial permittees. Control measures that the municipality may suggest include preventing exposure of pollutant sources to precipitation, on-site pretreatment, and oil/water separators. Applicants should provide a schedule for setting up this program component at priority industrial facilities. The schedule should include educational services for industrial site operators and technical BMP guidance, training courses, videos, workshops, and seminars for plan reviewers, inspectors, contractors, and developers.

6.3.3.4 Inspection and Monitoring

The proposed management program should describe the inspection procedures that will be followed. Storm water inspections can be coupled with inspections for other purposes (e.g., pretreatment programs, fire and safety). Proposed management programs should address minimum frequency for routine inspections. For example, how often, how much of the site, and how long an inspection may take are appropriate to explain in this proposed management program component. Applicants should also describe procedures for conducting inspections and provide an inspector's checklist.

In addition, these inspection procedures should identify the minimum number of inspectors that will be employed and describe the programs to train them. For example, if the number of inspectors is expected to increase over the term of the permit, it should be noted in the proposed management program. Also, if storm water inspections are combined with other program inspections, means of cross-training inspectors and coordinating schedules should be outlined.

Municipalities are urged to evaluate pollution prevention plans and discharge monitoring data collected by the industrial facility to ensure that the facility is in compliance with its NPDES storm water permit. Site inspections should include (1) an evaluation of the pollution prevention plan and any other pertinent documents, and (2) an on-site visual inspection of the facility to evaluate the potential for discharges of contaminated storm water from the site and to assess the effectiveness of the pollution prevention plan. A municipality could begin the inspection process with information from the facility's notification to the municipality, which should have been submitted by May 15, 1991. Industrial facilities must also submit an individual NPDES permit application, participate in a group storm water permit application, or file a Notice of Intent (NOI) to be covered by a general permit to the NPDES permitting authority. Section 308 of the CWA provides the legal authority for any individual (including a municipality) to obtain information from the NPDES permitting authority.

The proposed management program also must include a description of a monitoring program for storm water discharges associated with industrial facilities [§122.26(d)(2)(iv)(C)(2)].

The monitoring program should describe the framework and rationale for selecting monitoring sites. Sites that may be appropriate for monitoring include locations with several upstream industrial facilities, industrial facilities that are representative of a significant number of similar facilities, and priority industrial sites with significant potential for high levels of pollutants in their storm water discharges. The description of the proposed

> §122.26(d)(2)(iv)(C)(2). [The application must describe] a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of qualitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease, COD, pH, BOD_5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21(g)(7)(iii) and (iv).

monitoring program should address how the monitoring data will be used and what the frequency of the monitoring will be.

Identifying who will actually conduct the monitoring (e.g., industry or municipality) is appropriate to include in the program description. Linking this element of the monitoring program to the Adequate Legal Authority section of the permit application is vital. The legal authority to require monitoring should prescribe the specific monitoring protocols required elsewhere in the regulation [§122.26(d)(2)(i)(F)]. Applicants should describe proposed procedures for monitoring industrial facilities, including methods for determining parameters to be sampled throughout the term of the permit. **At a minimum, parameters that must be considered for monitoring include:**

- Any pollutant limited in effluent limitations guidelines for the subcategory of industry;
- Any pollutant that is controlled in a NPDES permit for the process discharge from an industrial site;
- Oil and grease, COD, pH, BOD_5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen; and

- Certain pollutant(s) known or suspected to be in the discharge, based on §122.21(g)(7)(iii) and (iv) (Section 5.3).

If a municipality believes (based on the results of monitoring and inspections) that an industrial facility is not meeting its NPDES permit requirements, the municipality should petition the NPDES authority to either require the facility to change its pollution prevention plan or institute an enforcement action. Municipalities may also file citizen suits under CWA Section 505 to enforce the conditions of the NPDES permit.

6.4 STRUCTURAL CONTROLS

6.4.1 Description of Structural Controls

Applicants are required to identify the location of major structural controls for storm water (retention basins, detention basins, major infiltration devices, etc.) in Part 1 of the application [§122.26(d)(1)(iii)(B)(5)]. In Part 2, applicants must describe additional controls that they plan to implement [§122.26(d)(2)(iv)]. The controls must address the activities described in Section 6.3. In addition, the applicant must describe maintenance procedures [§122.26(d)(2)(iv)(A)(1), discussed in Section 6.4.2]. Later, when the municipality submits its annual report, it will have to report on its progress in implementing these controls [§122.42(c)(1), discussed in Section 7.3 of this guidance].

The matrix in Exhibit 6-3 provides information on commonly used structural and source control BMPs. Structural practices to control urban storm water runoff rely on three basic mechanisms: **detention, infiltration,** and **filtration**. More detailed technical information about source controls (particularly in the selection of structural BMPs) is available in the technical BMP manuals (MWCOG, 1991; Schueler, 1987; WDOE 1991; and EPA 1990c). The following summary of structural and source control BMPs draws extensively from those manuals.

Applicants should note that CWA Section 404 permits may be required for some structural controls, including any control projects that involve the discharge of dredged or fill material into waters of the United States, including wetlands. States may also require permits that address water quality and quantity. To the extent possible, municipalities should avoid locating structural controls in natural wetlands. Before considering siting of controls in a natural wetland, the municipality should demonstrate that it is not possible or practicable to construct them in sites that do not contain natural wetlands, and that the use of other nonstructural or source controls are not practicable or as effective. In addition, impacts to wetlands should be minimized by identifying those wetlands that are severely degraded or that depend on runoff as the primary water source. Moreover, natural wetlands should only be used in conjunction with other practices, so that the wetland serves a "final polishing" function (usually targeting reduction of primary nutrients and sediments). Finally, practices should be used that settle solids, regulate flow, and remove contaminants prior to discharging storm water into a wetland.

Another concern for siting controls is the possible adverse effect that infiltration and detention controls may have on ground water. This issue is addressed in more detail in Section 7.2.3.

Exhibit 6-3
Structural Controls Matrix

CONTROL AND MAINTENANCE REQUIREMENTS	ADVANTAGES	DISADVANTAGES
Extended Detention Dry Basin • Periodic mowing • Regular debris removal • Sediment removal annually	• Provides peak flow control • Possible to provide good particulates removal • Can serve large development • Requires less capital cost and land area when compared to wet basin • Does not usually release warmed or oxygen-depleted water downstream • Protects against downstream channel erosion • Can create valuable wetland and meadow habitat when properly landscaped	• Low removal rates for soluble pollutants • Generally not feasible for drainage areas less than 10 acres • If not adequately maintained, can become a nuisance; (becomes unsightly, breeds mosquitos, and creates undesirable odors) • Periodic mowing and maintenance can be detrimental to nesting birds or other animals inhabiting the area
Vegetative Filter Strip • Inspection • Fertilizer use if necessary to maintain stable vegetation	• Low maintenance requirements • Can be used as part of the runoff conveyance system to provide pretreatment • Can reduce particulate pollutant levels in areas where runoff velocity is low to moderate • Enhances urban wildlife habitat diversity • Economical	• May concentrate water, significantly reducing effectiveness • Soluble pollutant removal highly variable • Limited feasibility in highly urbanized areas where runoff velocities are high and flow is concentrated • Requires periodic repair, regrading, and sediment removal to prevent channelization • Maintenance can be detrimental to nesting birds or other animals inhabiting the area • Fertilizer use can lead to higher nutrient loadings in storm water runoff
Grassed Swale • Periodic mowing • Fertilizer use if necessary to maintain stable vegetation	• Requires minimal land area • Can be used as part of the runoff conveyance system to provide pretreatment • Can provide sufficient runoff control to replace curb and gutter in single-family residential subdivisions and on highway medians • Economical and aesthetically pleasing	• Low pollutant removal rates • Leaching from culverts and fertilized lawns may actually increase the presence of trace metals and nutrients • Fertilizer use can lead to higher nutrient loadings in storm water runoff

Exhibit 6-3 (continued)
Structural Controls Matrix

CONTROL AND MAINTENANCE REQUIREMENTS	ADVANTAGES	DISADVANTAGES
Porous Pavement • Routine removal of fine particles from surface • May need weight limit of traffic imposed for protection	• Provides ground water recharge • Provides water quality control without additional consumption of land • Can provide peak flow control • High removal rates for sediment, nutrients, organic matter, and trace metals • When operating properly can replicate pre-development hydrologic conditions • Eliminates the need for storm water drainage, conveyance, and treatment systems off-site	• Requires regular maintenance • Possible risks of ground water contamination • Only feasible where soil is permeable, of sufficient depth to bedrock and water table, and gentle slopes are present • Not suitable for areas with high traffic volume or heavy vehicles • Need extensive feasibility tests, inspections, and very high level of construction workmanship • High failure rate due to clogging • Not suitable to serve large offsite pervious areas • Limited use in snowy climates where sanding and salting operations occur
Concrete Grid Pavement • Periodic mowing, if planted	• Provides peak flow control • Provides ground water recharge • Provides water quality control without additional consumption of land	• Requires regular maintenance • Not suitable for area with high traffic volume • Possible risk of contaminating ground water • Only feasible where soil is permeable, of sufficient depth to bedrock and water table, and gentle slopes are present
Filtration Basin • Periodic vacuuming and power washing	• Ability to accommodate moderately large-sized development (3-80 acres) • Flexibility to provide or not provide ground water recharge • Can provide peak volume control	• Requires pretreatment of storm water through sedimentation to prevent filter media from premature clogging

Exhibit 6-3 (continued)
Structural Controls Matrix

CONTROL AND MAINTENANCE REQUIREMENTS	ADVANTAGES	DISADVANTAGES
Wet Retention Basin • Periodic dredging, preferably from forebay area, if properly designed • Mowing of impoundment to prevent successional growth	• Provides peak flow control • Can serve large developments; most effective for large, intensively developed sites • Enhances species diversity, aesthetics, and provides recreational benefits • Little ground water discharge • Permanent pool in wet ponds helps prevent scour and resuspension of sediments • Provides moderate to high removal of both particulate and soluble pollutants	• Generally not feasible for drainage area less than 10 acres • Potential for safety and liability issues if not properly built and maintained • If not adequately maintained, can become a nuisance; (becomes unsightly, breeds mosquitos, and creates undesirable odors) • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Not suitable for hydrologic soil groups "A" and "B" (SCS classification) • Potential for thermal discharge and oxygen depletion, which may severely impact downstream aquatic life
Extended Detention Wet Basin • Periodic dredging of sediment forebay	• Provides peak flow control • Can serve large developments; most effective for large, intensively developed sites • Enhances species diversity, aesthetics, and provides recreational benefits • Permanent pool in wet ponds helps prevent scour and resuspension of sediments • Provides better nutrient removal than traditional wet basin	• Not feasible for drainage area less than 10 acres • Potential for safety and liability issues if not properly built and maintained • If not adequately maintained, can become a nuisance; (becomes unsightly, breeds mosquitoes, and creates undesirable odors) • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Not suitable for hydrologic soil groups "A" and "B" (SCS classification) • Potential for thermal discharge and oxygen depletion, which may severely impact downstream aquatic life

Sources: Modified from MWCOG, 1991; Schueler 1987; and WDOE, 1991.

6.4.1.1 Detention Controls

Detention controls temporarily store storm water runoff to control peak runoff rates and provide a reduction in pollutant concentrations by the gravitational settling of suspended solids and associated contaminants. Except for incidental losses due to evaporation or percolation, essentially all the detained water is subsequently discharged to a surface water conveyance (e.g., a stream or MS4). The most common examples of detention practices are extended detention basins and wet (retention) basins.

Variations on these basic detention controls include constructed storm water wetlands and multiple pond systems. These types of controls also rely on detaining flows (leading to sedimentation) as the primary means of pollutant removal. Recent investigations suggest that wetlands vegetation within a detention control can also reduce nutrient loads and certain other pollutants by incorporating them into plant tissue.

If properly designed, detention controls can protect downstream channels by reducing the frequency of bankfull flood events and associated erosion. Reduction in velocity and sediment load is also important for minimizing the adverse impacts of discharges to MS4s. Detention facilities also can provide terrestrial and aquatic wildlife habitat if they are landscaped and planted appropriately.

When considering detention controls, the municipality should consider the potential negative effects of downstream warming that may be caused by the shallowness of the water in the control. The municipality should also consider negative impacts of detention controls, such as reduced baseflow; bacterial contamination due to waterfowl; and potential impacts to wildlife from concentrated contaminants, waterfowl diseases, and maintenance practices. Safety and liability issues and nuisance factors, such as mosquitoes and odor, also should be considered. Setting detention controls in sensitive floodplains or in existing wetlands should generally be avoided. The flooding effect of impounding and detaining water is a particular concern if the upstream watershed drains more than 250 acres, because the volume of runoff and required detention times can cause inundation of upstream channels to occur.

Detention controls incorporating multiple pond systems and/or constructed storm water wetlands also treat runoff through the processes of absorption, filtration, biological uptake, volatilization, precipitation, and microbial decomposition. Recent investigations by the Metropolitan Washington Council of Governments suggest that multiple pond systems, in particular, have shown potential to provide higher and more consistent levels of treatment than traditional detention controls. The redundancy afforded by the multiple pond system generally increases the reliability of the control. However, the potential concerns and drawbacks affecting retention basins also apply to these systems. Many of these systems are currently being designed to include vegetative buffers and deep water areas to enhance wildlife habitat and to improve the appearance of the facility. If a municipality selects one of these more innovative designs, it should recognize that periodic maintenance is necessary. The effectiveness of these controls, like most controls, depends on proper operation, maintenance, and monitoring of the entire system.

<u>Wet (Retention) Basins</u>

Wet (retention) basins are designed to maintain a permanent pool of water and temporarily store storm water runoff until it is released at a controlled rate. Unlike extended detention ponds, wet basins cannot detain runoff for long times, because most of their storage capacity is needed for holding the permanent pool. Enhanced designs include a forebay to trap incoming sediment where it can be easily removed. A fringe wetland also can be established around the perimeter of the basin. Similar to detention controls, locating retention basins in sensitive floodplains or existing wetlands should be avoided if possible.

Extended Detention Basins

Extended detention basins temporarily detain a portion of storm water runoff for 24 to 48 hours after a storm, gradually releasing the stored water through a fixed opening to allow urban pollutants to settle out. The basins normally return to a "dry" condition between storm events and do not have any permanent standing water. These basins are typically composed of two stages: an upper stage, which remains dry except during larger storms, and a lower stage, which is designed for typical storms. Pollutant removal from extended detention basins can be enhanced if they are equipped with plunge pools near the inlet, a micropool at the outlet, and an adjustable reverse-sloped pipe as the extended detention control device.

Water Quality Inlets

Water quality inlets (also referred to as catch basins) are small underground systems that, like retention basins, rely on settling to remove pollutants before discharging water to the MS4. Several designs of water quality inlets exist. In their simplest form, catch basins are single-chambered storm water inlets with the bottom lowered to provide 2 to 4 feet of additional space between the outlet pipe and the bottom of the structure for collection of trash and sediment. Some water quality inlets include a second chamber with a sand filter to provide additional removal by filtration. The first chamber provides effective removal of coarse particles and helps prevent premature clogging of the filter media.

Water quality inlets may include an oil/grit separator. There are 3 basic types of oil/grit separators: the spill control (SC), the coalescing plate interceptor (CPI), and a design credited to the American Petroleum Institute (API). Most of the oil/grit separators that are promoted for use in reducing hydrocarbon loads in storm water are a modification of the API design, although there are appropriate applications for all three separator designs. Oil/grit separators based on the API design consist of three chambers. The first chamber removes coarse material and debris. The second chamber provides separation of oil, grease, and gasoline from the storm water runoff; and the third chamber provides a safety relief should a blockage occur.

Recent experiences have shown that, because of their volume limitations, oil/grit separators have limited pollutant removal effectiveness. They are perhaps the best example of a structural control that is only effective with frequent maintenance. Proper disposal of the standing water, trapped sediments, and floating hydrocarbons are problems in the few locations that have been studied.

Constructed Storm Water Wetlands

Constructed storm water wetlands are a hybrid, drawing on elements of detention and retention basins. Constructed storm water wetlands are shallow pools and are often designed to simulate the pollutant removal functions of natural wetlands. Enhanced designs may include a sediment forebay, carefully contoured topography, and multiple species of wetland plants. Constructed storm water wetlands, while a promising technology for pollutant removal from storm water, may not replicate all the ecological functions of natural wetlands.

6.4.1.2 Infiltration Controls

Infiltration controls rely chiefly on absorption to treat storm water discharges. In the ideal case, storm water percolates through a porous medium and into native soils where filtration and biological action remove pollutants. Typical controls of this type include infiltration trenches, infiltration basins, filtration basins, porous pavement, and concrete or block pavers. Systems that rely on soil absorption work best in deep, highly permeable soils that are at least four feet away from the seasonal ground-water table.

The Soil Conservation Service (SCS) classifies soils into four major soil groups A-D. The soil groups are as follows:

Group A: Sand, loamy sand
Group B: Sandy loam, loam
Group C: Silt loam, sandy clay loam
Group D: Clay loam, silty clay loam, sandy clay, silty clay, and clay

Soils in Group A provide the highest infiltration rate while soils in Group D provide the lowest. Suitable soils for infiltration-type controls typically fall in soil groups A and B. Other types of soils may be suitable, provided the clay content does not exceed 30 percent (clay has very low hydraulic conductivity). The clay content of soil may be determined from the SCS soil textural triangle, which can be found in many civil engineering references texts.

If suitable soils are available, the widespread use of infiltration in a watershed can be useful in helping to maintain, restore, or replicate pre-development hydrology. Specific benefits of infiltration often include increased dry-weather baseflow in streams and a reduction in the frequency of bankfull floods. However, infiltration systems are not recommended unless soil conditions warrant. Also, infiltration should not be used where ground water requires protection. For example, the use of infiltration-type controls may not be appropriate in areas that recharge sole source aquifers.

Infiltration Basins

Infiltration basins are areas that intercept incoming storm water runoff and temporarily store it until it gradually infiltrates into the soil surrounding the basin. Infiltration basins should be designed to control drainage areas ranging from about 5 to 50 acres. They also should drain within 48 to 72 hours to maintain aerobic conditions favoring bacteria that aid in pollutant removal, and to ensure that the basin is ready to receive the next storm. The runoff entering the basin is usually pretreated to remove coarse sediment that may clog the surface soil pores on the basin floor. Concentrated runoff may flow through a sediment trap or by sheet flow (vegetative filter strip).

Infiltration Trenches

Infiltration trenches are shallow (e.g., 2 to 10 feet deep) excavated ditches or vaults that have been backfilled with a coarse stone aggregate. The aggregate forms an underground reservoir that has approximately 40 percent void space. Storm water runoff diverted into the trench gradually infiltrates from the bottom of the trench into the subsoil and eventually into the ground water. Variations in the design of infiltration trenches include dry wells and percolation pits that are designed to control small volumes of runoff, such as the runoff from a rooftop. A more complex variation is the enhanced infiltration trench, which is equipped with filter fabric or a more extensive pretreatment system to remove sediment and oil. Depending on the quality of the runoff, pretreatment may be necessary to lower the failure rate of the trench. Infiltration trenches are generally best suited for drainage areas of less than 10 acres. They are particularly applicable for use on residential lots, small commercial areas, down slope from parking lots, and under drainage swales.

Grassed Swales

A grassed swale is an infiltration method that is usually used as a form of pretreatment before discharging runoff to another storm water control device (e.g., a detention basin). However, the grassed swale itself is a control that can remove significant amounts of pollutants through sediment entrainment. A grassed swale is a shallow, vegetated, man-made ditch with the bottom elevation above the water table to allow runoff to infiltrate into the ground water. The vegetation helps to prevent erosion, filters sediment, and allows for some uptake of nutrients.

Porous Pavement

Porous pavement, which is basically traditional asphalt aggregate without the fine particles, is an alternative to conventional pavement. Proper design and application of this control can reduce or eliminate the need for curbs and gutters, storm drains and sewers, and offside controls. Instead, runoff is diverted through a porous asphalt layer into an underground stone reservoir. The stored runoff gradually exfiltrates out of the stone reservóir into the subsoil. Soil considerations are important when evaluating the appropriateness of this control. Generally, grades should be gentle, and subsoil should be at least 3 feet thick (to bedrock) and moderately permeable (capable of infiltrating about one half inch per hour). Because porous pavement tends to clog with fine sediments and because it loses its effectiveness under heavy loads, its application should generally be limited to low-traffic areas (e.g., overflow parking areas) and areas that are not exposed to large bearing loads caused by heavy vehicles.

Concrete Grid Pavement

Concrete grid pavement has concrete blocks with regularly interdispersed void areas that are filled with pervious materials, such as gravel, sand, or grass. The blocks are typically placed on a sand or gravel base. They are usually designed to provide a load-bearing surface adequate for supporting vehicles, while allowing infiltration of surface water into the underlying soil.

6.4.1.3 **Filtration Controls**

Filtration controls treat storm water flows by using vegetation or sand to filter and settle pollutants. Generally, these controls are most effective before the flows become concentrated (e.g., sheet flow). In certain instances, infiltration and treatment in the subsoil also may occur through the processes of absorption and adsorption. After passing through the filtration media, the treated water is usually directed to a stream or MS4, although it may be evaporated or percolated into the ground. Filtration controls include filter strips, grass swales, and sand filters. Sand filters are particularly useful for ground water protection. Applicants must consider the influence of climate when they select vegetative systems.

Vegetative Filter Strips

Vegetative filter strips (also called bio-filters) are vegetated sections of land designed to accept runoff as overland sheet flow from upstream development. They may adopt any natural vegetated form, from grassy meadow to small forest. The dense vegetative cover facilitates sediment reduction and pollutant removal. Filter strips cannot treat high-velocity flows. Therefore, these strips generally have been recommended for use in agriculture and low-density development and other situations where runoff does not tend to be concentrated. Unlike grassed swales, filter strips are effective only for overland sheet flow, as opposed to concentrated flow. Grading and level spreaders can be used to reduce the energy of concentrated flows and distribute the runoff evenly across the filter strip. Vegetative filter strips are often used as pretreatment for other structural practices, such as infiltration trenches. Leaving a buffer of natural vegetation along an urban stream valley is an example of a vegetative filter strip and also an example of a nonstructural control.

Filtration Basins

Filtration basins are usually small impoundments lined with filter media, such as sand or gravel. Storm water drains through the filter media and perforated pipes into the subsoil. For optimal pollutant removal, recommended detention times range from 24 to 48 hours with a maximum drainage area of about 50 acres. Grassed swales or other structural controls can be used to filter coarse sediments and thereby minimize clogging of the filter medium.

6.4.2 Maintenance Activities

After summarizing the location of major structural storm water controls, applicants must submit a description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants.

> §122.26(d)(2)(iv)(A)(1). [The application must include a] description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers.

Typical maintenance requirements include:

- Inspection of basins and ponds after every major storm for the first few months after construction and annually thereafter;
- Mowing of grass filter strips and swales at the frequency necessary to prevent woody growth and promote dense vegetation;
- Regular removal of litter and debris from dry ponds, forebays, and water quality inlets;
- Periodic stabilization and revegetation of eroded areas;
- Periodic removal and replacement of filter media from infiltration trenches and filtration ponds;
- Deep tilling of infiltration basins to maintain infiltrative capability; and
- Frequent vacuuming or jet hosing of porous pavement or concrete grid pavements.

Lack of maintenance often limits the effectiveness of storm water structural controls such as detention/retention basins and infiltration devices. Maintenance programs should address measures for catch basins and drainage channels in addition to major structural controls.

The proposed program should provide for maintenance logs and identify specific maintenance activities for each class of control, such as removing sediment from retention ponds every five years, cleaning catch basins annually, and removing litter from channels twice a year. If maintenance activities are scheduled infrequently, inspections must be scheduled to ensure that the control is operating adequately. In cases where scheduled maintenance is not appropriate, maintenance should be based on inspections of the control structure or frequency of storm events. If maintenance depends on the results of inspections or if it occurs infrequently, the applicant must provide an inspection schedule. The applicant should also identify the municipal department(s) responsible for the maintenance program.

Municipalities should use caution in adopting controls that do not have sufficient history of use for their performance characteristics and maintenance requirements to be adequately evaluated. A good example is the oil/grit separator used on small commercial or retail sites. Some municipalities have required the use of these technologies, but due to poor performance, municipalities have often rescinded the requirement. In these cases, it is not clear whether the control technology was ineffective or the maintenance program was flawed.

Because maintenance is critical to successful program implementation, it must be considered throughout the term of the permit. Applicants may wish to develop a matrix that identifies maintenance tasks on a timeline indicating criteria for inspection, repair, and replacement. PERT charts, GANT charts, or other critical path analyses (available for personal computers) can help organize a maintenance program and schedule. For a summarized listing of appropriate maintenance activities and schedules refer to the matrix in Exhibit 6-3.

6.4.3 Considerations for Planning and Siting Controls

The storm water management program should describe the criteria used to identify that a particular structural control is warranted and the circumstances under which it will be required. The possibilities for new control sites should be evaluated for their storm water quality control potential. Guidelines and performance standards that identify specific structural controls for new development should be proposed in the procedures for new development. From this evaluation, priorities based on the feasibility of implementing a particular control at a given location can be determined.

6.4.3.1 Use of Municipal Lands

Applicants should discuss existing major structural controls and sites that have the potential for new structural controls which could be installed on municipal lands and other major rights-of-way (e.g., major roads and highways). Note that existing controls are identified in Part 1 applications [(§122.26(d)(1)(iii)(B)(5)]. The location of publicly owned parks, recreational areas, and other open areas are also identified [§122.26(d)(1)(iii)*(6)*].

To determine what storm water quality controls are necessary for public lands and facilities, current activities and functions that may affect the quality of storm water discharges should be identified. Such activities and functions include parks, trails, and other recreational land uses, road maintenance and snow management, and storage and repair yards/shops for municipal vehicles. An inventory of public land uses may be necessary to help make determinations of what controls are needed. An effective inventory should involve coordination among all of the local departments and agencies that have authority over the use of public lands and facilities.

Opportunities for controlling storm water quality problems that are identified through the inventory process can be evaluated on a site-specific basis and included in the proposed management program.

There are several benefits to the establishment of structural controls on municipal lands:

- Municipal lands often provide greater retrofit opportunities because they typically do not require additional property purchases;
- Municipal lands ensure opportunities to provide future maintenance and security in preservation of the retrofit control;
- Applicants may be able to adapt existing municipal functions (such as industrial pretreatment program implementation, fire-safety inspections, and flood-control activities) to address storm water quality concerns (Expanding their mission to address storm water concerns may be more cost-effective than initiating entirely new programs.);
- Applicants may be able to adapt functions of development on municipal lands (such as planning, zoning, and construction oversight functions); and
- After considering controls on municipal lands, the applicant will be in a better position to address the private land under its jurisdiction.

As a precaution, however, applicants need to consider potential conflicts arising over the multiple use of public lands. Criteria other than land ownership (e.g., locating controls downstream of developed areas) also should be considered when deciding where to locate storm water runoff controls.

6.4.3.2 Use of Private Lands

A municipality also may incorporate storm water quality controls into its land use plan to indicate controls that may be necessary for new development. Some of the best opportunities to prevent pollution and to implement effective storm water quality controls occur during development. Local governments typically play a strong role in overseeing new development and have, or can adapt, administrative infrastructure to address storm water quality concerns.

The storm water management process should begin with land use planning and zoning and continue through the development and redevelopment processes. Municipalities generally can obtain commitments from land developers more easily prior to relinquishing jurisdictional leverage over the parcel where the potential control is to be located. Leverage can be achieved through plan approval or zoning changes. The negotiation process for the dedication, condemnation, or other acquisition of land and the process for getting the land developer to construct or otherwise implement controls will vary dramatically among municipalities, particularly among those in different States.

Source and structural controls are most cost-effective when development is planned with storm water quality controls in mind. However, it is probably more appropriate for the municipality to propose a flexible plan that specifies a variety of program objectives through the development process rather than identifying a certain priority and rigid schedule. Other benefits of early and flexible planning include ecological diversity, wetlands preservation, and the creation of controls that also function as amenities. Comprehensive land use plans, zoning ordinances, and subdivision ordinances are important mechanisms to implement these controls early in the development process. Consideration of storm water quality during pre-development is one of the most effective ways to implement controls. This is because the maximum flexibility (and opportunity) to incorporate BMPs exists prior to final land use decisions and construction activities (see Section 6.3.1.1)

6.4.3.3 Siting Considerations

Imperviousness

The degree of imperviousness affects the concentration of pollutants in storm water, which in turn affects the type of structural controls that may be necessary. As the imperviousness of an area increases, the runoff volume and the pollutant loading increase. Studies show that runoff from industrial areas, which generally have a high degree of imperviousness, can have a wider variety and greater concentration of pollutants than runoff from other land uses. Recent studies also indicate that the degree of imperviousness can be inferred from the level of degradation in urban receiving streams. (For example, see Schueler 1991 and Klien 1979.) Population projections will not indicate the degree to which industrial land use will increase unless planning and zoning information is also considered.

Soil Conditions

Controls designed to infiltrate storm water will be affected by site specific soil conditions. For example, clay content of the soil and the antecedent moisture content (degree of soil saturation at the time of a given storm event) will strongly influence the effectiveness, and therefore the applicability, of infiltration controls for a given location.

6.5 PROGRAM AND SCHEDULE TO DETECT AND REMOVE ILLICIT DISCHARGES AND IMPROPER DISPOSAL

NPDES permits for discharges from MS4s require effective detection and removal from the MS4 of illicit or improper discharges and disposal.

§122.26(d)(2)(iv)(B). [The application must include a] description of a program, including a schedule, to detect and remove (or require the discharger to the municipal separate storm sewer to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer.

The NURP study concluded that the quality of urban runoff can be adversely impacted by illicit connections and illegal dumping. Often, large amounts of wastes, particularly used oils, are improperly disposed of in storm sewers. Elimination of these sources of pollutants would result in a dramatic improvement in the quality of storm water discharges from MS4s. Procedures to eliminate such discharges should be an important part of the proposed management program.

The regulatory requirement cited above is intended to directly implement the mandate of Section 402(p)(3)(B)(ii) of the CWA, which requires permits for MS4s to effectively prohibit non-storm water discharges into storm sewers. In certain instances, the most appropriate action will be for the municipality to ensure that illicit discharges become covered by a NPDES permit. However, in most cases, elimination of illicit discharges or improper dumping is the appropriate focus of this program component. The quality of storm water runoff from inner-city core areas, particularly in older parts of the country, would benefit most from this component.

The applicant should propose a schedule for implementing this program component throughout the initial permit term. This schedule should reflect the priorities identified by the municipality during the application process and be based on the problems particular to the specific MS4.

6.5.1 Prohibiting Illicit Discharges

The proposed management program must include a description of inspection procedures, orders, ordinances, and other legal authorities necessary to prevent illicit discharges to the MS4.

§122.26(d)(2)(iv)(B)(*1*). [The application must include a] description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; this program description shall address all types of illicit discharges, however the following category of non-storm water discharges or flows shall be addressed where such discharges are identified by the municipality as sources of pollutants to waters of the United States . . . . *[these sources are listed in the guidance]*.

This proposed management program component also should describe how the prohibition on illicit discharges will be implemented and enforced. The description should include a schedule and allocation of staff and resources. A direct linkage should exist between this program component and the adequate legal authority requirements for the ordinances and orders to effectively implement the prohibition of illicit discharges.

While this program component is required to prohibit all types of illicit discharges, the following categories of non-storm water discharges need only be prohibited by the MS4 when they are identified by the MS4 as sources of pollutants to waters of the United States:

- Water line flushing
- Landscape irrigation
- Diverted stream flows
- Rising ground waters
- Uncontaminated ground water infiltration [as defined at 40 CFR 35.2005(20)] to separate storm sewers
- Uncontaminated pumped ground water
- Discharges from potable water sources
- Foundation drains
- Air conditioning condensation
- Irrigation water

- Springs
- Water from crawl space pumps
- Footing drains
- Lawn watering
- Individual residential car washing
- Flows from riparian habitats and wetlands
- Dechlorinated swimming pool discharges
- Street wash water

While EPA does not consider these flows to be innocuous, they are only regulated by the storm water program to the extent that they may be identified as significant sources of pollutants to waters of the United States under certain circumstances. If an applicant knows, for example, that landscape irrigation water from a particular site flows through and picks up pesticides or excess nutrients from fertilizer applications, there may be a reasonable potential for a storm water discharge to result in a water quality impact. In such an event, the applicant should contact the NPDES permitting authority to request that the authority order the discharger to the MS4 to obtain a separate NPDES permit (or in this case, the discharge could be controlled through the storm water management program of the MS4).

The applicant should consider the specific land use, age, and stage of development in this program component. For example, one study in an established metropolitan area found that 60 percent of automobile-related businesses had improper storm drain connections. While some of the problems discovered in this study were the result of improper plumbing or illegal connections to storm drains, the majority of the connections were approved by the municipality when they were built.

For problem identification and problem-solving, a municipality may elect to implement a follow-up study that traces identified pollution incidents to their source (e.g., up the system). A variety of pollutant-tracing techniques and field screening can be used to identify illicit discharges.

6.5.2 Field Screening

Part 1 of the application requires applicants to submit the results of field screening studies to evaluate the possible occurrence of illicit connections and improper dumping [§122.26(d)(1)(iv)(D)]. Dry weather flows that were encountered during the initial field screening were sampled and analyzed. The analysis was intended to provide information about illicit connections and improper dumping.

In Part 2, applicants are required to propose procedures for continued field screening during the term of the permit.

> §122.26(d)(2)(iv)(B)(2). [The application must include a] description of procedures to conduct on-going field screening activities during the life of the permit, including areas or locations that will be evaluated by such field screens.

Applicants can propose to use procedures similar to those used for field screening required in Part 1 of the application or they can propose alternative procedures and techniques. The Part 1 field screening requirements are found in §122.26(d)(1)(iv)(D) and are explained in the Part 1 guidance manual.

The Part 2 proposed field screening program component should describe areas of the system where the continuation of the field screening program will be conducted and the rationale for selecting these areas. For example, the rationale for continuing field screening at a given location might be that a wide variation in results was obtained during the initial screens. In addition, the applicant should propose field screening for a portion of any recently-identified major outfalls that were not known to the applicant when it prepared its Part 1 application, provided sampling of these outfalls is safe and practicable.

The potential for illicit discharges and improper disposal is generally higher for areas of older development, areas with many automobile-related industries, and areas with significant numbers of heavy industrial facilities. Therefore, in most cases applicants should include these areas in the proposed field screening program.

The description of the field screening component should provide a detailed summary of the departmental responsibility for field activities, frequency of inspections, procedures and equipment to be used, and the procedures for documenting field activities, both in the field and in the office. Generally, the Part 2 field screening program should reflect a continuously narrowing process to trace illicit and improper sources.

6.5.3 Investigation of Potential Illicit Discharges

In order to submit a comprehensive proposed management program, applicants are required to describe procedures for investigating portions of the municipal system where field screening or other information indicates a reasonable potential for illicit discharges.

> §122.26(d)(2)(iv)(B)(3). [The application must include a] description of procedures to be followed to investigate portions of the separate storm sewer system that, based on the results of the field screen, or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water (such procedures may include: sampling procedures for constituents such as fecal coliform, fecal streptococcus, surfactants (MBAS), residual chlorine, fluorides and potassium; testing with fluorometric dyes; or conducting in storm sewer inspections where safety and other considerations allow. Such description shall include the location of storm sewers that have been identified for such evaluation).

Applicants should propose criteria to identify portions of the system where follow-up investigations are appropriate. For example, calculating a frequency distribution of dry weather flows at each screening site could aid in establishing criteria to identify where follow-up investigations are appropriate.

Procedures to investigate priority locations for illicit connections include inspection of the storm sewer system, use of remote-control cameras, on-site inspections and dye-testing at priority or suspect facilities, and additional discharge monitoring to pinpoint pollutant sources. In some cases, these investigations may be coordinated with pretreatment program inspections. Such approaches are summarized in Exhibit 6-4. Coordinating inspections can be a very effective use of resources. For example, portions of the sanitary sewer system that need evaluation to detect illicit discharge may already be undergoing inspection by operators of the municipal treatment plant.

A checklist should be developed for inspectors to use to detect illicit connections. The checklist should be structured to ensure a comprehensive evaluation of the problem and stipulate the use of the easiest and least expensive detection methods first.

Regardless of the format in which information is compiled (e.g., table, list, text description), EPA suggests that the applicant prepare a map identifying the location of suspected problem areas. The map should be provided as part of the Part 2 application.

The proposed program component description should describe a step-by-step process to investigate, identify, and prohibit illicit discharges. If field screening leads to positive tests of fecal coliform, fecal streptococcus, surfactants, residual chlorine, fluorides, or potassium, a municipality should reconsider whether any of the non-storm water discharges described in Section 6.5.1 are the source (see previous section).

Exhibit 6-4
Sample Illicit Discharge Investigation Procedures Options

Results of Initial Field Screen	Procedures for Detailed Analysis	Comments
Plumbing unidentifiable	Cameras	Effective for identifying deterioration
Uncertain use of facility	On-site inspections	May be combined with other inspections
Several facilities or complex plumbing	Dye-testing	Simple and accurate if system not interconnected
Unusual pollutants	Monitoring	Particularly useful for fingerprinting

6.5.4 Spill Response and Prevention

The proposed management program must describe procedures that the municipality will implement during the term of the permit to prevent, contain, and respond to spills that may discharge into the MS4.

> §122.26(d)(2)(iv)(B)(4). [The application must include a] description of procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer.

The municipality and the property owners (and/or operators) of sites where spills may occur need to implement procedures to prevent, contain and respond to spills. One way to implement these procedures is to modify the land use planning process and ordinance enforcement. Such modifications would require notification and emergency preparedness procedures for any land use activity that could lead to leaks and spills. Another method is to coordinate with on-going programs in other regulated areas where detection of spills is important, such as pretreatment and hazardous materials management. The goal of a spill-prevention program is to reduce the frequency and extent of spills of hazardous materials, oils, and other materials which can cause water quality impairment. Spill-containment programs may establish minimum chemical storage and handling requirements, require users to submit prevention and control plans, and ensure site inspections. The content of the descriptions that should be submitted with the Part 2 application for each of these program elements is discussed in more detail below.

Spill-response programs are intended to reduce risk to the public and the environment. Although these programs tend to focus on issues of public health and safety, such as exposure to toxic materials, fires, or explosions, spill-response teams should attempt to prevent or minimize contamination of surface water, ground water, and soil. Spill-response programs often require a coordinated response from a number of municipal departments (e.g., fire, police, health, and public works). Municipalities should describe how response procedures within these programs attempt to mitigate potential pollutant discharges to surface waters.

For example, some industrial pretreatment programs specifically require that leaks or spills be routed to the storm sewer rather than the sanitary sewer generally to protect worker health and safety and to protect biological treatment capabilities. This issue serves to reinforce the need for coordination between the various municipal programs that are related in some way to storm water.

The proposed program should identify the municipal departments responsible for implementing the program, and also should address employee training, reporting procedures, containment of spills, storage and disposal activities, documentation, and follow-up procedures. Generally, the proposed program for spill response and prevention should focus on good housekeeping and materials management practices, which are discussed in more detail below.

One of the initial elements in the development of a successful spill response and prevention program is to assess the potential of various sources at a particular property to contribute pollutants to the storm water discharges from the site. This assessment should inventory the land use, types of materials handled, and the location and types of materials management activities. Factors to consider when evaluating the pollution potential of runoff from various portions of a site include those that are likely to lead to the identification of specific structural or nonstructural controls to address problems.

Other factors to consider are the toxicity and quantity of any chemicals used, produced, stored, or discharged from the site; the history of any NPDES permit violations from a site; history of significant leaks or spills of toxic or hazardous pollutants; and the designated uses of the receiving waters.

This program element should also include a description of storm water management controls that are appropriate for the site that would control or allow for the mitigation of any leak or spill and a proposal to implement such controls. The priorities developed in the implementation proposal should reflect the nature of identified sources of pollutants at the site.

The description of spill response and prevention activities should include the steps a municipality will take to prevent, and when necessary, adequately respond to spills discharged to its MS4. The MS4 might identify special training requirements for municipal employees in order to respond to spills of hazardous chemicals from a particular facility into the storm sewer system.

Sources with the greatest potential for spills to occur (or cause the most severe damage) should be identified in the proposed storm water management program. If appropriate, specific materials handling procedures and storage requirements should be identified for these sources. Requirements for these sources could be modeled after the Spill Prevention, Control, and Countermeasure (SPCC) Plans that are required for certain facilities under Section 311 of the CWA.

Under the SPCC program, for example, personnel are trained and given responsibility for inspecting the facility for leaks and spills. These inspections include equipment and materials handling areas, which need to be investigated for evidence of, or the potential for, pollutants entering the drainage system. Procedures to ensure the availability of appropriate personnel and equipment for cleaning up spills must be identified. A system to ensure that appropriate corrective action has occurred in response to inadequacies identified during the inspection is also established under the program.

Not all of the SPCC program elements may be necessary for municipal applicants. However, EPA recommends that the proposed storm water management program describe how the records of inspections will be maintained and made available for investigations of causal factors and program effectiveness. Incidents of leaks, spills, and improper dumping, along with other information describing the quality and quantity of storm water discharges should be included in the records. Inspections and maintenance activities, such as containment berm integrity testing or the cleaning of oil/water separators should be documented and recorded in a maintenance log.

6.5.5 Public Awareness and Reporting Program

Applicants must propose a management program component that promotes, publicizes, and facilitates public reporting of illicit discharges or water quality impacts associated with discharges from MS4s.

> §122.26(d)(2)(iv)(B)(5). [The application must include a] description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers.

Timely reporting by the public of improper disposal and illicit discharges are critical components of programs to control such sources.

To enhance public awareness, programs may include setting up a public information hotline number; educating school students; establishing community and volunteer "watchdog" groups (e.g., "Adopt-a-Stream Program"); using inserts into utility bills; and newspaper, television and radio announcements to inform the public about what to look for and how to report incidents. The public awareness efforts should clarify to the public that they are the ultimate beneficiaries of a successful storm water management program.

6.5.6 Proper Management of Used Oil and Toxics

EPA estimates that annually, 267 million gallons of used oil, including 135 million gallons of used oil from do-it-yourself automobile oil changes, are disposed of improperly. An additional 70 million gallons of used oil, most coming from service stations and repair shops, are used for road oiling (55 FR 48056, November 16, 1990). If private individuals find the proper disposal of used oil or toxic materials difficult, incidents of improper disposal increase. For example, when a large fraction of service stations do not accept do-it-yourself used oil, improper disposal into the municipal storm sewer rises. Therefore, applicants are required to propose a program component that will facilitate the proper disposal of used oil and toxics from households by establishing municipally operated collection sites, or ensuring that privately-operated collection sites are available.

> §122.26(d)(2)(iv)(B)(6). [The application must include a] description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials.

The proposed program should describe outreach plans to handlers of used oil and to the public, and operating plans for oil and household waste collection programs.

Examples of effective public outreach for these types of programs include dedicated municipal phone numbers (e.g., a used oil/toxic materials hotline), pamphlets, and requirements that oil retailers post the location of the nearest used oil collection facility. Programs can also inform the public about alternatives to toxic materials. Catch basin/storm sewer inlet stenciling programs can also be proposed as part of the program to increase public awareness of the connection between storm sewers and local water resources.

6.5.7 Infiltration of Seepage

In order to effectively complete this portion of a proposed management plan, the applicant must describe controls to limit infiltration of seepage from municipal sanitary sewers to MS4s, if necessary.

> §122.26(d)(2)(iv)(B)(7). [The application must include a] description of controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems where necessary.

Raw sewage can seep from sanitary sewage collection systems through leaks and cracks in aging pipes, poorly constructed manholes and joints, and main breaks. Sewage from a leaky sanitary system can flow to storm sewers or contaminate ground water supplies. Interaction between sanitary sewers and separate storm sewers may occur at manholes and where sanitary sewer laterals and storm sewer trenches cross. Separate storm sewers and sanitary sewers may share the same trench, which is generally filled with very porous material such as gravel.

One indication of seepage from a sewage collection system may be infiltration of water. Often, the rate of exfiltration (seepage) from sanitary collection systems is significantly greater than the rate of infiltration into the system. An EPA study on sewer exfiltration found significant ratios of the rate of exfiltration of sewage to the rate of infiltration of ground water or storm water into sanitary sewers. Field and laboratory results found this ratio to vary between 1.5 to 1 and 14 to 1.

In some cases, preventive maintenance surveys or on-going infiltration and inflow (I&I) programs to determine where water is entering a sanitary sewer system may be modified to locate the source and fate of exfiltration from the system.

Identifying infiltration of seepage into a MS4 is a good example of the need for various municipal functions to be effectively coordinated. Proposed storm water management programs might discuss how personnel responsible for inspections of the sanitary sewer system could inspect for sources of exfiltration during I&I inspections, and pass any findings to personnel responsible for maintaining the MS4. If seepage is believed to be a problem, a coordinated effort with the maintenance department of the municipal sanitary sewer system is recommended.

The proposed storm water management program also should include provisions to address the discovery of previously unknown problems. There should be procedures to enact a coordinated program between the operators of the storm sewer and sanitary sewer (which in many cases will be within the same municipal agency or department).

EPA recommends that the proposed storm water management program describe controls that will be used to address seepage from malfunctioning septic systems in areas not served by a sewage treatment works. Malfunctioning septic systems may lead to more significant surface runoff pollution problems than ground water problems. A malfunctioning septic system is less likely to cause ground water contamination where an impervious bacterial mat in the soil retards the downward movement of wastewater. (Poorly located septic systems that are operating properly are the greatest threat to ground water).

Surface malfunctions of septic systems are caused by clogged or impermeable soils, or when stopped up or collapsed pipes force untreated wastewater to the surface. Surface malfunctions can vary in degree from occasional damp patches on the surface to constant pooling or runoff of wastewater to a storm sewer. An improper remedy for a surface malfunction is to install a pipe or trench over soil absorption systems to route untreated overflow away from the septic system. This results in direct discharges to drainage ditches, empty lots, or surface waters.

Proper controls range from prescribing maximum intervals between tank pump-out to the installation of sand filters. Discharge from sand filters to surface waters may require a separate NPDES permit, because such discharge is not storm water.

Additional information about the most appropriate controls for use in correcting malfunctioning septic systems is probably best obtained from local or regional sources. Organizations such as extension services, soil and water conservation districts, and planning agencies may be good sources of information about methods that have been successful (and also those that have failed).

By obtaining this type of information, the applicant can determine what control techniques have been successful in correcting malfunctioning septic systems in similar types of soils. The value of this approach is that the applicant will know that a certain control technique has been used to correct a malfunctioning septic system in the same types of soils that occur in the municipality. Where only part of the MS4 drainage area is served by septic systems, proposed programs should address setting and maintenance of septic systems, including draft requirements and implementation procedures.

6.6 SIGNATORY AND CERTIFICATION REQUIREMENTS

Under the Federal NPDES regulations [§122.22(a)], all NPDES permit applications (including municipal storm water permit applications) must be signed by an authorized person, as defined in the regulations. Permit applications submitted by a municipality, State, Federal, or other public agency must be signed by either a principal executive officer or ranking elected official [§122.22(a)(3)]. To fulfill the signatory requirements, the person signing the municipal application must provide his or her name (printed or typed), title, and date signed. In addition, the applicant should provide the name, address, and telephone number of the person signing the application or another point of contact that can answer questions about the application.

In addition, §122.22(d) states that any person signing a permit application must make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

6.7 IMPLEMENTATION OF THE STORM WATER PROGRAM

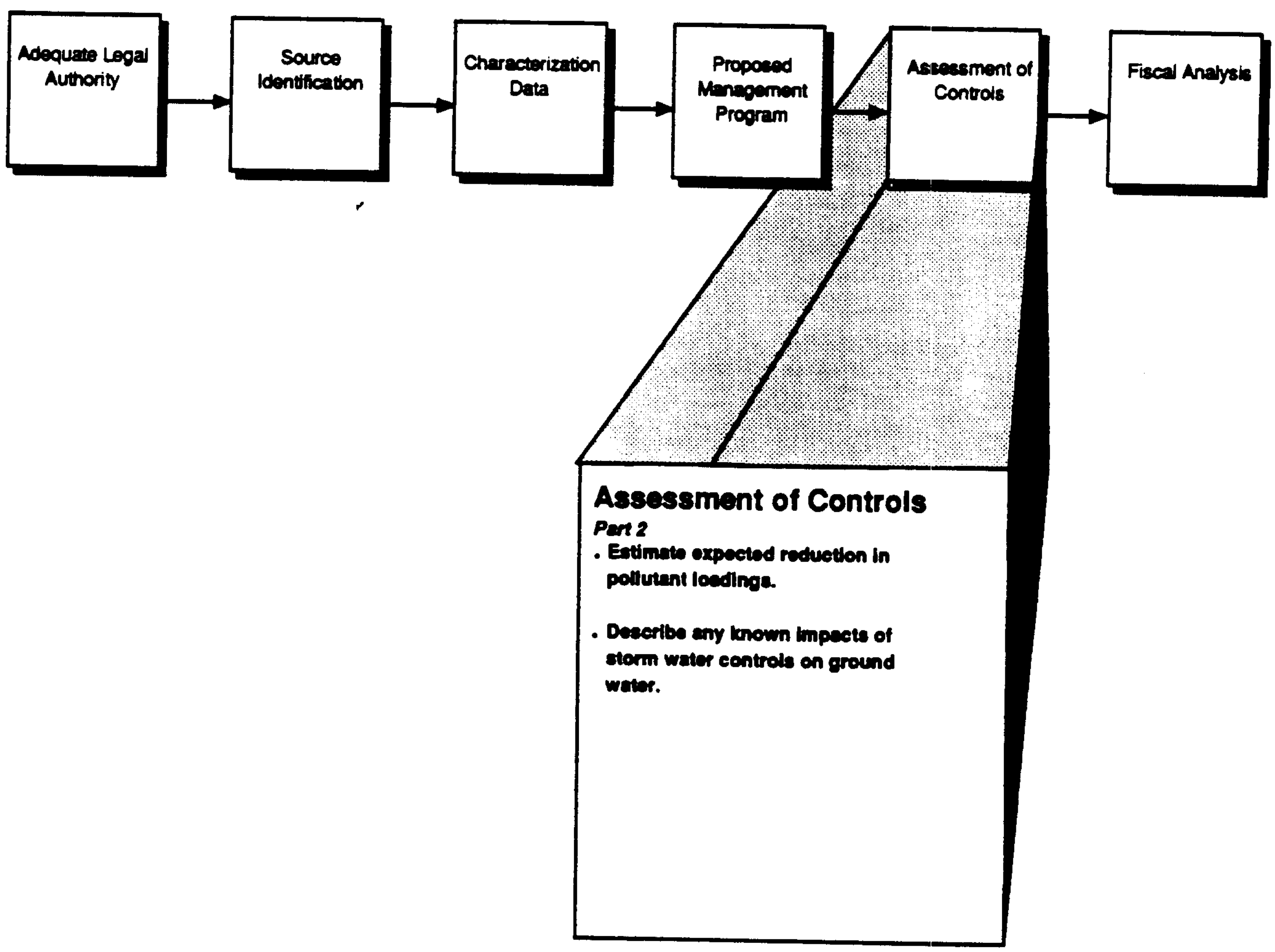
EPA anticipates that municipal storm water management programs will mature over time to reflect advances in technology, additional data collection, changing conditions, program development, stage of implementation, and improvements in water quality. Therefore, applicants may emphasize different program components to reflect implementation priorities. The proposed management program should clearly identify each of the program components and include a schedule for implementation. Each component of the Part 2 application should be classified as: full implementation, phased implementation, pilot study, or feasibility analysis. In annual reports on the progress of storm water management programs, municipalities must report on the status of implementing program provisions [§122.42(c)(1), or Section 7.3 of the guidance].

- **Full Implementation.** Fully implemented components should be proposed when the municipality is prepared to begin or continue full implementation after its permit is issued and it expects to continue the component throughout the life of the permit. Full implementation of a program component is generally the preferred way of demonstrating the required level of control.

- **Phased Implementation.** Phased implementation should be proposed when the level of effort to implement the component will vary during the term of the permit. Phased implementation may be appropriate when additional data must be collected or technical guidance, training materials, or appropriate ordinances must be developed prior to full implementation. A schedule that includes milestones should be part of the description.

- **Pilot Studies.** Although the municipality must implement and comply with *each* provision of the municipal storm water permit, the municipality may choose to carry out pilot studies that involve limited experimental implementation of a program component. In some cases, pilot studies may be authorized by the permit. Used to evaluate the effectiveness of a program component, pilot studies may be appropriate when a technology is unproven or when data must be collected to develop operating standards or procedures. A schedule including milestones should be included in the description of a pilot study. This schedule should provide options for phased implementation of the program component, showing alternatives based on various possible results of the pilot study.

CHAPTER 7
ASSESSMENT OF CONTROLS



7.0 ASSESSMENT OF CONTROLS

7.1 BACKGROUND

Part 2 applications require that municipalities estimate the effectiveness of their proposed storm water quality management programs. The regulations require an initial estimate or assessment because the performance of appropriate management controls is highly dependent on site-specific factors. Program effectiveness can be estimated through both **direct measurements** (such as reductions in annual pollutant loads) and **indirect measurements** (such as measurements that demonstrate increased public awareness of storm water quality issues). At a minimum, applicants must submit estimated reductions in pollutant loads expected to result from implemented controls and describe known impacts of storm water controls on ground water.

> **122.26(d)(2)(v).** *Assessment of controls.* The application must include] estimated reductions in loadings of pollutants for discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water.

Reductions in pollutant loads due to the implementation and maintenance of structural controls provide direct measurements of the effectiveness of the storm water management program. In addition, EPA encourages applicants to go beyond the minimum requirement and assess the effectiveness of their storm water management program through other direct measurements as well as indirect measurements. As discussed below, indirect measurements provide surrogate estimates of qualitative factors, such as increased public awareness of storm water quality issues.

Estimates of the effectiveness of the storm water management program will assist the municipality and the permit writer in:

- Determining whether the most cost-effective best management practices (BMPs) are included in the storm water management program;
- Ensuring that the storm water management program includes adequate public participation programs and intergovernmental coordination;
- Establishing on-going monitoring inspection and surveillance programs that help refine estimates of program effectiveness; and
- Developing a strategy to evaluate progress toward achieving water quality goals.

7.2 ASSESSMENT OF STORM WATER MANAGEMENT PROGRAM

For some components of a proposed storm water management program, such as structural controls (e.g., vegetative streambank stabilization, sediment pond or basin, etc.), the effect on pollution in storm water runoff is observable, and pollutant removal efficiencies can be estimated directly. For other components, pollutant reductions may be difficult to quantify. Applicants may need to use indirect estimates. For example, a program component may address source controls such as changing the behavior of citizens in the community, or improving the municipal control of industrial or commercial runoff. For components of the proposed management program where pollutant removal efficiency cannot be reasonably estimated, applicants are strongly encouraged to identify some indirect measurement that can be used to evaluate the success of the practice.

7.2.1 Direct Measurements of Program Effectiveness

As discussed above, 40 CFR 122.26(d)(2)(v) requires that applicants submit estimates of expected pollutant load reductions with their Part 2 applications. To supplement these estimates, applicants could provide estimates of other direct measurements of program effectiveness, including:

- Removal efficiencies of BMPs that control storm water quality;
- Reductions in the volume of storm water discharged;
- Reductions in event mean concentrations; or
- Reductions in seasonal pollutant loadings.

Such direct estimates do not have to be verified with quantitative data, but can be based on accepted engineering design practices. However, the applicant should describe its procedures for estimating the effectiveness of the control. Applicants should present estimates of pollutant load reductions or other measurements separately for each component of the proposed management program. Applicants should provide estimated reductions on a watershed basis and system-wide basis.

Reductions in pollutant loadings can be estimated by first estimating the pollutant loading (based on concentrations and flows) that would result without the control measure. This value should then be multiplied by the efficiency of the control expressed in terms of a fraction or percentage. Estimated control efficiencies can be obtained from published sources, such as Schueler (1987) (see bibliography in Appendix A). Note that for most control measures, the pollutant removal efficiency differs for different classes of pollutants.

After the municipality's storm water management program is implemented, the municipality can work to refine its initial assessment of the program. For example, the permit will require applicants to submit estimates of event mean concentrations and estimates of annual pollutant loadings for each outfall in the system [§122.26(d)(2)(iii)(C), discussed in Section 5.5 of this guidance]. These estimates can be compared with the applicant's initial estimates.

In addition, the estimated removal efficiencies can be refined through the monitoring program required by §122.26(d)(2)(iii)(D) (discussed in Section 5.6 of this guidance). To refine these estimates, the monitoring program should include measurements at the inflow and outflow points of the control. Throughout the permit term, the municipality must submit refinements to its assessment or additional direct measurements of program effectiveness in its annual report (Section 7.3).

The applicant should use direct measurements of program effectiveness as it begins to assess its long-term progress in improving water quality through storm water management practices. Direct measurements of program effectiveness may not provide meaningful conclusions on trends in water quality improvements for a couple of permit terms. However, applicants are encouraged to use direct measurements of program effectiveness, such as annual pollutant loads, event mean concentrations, and seasonal pollutant loadings, to begin to estimate long-term trends. Several statistical methods that rely on linear regression have been developed to model these measurements to determine if trends exist.

7.2.2 Indirect Measurements of Program Effectiveness

When pollutant reductions cannot be estimated through direct measurement, appropriate indirect measurements may be used. These may include the estimated level of increased enforcement activity, increased public awareness, or reduction in number of illegal dumping incidents. For example, a field screening program to identify illicit connections and improper dumping in Fort Worth, Texas, used reductions in observations of indicator pollutants as a measure of the success of the program (Fort Worth, 1988).

Other possible indirect measurements include:

- Gallons of used oil recycled;
- Amount of household hazardous waste collected;
- Number of educational brochures on storm water quality distributed;
- Number of public hearings on storm water and attendance at these hearings;
- Circulation of an annual report or periodic newsletters on progress in meeting storm water quality goals;
- Number of reports of illicit discharges or illegal dumping;
- Number of spill clean-ups;
- Number of sewer inlets stenciled;
- Acres of open space;
- Number of construction and erosion and sediment control plans submitted and approved.

Many of these indirect measurements will help to indicate whether the storm water management program includes adequate public participation and intergovernmental coordination.

7.2.3 Impacts of Storm Water Controls on Ground Water

Structural BMPs may have an impact on other media. Therefore, the Part 2 application requires that applicants discuss known impacts of storm water controls on ground water. Impacts should be identified separately for each component of the proposed management program. These controls may increase the quantity of ground water (such as infiltration leading to recharge), but degrade the quality of the ground water. For example, in arid parts of the Southwest, imported water is often used for irrigation. This increases the quantity of ground water, but, because of high levels of nutrients and total suspended and dissolved solids in the irrigation water, also results in impacts on ground water quality.

In addition, the applicant should evaluate whether structural controls for storm water impact other media, such as wetlands.

7.3. ANNUAL REPORTS ON THE EFFECTIVENESS OF THE STORM WATER MANAGEMENT PROGRAM

Under §122.42(c), applicants must provide annual reports on the progress of their storm water management programs. These reports, which are due on the anniversaries of permit issuance, must include:

- The status of implementing the components of the storm water management program that are required by the permit;
- Proposed changes to the storm water management programs that are established as permit conditions;

- Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application;

- Summary of data, including monitoring data, that are accumulated throughout the reporting year;

- Projected annual expenditures and budget for the year following each annual report;

- A summary describing the number and nature of enforcement actions, inspections, and public education programs; and

- Identification of water quality improvements or degradation.

Applicants should refer to the specific regulatory language in §122.42(c) for a more complete discussion of annual reporting requirements.

Although the Part 2 application requirements do not specifically address annual reporting requirements, applicants should consider their strategy for preparing annual reports when they complete their Part 2 applications. A municipality may develop a strategy to assess the progress of its storm water management program throughout the term of the permit in addition to providing a baseline assessment of its program. To develop the strategy, applicants should:

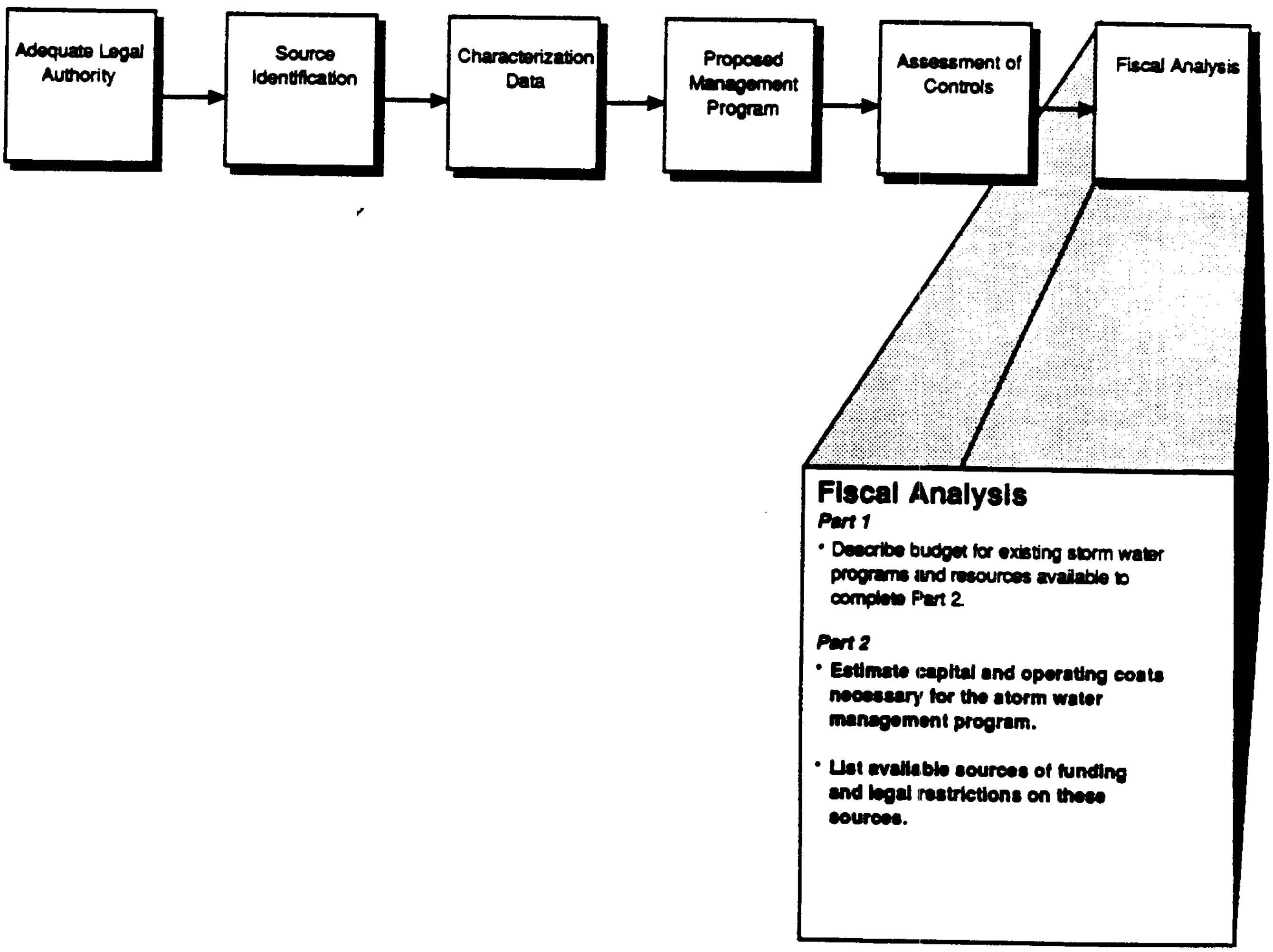
- Identify the direct or indirect measurements that will be used to track the long-term progress of the applicant's program towards achieving improvements in storm water quality (the results of this assessment would appear in the municipality's annual report);

- Discuss the role of monitoring data in substantiating or refining their assessment of the progress of their program towards established objectives and goals; and

- Discuss how future additions or revisions to the assessment measurements or strategy will be implemented by the municipality (e.g., what roles and responsibilities will participating municipal agencies and/or organizations have in this area).

It is anticipated that many municipalities will use the same criteria or measurements that were used in the baseline assessment to develop their long-term assessment strategy. This is an acceptable approach provided that the municipality delineates how their program provides for a longer term assessment of the progress of their storm water management program. The municipality is encouraged to consider in advance the information requirements for annual reporting that are identified above when developing their long-term assessment strategy.

CHAPTER 8
FISCAL ANALYSIS



8.0 FISCAL ANALYSIS

8.1 BACKGROUND

NPDES permits for discharges from MS4s will require municipal permittees to implement management programs, conduct long term storm water monitoring, and provide other information. Because these activities will result in expense to the municipality, a fiscal analysis is required in the Part 2 application.

Applicants must provide yearly cost estimates for these programs. Applicants also must provide a schedule indicating when funds will be available. Examining the levels of proposed spending and funding allows the permitting authority to gauge the ability of the applicant to implement the program and predict its effectiveness. The fiscal analysis also will help the permit writer determine whether the applicant has met the statutory requirement of reducing the discharge of pollutant to the MS4 to the maximum extent practicable. Finally, the estimates help the applicant evaluate the feasibility and cost-effectiveness of its program. A municipality must update its fiscal analysis each year for the annual report on the progress in implementing their storm water management program [40 CFR 122.42(c)(3) and (5), discussed in Section 7.3 of this guidance].

> **§122.26(d)(2)(vi).** [The application must include] for each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2)(iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds.

8.2 PROCEDURE FOR CONDUCTING A FISCAL ANALYSIS

Under §122.26(d)(2)(vi), each applicant must demonstrate sufficient financial resources to implement the conditions of the permit.

Adequate resources may be demonstrated by performing a fiscal analysis of the estimated capital and operation and maintenance expenditures required to complete the activities required by the regulations. This fiscal analysis must be performed for each fiscal year to be covered by the permit (5 years, in most cases). The analysis must describe the source of the funds used to meet the necessary expenditures, including any legal restrictions on the appropriated funds.

The following procedure is an example of a method of conducting the necessary fiscal analysis.

Step 1. Identify the major tasks for each component covered by this application requirement, including:

- Elements of the proposed management program;
- Estimates of seasonal loads and event mean concentrations for each major outfall covered by the permit; and
- Proposed monitoring program.

Step 2. Develop a schedule outlining when each of the tasks identified in Step 1 will be undertaken. Some tasks may be performed just once, others may be on-going. For example, the schedule should include, among other things:

- The installation of any new control measures identified in the proposed management program [§122.26(d)(2)(iv), discussed in Section 6.4];

- A maintenance schedule for structural best management practices (BMPs) [§122.26(d)(2)(iv)(A)(*1*), discussed in Section 6.4.3];

- Development of seasonal pollutant loadings and event mean concentrations of a representative storm [§122.26(d)(2)(iii)(C), discussed in Section 5.5];

- Monitoring program for representative data collection for the term of the permit [§122.26(d)(2)(iii)(D), discussed in Section 5.6];

- Monitoring program for industrial facilities [§122.26(d)(2)(iv)(C)(2), discussed in Section 6.3.3];

- On-going field screening program for illicit discharges [§122.26(d)(2)(iv)(B), discussed in Section 6.5];

- Development of certification programs for construction workers or pesticide applicators, if appropriate [§122.26(d)(2)(iv), discussed in Sections 6.3.1 and 6.3.2]; and

- Implementation schedules for other components of the storm water application that have not been fully implemented at the time of application, such as additional legal authority or comprehensive development plans.

Step 3. Estimate the capital expenses necessary to accomplish the tasks identified in Step 1 and determine a schedule for purchase. Applicants may elect to define categories of capital expenditures such as "monitoring equipment," "miscellaneous monitoring supplies," "personal protective equipment," etc.

Step 4. Estimate other non-capital costs to implement the tasks identified in Step 1. Use the schedule developed in Step 2 to spread costs over the term of the permit. Costs should be presented as a total annual cost for each proposed program component. In addition, estimates of the total annual costs and annual per capita costs should be provided. Per capita costs can be compared with the per capita costs of other programs, such as sewage treatment programs.

These costs may include items such as :

- Newspaper ads announcing new programs or recycling centers;

- Holding public meetings or hearings; and

- Labor for department personnel to speak to citizens groups.

Step 5. Identify funding to be applied. Applicants must describe the sources of funding and any legal restrictions on that funding. Sources may include general revenues, storm water utilities, plan review fees, permit fees, industrial/commercial user fees, special assessment district funds, and revenue bonds. Some funding sources, such as general revenues based on property taxes, are generally unrestricted, but can be allocated by local officials annually. In a few cases, a local property tax may be dedicated to finance a storm water management program. For example, one county finances its storm water management program through a dedicated property tax of $0.135 per $100 assessed valuation. Other municipalities add special assessments to property tax bills.

A storm water utility is another source of funding dedicated to financing storm water management activities. The storm water utility offers the advantage of a stable and predictable source of funds. Other advantages of storm water utilities over general revenues are that utility charges can be more equitably based on the user's contribution to local storm water problems, and a utility provides a mechanism to incorporate incentives for on-site storm water management.

In many cases, municipalities will evaluate sources of funds that are not currently available, such as a new storm water utility. In these cases, applicants must include a schedule of when funds will be available. For example, it usually takes a municipality 18 to 24 months of planning before local elected officials authorize a storm water utility, and another 6 to 12 months to implement the utility (Lindsey, 1988). Key milestones for planning and implementing the funding mechanism must be identified in the schedule. The following components have been found to be important in establishing storm water utilities:

- Determining the most appropriate administrative structure for implementing a storm water management program;
- Adopting a storm water utility ordinance;
- Estimating revenue needs and planning for cost recovery;
- Establishing a utility rate structure and billing system;
- Establishing a system for developer contributions; and
- Implementing a public information program.

Step 6. Compare the funding sources with the funding needs. As a last step in this process, the municipality must ensure that adequate funding is available to cover the cost of implementing the storm water management program. If adequate funding is not available, the municipality must consider alternate sources of funding, such as a storm water utility.

APPENDIX A:
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BIBLIOGRAPHY*

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Wetlands: Their Use and Regulation, U.S. Congress, Office of Technology Assessment, OTA-00-206. March 1984.

* For additional sources of information, applicants may wish to consult the documents listed in the bibliohraphy of: Urban Drainage & Flood Control District, *Urban Storm Drainage Criteria Manual, Vol.III*, Urban Drainage and Flood Control District, Denver, CO. September 1, 1992.

APPENDIX B:
PART 2 APPLICATION
REQUIREMENTS

certify, pursuant to 5 U.S.C. 605(b), that these amendments do not have a significant impact on a substantial number of small entities.

List of Subjects in 40 CFR Parts 122, 123, and 124

Administrative practice and procedure, Environmental protection, Reporting and recordkeeping requirements, Water pollution control.

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

Dated: October 31, 1990.

William K. Reilly,

Administrator.

For the reasons stated in the preamble, parts 122, 123, and 124 of title 40 of the Code of Federal Regulations are amended as follows:

PART 122—EPA ADMINISTERED PERMIT PROGRAMS; THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Subpart B—Permit Application and Special NPDES Program Requirements

1. The authority citation for part 122 continues to read as follows:

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

2. Section 122.1 is amended by revising paragraph (b)(2)(iv) to read as follows:

§ 122.1 Purpose and scope.

* * * * *

(b) * * *

(2) * * *

(iv) Discharges of storm water as set forth in § 122.26; and

* * * * *

3. Section 122.21 is amended by revising paragraph (c)(1), by removing the last sentence of paragraph (f)(7), by removing paragraph (f)(9), by adding two sentences at the end of paragraph (g)(3), by revising paragraph (g)(7) introductory text, by removing and reserving paragraph (g)(10) and by revising the introductory text of paragraph (k) to read as follows:

§ 122.21 Application for a permit (applicable to State programs, see § 123.25).

* * * * *

(c) *Time to apply.* (1) Any person proposing a new discharge, shall submit an application at least 180 days before the date on which the discharge is to commence, unless permission for a later date has been granted by the Director. Facilities proposing a new discharge of storm water associated with industrial activity shall submit an application 180 days before that facility commences industrial activity which may result in a discharge of storm water associated with that industrial activity. Facilities described under § 122.26(b)(14)(x) shall submit applications at least 90 days before the date on which construction is to commence. Different submittal dates may be required under the terms of applicable general permits. Persons proposing a new discharge are encouraged to submit their applications well in advance of the 90 or 180 day requirements to avoid delay. See also paragraph (k) of this section and § 122.26 (c)(1)(i)(G) and (c)(1)(ii).

* * * * *

(g) * * *

(3) * * * The average flow of point sources composed of storm water may be estimated. The basis for the rainfall event and the method of estimation must be indicated.

* * * * *

(7) *Effluent characteristics.* Information on the discharge of pollutants specified in this paragraph (except information on storm water discharges which is to be provided as specified in § 122.26). When "quantitative data" for a pollutant are required, the applicant must collect a sample of effluent and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method. When an applicant has two or more outfalls with substantially identical effluents, the Director may allow the applicant to test only one outfall and report that the quantitative data also apply to the substantially identical outfalls. The requirements in paragraphs (g)(7) (iii) and (iv) of this section that an applicant must provide quantitative data for certain pollutants known or believed to be present do not apply to pollutants present in a discharge solely as the result of their presence in intake water; however, an applicant must report such pollutants as present. Grab samples must be used for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform and fecal streptococcus. For all other pollutants, 24-hour composite samples must be used. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period greater than 24 hours. In addition, for discharges other than storm water discharges, the Director may waive composite sampling for any outfall for which the applicant demonstrates that the use of an automatic sampler is infeasible and that the minimum of four (4) grab samples will be a representative sample of the effluent being discharged. For storm water discharges, all samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inch and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area. For all applicants, a flow-weighted composite shall be taken for either the entire discharge or for the first three hours of the discharge. The flow-weighted composite sample for a storm water discharge may be taken with a continuous sampler or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire discharge or for the first three hours of the discharge, with each aliquot being separated by a minimum period of fifteen minutes (applicants submitting permit applications for storm water discharges under § 122.26(d) may collect flow weighted composite samples using different protocols with respect to the time duration between the collection of sample aliquots, subject to the approval of the Director). However, a minimum of one grab sample may be taken for storm water discharges from holding ponds or other impoundments with a retention period greater than 24 hours. For a flow-weighted composite sample, only one analysis of the composite of aliquots is required. For storm water discharge samples taken from discharges associated with industrial activities, quantitative data must be reported for the grab sample taken during the first thirty minutes (or as soon thereafter as practicable) of the discharge for all pollutants specified in § 122.26(c)(1). For all storm water permit applicants taking flow-weighted composites, quantitative data must be reported for all pollutants specified in § 122.26 except pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, fecal coliform, and fecal streptococcus. The Director may allow or establish appropriate site-specific sampling procedures or requirements, including sampling locations, the season in which the sampling takes place, the minimum duration between the previous measurable storm event and the storm event sampled, the minimum or maximum level of precipitation required for an appropriate storm event, the form of precipitation sampled (snow melt or rain fall), protocols fo- collecting samples under 40 CFR part 136, and additional time for submitting data on a

case-by-case basis. An applicant is expected to "know or have reason to believe" that a pollutant is present in an effluent based on an evaluation of the expected use, production, or storage of the pollutant, or on any previous analyses for the pollutant. (For example, any pesticide manufactured by a facility may be expected to be present in contaminated storm water runoff from the facility.)

* * * * *

(k) *Application requirements for new sources and new discharges.* New manufacturing, commercial, mining and silvicultural dischargers applying for NPDES permits (except for new discharges of facilities subject to the requirements of paragraph (h) of this section or new discharges of storm water associated with industrial activity which are subject to the requirements of § 122.26(c)(1) and this section (except as provided by § 122.26(c)(1)(ii)) shall provide the following information to the Director, using the application forms provided by the Director:

* * * * *

4. Section 122.22(b) introductory text is revised to read as follows:

§ 122.22 Signatories to permit applications and reports (applicable to State programs, see § 123.25).

* * * * *

(b) All reports required by permits, and other information requested by the Director shall be signed by a person described in paragraph (a) of this section, or by a duly authorized representative of that person. A person is a duly authorized representative only if:

* * * * *

5. Section 122.26 is revised to read as follows:

§ 122.26 Storm water discharges (applicable to State NPDES programs, see § 123.25).

(a) *Permit requirement.* (1) Prior to October 1, 1992, discharges composed entirely of storm water shall not be required to obtain a NPDES permit except:

(i) A discharge with respect to which a permit has been issued prior to February 4, 1987;

(ii) A discharge associated with industrial activity (see § 122.26(a)(4));

(iii) A discharge from a large municipal separate storm sewer system;

(iv) A discharge from a medium municipal separate storm sewer system;

(v) A discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. This designation may include a discharge from any conveyance or system of conveyances used for collecting and conveying storm water runoff or a system of discharges from municipal separate storm sewers, except for those discharges from conveyances which do not require a permit under paragraph (a)(2) of this section or agricultural storm water runoff which is exempted from the definition of point source at § 122.2. The Director may designate discharges from municipal separate storm sewers on a system-wide or jurisdiction-wide basis. In making this determination the Director may consider the following factors:

(A) The location of the discharge with respect to waters of the United States as defined at 40 CFR 122.2.

(B) The size of the discharge;

(C) The quantity and nature of the pollutants discharged to waters of the United States; and

(D) Other relevant factors.

(2) The Director may not require a permit for discharges of storm water runoff from mining operations or oil and gas exploration, production, processing or treatment operations or transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(3) *Large and medium municipal separate storm sewer systems.* (i) Permits must be obtained for all discharges from large and medium municipal separate storm sewer systems.

(ii) The Director may either issue one system-wide permit covering all discharges from municipal separate storm sewers within a large or medium municipal storm sewer system or issue distinct permits for appropriate categories of discharges within a large or medium municipal separate storm sewer system including, but not limited to: all discharges owned or operated by the same municipality; located within the same jurisdiction; all discharges within a system that discharge to the same watershed; discharges within a system that are similar in nature; or for individual discharges from municipal separate storm sewers within the system.

(iii) The operator of a discharge from a municipal separate storm sewer which is part of a large or medium municipal separate storm sewer system must either:

(A) Participate in a permit application (to be a permittee or a co-permittee) with one or more other operators of discharges from the large or medium municipal storm sewer system which covers all, or a portion of all, discharges from the municipal separate storm sewer system;

(B) Submit a distinct permit application which only covers discharges from the municipal separate storm sewers for which the operator is responsible; or

(C) A regional authority may be responsible for submitting a permit application under the following guidelines:

(*1*) The regional authority together with co-applicants shall have authority over a storm water management program that is in existence, or shall be in existence at the time part 1 of the application is due;

(*2*) The permit applicant or co-applicants shall establish their ability to make a timely submission of part 1 and part 2 of the municipal application;

(*3*) Each of the operators of municipal separate storm sewers within the systems described in paragraphs (b)(4) (i), (ii), and (iii) or (b)(7) (i), (ii), and (iii) of this section, that are under the purview of the designated regional authority, shall comply with the application requirements of paragraph (d) of this section.

(iv) One permit application may be submitted for all or a portion of all municipal separate storm sewers within adjacent or interconnected large or medium municipal separate storm sewer systems. The Director may issue one system-wide permit covering all, or a portion of all municipal separate storm sewers in adjacent or interconnected large or medium municipal separate storm sewer systems.

(v) Permits for all or a portion of all discharges from large or medium municipal separate storm sewer systems that are issued on a system-wide, jurisdiction-wide, watershed or other basis may specify different conditions relating to different discharges covered by the permit, including different management programs for different drainage areas which contribute storm water to the system.

(vi) Co-permittees need only comply with permit conditions relating to discharges from the municipal separate storm sewers for which they are operators.

(4) *Discharges through large and medium municipal separate storm sewer systems.* In addition to meeting the requirements of paragraph (c) of this section, an operator of a storm water discharge associated with industrial activity which discharges through a large or medium municipal separate storm sewer system shall submit, to the operator of the municipal separate storm sewer system receiving the discharge no later than May 15, 1991, or 180 days prior to commencing such discharge: the name of the facility; a contact person and phone number; the location of the discharge; a description, including Standard Industrial Classification, which best reflects the principal products or services provided by each facility; and any existing NPDES permit number.

(5) *Other municipal separate storm sewers.* The Director may issue permits for municipal separate storm sewers that are designated under paragraph (a)(1)(v) of this section on a system-wide basis, jurisdiction-wide basis, watershed basis or other appropriate basis, or may issue permits for individual discharges.

(6) *Non-municipal separate storm sewers.* For storm water discharges associated with industrial activity from point sources which discharge through a non-municipal or non-publicly owned separate storm sewer system, the Director, in his discretion, may issue: a single NPDES permit, with each discharger a co-permittee to a permit issued to the operator of the portion of the system that discharges into waters of the United States; or, individual permits to each discharger of storm water associated with industrial activity through the non-municipal conveyance system.

(i) All storm water discharges associated with industrial activity that discharge through a storm water discharge system that is not a municipal separate storm sewer must be covered by an individual permit, or a permit issued to the operator of the portion of the system that discharges to waters of the United States, with each discharger to the non-municipal conveyance a co-permittee to that permit.

(ii) Where there is more than one operator of a single system of such conveyances, all operators of storm water discharges associated with industrial activity must submit applications.

(iii) Any permit covering more than one operator shall identify the effluent limitations, or other permit conditions, if any, that apply to each operator.

(7) *Combined sewer systems.* Conveyances that discharge storm water runoff combined with municipal sewage are point sources that must obtain NPDES permits in accordance with the procedures of § 122.21 and are not subject to the provisions of this section.

(8) Whether a discharge from a municipal separate storm sewer is or is not subject to regulation under this section shall have no bearing on whether the owner or operator of the discharge is eligible for funding under title II, title III or title VI of the Clean Water Act. *See* 40 CFR part 35, subpart I, appendix A(b)H.2.j.

(b) *Definitions.* (1) *Co-permittee* means a permittee to a NPDES permit that is only responsible for permit conditions relating to the discharge for which it is operator.

(2) *Illicit discharge* means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

(3) *Incorporated place* means the District of Columbia, or a city, town, township, or village that is incorporated under the laws of the State in which it is located.

(4) *Large municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 250,000 or more as determined by the latest Decennial Census by the Bureau of Census (appendix F); or

(ii) Located in the counties listed in appendix H, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(4)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; and

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a large municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraph (b)(4) (i), (ii), (iii) of this section.

(5) *Major municipal separate storm sewer outfall* (or "major outfall") means a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for municipal separate storm sewers that receive storm water from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

(6) *Major outfall* means a major municipal separate storm sewer outfall.

(7) *Medium municipal separate storm sewer system* means all municipal separate storm sewers that are either:

(i) Located in an incorporated place with a population of 100,000 or more but less than 250,000, as determined by the latest Decennial Census by the Bureau of Census (appendix G); or

(ii) Located in the counties listed in appendix I, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties; or

(iii) Owned or operated by a municipality other than those described in paragraph (b)(4) (i) or (ii) of this section and that are designated by the Director as part of the large or medium municipal separate storm sewer system due to the interrelationship between the discharges of the designated storm sewer and the discharges from municipal separate storm sewers described under paragraph (b)(4) (i) or (ii) of this section. In making this determination the Director may consider the following factors:

(A) Physical interconnections between the municipal separate storm sewers;

(B) The location of discharges from the designated municipal separate storm sewer relative to discharges from municipal separate storm sewers described in paragraph (b)(7)(i) of this section;

(C) The quantity and nature of pollutants discharged to waters of the United States;

(D) The nature of the receiving waters; or

(E) Other relevant factors; or

(iv) The Director may, upon petition, designate as a medium municipal separate storm sewer system, municipal separate storm sewers located within the boundaries of a region defined by a storm water management regional authority based on a jurisdictional, watershed, or other appropriate basis that includes one or more of the systems described in paragraphs (b)(7) (i), (ii), (iii) of this section.

(8) *Municipal separate storm sewer* means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

(9) *Outfall* means a *point source* as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other waters of the United States and are used to convey waters of the United States.

(10) *Overburden* means any material of any nature, consolidated or unconsolidated, that overlies a mineral deposit, excluding topsoil or similar naturally-occurring surface materials that are not disturbed by mining operations.

(11) *Runoff coefficient* means the fraction of total rainfall that will appear at a conveyance as runoff.

(12) *Significant materials* includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of CERCLA; any chemical the facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

(13) *Storm water* means storm water runoff, snow melt runoff, and surface runoff and drainage.

(14) *Storm water discharge associated with industrial activity* means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR part 122. For the categories of industries identified in paragraphs (b)(14) (i) through (x) of this section, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR part 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in paragraph (b)(14)(xi) of this section, the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (b)(14)(i)-(xi) of this section) include those facilities designated under the provisions of paragraph (a)(1)(v) of this section. The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection:

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) in paragraph (b)(14) of this section);

(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, 373;

(iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mining claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (b)(14) (i)-(vii) or (ix)-(xi) of this section are associated with industrial activity;

(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA;

(x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;

(xi) Facilities under Standard Industrial Classifications 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories (ii)-(x));

(c) *Application requirements for storm water discharges associated with industrial activity*—(1) *Individual application.* Dischargers of storm water associated with industrial activity are required to apply for an individual permit, apply for a permit through a group application, or seek coverage under a promulgated storm water general permit. Facilities that are required to obtain an individual permit, or any discharge of storm water which the Director is evaluating for designation (*see* 40 CFR 124.52(c)) under paragraph (a)(1)(v) of this section and is not a municipal separate storm sewer, and which is not part of a group application described under paragraph (c)(2) of this section, shall submit an NPDES application in accordance with the requirements of § 122.21 as modified and supplemented by the provisions of the remainder of this paragraph. Applicants for discharges composed entirely of storm water shall submit Form 1 and Form 2F. Applicants for discharges composed of storm water and non-storm water shall submit Form 1, Form 2C, and Form 2F. Applicants for new sources or new discharges (as defined in § 122.2 of this part) composed of storm water and non-storm water shall submit Form 1, Form 2D, and Form 2F.

(i) Except as provided in § 122.26(c)(1)(ii)-(iv), the operator of a storm water discharge associated with industrial activity subject to this section shall provide:

(A) A site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) of the facility including: each of its drainage and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each past or present area used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied, each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility;

(B) An estimate of the area of impervious surfaces (including paved areas and building roofs) and the total area drained by each outfall (within a mile radius of the facility) and a narrative description of the following: Significant materials that in the three years prior to the submittal of this application have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of such materials; materials management practices employed, in the three years prior to the submittal of this application, to minimize contact by these materials with storm water runoff; materials loading and access areas; the location, manner and frequency in which pesticides, herbicides, soil conditioners and fertilizers are applied; the location and a description of existing structural and non-structural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the ultimate disposal of any solid or fluid wastes other than by discharge;

(C) A certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by a NPDES permit; tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. The certification shall include a description of the method used, the date of any testing, and the on-site drainage points that were directly observed during a test;

(D) Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility that have taken place within the three years prior to the submittal of this application;

(E) Quantitative data based on samples collected during storm events and collected in accordance with § 122.21 of this part from all outfalls containing a storm water discharge associated with industrial activity for the following parameters:

(*1*) Any pollutant limited in an effluent guideline to which the facility is subject;

(*2*) Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit);

(*3*) Oil and grease, pH, BOD5, COD, TSS, total phosphorus, total Kjeldahl nitrogen, and nitrate plus nitrite nitrogen;

(*4*) Any information on the discharge required under paragraph § 122.21(g)(7)(iii) and (iv) of this part;

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(*5*) Flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, and the method of flow measurement or estimation; and

(*6*) The date and duration (in hours) of the storm event(s) sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event (in hours);

(F) Operators of a discharge which is composed entirely of storm water are exempt from the requirements of § 122.21 (g)(2), (g)(3), (g)(4), (g)(5), (g)(7)(i), (g)(7)(ii), and (g)(7)(v); and

(G) Operators of new sources or new discharges (as defined in § 122.2 of this part) which are composed in part or entirely of storm water must include estimates for the pollutants or parameters listed in paragraph (c)(1)(i)(E) of this section instead of actual sampling data, along with the source of each estimate. Operators of new sources or new discharges composed in part or entirely of storm water must provide quantitative data for the parameters listed in paragraph (c)(1)(i)(E) of this section within two years after commencement of discharge, unless such data has already been reported under the monitoring requirements of the NPDES permit for the discharge. Operators of a new source or new discharge which is composed entirely of storm water are exempt from the requirements of § 122.21 (k)(3)(ii), (k)(3)(iii), and (k)(5).

(ii) The operator of an existing or new storm water discharge that is associated with industrial activity solely under paragraph (b)(14)(x) of this section, is exempt from the requirements of § 122.21(g) and paragraph (c)(1)(i) of this section. Such operator shall provide a narrative description of:

(A) The location (including a map) and the nature of the construction activity:

(B) The total area of the site and the area of the site that is expected to undergo excavation during the life of the permit;

(C) Proposed measures, including best management practices, to control pollutants in storm water discharges during construction, including a brief description of applicable State and local erosion and sediment control requirements;

(D) Proposed measures to control pollutants in storm water discharges that will occur after construction operations have been completed, including a brief description of applicable State or local erosion and sediment control requirements;

(E) An estimate of the runoff coefficient of the site and the increase in impervious area after the construction addressed in the permit application is completed, the nature of fill material and existing data describing the soil or the quality of the discharge; and

(F) The name of the receiving water.

(iii) The operator of an existing or new discharge composed entirely of storm water from an oil or gas exploration, production, processing, or treatment operation, or transmission facility is not required to submit a permit application in accordance with paragraph (c)(1)(i) of this section, unless the facility:

(A) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 117.21 or 40 CFR 302.6 at anytime since November 16, 1987; or

(B) Has had a discharge of storm water resulting in the discharge of a reportable quantity for which notification is or was required pursuant to 40 CFR 110.6 at any time since November 16, 1987; or

(C) Contributes to a violation of a water quality standard.

(iv) The operator of an existing or new discharge composed entirely of storm water from a mining operation is not required to submit a permit application unless the discharge has come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations.

(v) Applicants shall provide such other information the Director may reasonably require under § 122.21(g)(13) of this part to determine whether to issue a permit and may require any facility subject to paragraph (c)(1)(ii) of this section to comply with paragraph (c)(1)(i) of this section.

(*2*) *Group application for discharges associated with industrial activity.* In lieu of individual applications or notice of intent to be covered by a general permit for storm water discharges associated with industrial activity, a group application may be filed by an entity representing a group of applicants (except facilities that have existing individual NPDES permits for storm water) that are part of the same subcategory (*see* 40 CFR subchapter N, part 405 to 471) or, where such grouping is inapplicable, are sufficiently similar as to be appropriate for general permit coverage under § 122.28 of this part. The part 1 application shall be submitted to the Office of Water Enforcement and Permits, U.S. EPA, 401 M Street, SW., Washington, DC 20460 (EN-336) for approval. Once a part 1 application is approved, group applicants are to submit Part 2 of the group application to the Office of Water Enforcement and Permits. A group application shall consist of:

(i) *Part 1.* Part 1 of a group application shall:

(A) Identify the participants in the group application by name and location. Facilities participating in the group application shall be listed in nine subdivisions, based on the facility location relative to the nine precipitation zones indicated in appendix E to this part.

(B) Include a narrative description summarizing the industrial activities of participants of the group application and explaining why the participants, as a whole, are sufficiently similar to be a covered by a general permit;

(C) Include a list of significant materials stored exposed to precipitation by participants in the group application and materials management practices employed to diminish contact by these materials with precipitation and storm water runoff;

(D) Identify ten percent of the dischargers participating in the group application (with a minimum of 10 dischargers, and either a minimum of two dischargers from each precipitation zone indicated in appendix E of this part in which ten or more members of the group are located, or one discharger from each precipitation zone indicated in appendix E of this part in which nine or fewer members of the group are located) from which quantitative data will be submitted in part 2. If more than 1,000 facilities are identified in a group application, no more than 100 dischargers must submit quantitative data in Part 2. Groups of between four and ten dischargers may be formed. However, in groups of between four and ten, at least half the facilities must submit quantitative data, and at least one facility in each precipitation zone in which members of the group are located must submit data. A description of why the facilities selected to perform sampling and analysis are representative of the group as a whole in terms of the information provided in paragraph (c)(1) (i)(B) and (i)(C) of this section, shall accompany this section. Different factors impacting the nature of the storm water discharges, such as processes used and material management, shall be represented, to the extent feasible, in a manner roughly equivalent to their proportion in the group.

(ii) *Part 2.* Part 2 of a group application shall contain quantitative

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data (NPDES Form 2F), as modified by paragraph (c)(1) of this section, so that when part 1 and part 2 of the group application are taken together, a complete NPDES application (Form 1, Form 2C, and Form 2F) can be evaluated for each discharger identified in paragraph (c)(2)(i)(D) of this section.

(d) *Application requirements for large and medium municipal separate storm sewer discharges.* The operator of a discharge from a large or medium municipal separate storm sewer or a municipal separate storm sewer that is designated by the Director under paragraph (a)(1)(v) of this section, may submit a jurisdiction-wide or system-wide permit application. Where more than one public entity owns or operates a municipal separate storm sewer within a geographic area (including adjacent or interconnected municipal separate storm sewer systems), such operators may be a coapplicant to the same application. Permit applications for discharges from large and medium municipal storm sewers or municipal storm sewers designated under paragraph (a)(1)(v) of this section shall include:

(1) *Part 1.* Part 1 of the application shall consist of:

(i) *General information.* The applicants' name, address, telephone number of contact person, ownership status and status as a State or local government entity.

(ii) *Legal authority.* A description of existing legal authority to control discharges to the municipal separate storm sewer system. When existing legal authority is not sufficient to meet the criteria provided in paragraph (d)(2)(i) of this section, the description shall list additional authorities as will be necessary to meet the criteria and shall include a schedule and commitment to seek such additional authority that will be needed to meet the criteria.

(iii) *Source identification.* (A) A description of the historic use of ordinances, guidance or other controls which limited the discharge of non-storm water discharges to any Publicly Owned Treatment Works serving the same area as the municipal separate storm sewer system.

(B) A USGS 7.5 minute topographic map (or equivalent topographic map with a scale between 1:10,000 and 1:24,000 if cost effective) extending one mile beyond the service boundaries of the municipal storm sewer system covered by the permit application. The following information shall be provided:

(*1*) The location of known municipal storm sewer system outfalls discharging to waters of the United States;

(*2*) A description of the land use activities (e.g. divisions indicating undeveloped, residential, commercial, agricultural and industrial uses) accompanied with estimates of population densities and projected growth for a ten year period within the drainage area served by the separate storm sewer. For each land use type, an estimate of an average runoff coefficient shall be provided;

(*3*) The location and a description of the activities of the facility of each currently operating or closed municipal landfill or other treatment, storage or disposal facility for municipal waste;

(*4*) The location and the permit number of any known discharge to the municipal storm sewer that has been issued a NPDES permit;

(*5*) The location of major structural controls for storm water discharge (retention basins, detention basins, major infiltration devices, etc.); and

(*6*) The identification of publicly owned parks, recreational areas, and other open lands.

(iv) *Discharge characterization.* (A) Monthly mean rain and snow fall estimates (or summary of weather bureau data) and the monthly average number of storm events.

(B) Existing quantitative data describing the volume and quality of discharges from the municipal storm sewer, including a description of the outfalls sampled, sampling procedures and analytical methods used.

(C) A list of water bodies that receive discharges from the municipal separate storm sewer system, including downstream segments, lakes and estuaries, where pollutants from the system discharges may accumulate and cause water degradation and a brief description of known water quality impacts. At a minimum, the description of impacts shall include a description of whether the water bodies receiving such discharges have been:

(*1*) Assessed and reported in section 305(b) reports submitted by the State, the basis for the assessment (evaluated or monitored), a summary of designated use support and attainment of Clean Water Act (CWA) goals (fishable and swimmable waters), and causes of nonsupport of designated uses;

(*2*) Listed under section 304(l)(1)(A)(i), section 304(l)(1)(A)(ii), or section 304(l)(1)(B) of the CWA that is not expected to meet water quality standards or water quality goals;

(*3*) Listed in State Nonpoint Source Assessments required by section 319(a) of the CWA that, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain water quality standards due to storm sewers, construction, highway maintenance and runoff from municipal landfills and municipal sludge adding significant pollution (or contributing to a violation of water quality standards);

(*4*) Identified and classified according to eutrophic condition of publicly owned lakes listed in State reports required under section 314(a) of the CWA (include the following: A description of those publicly owned lakes for which uses are known to be impaired; a description of procedures, processes and methods to control the discharge of pollutants from municipal separate storm sewers into such lakes; and a description of methods and procedures to restore the quality of such lakes);

(*5*) Areas of concern of the Great Lakes identified by the International Joint Commission;

(*6*) Designated estuaries under the National Estuary Program under section 320 of the CWA;

(*7*) Recognized by the applicant as highly valued or sensitive waters;

(*8*) Defined by the State or U.S. Fish and Wildlife Services's National Wetlands Inventory as wetlands; and

(*9*) Found to have pollutants in bottom sediments, fish tissue or biosurvey data.

(D) *Field screening.* Results of a field screening analysis for illicit connections and illegal dumping for either selected field screening points or major outfalls covered in the permit application. At a minimum, a screening analysis shall include a narrative description, for either each field screening point or major outfall, of visual observations made during dry weather periods. If any flow is observed, two grab samples shall be collected during a 24 hour period with a minimum period of four hours between samples. For all such samples, a narrative description of the color, odor, turbidity, the presence of an oil sheen or surface scum as well as any other relevant observations regarding the potential presence of non-storm water discharges or illegal dumping shall be provided. In addition, a narrative description of the results of a field analysis using suitable methods to estimate pH, total chlorine, total copper, total phenol, and detergents (or surfactants) shall be provided along with a description of the flow rate. Where the field analysis does not involve analytical methods approved under 40 CFR part 136, the applicant shall provide a description of the method used including the name of the manufacturer of the test method along with the range and accuracy of the test. Field screening points shall be either major outfalls or other outfall points (or

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any other point of access such as manholes) randomly located throughout the storm sewer system by placing a grid over a drainage system map and identifying those cells of the grid which contain a segment of the storm sewer system or major outfall. The field screening points shall be established using the following guidelines and criteria:

(*1*) A grid system consisting of perpendicular north-south and east-west lines spaced ¼ mile apart shall be overlayed on a map of the municipal storm sewer system, creating a series of cells;

(*2*) All cells that contain a segment of the storm sewer system shall be identified; one field screening point shall be selected in each cell; major outfalls may be used as field screening points;

(*3*) Field screening points should be located downstream of any sources of suspected illegal or illicit activity;

(*4*) Field screening points shall be located to the degree practicable at the farthest manhole or other accessible location downstream in the system, within each cell; however, safety of personnel and accessibility of the location should be considered in making this determination;

(*5*) Hydrological conditions; total drainage area of the site; population density of the site; traffic density; age of the structures or buildings in the area; history of the area; and land use types;

(*6*) For medium municipal separate storm sewer systems, no more than 250 cells need to have identified field screening points; in large municipal separate storm sewer systems, no more than 500 cells need to have identified field screening points; cells established by the grid that contain no storm sewer segments will be eliminated from consideration; if fewer than 250 cells in medium municipal sewers are created, and fewer than 500 in large systems are created by the overlay on the municipal sewer map, then all those cells which contain a segment of the sewer system shall be subject to field screening (unless access to the separate storm sewer system is impossible); and

(*7*) Large or medium municipal separate storm sewer systems which are unable to utilize the procedures described in paragraphs [illegible](1)(iv)(D) (*1*) through (*6*) of this section, because a sufficiently detailed map of the separate storm sewer systems is unavailable, shall field screen no more than 500 or 250 major outfalls respectively (or all major outfalls in the system, if less); in such circumstances, the applicant shall establish a grid system consisting of north-south and east-west lines spaced ¼ mile apart as an overlay to the boundaries of the municipal storm sewer system, thereby creating a series of cells; the applicant will then select major outfalls in as many cells as possible until at least 500 major outfalls (large municipalities) or 250 major outfalls (medium municipalities) are selected; a field screening analysis shall be undertaken at these major outfalls.

(E) *Characterization plan.* Information and a proposed program to meet the requirements of paragraph (d)(2)(iii) of this section. Such description shall include: the location of outfalls or field screening points appropriate for representative data collection under paragraph (d)(2)(iii)(A) of this section, a description of why the outfall or field screening point is representative, the seasons during which sampling is intended, a description of the sampling equipment. The proposed location of outfalls or field screening points for such sampling should reflect water quality concerns (*see* paragraph (d)(1)(iv)(C) of this section) to the extent practicable.

(v) *Management programs.* (A) A description of the existing management programs to control pollutants from the municipal separate storm sewer system. The description shall provide information on existing structural and source controls, including operation and maintenance measures for structural controls, that are currently being implemented. Such controls may include, but are not limited to: Procedures to control pollution resulting from construction activities; floodplain management controls; wetland protection measures; best management practices for new subdivisions; and emergency spill response programs. The description may address controls established under State law as well as local requirements.

(B) A description of the existing program to identify illicit connections to the municipal storm sewer system. The description should include inspection procedures and methods for detecting and preventing illicit discharges, and describe areas where this program has been implemented.

(vi) *Fiscal resources.* (A) A description of the financial resources currently available to the municipality to complete part 2 of the permit application. A description of the municipality's budget for existing storm water programs, including an overview of the municipality's financial resources and budget, including overall indebtedness and assets, and sources of funds for storm water programs.

(2) *Part 2.* Part 2 of the application shall consist of:

(i) *Adequate legal authority.* A demonstration that the applicant can operate pursuant to legal authority established by statute, ordinance or series of contracts which authorizes or enables the applicant at a minimum to:

(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;

(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer;

(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water;

(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;

(E) Require compliance with conditions in ordinances, permits, contracts or orders; and

(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

(ii) *Source identification.* The location of any major outfall that discharges to waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(*1*) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;

(iii) *Characterization data.* When "quantitative data" for a pollutant are required under paragraph (d)(a)(iii)(A)(*3*) of this paragraph, the applicant must collect a sample of effluent in accordance with 40 CFR 122.21(g)(7) and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method but must provide a description of the method. The applicant must provide information characterizing the quality and quantity of discharges covered in the permit application, including:

(A) Quantitative data from representative outfalls designated by the Director (based on information received

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in part 1 of the application, the Director shall designate between five and ten outfalls or field screening points as representative of the commercial, residential and industrial land use activities of the drainage area contributing to the system or, where there are less than five outfalls covered in the application, the Director shall designate all outfalls) developed as follows:

(*1*) For each outfall or field screening point designated under this subparagraph, samples shall be collected of storm water discharges from three storm events occurring at least one month apart in accordance with the requirements at § 122.21(g)(7) (the Director may allow exemptions to sampling three storm events when climatic conditions create good cause for such exemptions);

(*2*) A narrative description shall be provided of the date and duration of the storm event(s) sampled, rainfall estimates of the storm event which generated the sampled discharge and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event;

(*3*) For samples collected and described under paragraphs (d)(2)(iii)(A)(*1*) and (A)(*2*) of this section, quantitative data shall be provided for: the organic pollutants listed in Table II; the pollutants listed in Table III (toxic metals, cyanide, and total phenols) of appendix D of 40 CFR part 122, and for the following pollutants:

Total suspended solids (TSS)
Total dissolved solids (TDS)
COD
BOD_5
Oil and grease
Fecal coliform
Fecal streptococcus
pH
Total Kjeldahl nitrogen
Nitrate plus nitrite
Dissolved phosphorus
Total ammonia plus organic nitrogen
Total phosphorus

(*4*) Additional limited quantitative data required by the Director for determining permit conditions (the Director may require that quantitative data shall be provided for additional parameters, and may establish sampling conditions such as the location, season of sample collection, form of precipitation (snow melt, rainfall) and other parameters necessary to insure representativeness);

(B) Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under § 122.21(c)(7)) for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

(C) A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(*1*) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section; and

(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.

(iv) *Proposed management program.* A proposed management program covers the duration of the permit. It shall include a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate. The program shall also include a description of staff and equipment available to implement the program. Separate proposed programs may be submitted by each coapplicant. Proposed programs may impose controls on a systemwide basis, a watershed basis, a jurisdiction basis, or on individual outfalls. Proposed programs will be considered by the Director when developing permit conditions to reduce pollutants in discharges to the maximum extent practicable. Proposed management programs shall describe priorities for implementing controls. Such programs shall be based on:

(A) A description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description shall include:

(*1*) A description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers;

(*2*) A description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed. (Controls to reduce pollutants in discharges from municipal separate storm sewers containing construction site runoff are addressed in paragraph (d)(2)(iv)(D) of this section;

(*3*) A description of practices for operating and maintaining public streets, roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities;

(*4*) A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible;

(*5*) A description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges (this program can be coordinated with the program developed under paragraph (d)(2)(iv)(C) of this section); and

(*6*) A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

(B) A description of a program, including a schedule, to detect and remove (or require the discharger to the municipal separate storm sewer to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. The proposed program shall include:

(*1*) A description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; this program description shall address all types of illicit discharges, however the following category of non-storm water discharges or flows shall be addressed where such discharges are identified by the municipality as sources of pollutants to waters of the United States: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers, uncomtaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (program descriptions shall address discharges or flows from fire fighting only where such discharges or flows are identified as significant sources of pollutants to waters of the United States);

(*2*) A description of procedures to conduct on-going field screening activities during the life of the permit, including areas or locations that will be evaluated by such field screens;

(*3*) A description of procedures to be followed to investigate portions of the separate storm sewer system that, based on the results of the field screen, or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water (such procedures may include: sampling procedures for constituents such as fecal coliform, fecal streptococcus, surfactants (MBAS), residual chlorine, fluorides and potassium; testing with fluorometric dyes; or conducting in storm sewer inspections where safety and other considerations allow. Such description shall include the location of storm sewers that have been identified for such evaluation);

(*4*) A description of procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer;

(*5*) A description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers;

(*6*) A description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials; and

(*7*) A description of controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems where necessary;

(C) A description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system. The program shall:

(*1*) Identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;

(*2*) Describe a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of quantitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease, COD, pH, BOD_5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21(g)(7) (iii) and (iv).

(D) A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system, which shall include:

(*1*) A description of procedures for site planning which incorporate consideration of potential water quality impacts;

(*2*) A description of requirements for nonstructural and structural best management practices;

(*3*) A description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality; and

(*4*) A description of appropriate educational and training measures for construction site operators.

(v) *Assessment of controls.* Estimated reductions in loadings of pollutants from discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water.

(vi) *Fiscal analysis.* For each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2) (iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds.

(vii) Where more than one legal entity submits an application, the application shall contain a description of the roles and responsibilities of each legal entity and procedures to ensure effective coordination.

(viii) Where requirements under paragraph (d)(1)(iv)(E), (d)(2)(ii), (d)(2)(iii)(B) and (d)(2)(iv) of this section are not practicable or are not applicable, the Director may exclude any operator of a discharge from a municipal separate storm sewer which is designated under paragraph (a)(1)(v), (b)(4)(ii) or (b)(7)(ii) of this section from such requirements. The Director shall not exclude the operator of a discharge from a municipal separate storm sewer identified in appendix F, G, H or I of part 122, from any of the permit application requirements under this paragraph except where authorized under this section.

(e) *Application deadlines.* Any operator of a point source required to obtain a permit under paragraph (a)(1) of this section that does not have an effective NPDES permit covering its storm water outfalls shall submit an application in accordance with the following deadlines:

(1) For any storm water discharge associated with industrial activity identified in paragraph (b)(14) (i)–(xi) of this section, that is not part of a group application as described in paragraph (c)(2) of this section or which is not covered under a promulgated storm water general permit, a permit application made pursuant to paragraph (c) of this section shall be submitted to the Director by November 18, 1991;

Overview of the Storm Water Program

EPA

U.S. Environmental Protection Agency
Office of Wastewater Enforcement and Compliance
Permits Division
401 M Street, SW
Washington, DC 20460

October 1993

STORM WATER PROGRAM

BACKGROUND

The 1972 amendments to the Federal Water Pollution Control Act (FWPCA, also referred to as the Clean Water Act or CWA) prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Efforts to improve water quality under the NPDES program traditionally have focused on reducing pollutants in discharges of industrial process wastewater and from municipal sewage treatment plants. Efforts to address storm water discharges under the NPDES program have generally been limited to certain industrial categories with effluent limitations for storm water.

In response to the need for comprehensive NPDES requirements for discharges of storm water, Congress amended the CWA in 1987 to require the Environmental Protection Agency (EPA) to establish phased NPDES requirements for storm water discharges. To implement these requirements, EPA published the initial permit application requirements for certain categories of storm water discharges associated with industrial activity, and discharges from municipal separate storm sewer systems located in municipalities with a population of 100,000 or more on November 16, 1990, (55 FR 47990). Storm water discharge permits will provide a mechanism for monitoring the discharge of pollutants to waters of the United States and for establishing appropriate controls.

ENVIRONMENTAL IMPACTS

Pollutants in storm water discharges from many sources are largely uncontrolled. The "National Water Quality Inventory, 1990 Report to Congress" provides a general assessment of water quality based on biennial reports submitted by the States under Section 305(b) of the Clean Water Act. The Report indicates that roughly 30% of identified cases of water quality impairment are attributable to storm water discharges. The States identified a number of major sources of storm water runoff that cause water quality impacts including separate storm sewers, construction, waste disposal, and resource extraction.

INDUSTRIAL FACILITIES COVERED

EPA has defined the term "storm water discharge associated with industrial activity" in a comprehensive manner to address over 100,000 facilities (see Attachment VII for a complete definition). All storm water discharges associated with industrial activity that discharge through municipal separate storm sewer systems or that discharge directly to waters of the U.S., are required to obtain NPDES permit coverage, including those which discharge through systems located in municipalities with a population of less than 100,000. Discharges of storm water to a sanitary sewer system or to a Publicly Owned Treatment Works (POTW) are excluded. Facilities with storm water discharges associated with industrial activity include: manufacturing facilities; construction operations disturbing 5 or more acres; hazardous waste treatment, storage, or disposal facilities; landfills; certain sewage treatment plants; recycling facilities; powerplants; mining operations; some oil and gas operations; airports; and certain other transportation facilities. Operators of industrial facilities that are Federally, State or municipally owned or operated that meet the description of the facilities listed in 40 CFR 122.26(b)(14)(i)-(xi) must also submit applications.

TRANSPORTATION ACT OF 1991

The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain industrial activities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water discharge permit applications for only airports, powerplants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority. The Transportation Act of 1991 also revises group application deadlines for facilities that are owned or operated by municipalities with a population of less than 250,000. See Attachment II for revised deadlines.

9th CIRCUIT COURT DECISION

The 9th Circuit United States Court of Appeals' opinion in NRDC v. EPA (June 4, 1992) and the opinion in AMC v. EPA (May 27, 1992), affirmed and upheld the basic structure and direction of the national storm water program. In "NRDC", the Court upheld the definition of "municipal separate storm sewer system," the standards for municipal storm water controls, the scope of storm water requirements for oil and gas operations, and EPA's decision not to provide public comment on Part 1 group industrial permit applications. On the question of deadlines, the Court noted that the storm water application deadlines clearly exceeded statutory requirements, but refused to "roll back" the current regulatory deadlines. The Court also emphasized, however, that any further regulatory extension would be illegal. In two other areas the Court invalidated and remanded for further proceedings two regulatory exemptions from the definition of "storm water discharges associated with industrial activity": (1) the exemption for construction sites disturbing less than 5 acres of land (category x), and (2) the exemption of certain "light" manufacturing facilities without exposure of materials and activities to storm water (category xi). In response to these two remands, the Agency intends to conduct further rulemaking proceedings on construction activities under 5 acres and light industry without exposure as ordered by the Court. EPA will not require permit applications for construction sites disturbing less than 5 acres of land and category xi facilities without exposure until this further rulemaking is completed. In "AMC," the Court upheld EPA's regulation of storm water discharges from inactive mines.

INDUSTRIAL APPLICATION OPTIONS

The November 16, 1990, storm water regulation presents three permit application options for storm water discharges associated with industrial activity. The first option is to submit an individual application consisting of Forms 1 and 2F. The second option is to participate in a group application. This option, however, is no longer available as the deadlines have passed. The third option is to file a Notice of Intent (NOI) to be covered under a general permit in accordance with the requirements of an issued general permit. The following overview briefly outlines each of these three options and the subsequent attachments provide a more detailed explanation.

A. INDIVIDUAL APPLICATIONS

Operators of facilities with storm water discharges associated with industrial activity who did not participate in a group application or did not obtain coverage under a general permit, must submit an individual application consisting of Form 1 and Form 2F. The information required in Form 2F includes a site drainage map, a narrative description of the site identifying potential pollutant sources, and quantitative testing data. There are specific requirements for construction activities and oil and gas operations and mining operations. See Attachment I for additional information.

B. GROUP APPLICATIONS

The group application procedure was an option available for facilities that have similar industrial operations, waste streams and other characteristics. Group applications reduced the burden on the regulated community by requiring the submission of quantitative data from only selected members of the group. The group application was submitted in two parts. Part 1 of the application identified all participants, provided facility specific information and proposed a representative sampling subgroup. Part 2 of the application consists of sampling data from each member of the sampling subgroup identified in Part 1 of the application. See Attachment II for additional information.

C. GENERAL PERMIT - NOI REQUIREMENTS

Industrial storm water dischargers that submit an NOI to be covered by the general permit are not required to submit an individual permit application or participate in a group application, provided the discharger is eligible for the permit and an individual permit application is not required by the Director on a case-by-case basis. Submitting an NOI represents a significantly less burden than submitting an individual application or participating in a group application. The NOI requirements for general permits usually address only general information and typically do not require the collection of monitoring data. Submittal of an NOI is only possible where applicable general permits have been issued by the permitting authority. EPA has finalized general permits for construction and industrial activity in the 12 States without NPDES authorization (57 FR 41176, September 9, 1992 and 57 FR 44412, September 25, 1992). As of September 1993, 36 of the 39 authorized NPDES States have general permit authority. See Attachments III, IV and V for additional information.

INDUSTRIAL PERMIT APPLICATION DEADLINES

Type of Application	Deadline	
▲ Individual	October 1, 1992	
▲ Group	Part 1	Part 2
All industrial activities except those owned or operated by a municipality with a population of 100,000 to 250,000.	September 30, 1991	October 1, 1992
Industrial activities owned or operated by a municipality with a population of less than 250,000.	May 18,1992	May 17, 1993
▲ General Permit NOI	October 1, 1992 (for EPA's general permits)	

MUNICIPAL APPLICATIONS

"Municipal separate storm sewer" is defined as any conveyance or system of conveyances that is owned or operated by a State or local government entity designed for collecting and conveying storm water which is not part of a POTW. The application requirements do not apply to discharges from combined sewers (systems designed as both a sanitary sewer and a storm sewer). Municipal separate storm sewer systems that are addressed by the November 16, 1990, regulations include storm sewer systems located in 173 cities with populations of 100,000 or more; located in 47 counties identified by EPA as having populations over 100,000 in unincorporated, urbanized areas; and systems that are designated by the Director based on consideration of the location of the discharge with respect to waters of the United States, the size of the discharge, the quantity and nature of the pollutants discharged to waters of the United States, the interrelationship to other regulated storm sewer systems, and other factors. The operator of a designated system will be notified by the Director. Under the November 16, 1990, storm water rule, those municipal separate storm sewer systems identified must submit a two-part application. The first part requires information regarding existing programs and the means available to the municipality to control pollutants. In addition, part one requires a field screening analysis of major outfalls to detect illicit connections. Building on this information, the second part requires a limited amount of representative quantitative data and a description of a proposed storm water management plan. See Attachment V for a detailed explanation of the two-part application process.

MUNICIPAL APPLICATIONS DEADLINES

[illegible]	Part 1	Part 2
Large Municipalities (over 250,000)	November 18, 1991	November 16, 1992
Medium Municipalities (100,000 - 250,000)	May 18, 1992	May 17, 1993

ATTACHMENT I

INDIVIDUAL APPLICATION REQUIREMENTS

These requirements address storm water discharges associated with industrial activity that are not authorized by a general permit and that are not included in a group application.

Application Forms

- Applicants for discharges composed entirely of storm water must submit **Forms 1 and 2F**
- Applicants for discharges composed of storm water and process wastewater must submit **Forms 1, 2C, and 2F**
- Applicants for new sources or new discharges composed of storm water and non-storm water must submit **Forms 1, 2D, and 2F**
- Applicants for discharges composed of storm water and nonprocess wastewater must submit **Forms 1, 2E, and 2F**
- Authorized NPDES States may establish their own forms which are at least as stringent as EPA's forms.
- Forms are available from State permitting authorities for facilities located in NPDES authorized States, or from EPA Regional Offices for facilities located in States without NPDES authorization.

Form 2F Requirements

- Site map showing topography and/or drainage areas and site characteristics.
- Estimate of impervious surface area and the total area drained by each outfall.
- Description of significant materials exposed to storm water, including current materials management practices.
- Certification that outfalls have been tested or evaluated for the presence of non-storm water discharges that are not covered by a NPDES permit.
- Information on significant leaks and spills in last 3 years.
- Quantitative testing data for the following parameters:
  - Any pollutants limited in an effluent guideline to which the facility is subject
  - Any pollutant listed in the facility's NPDES permit for process wastewater
  - Oil and grease, pH, BOD_5, COD, TSS, total phosphorus, nitrate plus nitrite nitrogen, and total Kjeldahl nitrogen
  - Certain pollutants known to be in the discharge
  - Flow measurements or estimates
  - Date and duration of storm event.

Individual Application Requirements for Construction Activities

- ▲ Provide a narrative description of:
  - Location and nature of construction activity (including a map)
  - Total area of the site and area to be excavated
  - Proposed measures to control pollutants in storm water discharges during and after construction operations
  - Estimate of runoff coefficient and increase in impervious areas after construction
  - Name of receiving water.
- ▲ No quantitative sampling.
- ▲ Application deadline
  - 90 days prior to date when construction begins.
- ▲ EPA has not developed a standard form for these discharges at this time (Form 2F is not required).

Application Requirements for Oil & Gas Operations and Mining Operations

- ▲ Operators of oil & gas facilities are not required to submit a permit application unless the facility:
  - Has had a discharge of a reportable quantity for which notice is required under CERCLA or CWA in the past 3 years, or
  - Contributes to a violation of a water quality standard.
- ▲ Operators of active and inactive mining sites are not required to submit permit applications unless the discharge has come into contact with any overburden, raw material, intermediate or finished products, byproducts, or waste products located onsite (inactive coal mining operations released from SMCRA performance bonds and non-coal mining operations released from applicable State or Federal reclamation requirements after December 17, 1990, are not required to submit permit applications).

Available Guidance

Guidance Manual For The Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity (Order #PB92199058), available from NTIS, *(703) 487-4650*; *NPDES Storm Water Sampling Guidance Document*, available from the Storm Water Hotline, *(703) 821-4823*.

Deadline

October 1, 1992, or 180 days prior to commencement of a new discharge.

ATTACHMENT II

GROUP APPLICATION REQUIREMENTS

Facilities that discharge storm water associated with industrial activity had until September 30, 1991, to file Part I of the group application in lieu of submitting a complete individual application or an NOI to be covered by a general permit. The Transportation Act of 1991, however, extended the group application deadlines for certain industrial activities owned or operated by a municipality with a population of 100,000 to 250,000. Facilities that are part of the same effluent guideline subcategory or with similar activities and operations were eligible to submit a group application. EPA received 1,243 Part I group applications covering approximately 60,000 facilities.

The group application was submitted in two parts. Part 1 of the application was due by September 30, 1991, and Part 2 of the application was due by October 1, 1992. These deadlines applied to all industrial activities except those owned or operated by a municipality with a population of 100,000 to 250,000. For these facilities, Part 1 of the application was due by May 18, 1992, and Part 2 of the application is due by May 17, 1993. Both parts were submitted directly to U.S. EPA Headquarters, Office of Wastewater Enforcement and Compliance (EN-336), 401 M Street, SW, Washington, DC 20460, regardless of whether or not the included facilities are in a NPDES authorized State. The Transportation Act also addressed municipally owned or operated industrial activities that were denied by EPA from the group application process. Such facilities must submit an individual application or be covered by a general permit within 180 days after the denial was made, or by October 1, 1992, whichever is later.

EPA is currently taking both parts of the application and formulating model permit language. The complete applications and model permit language will then be distributed to every NPDES authorized State or EPA Region (if the State is not NPDES authorized) in which participants are located. The State then reviews the application and model permit language. The State may consider the application and model permit language when issuing permits (either individual or general). The State may ask each or any of the applicants for more information on their facility and/or discharge if the State needs additional information. EPA Regional Offices will follow these same steps for participants located in States without NPDES authorization.

<u>Part 1</u>

- ▲ A list of participants by name, location, and precipitation zone
- ▲ A summary of each participant's industrial activities
- ▲ An explanation of why the participants are sufficiently similar
- ▲ A list of significant materials stored outside by each participant and materials management practices
- ▲ A list of representative dischargers that will submit test data in Part 2.

<u>Part 2</u>

- ▲ Quantitative testing data must be submitted by those facilities identified as "samplers" in Part I of the application.

  - For groups of 4 to 20 members, 50 percent of the facilities must submit data; for groups with 21 to 99, a minimum of 10 dischargers must submit quantitative data; for groups with 100 to 1,000 members, a minimum of 10 percent of the facilities must submit data; for groups with greater than 1,000 members, no more than 100 facilities must submit data; there must be 2 dischargers from each precipitation zone in which 10 or more members of the group are located, or 1 discharger from each precipitation zone in which 9 or fewer members are located. Testing requirements are described under 40 CFR 122.26(c)(1)(i)(E) and 40 CFR 122.21(g)(7).

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Additional Information

A model group application accompanied by detailed information on how to complete both Part 1 and Part 2 group applications is available from the Storm Water Hotline, *(703) 821-4823*. Technical support with regard to sampling procedures is also available from the hotline *(NPDES Storm Water Sampling Guidance Document)*.

Deadlines

- ▲ All Industrial Activities Except Those Owned Or Operated By A Municipality With A Population of 100,000 to 250,000

  Part 1 - September 30, 1991
  Part 2 - October 1, 1992

- ▲ Industrial Activities Owned or Operated By A Municipality With A Population of 100,000 to 250,000

  Part 1 - May 18, 1992
  Part 2 - May 17, 1993

ATTACHMENT III

EPA GENERAL PERMIT REQUIREMENTS (GENERAL INFORMATION)

On September 9 and 25, 1992, EPA issued general permits for construction and industrial activities (57 FR 41176 and 44412) which are intended to initially cover the majority of storm water discharges associated with industrial activity in 12 States and 6 territories without authorized NPDES programs. As of March 1993, 35 of the 39 authorized NPDES States have authority to issue general permits. Facilities in authorized NPDES States should contact their State permitting agencies to determine the status of the general permitting program. The following tables (Attachments III, IV and V) outline conditions in EPA's general permits for industrial activities and construction activities.

Areas of Coverage

- **Region I**— MA, ME, NH; Indian lands in MA, NH, ME. **Region II**—PR and Indian lands in NY. **Region III**—DC, Federal facilities in DE. **Region IV**— FL; Indian lands in FL, MS, NC. **Region VI**—LA, NM, OK, TX. **Region VII**—SD; Indian lands in CO, MT, ND, SD, UT (except Goshute Reservation and Navajo Reservation lands), WY; Federal facilities in CO; Ute Mountain Reservation in CO, and NM. **Region IX**— American Samoa and Guam; AZ; Territories of Johnston Atoll, and Midway and Wake Island; Indian lands in CA, and NV; Goshute Reservations in UT and NV, Navajo Reservations in UT, NM, and AZ, Duck Valley Reservation in NV and ID. **Region X**—AK, and ID; Indian lands in AK, ID (except Duck Valley Reservation lands), and WA; Federal facilities in WA.

Types of Discharges Covered

- EPA's general permits cover the majority of storm water discharges associated with industrial activity. Storm water discharges associated with industrial activity that cannot be authorized by EPA's general permits include those:
  - With an existing effluent limitations guideline for storm water
  - That are mixed with non-storm water, unless the non-storm water discharges are in compliance with a different NPDES permit
  - With an existing NPDES individual or general permit for the storm water discharges
  - That are or may reasonably be expected to be contributing to a violation of a water quality standard
  - That are likely to adversely effect a listed or proposed to be listed endangered or threatened species or its critical habitat
  - From inactive mining, or inactive oil and gas operations or inactive landfills occurring on Federal lands where an operator cannot be identified (industrial permit only).

NOI Requirements

- A facility must submit a Notice of Intent (NOI) to be authorized by the general permit.
- NOI's do not require the collection of discharge sampling data.
- Facilities which discharge to a large or medium municipal separate storm sewer system must also submit signed copies of the NOI to the operator of the municipal system.
- Operators of construction activities must also submit signed copies of the NOI to State or local agencies approving sediment and erosion or storm water management plans under

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which the construction activity is operating.

Deadlines for NOI's

- On or before October 1, 1992 for existing industrial activities
- For facilities or construction activities which begin industrial activity after October 1, 1992, an NOI shall be submitted at least 2 days prior to the commencement of the industrial activity.
- NOI's must be sent to the following address:

  Storm Water Notice of Intent
  P.O. Box 1215
  Newington, VA 22122

Special Conditions

- Prohibition on most types of non-storm water discharges as a component of discharges authorized by this permit. (These discharges should already have an NPDES permit.) However, EPA's permits authorize certain types of non-storm water discharges.
- In the event there is a release(s) of a hazardous substance in excess of reportable quantities established under the CWA or CERCLA (see 40 CFR 117.3, 40 CFR 302.4) the discharger must:
  - Notify the National Response Center and the Director, and modify the storm water pollution prevention plan.

Pollution Prevention Plan Requirements

- Operators of all facilities covered by EPA's general permits must prepare and implement a storm water pollution prevention plan.

ATTACHMENT IV

EPA INDUSTRIAL GENERAL PERMIT (SPECIFIC REQUIREMENTS)

Contents of NOI for Industrial Activities

- ▲ Street address or latitude/longitude
- ▲ SIC Code or identification of industrial activity
- ▲ Operator's name, address, telephone number, and status as Federal, State, private, public, or other entity
- ▲ Permit number(s) of any existing NPDES permit(s)
- ▲ Name of receiving water(s)
- ▲ Indication of whether the owner or operator has existing quantitative data describing the concentration of pollutants in storm water discharges
- ▲ A certification that a storm water pollution prevention plan has been prepared for the facility (for industrial activities that begin operations after October 1, 1992).

Pollution Prevention Plan Requirements for Industrial Activities

The Pollution Prevention Plan is considered to be the most important requirement of the General Permit. Each industrial facility covered by the general permit must develop a Plan, tailored to the site specific conditions, and designed with the goal to control the amount of pollutants in storm water discharges from the site.

- ▲ **Pollution Prevention Team** - Each facility will select a Pollution Prevention Team from its staff, and the Team will be responsible for developing and implementing the Plan.
- ▲ **Components of the Plan** - The permit requires that the Plan contain a description of potential pollutant sources, and a description of the measures and controls to prevent or minimize pollution of storm water. The description of potential pollutant sources must include:
  - A map of the facility indicating the areas which drain to each storm water discharge point
  - An indication of the industrial activities which occur in each drainage area
  - A prediction of the pollutants which are likely to be present in the storm water
  - A description the likely source of pollutants from the site
  - An inventory of the materials which may be exposed to storm water
  - The history of spills or leaks of toxic or hazardous materials for the past 3 years.

  The measures and controls to prevent or minimize pollution of storm water must include:

  - Good housekeeping or upkeep of industrial areas exposed to storm water
  - Preventive maintenance of storm water controls and other facility equipment
  - Spill prevention and response procedures to minimize the potential for and the impact of spills
  - Test all outfalls to insure there are no cross connections (only storm water is discharged)

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- Training of employees on pollution prevention measures and controls, and record keeping.

The permit also requires that facilities:

- Identify areas with a high potential for erosion and the stabilization measures or structural controls to be used to limit erosion in these areas
- Implement traditional storm water management measures (oil/water separators, vegetative swales, detention ponds, etc) where they are appropriate for the site.

▲ **Inspection/Site Compliance Evaluation** - Facility personnel must inspect the plant equipment and industrial areas on a regular basis. At least once every year a more thorough site compliance evaluation must be performed by facility personnel

- Look for evidence of pollutants entering the drainage system
- Evaluate the performance of pollution prevention measures
- Identify areas where the Plan should be revised to reduce the discharge of pollutants
- Document both the routine inspections and the annual site compliance evaluation in a report.

▲ **Consistency** - The Plan can incorporate other plans which a facility may have already prepared for other permits including Spill Prevention Control and Countermeasure (SPCC) Plans, or Best Management Practices (BMP) Programs.

▲ **Deadlines** - The plan must be prepared on or before April 1, 1993, and the facility must be in compliance with the plan on or before October 1, 1993.

▲ **Signature** - The plan must be signed by a responsible corporate official such as the president, vice president or general partner.

▲ **Plan Review** - The plan is to be kept at the permitted facility at all times. The plan should be submitted for review only when requested by EPA.

Semi-Annual Monitoring/Annual Reporting Requirements

▲ EPCRA Section 313 facilities

▲ Primary metal industries Standard Industrial Classification (SIC) 33

▲ Land disposal units/incinerators/BIF's

▲ Wood treatment facilities

▲ Facilities with coal pile runoff

▲ Battery reclaimers

Annual Monitoring/No Reporting Requirements

▲ Airports with at least 50,000 flight operations per year

▲ Coal-fired steam electric facilities

▲ Animal handling/meat packing facilities

- Additional facilities, including:
  - SIC 30 and 28 with storage piles for solid chemicals used as raw materials that are exposed to precipitation
  - Certain automobile junkyards
  - Lime manufacturing facilities where storm water comes into contact with lime storage piles
  - Oil handling sites at oil fired steam electric power generating facilities
  - Cement manufacturing and cement kilns
  - Ready-mix concrete facilities
  - Shipbuilding and repairing facilities

Additional Monitoring Requirements

- Testing parameters for facilities are listed in the general permits.
- At a minimum, all dischargers must conduct an annual site inspection of the facility.

Alternative Certification

- A discharger is not subject to the monitoring requirements for a given outfall if there is no exposure of industrial areas or activities to storm water within the drainage area of that outfall within a given year.
- The discharger must certify, on an annual basis, that there is no exposure to storm water, and such certification must be retained in the storm water pollution prevention plan. Facilities subject to semi-annual monitoring requirements must submit this certification to EPA in lieu of monitoring data.

Numeric Effluent Limitations

- Coal pile runoff: 50 mg/l Total Suspended Solids (TSS) and 6-9 pH

Available Guidance

Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices, available from NTIS (703) 487-4650, order number PB 92-235969; *Summary: Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices* (October 1992), available from the Storm Water Hotline, (703) 821-4823.

ATTACHMENT V

EPA CONSTRUCTION GENERAL PERMIT REQUIREMENTS (SPECIFIC REQUIREMENTS)

Coverage

- ▲ Storm water discharges from construction sites that are authorized by this permit include those that will result in the disturbance of 5 or more acres of land.

Contents of NOI for Construction Activities

- ▲ Street address or latitude/longitude
- ▲ The name, address, telephone number of the operator(s) with day to day operational control and operator status as Federal, State, private, public, or other entity
- ▲ Permit number(s) of any existing NPDES permit(s)
- ▲ Name of receiving water(s)
- ▲ Indication of whether the owner or operator has existing quantitative data describing the concentration of pollutants in storm water discharges
- ▲ An estimate of the project start date and completion dates and estimates of the number of disturbed acres
- ▲ A certification that a storm water pollution prevention plan has been prepared for the facility

Deadlines for Notification

- ▲ An NOI shall be submitted at least 2 days prior to the commencement of construction (commencement of construction is defined as the initial disturbance of soils associated with clearing, grading, or excavating activities or other construction activities) at any site that will result in the disturbance of 5 or more acres total land area.

Pollution Prevention Plan Requirements for Construction Activities

The Pollution Prevention Plan is considered to be the most important requirement of the General Permit. Each construction activity covered by the general permit must develop a Plan, tailored to the site specific conditions, and designed with the goal to control the amount of pollutants in storm water discharges from the site.

- ▲ **Components of the Plan** - The permit requires that the Plan contain a site description, and a description of the measures and controls to prevent or minimize pollution of storm water. The site description must include:

  - A description of the nature of the construction activity
  - A sequence of major construction activities
  - An estimate of the total area of the site and of the area to be disturbed
  - An estimate of the runoff coefficient of the site after construction is complete
  - Any existing data on the quality of storm water discharge from the site
  - The name of the receiving water
  - Any information on the type of soils at the site; and
  - A site map indicating drainage patterns and slopes after grading activities are complete, areas of soil disturbance, the outline of the area to be disturbed, the location of stabilization measures and controls, and surface waters at the discharge points.

- **Measures and Controls** - Measures and controls to prevent or minimize pollution of storm water must include three different types of controls: erosion and sediment controls, storm water management controls and other controls:

  - Erosion and Sediment Controls

    - Stabilization (seeding, mulching, etc.) - Disturbed areas where construction has permanently or temporarily ceased must be stabilized within 14 days of the last disturbance or as soon as practicable in semi-arid and arid areas. (Areas which will be redisturbed within 21 days do not have to be stabilized).

    - Structural Controls - Sites with common drainage locations that serve 10 or more disturbed acres must install a sediment basin where it is attainable (where a basin is not attainable, sediment traps, silt fence or other equivalent measures must be installed. Sediment basins must provide 3,600 cubic feet of storage per acre drained. Drainage locations which serve less than 10 disturbed acres must install either a sediment basin, sediment trap or silt fence along the down slope and side slope perimeter.

- Plan shall be completed prior to submittal of an NOI and updated as appropriate.

- For construction activities that have begun after October 1, 1992, the plan shall provide for compliance with the terms and schedule of the plan beginning with the initiation of construction activities.

Available Guidance

Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices, available from NTIS (703) 487-4650, order number PB 92-235951; *Summary: Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices* (October 1992), available from the Storm Water Hotline (703) 821-4823.

ATTACHMENT VI

MUNICIPAL APPLICATION REQUIREMENTS

The CWA requires that NPDES permits for discharges from municipal separate storm sewer systems include a requirement to effectively prohibit non-storm water discharges into the storm sewers, and controls to reduce the discharge of pollutants to the maximum extent practicable (including management practices, control techniques and system design and engineering methods, and other provisions appropriate for the control of such pollutants). EPA or authorized NPDES States may issue system-wide or jurisdiction-wide permits covering all discharges from a municipal separate storm sewer system. The November 1990 storm water final rule established requirements for a two-part permit application designed to facilitate development of site specific permit conditions. The permit application requirements provide municipal applicants an opportunity to propose appropriate management programs to control pollutants in discharges from their municipal systems. This increases flexibility to develop appropriate permit conditions and ensures input from municipalities in developing appropriate controls.

<u>Part 1</u>

- ▲ General information (name, address, etc.)
- ▲ Existing legal authority and any additional authorities needed
- ▲ Source identification information
- ▲ Discharge characterization including:
  - Monthly mean rain and snow fall estimates
  - Existing quantitative data on volume and quality of storm water discharges
  - A list of receiving water bodies and existing information on the impacts of receiving waters
  - Field screening analysis for illicit connections and illegal dumping.
- ▲ Characterization plan identifying representative outfalls for further sampling in Part 2
- ▲ Description of existing management programs to control pollutants from the municipal separate storm sewer and to identify illicit connections
- ▲ Description of financial budget and resources currently available to complete Part 2.

<u>Part 2</u>

- ▲ Demonstration of adequate legal authority to control discharges, prohibit illicit discharges, require compliance, and carry out inspections, surveillance, and monitoring
- ▲ Source identification indicating the location of any major outfalls and identifying facilities that discharge storm water associated with industrial activity through the municipal separate storm sewer
- ▲ Discharge characterization data including
  - Quantitative data from 5-10 representative locations in approved sampling plans
  - For selected conventional pollutants and heavy metals, estimates of the annual pollutant load and event mean concentration of system discharges

- Proposed schedule to provide estimates of seasonal pollutant loads and the mean concentration for certain detected constituents in a representative storm event
- Proposed monitoring program for representative data collection.

▲ Proposed management program including descriptions of:

- Structural and source control measures that are to be implemented to reduce pollutants in runoff from commercial and residential areas
- Program to detect and remove illicit discharges
- Program to monitor and control pollutants from municipal landfills, hazardous waste treatment, disposal, and recovery facilities; EPCRA Section 313 facilities; and other priority industrial facilities
- Program to control pollutants in construction site runoff.

▲ Estimated reduction in loadings of pollutants as a result of the management program

▲ Fiscal analysis of necessary capital and operation and maintenance expenditures.

Available Guidance

Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges from Municipal Separate Storm Sewer Systems and *NPDES Storm Water Sampling Guidance Document*, available from NTIS *(703) 487-4650*, order number PB 92-114578; *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Seperate Storm Sewers Systems*, available from the Storm Water Hotline, (703) 821-4823.

Deadlines

▲ Large Municipal Systems With A Population Of 250,000 Or More:

(55 FR 48073, Novemer 16, 1990, Appendices F and H)

Part 1 - November 18, 1991
Part 2 - November 16, 1992

▲ Medium Municipal Systems With A Population of 100,000 to 250,000:

(55 FR 48074, November 16, 1990 Appendices G and I)

Part 1 - May 18, 1992
Part 2 - May 17, 1993

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ATTACHMENT VII

STORM WATER DISCHARGE ASSOCIATED WITH INDUSTRIAL ACTIVITY

The discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR Part 122. For the categories of industries identified in subparagraphs (i) through (x) of this subsection, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in subparagraph (xi), the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste material, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the: storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (i)-(xi) include those facilities designated under the provision of 122.26(a)(1)(v). The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection:

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N (except facilities with toxic pollutant effluent standards which are excepted under category (xi) of this paragraph);
(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283 and 285) 29, 311, 32 (except 323), 33, 3441, 372;
(iii) Facilities classified as Standard Industrial Classifications 10 though 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990 and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining mining claim);
(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of RCRA;
(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under Subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobiles junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;
(vii) Steam electric power generating facilities, including coal handling sites;
(viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (i)-(vii) or (ix)-(xi) of this subsection are associated with industrial activity;
(ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA;
(x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;
(xi) Facilities under Standard Industrial Classification 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories (ii)-(x))

Note: The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain facilities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water discharge permit applications for only airports, power plants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority.

State of California

Memorandum

To: Storm Water Permit Program Coordinators

Date: September 8, 1994

From: Thomas Mumley
California Regional Water Quality Control Board
San Francisco Bay Region
2101 Webster Street, Suite 500, Oakland, 94612

Subject: **MUNICIPAL STORM WATER MANAGEMENT PLAN COMPONENTS**

The attached draft Municipal Storm Water Management Plan Components is intended to provide a starting point for establishing a consistent framework for such plans for all municipal programs in the State. I have proposed the categorical program action areas based on experiences with existing programs and existing plans in the San Francisco Bay Region. As proposed, the categorical areas and sub-areas would be essential components of a Municipal Storm Water Management Plan. It would be the responsibility of a municipality to demonstrate that a specific area does not apply to their program or to propose equivalent alternatives with justification.

The categorical areas represent elements integral to the establishment of a storm water management program, as well as specific sources, specific areas of activities, or specific activities that need to managed. The actual management action, such as the type of control measures that would be implemented, or level of implementation of the control measure, would be determined mostly at the discretion of the municipal program. We should also recognize that at this time the appropriate action, in a specific area for a specific municipal program, may be to propose the steps that they will take to scope alternative control measures, prepare for implementation, implement on a reduced or pilot scale, and ultimately select and implement a control measure on a full scale. In such cases the plan would identify milestones and evaluation techniques that will be met and used in the process of progressing through the proposed steps.

Over time we would identify specific control measures that apply in each area and categorize the measure as mandatory, optional, or mandatory under specific conditions. (Mandatory would be interpreted to allow for implementation of equivalently effective alternative measures.) Over time we would also develop information of the effectiveness of specific control measures and develop performance standards for their design, operation, and maintenance. These performance standards would be developed through monitoring programs and serve as the building blocks for defining maximum extent practicable.

By establishing a consistent framework of action areas, we also provide a basis for coordination and collaboration of all municipal programs, and consistent reporting and evaluation standards.

MUNICIPAL STORM WATER MANAGEMENT PLAN COMPONENTS

The Municipal Storm Water Early Permit renewal process requires the submittal of a Storm Water Management Plan for the permitted area covering the entire five year period of the permit. A single plan is expected for each permit, with each of the permittees contributing to the plan. The plan should address all of the following components, including a discussion of how each of the components fit into a single unified program. Every element of the plan must contain compliance schedules with firm dates that will be met. The permittees should suggest schedules for submittals that are realistic for their particular fiscal year. The management plans should emphasize pollution prevention rather than relying solely on pollution control.

This document has been prepared by the staff of the State Water Resources Control Board and the Regional Water Control Boards, in an effort to assist permittees who hold municipal separate storm sewer permitsto comply with those permits. This document has not been adopted by either of the Boards. Its provisions, with the exception of the federal regulations, in italics, are not mandatory, and are provided solely as an aid to permittees.

> *122.26(d)(1)(i) General information. The applicants' name, address, telephone number of contact person, ownership status and status as a State or local government entity.*

> *122.26(d)(1)(v) Management programs. (A) A description of the existing management programs to control pollutants from the municipal separate storm sewer system. The description shall provide information on existing structural and source controls, including operation and maintenance measures for structural controls, that are currently being implemented. Such controls may include, but are not limited to: Procedures to control pollution resulting from construction activities; floodplain management controls; wetland protection measures; best management practices for new subdivisions; and emergency spill response programs. The description may address controls established under State law as well as local requirements.*

> *122.26(d)(2)(iv) Proposed management program. A proposed management program covers the duration of the permit. It shall include a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate. The program shall also include a description of staff and equipment available to implement the program. Separate proposed programs may be submitted by each coapplicant. Proposed programs may impose controls on a systemwide basis, a watershed basis, a jurisdiction basis, or on individual outfalls. Proposed programs will be considered by the Director when developing permit conditions to reduce pollutants in discharges to the maximum extent practicable. Proposed management programs shall describe priorities for implementing controls.*

I. PROGRAM MANAGEMENT - Area wide permits are permits that are issued to a group of municipal governments. The governments are given a single permit and pay a single fee. It is anticipated that although each governmental entity will have their own program, they will function as a unified entity in their permit responses. The area wide permits require cooperation by a number of government entities including cities, counties, agencies such as flood control districts or water districts, and state agencies such as CALTRANS. Each governmental entity will have, in addition, a variety of agencies that have responsibilities either directly, or indirectly for storm water related activities. The plan must include a discussion of who is involved in the program, how they will function together, what kind of interagency funding arrangements are made. For each permittee, the plan must also outline the funding and funding mechanism to be used, and the legal authority that will be used to enforce the program.

   A. PROGRAM STRUCTURE - Each permit will require a structure for the participatory agencies to work together under a unified plan. While each permittee will have an individual program to address the particular needs of their city or agency, a framework must be developed to allow cooperation between them. In addition, cities will have common problems that will be more efficiently addressed as a whole rather than individually. For most area-wide permits, a city or county acts as the lead agency or coordinator for day to day business, setting meetings and preparing submittals. They assume no responsibility for any other city's program, and are not viewed as the responsible agency for the permit. Each area-wide permit will require a mechanism to make decisions for the permittees, develop program guidlines for each of the permit areas, assess the adequacy and consistency of each permittees submittals in each of the program areas, address the inadequate program areas with each of the permitteees, and prepare unified submittals for the Regional Boards. The mechanism can either be a single government entity such as a county, or it can be a Management Committee made up of representatives of the permittees.

      1. Management Committee - An overall decision making body that is representative of all of the permittees.
         a. Describe the purpose of the committee, and how its responsibilities fit into the overall program framework.
         b. Describe the makeup of the committee, how the committee will communicate, and how it will coordinate its activities.

c. Describe what the authority of the committee will be and its procedures for decision making.

2. Subcommittees - We expect that programs will have the need to establish focused subcommittees specific to program action areas. List the subcommittees to be formed (or that already exist), tell the focus of the group, the participants, the tasks to be accomplished, the products to come out of the group, and the time frame to be followed. These committees should develop guidelines for program implementation for each of the program areas and a methodology for determining the adequacy of each permittee's program. All of the permittees should participate on at least one of the committees.
   a. Roles/responsibilities - Develop methodology for compliance with the permit elements, and set levels of expected effort. Review the submittals of each permittee for adequacy according to the criteria established for each program element- submit the reviews as part of the annual report.

B. INSTITUTIONAL ARRANGEMENTS - Management of the storm water program will require the cooperation of all of the governmental entities named on the permit. No one agency within a city or county has the authority to assume the responsibility of all activities within the municipality. Consequently, the permit is issued to a city or county, and not to a specific agency within the municipality. (Although, certain agencies, such as flood control agencies, may be cited as a permittee.) It is expected that all of the organizations within each municipality who have programs that have an impact on storm water quality will be educated about the storm water program and actively participate in implementation of it. There must be formal arrangements whereby all municipalities can participate in the same permit program, share costs and work jointly. The agencies within a municipality must also be able to communicate with each other and work jointly.

122.26(d)(2)(i)(D) *Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;*

122.26(d)(2)(vii) Where more than one legal entity submits an application, the application shall contain a description of the roles and responsibilities of each legal entity and procedures to ensure effective coordination.

1. Program Participant Arrangements - Describe the relationship and formal arrangements among all permittees.

   a. City-City-County - Identify all of the governmental authorities involved, and who the lead agency will be within each of those authorities for the storm water program. Identify the lead agency for coordination of the permit. The lead agency provides no more than coordination, they do not assume responsibility for the adequacy of any city's program. Identify the responsibilities of each agency, how decisions will be made, and what communication protocols will be used. Identify what method will be used to develop a responsible management committee, or similar mechanism, and vest it with decision making powers.
   b. Format - What institutional arrangements have been used to formalize the agreement between the government entities, what arrangements have been made to allow cost sharing.
      i. Joint Powers Authority
      ii. Memorandum of Agreement/Understanding

2. Area-wide Interagency - Describe the function of each agency as it relates to the storm water program. Tell how each agency will be made aware of their responsibilities under the storm water program, and what they will do to comply with the regulations. Describe any responsibility or activity that impacts or overlaps the storm water program. Describe each activity/responsibility, how it impacts or overlaps the storm water program, how the agency will coordinate their activity with the storm water program, and how pertinent information will be exchanged. Describe the formal institutional arrangements or mechanisms that will be used to oversee or coordinate with each agency.
   a. County Hazmat - Waste regulations, Household hazardous waste program, Industrial Inspections
   b. County Health - Inspections of Restaurants and other food handling establishments.
   c. Flood Control - Operation and maintenance of the storm system
   d. Local Transportation/Congestion Management
   e. County (Regional) Parks
   f. Mosquito Abatement
   g. Fruit Fly Abatement
   h. Water Districts
   i. County Agricultural Agencies

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j. Others
3. City-specific Interagency Arrangements - This should reflect the structure in each city.
    a. Public works
        i. Engineering
        ii. Operations & Maintenance
        iii. Streets/roads - by law, these are part of the storm water conveyance system
        iv. Others
    b. Planning - New Construction and Redevelopment, coordination with CEQA and local permitting. Retrofit of existing structures.
    c. Parks and Recreation
    d. POTWs
    e. Others

C. FISCAL RESOURCES - Every permittee must have a mechanism for funding their storm water program. The plan should show what the funding is, the source of the funding, and how it will be distributed. The regulations require a budget for every year of the five year permit period. While it may not be possible for a city to commit to a set budget for future years, it is possible to make estimates about the cost of the program that is proposed. This should include an estimate of the cost of each of the elements, the personnel or contracts that will be required to implement the program, the anticipated funding source, and process and time schedule for establishing detailed annual budgets. Include a detailed budget for the first year.

122.26(d)(1)(vi) Fiscal resources. (A) A description of the financial resources currently available to the municipality to complete part 2 of the permit application. A description of the municipality's budget for existing storm water programs, including an overview of the municipality's financial resources and budget, including overall indebtedness and assets, and sources of funds for storm water programs.

122.26(d)(2)(vi) Fiscal analysis. For each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2) (iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds.

1. Area-wide
    a. Funding source(s)
    b. Staff resources
    c. Contract services
    d. Cost share (funds associated with existing activities/related programs) - if management practices currently in place under another program are to be included as part of the storm water program, the costs associated with those practices should be included as part of the budget. The program should also have a demonstrable water quality perspective.
2. City-specific
    a. Funding source(s)
    b. Staff resources
    c. Contract services
    d. Cost share (funds associated with existing activities/related programs) - if management practices currently in place under another program are to be included as part of the storm water program, the costs associated with those practices should be included as part of the budget. The program should also have a demonstrable water quality perspective.

D. LEGAL AUTHORITY - The regulations require permittees to demonstrate adequate legal authority to carry out the storm water program, including controls on industry and construction. You must cite your legal authority, or where it does not yet exist, give a plan and timetable for developing it.

122.26(d)(1)(ii) Legal authority. A description of existing legal authority to control discharges to the municipal separate storm sewer system. When existing legal authority is not sufficient to meet the criteria provided in paragraph (d)(2)(i) of this section, the description shall list additional authorities as will be necessary to meet the criteria and shall include a schedule and commitment to seek such additional authority that will be needed to meet the criteria.

122.26(d)(2)(i) Adequate legal authority. A demonstration that the applicant can operate pursuant to legal authority

established by statute, ordinance or series of contracts which authorizes or enables the applicant at a minimum to:
(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;
(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer;
(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water;
(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;
(E) Require compliance with conditions in ordinances, permits, contracts or orders; and
(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

1. List of essential authorities - Describe how the authority already existing in your municipality fills the requirements in the regulations. The ordinances must be adequate and they must be enforced.
2. Ordinance
   a. Exists
   b. Planned
3. Implementation procedures
4. Responsible parties

II. ILLICIT DISCHARGES - The regulations require every permittee to have a plan for fiding and preventing illegal discharges, and a mechanism for enforcing against illegal dischargers.

122.26(d)(1)(iii) Source identification. (A) A description of the historic use of ordinances, guidance or other controls which limited the discharge of non-storm water discharges to any Publicly Owned Treatment Works serving the same area as the municipal separate storm sewer system.

122.26(d)(2)(v)(B) A description of the existing program to identify illicit connections to the municipal storm sewer system. The description should include inspection procedures and methods for detecting and preventing illicit discharges, and describe areas where this program has been implemented.

122.26(d)(1)(iv)(D) Field screening. Results of a field screening analysis for illicit connections and illegal dumping for either selected field screening points or major outfalls covered in the permit application.

122.26(d)(2)(iv)(B) A description of a program, including a schedule to detect and remove (or require the discharger ... to obtain a ... NPDES permit for) illicit discharges and improper disposal into the storm sewer.

A. ILLICIT CONNECTIONS - The storm drain system should have been surveyed during the first permit period to ensure that all of the connections made to the system are both legal and appropriate. If the system has not yet been surveyed the plan should contain a proposed plan for doing it. The plan should contain a proposal for how the system will be surveyed, who will do the survey and a time table for completion. It should also specify what will be done with the illicit connections that are found. In addition, there should be a plan for ongoing system inspections.
   1. System survey
   2. Ongoing system inspections - The extent of this program would vary widely based on the needs of an individual city.
   3. Reporting

B. ILLEGAL DUMPING - It is important to stop illegal dumping. Unfortunately, it is difficult to detect, because it is usually done both irregularly and covertly. The best method for stopping illegal dumping is educating the public, both to raise the awareness of what is illegal dumping so that people are not doing it, and to encourage the public to contact the authorities if they witness illegal dumping. All city inspectors and police and fire personnel should be trained to recognize and respond to illegal dumping. There should be a clear response mechanism, such as a hotline that anyone can use to report incidence of illegal dumping. In addition there should be ongoing system surveillance. If illegal dumping or spills are reported and responded to, there should be some follow up mechanism.
   1. Outreach

2. System surveillance
3. Spill response - When a spill is identified, it must be cleaned up. The city must have the legal authority to act against the discharger, and the ability to handle the clean up or require the discharger to clean it up. The Regional Water Board and other State agencies can be brought in if a spill occurs that is beyond the ability of the city to the clean up.
4. Complaint response - When a complaint is made, it must be responded to. The city must have the legal authority to act against the discharger, and the ability to handle the clean up or require the discharger to clean it up. The Regional Water Board and other State agencies can be brought in if a spill occurs that is beyond the ability of the city to the clean up.
5. Coordination of alternative disposal - Household hazardous waste recycling programs are mandated for many of the items that are routinely illegally dumped, such as used oil. Describe these programs and any other alternative disposal programs that are available.
6. Reporting - Incidents of illegal dumping and spills should be reported to the Regional Board on a regular basis in writing. All complaint response should be tracked in writing and submitted to the Regional Board.

C. ENFORCEMENT PROCEDURES - Cite your local legal authority and describe your mechanism for enforcing against dischargers who are illegally dumping or who have illicit connections.

D. COORDINATION WITH STATE NON-STORM WATER PERMITS - All other state laws and programs that overlap with or are in conflict with the storm water program must be addressed. Non-storm water discharges are prohibited unless authorized by NPDES permit. Even if the Regional Board issues a permit for a discharge, the city can refuse to accept the discharge into their system. The regulations exclude certain non-storm water discharges from the prohibition unless a municipality identifies them as sources of pollutants. Permittees must identify the discharges they will allow, and the management measures that they will require on these discharges. However, all discharges that are prohibited by a Regional Board must also be prohibited by a municipality. A municipality cannot be less stringent than the state.

1. Identification of permissible/permitable discharges
2. Appropriate management practices
3. Reporting

III. INDUSTRIAL/COMMERCIAL SOURCES - Municipalities are responsible for all discharges from commercial facilities as well as industries and construction sites within their jurisdiction regardless of coverage under the statewide general permits. This includes facilities required to be permitted under the State Industrial Storm Water Program and industries and commercial facilities that are not required to be permitted. Pollution prevention should be emphasized. The Regional Water Board will enforce the General Permits and municipalities are expected to enforce their local ordinances.

122.26(d)(2)(ii) Source identification. The location of any major outfall that discharges to waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(1) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;

122.26(d)(2)(iv)(A) A description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls.

122.26(d)(2)(C) A description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system. The program shall:

(1) Identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;
(2) Describe a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of quantitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease, COD, pH, BOD5, TSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21(g)(7) (iii) and (iv).

A. IDENTIFICATION OF SOURCES - Indicate what sources were identified during the first permit period. Tell what measures will be taken to identify other sources, what agency will do the source identification, what methods of source identification will be used, and the time table for completing this investigation. This source identification should allow cities to prioritize industrial and commercial sources and to determine the schedule for inspection. At the minimum all potential sources should be inspected at least once during the permit period. Some facilities will require more frequent inspections.
   1. Categorical list
   2. Ranking
   3. Update procedure

B. CONTROL MEASURES (identification) - For each pollutant source, either by industrial or commercial category or specific activity, determine what measures are applicable for control of the source: which, of these measures, are technically and financially feasible, and which measures will be used. Indicate who will implement the measures, how they will be implemented and the time table for implementation. The plan should include a tiered approach. Describe what measures either have been implemented already, or can be immediately implemented, other measures that can be implemented over the short term and measures that are more costly or difficult that can be used if necessary in the long term. Describe any studies or pilot projects that are contemplated to study these measures.
   1. Pollution prevention measures - Education on source minimization and pollution prevention is an important control measure.
      a. Site design options
      b. Housekeeping/maintenance practices
   2. Structural (treatment) measures
      a. Applicability
      b. Effectiveness
      c. Retrofit opportunities

C. OUTREACH - Indicate the purpose of the outreach, the target audience, the intended messages, who will be responsible for the outreach, how the outreach will be done, and the time table for implementation.
   1. General guidance - All potential industrial and commercial dischargers should be informed of their obligations under the storm water program. Dischargers should also be informed of ways of complying with the storm water program, including general outreach on pollution prevention measures.
   2. Industrial category guidance - Specific outreach should be developed for industrial or commercial categories that permittee identify as high priority industries.
   3. Industrial activity guidance - Specific outreach should be developed for high priority activities such as loading docks or vehicle washing and maintenance.

D. INSPECTIONS - Most municipalities already have programs in which they inspect businesses, these include HAZMAT, Health and Pretreatment Programs among others. Inspections for the storm water program can either be incorporated into these other inspection programs, or they can be done as a stand alone program with separate inspectors. Indicate the purpose of the inspections, the priority for inspections, how the facilities were chosen for inspection, what the inspection will consist of, how the inspection will be carried out, who will be responsible for the inspections, how the inspectors will be trained, when the inspection program will be implemented and a schedule for completion of the inspections. Indicate also how the results will be reported and to whom. If an immediate problem is found how will it be handled? To whom will it be reported? How will follow up to these inspections be handled? Will there be a mechanism for a revisit inspection?
   1. Checklist
   2. Schedule
   3. Reports
   4. Follow-up procedures

E. LOCAL PERMITS / INCENTIVE PROGRAM - While not required by the Regulations, a municipality should consider controlling industrial and commercial sources through the use of local storm water permits, or clean business incentive programs.

F. TRAINING - Implementation of an industrial storm water program will require an informed and aware staff. All public employees should be trained in the storm water regulations, both so that they abide by the regulations in the course of their work day and so that they can tell if an activity that they witness is legal. In addition inspectors who visit commercial or industrial facilities, or who go to construction sites can determine compliance with the storm water regulations and educate the facilities about the requirements of the program.

1. Public employees
2. Inspectors

G. COORDINATION WITH STATE INDUSTRIAL STORM WATER PERMIT - It is anticipated that the municipalities will have regulations through ordinance or other legal mechanisms that would be written such that compliance with a municipality's regulations would cause an industrial discharger to be in compliance with the State General Permit. It is anticipated that coordination between the Regional Boards and the municipalities will be required. As such, the municipalities should discuss the anticipated relationship or agreement they would have with the Regional Board, and the mechanism they will pursue to enact such an agreement or relationship.

1. Memorandum of Understanding - An MOU can be used to formalize the agreement between municipalities and the Regional Board on the industrial compliance program.
2. Reports
3. Other issues

IV. NEW DEVELOPMENT AND RE-DEVELOPMENT - Each permittee must have a plan for managing storm water runoff from new construction and re-development. The plan must cover both construction covered by the State Construction Storm Water General Permit and construction under five acres. The plan should emphasize pollution prevention, especially erosion prevention.

122.26(d)(2)(iv)(A)(2) A description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed.

122.26(d)(2)(iv)(D) A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system, which shall include:
(1) A description of procedures for site planning which incorporate consideration of potential water quality impacts;
(2) A description of requirements for nonstructural and structural best management practices;
(3) A description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality; and
(4) A description of appropriate educational and training measures for construction site operators.

A. PLANNING PROCESS - The planning process for new development and re-development must address a comprehensive plan to develop, implement and enforce controls to reduce the discharge of pollutants from areas of new development and significant redevelopment. Master planning and other studies regarding flood management must assess the impact on water quality.

1. Watershed protection policies
2. Coordination with CEQA
3. Site planning practices
4. General Plan changes
5. Use of master plans
6. Other policies
7. Planning - public works interface
8. Implementation procedures

B. CONSTRUCTION SITES - Construction site management must consider the requirements of the State Construction Storm Water General Permit. Erosion prevention using vegetation, soil stabilization and timing of grading should be emphasized.

1. Erosion control requirements
2. Chemical and waste management requirements
3. Inspections
   a. Checklist
   b. Schedule
   c. Reports

d. Follow-up procedures

C. LOCAL PERMITS - Optional
1. Coordination with existing permits
2. New permit issues

D. TRAINING
1. Planning personnel
2. Public Works personnel
3. Inspectors

E. CONTROL MEASURES - Permanent measures to be installed during construction to control runoff from the final development or redevelopment.
1. Pollution prevention measures
a. Site design - inlet design to allow easy and frequent cleaning.
b. Education/training
c. Other
2. Post construction (treatment) measures - grassy swales, extended detention basins, sand filters, constructed wetlands, oil/water separators.
a. Applicability
b. Effectiveness
c. Retrofit opportunities
3. Operation and maintenance - It must be clear who is responsible for the long term maintenance, and who will pay for it.
a. Requirements
b. Responsible party
4. Conflicts with other mandates - Regulations from other agencies can conflict with recommended practices in the storm water program. An example of this is the storage of materials. While the storm water program recommends covering materials, fire codes will not allow some materials to be covered. In another area, the minimization of impervious areas and design of landscaping to allow flow to the vegetated areas are recommended practices in storm water. Often local building ordinances dictate the amount of impervious areas and the configuration of the landscaping. These conflicts should be identified and an attempt made to resolve them.
a. Identification of conflicts
i. Landscaping
ii. Pavement/curbs
b. Conflict resolution

F. OUTREACH
1. Developers
2. Contractors
3. Other parties

G. ENFORCEMENT - Municipalities must enforce their ordinances, including their grading ordinances.

H. COORDINATION WITH STATE CONSTRUCTION STORM WATER PERMIT - It is anticipated that the municipalities will have regulations through ordinance or other legal mechanisms that would be written such that compliance with a municipality's regulations would cause a construction project to be in compliance with the State General Construction Permit. Coordination between the Regional Boards and the municipalities will be necessary. As such, the municipalities should discuss the anticipated relationship or agreement they would have with the Regional Board, and the mechanism they will pursue to enact such an agreement or relationship.

1. Memorandum of Understanding - An MOU can be used to formalize the agreement between municipalities and the Regional Board on the construction compliance program.
2. Reports

3. Other issues

V. PUBLIC AGENCY ACTIVITIES - All municipalities perform functions that have an impact on storm water quality. These include among other things, vehicle maintenance, landscape maintenance and weed control, water body maintenance including swimming pool maintenance, construction and maintenance of streets and roads, and construction and maintenance of the flood control system. Since municipalities must address all significant sources of pollutants, all of these activities must be examined and if appropriate, controlled.

122.26(d)(2)(iv) Management programs. (A) A description of the existing management programs to control pollutants from the municipal separate storm sewer system. The description shall provide information on existing structural and source controls, including operation and maintenance measures for structural controls, that are currently being implemented. Such controls may include, but are not limited to: Procedures to control pollution resulting from construction activities; floodplain management controls; wetland protection measures; best management practices for new subdivisions; and emergency spill response programs. The description may address controls established under State law as well as local requirements.

122.26(d)(2)(iv)(A)(1) A description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers;

122.26(d)(2)(iv)(A)(3) A description of practices for operating and maintaining public streets, roads and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities;

122.26(d)(2)(iv)(A)(4) A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible;

122.26(d)(2)(iv)(A)(5) A description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage, or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;

122.26(d)(2)(iv)(A)(6) A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides, and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

A. SEWAGE SYSTEMS - Sewage spills must not be allowed to go into the storm drain. Sewage must be contained and vacuum pumped. Storm drains must be protected during a sewage spill.

B. CORPORATION YARDS - Corporation yards include any area or facility that is used for vehicle maintenance or washing, other maintenance, chemical storage or use, such as a paint facility, and waste management. Identify all corporation yards and give their locations and describe their functions.

1. Storm Water Pollution Prevention Plans - SWPPP are not required, however, municipalities are required to control any potential source of pollution, and SWPPP are a good vehicle for compliance. Identify what the potential storm water problems are, who is responsible for implementing the storm water measures, what management practices will be used, and how they will be implemented. For measures that are not already in place give a timetable for implementation. Tell how the effectiveness of the BMPs will be judged. If a municipality chooses not to use SWPPP, they must use an equivalent method to handle their corporation yard discharges.

C. PARKS AND RECREATION - Park Departments manage landscaping and swimming pools. Both of these activities involve the use of chemicals, waste management, and non-storm water discharges. Their use of chemicals must be addressed in the storm water management plan. In addition maintenance of swimming pools requires the periodic discharge of large quantities of swimming pool water.

1. Fertilizers/Pesticides
   a. Use / Application management
   b. Storage
2. Facility Management
   a. Wash waters
   b. Maintenance
   c. Swimming pool waters

D. STORM DRAIN SYSTEM OPERATION AND MANAGEMENT - The maintenance and operation of the storm drain system has an impact on storm water quality and must be addressed in the management plan. Material clogging storm drains can not be discharged into drains. It must be removed and disposed of properly.
   1. Inlet maintenance
   2. Drain maintenance
   3. Waste management
   4. New system designs
   5. Retro-fit opportunities

E. STREETS AND ROADS - Construction, operation, and maintenance of roads has an impact on storm water quality and must be addressed in the management plan..
   1. Sweeping - Street sweeping waste cannot be dumped in storm drain.
      a. Storm water quality based operation
      b. Waste management
   2. Street/pavement washing - Wash waters must be managed as non-storm water discharges.
   3. Maintenance
      a. Saw-cut slurry management
      b. Paving practices
      c. Waste management
      d. Medians/Landscaped Right of Way
         i. Irrigation
         ii. Fertilizer/pesticides

F. FLOOD CONTROL - Flood control practices have an impact on storm water quality and must be addressed in the management plan. Flood control managers must be educated about storm water quality requirements. Water quality must be a consideration in moving the water through the system.
   1. Coordination with new projects
   2. Coordination of maintenance activities
      a. Desilting/sediment removal
      b. Vegetation management
      c. Waste management
   3. Operation of facilities
      a. Detention basins - BMPs must be implemented when draining or pumping detention basins. Risers should not be directed into storm drain inlets.
      b. Other
   4. Retrofit opportunities

G. PUBLIC FACILITIES - Storm water runoff and non-storm water discharges from other public facilities must be addressed. Chemical use by these facilities should also be included. Address pressure blasting/cleaning sidewalks and concrete.
   1. Parking facilities
   2. Golf courses
   3. Schools
   4. Hospitals
   5. Parks / Landscapes
   6. Other buildings/plazas/etc.

H. PONDS, FOUNTAINS, AND OTHER PUBLIC WATER BODIES - Maintenance practices used on public water bodies, including waste management and non-storm water discharges, must be addressed in the plan.
   1. Algae control
      a. Use of chemicals
   2. Chlorine management
   3. Maintenance

VI. RESIDENTIAL (Not Elsewhere Covered) - Residential activities including private vehicle washing and maintenance; use of chemicals such as pesticides, herbicides and paints; private swimming pool maintenance; and other household and landscape maintenance can contribute to storm water pollution. Identify measures that can be taken to improve the quality of the runoff from residential area. Emphasize pollution prevention and the identification and use of safe substitutes.

VII. PUBLIC INFORMATION AND PARTICIPATION - It is necessary to involve the public in the storm water program in order to have an effective municipal program. The outreach program should be focused on the specific needs of individual cities. Tell how the public education needs were determined, who is responsible for developing and implementing the education program, what program and what materials will be developed, give a timetable for implementing the program, and the method to be used to determine its effectiveness.

122.26(d)(2)(iv) Proposed management program. A proposed management program covers the duration of the permit. It shall include a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate.

122.26(d)(2)(iv)(B)(5) A description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers;

122.26(d)(2)(iv)(B)(6) A description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials; and

A. GENERAL OUTREACH - Describe your outreach materials developed for the general public. Tell what the focus of the materials are, and how you arrived at that focus. Tell what materials have already been developed and how they are distributed. Tell what materials are still to be produced, what they address, who is producing them, how they will be distributed, what kind of follow up opportunities are provided, and the timetable for production and distribution.
   1. Written material
   2. Audio material
   3. Video material
   4. Distribution plan

B. FOCUSED OUTREACH - Describe your outreach materials developed for specific groups. Tell how these groups were identified and prioritized. Tell what the focus of the materials are, and how you arrived at that focus. Tell what materials have already been developed and how they are distributed. Tell what materials are still to be produced, what they address, who is producing them, how they will be distributed, what kind of follow up opportunities are provided, and the timetable for production and distribution.
   1. Pollutant specific
   2. Practice/activity specific
   3. Business specific

C. EDUCATION PROGRAMS
   1. Public employees - It is important to educate all of the public employees about the storm water program both so that they do not continue with practices that are counter productive and so that they can participate in its implementation and enforcement. Describe your public employee outreach programs. Tell what the focus of the training is, how it is implemented, who is implementing it, the schedule for training, and the opportunities for continuing education.
   2. K-12 - Describe programs developed for schools. These programs should include storm water awareness, illegal dumping awareness, source minimization and pollution prevention.
   3. Other

D. CITIZENS PARTICIPATION
   1. Volunteer monitoring
   2. Cooperative outreach
   3. Complaint procedures - Describe any mechanism available for citizen reports of illegal discharge illicit connections or potential pollution problems.

E. EFFECTIVENESS EVALUATION - Quantifying the effectiveness of education and outreach efforts may be difficult. Municipalities must develop a process by which they can evaluate the effectiveness of their program, and recommend changes to it.

VIII. PROGRAM EVALUATION - The storm water program developed under this plan must be evaluated for its effectiveness on a regular basis. The plan for this evaluation must include a schedule for evaluation, a methodology for the evaluation, a discussion of who will carry out the evaluation, and what will be evaluated. In addition, there must be a mechanism to follow up on the information generated by the evaluation. The plan should be adjusted based on the program evaluation.

122.26(d)(2)(v) Assessment of controls. Estimated reductions in loadings of pollutants from discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water.

A. PERFORMANCE STANDARDS - The permittees, possibly through management-committee sub-committees, must develop standards to judge the effectiveness of their activities and control measures. As an example, for street sweeping, permittees must devise a way of determining if the street sweeping has an impact on water quality. This could include determining what kind of pollutants are removed by the sweeping, measuring the size of the pollutants and the amount removed. Methodologies should be developed for each, which if followed, will assure that each control measure or action is implemented to the maximum extent practicable. For street sweeping, this would include the frequency of sweeping, the method of sweeping, the equipment used, how the equipment is cleaned and maintained, and the method of disposal for the material collected. Contol measure studies can be coordinated on a larger scale, such as statewide, so that each municipality is studying a different procedure.
   1. Development procedure
   2. Role of subcommittees
   3. Activity/source/action area specific

B. ANNUAL REPORTS - Reports must be submitted after the end of each fiscal year. Permittees should propose a date for submittals that works for them. The reports should be more than a simple compilation of activities. Rather, they should be used to evaluate the program and the effectiveness of the management measures. Each annual report should contain a report on the program implemented during the previous year and a plan that will be implemented during the current year. In addition, the findings of the evaluation of the previous years program should be used to suggest changes that are appropriate for implementation during the next year. Any revisions to the five year plan should be addressed here.
   1. Format/Structure - Each group of permittees under an area wide permit should develop a format that all the permittees will use for the annual report.
   2. Effectiveness measures - The co-permittees are responsible for developing methods for determining the effectiveness of the BMPs that they implement, for their particular program, and developing a level of effort that will be required in each area.
   3. Content

C. SUB-ANNUAL REPORTS - Each year, before the end of the fiscal year, the permittees should submit a report that contains a draft preliminary report addressing the implementation of that years program, a preliminary budget for the next year program addressing the funding issues for the upcoming budget process, and a preliminary plan for the next year showing what revisions to the five year plan will be required. In some regions, rather than a sub-annual report, the permittees will meet with the Regional Board to discuss these issues.
   1. Purpose
   2. Format/Structure
   3. Content

D. INTERNAL REPORTING - We suggest the development of a process for interagency - intragency exchange information among themselves and to develop the annual and semiannual reports
   1. Standard forms
   2. Procedures
   3. Record keeping - The Regional Board does not need to see all of the extraneous information, but there should be a mechanism for storage of records in case they are needed.

E. STORM WATER MANAGEMENT PLAN REVISIONS - There should be a review process which will allow you to revise the plan for the next year and for the rest of the permit period.
   1. Process
   2. Reporting

IX. MONITORING - Monitoring serves several purposes. It allows a baseline characterization of storm water/urban runoff from the permitted area, it identifies the problems and their sources and evaluates impacts on receiving waters, it allows the permittee to determine what are appropriate, and it allows a permittee to judge the effectiveness of its control measures. Monitoring is not limited to water sampling. It can include such elements as visual inspections of above and underground systems or compilation of chemical use data.

Characterization of the permitted area, the watershed, the storm drain system, the receiving waters, and the land use was required in the previous permits. The information collected from previous efforts should be used in baseline characterization. This plan should also tell what the future monitoring objectives are, what information will be collected, the purpose of the information, how it will be collected and used, and how the information will be analyzed, reported and stored.

122.26(d)(1)(B) Existing quantitative data describing the volume and quality of discharges from the municipal storm sewer, including a description of the outfalls sampled, sampling procedures and analytical methods used.

122.26(d)(2)(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

122.26(d)(2)(ii) Source identification. The location of any major outfall that discharges to waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(1) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;

122.26(d)(1)(iii)(C) A list of water bodies that receive discharges from the municipal separate storm sewer system, including downstream segments, lakes and estuaries, where pollutants from the system discharges may accumulate and cause water degradation and a brief description of known water quality impacts.

122.26(d)(2)(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.

122.26(d)(2)(B) Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under Section 122.21(c)(7)) for BOD5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

122.26(d)(2)(C) A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(1) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section;

A. SYSTEM CHARACTERIZATION - The previous permit required a complete characterization of the entire system. This included the storm drain system, the receiving waters and the land use activities.
   1. Watershed - Characterize each watershed including the storm drain system, the land uses and the particular problems of the receiving waters.
   2. Storm drain system - Characterize the system including all major outfalls.
      a. Inlets
      b. Outlets
   3. Receiving waters - Identify and evaluate water bodies. Use existing water quality data along with current monitoring efforts to characterize and prioritize the receiving waters. Perform additional monitoring as necessary to characterize the receiving waters.
      a. Streams
      b. Lakes
      c. Bays
      d. Wetlands

    e. Other habitat

4. Land use - Characterize the land use in the permitted area. Characterize the storm water discharges from specific land use categories and mixed land use.
    a. General categories
    b. Specific features/sources

B. SOURCE IDENTIFICATION - Do focused monitoring on pollutants of concern.
1. Specific land-use
2. Specific activities

C. CONTROL MEASURE EFFECTIVENESS - Monitor to determine the effectiveness of control measures. Identify what control measure studies will be done and how they will be prioritized. Give a schedule for doing the studies.
1. Specific Sources (e.g., corp yards)
2. Specific Activities (e.g., waste management)
3. Special Studies

D. POLLUTANT LOADING - An initial determination of the pollutant loading, both system wide and specific to land use types should be made through monitoring and modeling. Once the initial determination is made, it is important to continue a minimal long term monitoring program to track trends in the pollutant loading over time.

1. System-wide
2. Land-use specific
3. Long-term stations

E. COMPONENTS OF A MONITORING PROGRAM PLAN - These are the expected elements of a monitoring plan. The elements suggested here do not replace any directions from the regulating Regional Board.
1. Monitoring/sampling points with map
    a. rationale for sampling points
2. Dry weather sampling
    a. frequency
    b. monitored parameters
    c. method for documentation of outfall field inspections
3. Storm sampling plan
    a. number of storm events to be samples
    b. method for determining representative event
    c. worker safety plan
    d. sampling plan
    e. timing of sampling
    f. monitored parameters
        i. how were parameters chose?
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        ii. minimum number of samples per hour
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    c. appropriate sampling technique for each pollutant
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    a. container type

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United States
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(4204)

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Municipal Wastewater Management Fact Sheets Storm Water Best Management Practices

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Keywords: *Ergonomics, *Manual lifting, *Industrial hygiene, *Occupational safety and health, Posture, Back injuries, Musculoskeletal system disorders, Truck drivers.

Abstract: The goal of this study was to apply ergonomic controls in the soft drink beverage delivery industry, and measure the effectiveness in reducing musculoskeletal injuries through psychophysical, physiological, and biomechanical methods. Nine driver/sales workers with an average of 20 years experience participated in the study. Risk factors inherent in the job included exposure to whole body vibration from driving the trucks, pushing and pulling loads exceeding 350 pounds, repetitive lifting and moving of crates, slip and fall injuries, surface conditions, exposure to sharp glass from broken glass bottles, robberies, and moving products from bays into trucks. All nine participants reported suffering a work related musculoskeletal injury, with eight reporting back injuries, five reporting arm injuries, and four reporting leg injuries. All had taken time off as a result of the injuries, with the average time off being 2.8 months.

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This document is part of a series of sets of municipal wastewater management fact sheets. These fact sheets are intended to serve a wide audience, including consulting engineers, municipal engineers, state regulators, municipal officials, and private citizens. Contents include: airplane deicing fluid recovery systems; bioretention; catch basin cleaning; coverings; dust control; employee training; flow diversion; highway ice and snow removal and minimization of associated environmental effects from these procedures; handling and disposal of collected solids/ residuals from storm water and sediment control processes; infiltration drain field infiltration trenches; internal reporting; materials inventory; non-storm water discharges; porous pavement; preventive maintenance; record keeping; sand filters; StromTreat system; spill prevention; storm water contamination assessments; storm water wetlands; vegetative covers; vegetative swales; visual inspection; vortex solids separators; water quality inlets; wet detention ponds.

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MUNICIPAL WASTEWATER MANAGEMENT
FACT SHEETS:
STORM WATER BEST MANAGEMENT PRACTICES

Municipal Technology Branch (4204)
United States Environmental Protection Agency
401 M Street, SW
Washington, DC, 20460

PREFACE

This document is part of a series of municipal wastewater management fact sheets. These fact sheets are intended to serve a wide audience including: the consulting engineer who is looking for basic technical information; the municipal engineer who must understand these technologies well enough to evaluate the assets and limitations; the municipal official who must sell the technologies as part of a comprehensive pollution prevention program; the state regulator who must approve the technologies used to meet permit requirements; and ultimately the citizen who must understand the importance of preventing pollution of the Nation's waters.

The material presented is guidance for general information only. The document does not provide sufficient information to design BMPs, but does provided sufficient information to compair alternatives. In some cases, the information represents new technology or new application of existing technology and is base on very limited data. This information should not be used without first obtaining competent advice with respect to its suitability to any general or specific application. References made in this document to any specific method, product or process does not constitute or imply an endorsement, recommendation or warranty by the U.S. Environmental Protection Agency.

Municipal Wastewater Management Fact Sheets are divided into several sets: Wet Weather Flow Management Practices; Innovative and Alternative Technologies; Biosolids Technologies and Practices; Wet Weather Technologies; Water Conservation, etc. Each set is published separately starting with Storm Water Best Management Practices, September, 1993. This document incorporates and superseeds previous storm water best management practice fact sheets (EPA 832-F-93-013, September 1993 and Addendum to EPA 832-F-93-013, September 1994) . Updates to this set of fact sheets and development of additional sets is dependent upon continued resources being available.

INTRODUCTION

Storm water runoff is part of a natural hydrologic process. However, human activities, particularly urbanization, can alter drainage patterns and add pollution to the rain water and snow melt that runs off the earth's surface and enters our Nation's rivers, streams, lakes, and coastal waters. A number of recent studies have shown that storm water runoff is a major source of water pollution as indicated by a decline in fish population and diversity, beach closings or restrictions on swimming and other water sports, bans on consumption of fish and shellfish and other public health concerns. These conditions limit our ability to enjoy many of the benefits that our Nation's waters provide.

In response to this problem, the States and many municipalities have been taking the initiative to manage storm water more effectively. In acknowledgement of these storm water management concerns, the U.S. Environmental Protection Agency (EPA) has undertaken a wide variety of activities, including providing technical assistance to States and municipalities to help them improve their storm water management programs.

This document contains fact sheets on storm water best management practices (BMPs). These fact sheets represent two types of BMPs: pollution prevention and treatment. Pollution prevention BMPs include both source controls and administrative practices. Treatment BMPs include both in-line ans off-line applications. However, many are not stand alone BMPs, but are most effective when combined with other BMPs in a comprehensive storm water management plan. These BMPs are suitable for both municipal and industrial applications and can be used to supplement other EPA guidance documents such as **Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices (EPA 832-R-92-006)** and **Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices (EPA 832-R-92-005)** as well as other State or local guidance.

In order to better serve our customers and identify additional information needs, a short questionnaire is included at the end of this document. Please take a few minutes to tell us if this document was helpful in meeting your needs and what other needs you have concerning storm water management. Responses can be mailed to the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC, 20460 or faxed to (202) 260-0116.

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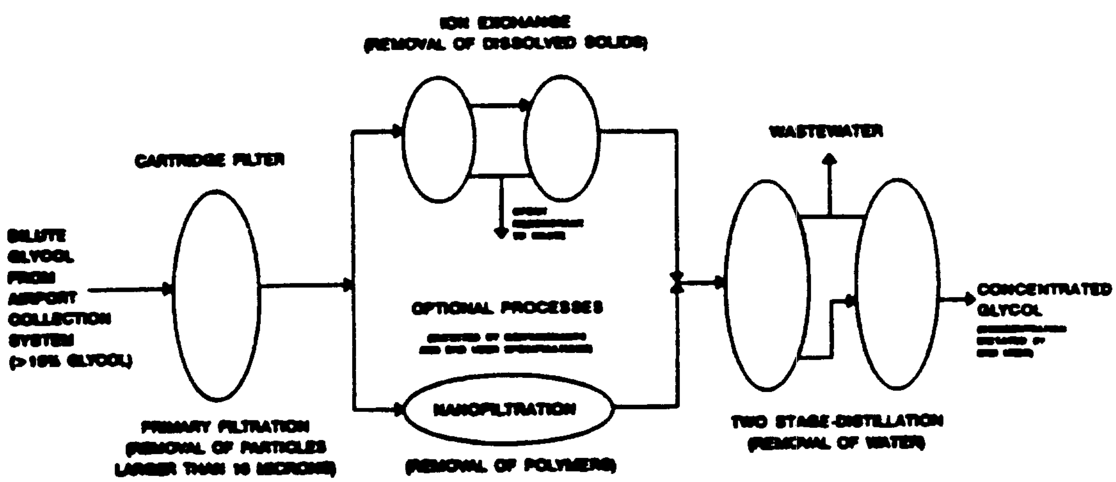
Customer Questionnaire

STORM WATER BMP: AIRPLANE DEICING FLUID RECOVERY SYSTEMS

EPA MTB
Office of Wastewater Management
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Ethylene or propylene glycol recovery is accomplished by a three-stage process typically consisting of primary filtration, contaminant removal via ion exchange or nanofiltration, and distillation as shown in Figure 1 below. The process technologies involved in glycol recovery have been proven in other industries and are now being applied to spent airplane deicing fluid (ADF).



SOURCE: Reference 3

FIGURE 1: TYPICAL AIRPLANE DEICING FLUID RECOVERY SYSTEM

The purpose of the primary filtration step is to remove entrained suspended solids from contact with the aircraft and pavement from the used ADF. The suspended solids must be removed to avoid plugging of downstream equipment and heat exchangers. Primary filtration is defined as the removal of solids greater than 10 micron in size. Primary filters employed by ADF systems may be polypropylene cartridge or bag filters. Ion exchange may be employed to remove dissolved solids such as chlorides and sulfates. Ion exchange removes ions from an aqueous solution by passing the wastewater through a solid material (called ion exchange resin) which accepts the unwanted ions, while giving back an equivalent number of desirable ions from the resin. Nanofiltration may be employed to remove polymeric additives. Nanofiltration systems are pressure-driven membrane operations that use porous membranes for the removal of colloidal material.

Colloidal material and polymeric molecules with molecular weights in excess of 500 are normally removed by nanofilters. The requirement to remove polymer additives is dictated by the specifications of the end user of the recovered ADF product.

The key process step in the overall ADF recycling system is distillation. Distillation is defined as the separation of more volatile materials (in this case, water) from less volatile materials (glycol) by a process of vaporization and condensation. Distillation is capable of recovering volatiles with little degradation, which is an important advantage in this application where the recovered product can be sold or recycled. Product purity of any desired level can theoretically be obtained by distillation, however in some cases the processing costs may be prohibitive. In most ADF applications, the separation of water from either a water-ethylene glycol or a water-propylene glycol mixture of ADF, employs a two stages of distillation process. This will typically, remove enough water to produce a recovered ADF with a minimum of a 50% glycol content. The requirement glycol concentration is dictated by the specifications of the end user of the recovered ADF product.

COMMON MODIFICATIONS

The details of the distillation process that each vendor employs are proprietary. Design variables include temperature, distillation column design (number of stages, type of packing, size) and reflux ratio. Batch distillation systems are generally employed due to the variation in the composition of the influent and the irregular supply of the feed. Secondary filtration and ion-exchange stages vary with the quality of the influent feed and the specifications of the end-user. The temperature of distillation also varies between ethylene glycol and propylene glycol recovery applications.

CURRENT STATUS

This fact sheet contains general information only, and should not be used as the basis for designing an airplane deicing fluid recovery system. While the basic technologies used to recycle ethylene and propylene glycol are well established, actual operating experience in recycling airplane deicing fluids is limited. To date, there is only one on-site application of ADF recovery operating in the United States. This is a pilot-scale operation conducted for Continental Airlines at the Denver Stapleton Airport. Another pilot-scale ADF operation is currently being conducted in Canada at the L.B. Pearson Airport in Toronto. While, recovery systems are proposed for the St. Louis, Missouri Airport and the Indianapolis, Indiana airport, these systems are not in operation. There are also three ADF recovery systems in operation at airports in Europe: Lulea, Sweden; Oslo, Norway; and Munich, Germany.

There are currently three vendors actively designing, testing or marketing ADF recovery systems for use on-site at airports in North America: DeIcing Systems (DIS), Glycol Specialists, Inc. (GSI), and Canadian Chemical Reclaiming (CCR). There are also a number of chemical waste service companies that will provide off-site processing for spent glycol for other industries. The technology and process applications of ADF are evolving rapidly. The equipment manufacturers and the airport operators should be contacted for the current state of the art information.

APPLICATIONS

Ethylene or propylene glycol recovery systems are generally applicable at any airport that collects ADF with a minimum concentration of approximately 15% glycol. Spent ADF mixtures with lower glycol content are generally impractical to recover via distillation, without expensive preconcentration steps such as reverse osmosis. Dilute streams are typically discharged to municipal wastewater treatment plants, if permitted, treated by oxidation to destroy the organics prior to direct discharge, or hauled away be a chemical waste contractor. A number of other BMPs such as water quality inlets and oil\water separators are being tested to demonstrate their ability and reliability to concentrate dilute streams.

LIMITATIONS

In order for the ADF to be recovered or regenerated, it must first be collected at the airport. The implementation of ADF collection must respond to the unique requirements of each airport. The feasibility of glycol recovery is dependent on the ability of the collection system to contain a relatively concentrated waste stream without significant contamination by other storm water components. Since distillation is an energy intensive process, it is generally not cost effective to distill and recycle waste glycol solutions at low concentrations (< 15%). However, individual airports may have to collect and recover lower concentrations of waste glycol solutions to satisfy requirements of their storm water NPDES permit. Remote or centralized deicing with the containment and collection of used glycol is one method for collecting a more concentrated used glycol. However, centralized deicing systems may be impractical for all but the largest airport operations due to their cost and physical size. For established airports, a switch to centralized deicing systems would present a number of operational and logistical problems. In lieu of a centralized facility, used glycol can be collected via vacuum trucks and fluid collections containers that siphon glycol from runway aprons. Roller sponge devices have been employed at the Toronto Airport with mixed results due to uneven surfaces.

Mixtures of ethylene and propylene glycols cannot be recovered effectively in a single batch process because the technology currently available cannot cost effectively separate the two glycols. While there is a market for either recovered ethylene glycol or propylene glycol, there is little demand for a recovered blend of both glycols by end users. In order to recover either ethylene or propylene glycol from spent ADF, an airport must use one or the other, or isolate application and runoff areas. Treated separately, each type of water-glycol mixture can then be recovered effectively via the distillation process.

DESIGN CRITERIA

There area number of important criteria that must be determined in order to properly design an ADF system. Table 1 below list some of the key criteria. Storage and handling of process chemicals, energy requirements, and disposal of spent chemicals and residuals generated in the recovery process must also be carefully considered. Other factors such as site drainage, weather patterns, water quality requirements, state and local restrictions, marketability of the recovered product, etc., will also influence the final design of the system.

Sodium hydroxide (NaOH) and hydrochloric acid (HCL) are required for regeneration of the ion exchange process unit. As a part of the recertification process, wetting agent and a corrosion inhibitor must be added to the recovered product prior to reuse as airplane deicing fluid. While recertification and reuse od recovered airplane deicing fluids is practiced in Europe, the Federal Aviation Administration (FAA) currently has no recertification guideline for reuse of recovered ADF in the United States. Care should be taken when handling these chemicals to avoid contact with skin. Eye protection should also be worn.

For the most part, energy requirements are dependent on the waste stream glycol concentration of the fluid to be recycled and the purity required by the end user. Recovery by distillation is energy-intensive, with nominal energy requirements being about 5.81×10^5 to 2.79×10^6 J/kg of feed (250 to 1200 BTU/lb of feed). As the technology is refined and as operating experience grows, these costs should decrease.Flush and spent

TABLE 1: KEY CRITERIA FOR DESIGNING AN AIRPLANE DEICING FLUID RECOVERY SYSTEM

- Deicing Fluid Data
  - Type
  - Concentration
  - Total consumption per season
  - Total consumption per peak-day
  - Average consumption per aircraft
- Airport Operations Data
  - Flights per day
  - Peak Traffic Periods
- Length of deicing season
  - Number of deicing days per season
  - Future traffic extension plans
- Spent Fluid Data
  - Volume generated
  - Glycol concentration
  - Contaminants
- Reuse Specifications
  - Glycol concentration
  - Acceptable impurities

SOURCE: References 10 and 11

wastewater are generated by recovery processes which employ ion-exchange systems. These fluids may be disposed of, after neutralization by addition of acids or bases, to the sanitary sewer. Spent filter cartridges may be generated in some systems and may be disposed of to landfills. Distillation condensate, with less than 1.5% glycol, is also generated and may be reused or disposed. Currently discharges to the sanitary sewer system may require permitting under local pretreatment programs.

PERFORMANCE

Three ADF recovery systems were evaluated using data provided by three vendors. In each ADF recovery system investigated, the quality of the fluid recovered was dictated by the specification objective. The data provided for the ethylene glycol recovery system at the Toronto Airport shows that the process reliably produced an effluent with a glycol content over 80%. The data from the ADF recovery system in Denver showed that high purity (98.5% glycol) can be reliably produced. The process at the Munich Airport reliably produced an effluent with a glycol content over 50%, which meets the lower end-user requirements in Europe.

COSTS

Since there are no full-scale ADF systems currently operation in the U.S., it is difficult to determine the actual construction costs. However, based on pilot study at the Denver Stapleton Airport, the total capital cost for the complete project, including deicing and anti-icing application equipment, collection piping, storage facilities, and glycol recovery system has been estimated to be between $6 and $7 million dollars. The construction costs for the ADF collection system, storage and handling facilities, piping, and recovery system has been estimated at approximately $600,000 (GSI, 1993).

The total capital cost for the new Denver International Airport, including deicing and anti-icing application pads and equipment, drainage and collection piping, storage and handling facilities, and complete glycol recovery system is currently estimated at between $20 and $25 million dollars. These costs are based on a complete package including planning, engineering design, equipment, construction and installation, start-up services and other contingencies. The construction costs for the ADF collection system, storage and handling facilities, piping, controls and instrumentation, and complete recovery system is currently estimated at approximately $5 million dollars.

The major operating expense for all ADF systems is cost of energy used in the distillation process. Other maintenance costs include flushing of filters and ion-exchange units, disposal of spent filter cartridges, process and neutralization chemical, lubrication of pumping equipment, and inspection and repairs to the distillation equipment and heat exchanger. The collection system and storage facilities will also require periodic cleaning and maintenance. Based on vary limited operating data from the pilot study at the Stapleton Airport, the cost for processing ADF with a 28 percent glycol concentration, is approximately 35 cents per gallon treated. However, this cost will vary depending on the volume treated and concentration of glycol in the waste stream. As the technology is refined and as operating experience grows, these costs should decrease.

ENVIRONMENTAL IMPACT

While the potential for volatile-organic emissions to the air is considered small, the discharges of air emissions from the distillation process through losses from condenser vents, accumulator tank vents, and storage tank vents must be considered. Ion-exchange flush and spent wastewater are generated by recovery processes may generally be discharged to the sanitary sewer. These spent byproducts may require neutralization by addition of acids or bases before discharge. Currently discharges to the sanitary sewer system may require permitting under local pretreatment programs. Spent filter cartridges may be generated in some systems. In most cases these can be disposed of in the local landfill.

Distillation condensate, with less than 1.5% glycol, is also generated and may be reused or disposed. However, release of more than 1 pound of ethylene glycol to the environment must be reported under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements. The EPA currently has under review a proposal to raise the disposal limit to 5000 pounds. This proposal is expected to be promulgated as a rule in calendar year 1995. A spill prevention control and countermeasure (SPCC) plan should be developed for all ADF systems to address the handling, storage and accidental release of chemicals, regenerated products and waste byproducts.

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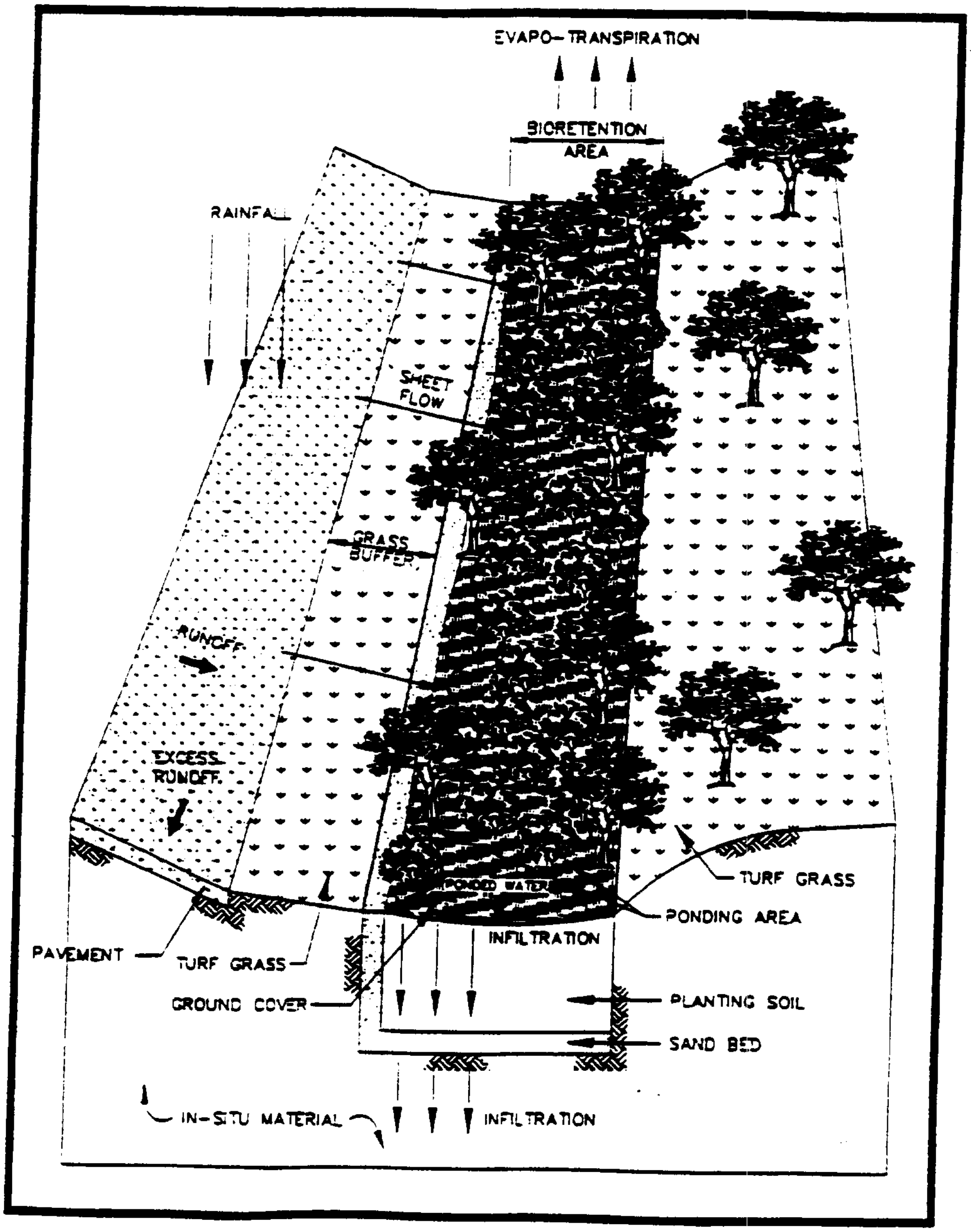
STORMWATER BMP: BIORETENTION

DESCRIPTION

Bioretention is a recently developed best management practice (BMP) developed by the Prince George's County, Maryland Department of Environmental Resources (PGDER). The BMP utilizes soils and plants to remove pollutants from stormwater runoff. As shown in Figure 1, runoff is conveyed as

FIGURE 1 BIORETENTION AREA



Source: PGDER, 1993.

sheet flow to the BMP, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff first passes over a sand bed, which slows the velocity and evenly distributes the runoff over the ponding area. Runoff also infiltrates the sand bed, which adds to the infiltration capacity of the bioretention area. After runoff passes over or infiltrates the sand bed it enters the ponding area. The ponding area is formed by depressing the surface organic layer and/or ground cover and the underlying planting soil. Water is ponded to a depth of 6 inches and gradually infiltrates the bioretention area or is evapotranspired. The grading of the bioretention area is done so that excess runoff is diverted away from the BMP. Stored water in the bioretention area planting soil exfiltrates over a period of days into the underlying soils of the BMP.

COMMON MODIFICATIONS

The City of Alexandria, Virginia has modified the design to include an underdrain within the sand bed to collect the infiltrated water and discharge it to a downstream sewer system. Underdrains were required due to impervious subsoils and marine clays. This modified design makes the bioretention area act more as a filter that discharges treated water than an infiltration device. The BMP can also be modified to include or not include a sand bed. The benefit of using a sand bed is the reduction in velocity and infiltration achieved with the bed. Design modifications are also being reviewed to potentially utilize both aerobic and anaerobic zones in the BMP. The anaerobic zone will promote denitrification.

CURRENT STATUS

Bioretention has been used successfully at urban and suburban areas in Prince George's County, Maryland (MD), Montgomery County, MD, Baltimore County, MD, and Prince William County, Virginia. The first system was installed nearly four years ago (1992). The BMP is planned for installation in Alexandria, Virginia and locations in North Carolina.

APPLICATIONS

Bioretention typically provides stormwater treatment for impervious surfaces at commercial, residential, and industrial areas. Three prime locations where the BMP could be used are at median strips, parking lot islands, and in swales. They are usually best used at locations that are upland from inlets that receive sheet flow from graded areas and at areas that will be excavated. Sheet flow should be conveyed to the BMP to minimize erosive conditions and to maximize treatment effectiveness. Low environmental impacts to a site are desired. Therefore, construction of bioretention areas best suited to sites where grading or excavation will occur so that the bioretention area can be readily incorporated in the site plan. Bioretention areas should be used in stabilized drainage areas to minimize the sediment loading to the BMP.

LIMITATIONS

Bioretention is not an appropriate BMP at locations where the water table is within 6 feet of the ground surface and when the surrounding soil stratum is unstable. In cold climates there is the potential for the soil to freeze and prevent runoff from infiltrating into the planting soil. The BMP is also not recommended for areas with slopes greater than 20 percent or where mature tree removal will be required. Clogging may be a potential problem, particularly if the BMP receives runoff with high sediment loads.

PERFORMANCE

Stormwater pollutant removal in bioretention is attributed to physical and biological processes that occur in the plants and soils of the BMP. These processes include adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization.

Adsorption is the process where pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Therefore, the infiltration rate of the soils must not exceed those specified or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and some hydrocarbons.

Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover and planting soil. The media trap particulate matter and allows water to pass through. The filtering effectiveness of the bioretention area may potentially decrease over time. Common particulates removed from stormwater include particulate organic matter and suspended solids.

Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria and aerobic bacteria are responsible for the decomposition of the organic matter (e.g., petroleum). Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated.

Sedimentation occurs in the swale or ponding area as the velocity slows and suspended solids fall out of suspension. Volatilization also plays a role in pollutant removal. Pollutants such as oils, hydrocarbons, and mercury can be removed from the wetland via evaporation or by aerosol formation under windy conditions.

Data is not available on the removal effectiveness of bioretention; however, results from performance studies for infiltration BMPs can be used due to the similarities in the BMPs. The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs, as shown in Table 1. As shown, the BMP could potentially have greater than 90 percent removal rates for total suspended solids, organics, metals, and bacteria. Excessive pollutant loadings (e.g., suspended solids) may exceed the removal capabilities of the bioretention area.

TABLE 1 ESTIMATED PERFORMANCE OF BIORETENTION (1)

Pollutant	Removal Rate
Total Suspended Solids	90 %
Total Phosphorus	60 %
Total Nitrogen	60 %
Organics	90 %
Metals	90 %
Bacteria	90 %

(1) Source: Schueler, 1987, 1992.

DESIGN CRITERIA

Design details have been specified by the Prince George's County DER in a document entitled *Design Manual for Use of Bioretention in Stormwater Management* (PGDER, 1993). The specifications were developed after extensive research on soil adsorption capacities and rates, water balance, plant pollutant removal potential, plant adsorption capacities and rates, and maintenance requirements. A case study was performed using the specifications at three commercial sites and one residential site in Prince George's County, Maryland.

Each of the components of the bioretention area is designed to perform a specific function. The function of the grass buffer strip is to reduce incoming runoff velocity and filter particulates from the runoff. The sand bed also reduces the velocity and provides some particulate filtration, as well as evenly spreading the flow over the bioretention area. Aeration and drainage of the planting soil is provided by the 1 foot deep sand bed. The ponding area provides a temporary storage location for runoff prior to its evaporation or infiltration. Particulates that had not been previously filtered out by the grass filter strip or the sand bed settle within the ponding area. The organic or mulch layer also filters pollutants and provides an environment conducive to the growth of microorganisms which degrade petroleum based products and other organic material. This layer acts as the leaf litter in a forest and prevents the erosion and drying of underlying soils. Planted ground cover and mulch reduce the potential for erosion, with mulch being slightly less effective than planted ground cover. The maximum sheet flow velocity prior to erosive conditions is 1 ft/sec and 3 ft/sec for planted ground cover and mulch, respectively. The clay in the planting soil provides adsorption sites for hydrocarbons, heavy metals, nutrients and other pollutants. Storage of stormwater is also provided by the voids in the planting soil. The stored water and nutrients in the water and soil are then available to the plants for uptake.

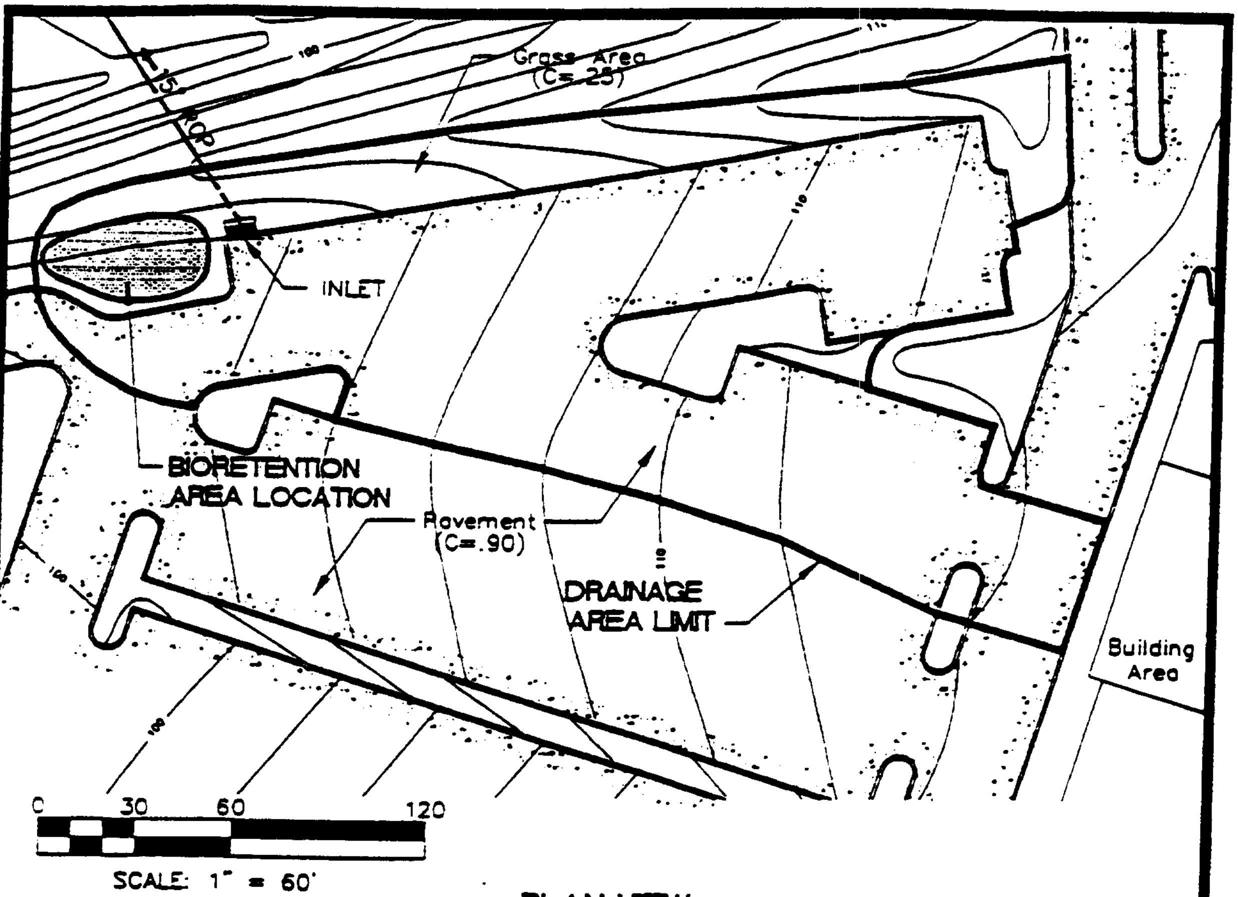
The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered. The existence of utilities (e.g., electric or gas) which would be costly to relocate may limit the feasibility of a site. Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil. An unstable surrounding soil stratum (e.g., Marlboro Clay) and soils with a clay content of greater than 25 percent may preclude the use of bioretention, as would a site with slopes greater than 20 percent or a site with mature trees that would be removed during construction of the BMP. Bioretention can be designed to be off-line or on-line of the existing drainage system. The "first flush" of runoff is diverted to the off-line system. On-line systems capture the first flush but that volume of water will likely be washed out by subsequent runoff.

The size of the drainage area for one bioretention area should be between 0.25 and 1 acre. Multiple bioretention areas may be required for larger drainage areas. The maximum drainage area for one area is determined by the amount of sheet flow generated from the 10-year storm. Flows greater than 5 cfs may potentially erode stabilized areas. In Maryland, a flow of 5 cfs generally occurs with a 10-year storm at one-acre commercial or residential sites. The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area is a function of the drainage area and the runoff generated from the area. The size should be 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient, "c", determined for the site. The 5 percent specification applies to a bioretention area that includes a sand bed and 7 percent applies to an area designed without the sand bed. An example of sizing a facility is shown in Figure 2. Sizing specifications are based on 0.5 inches to 0.7 inches of precipitation over a 6-hour period, which is the mean storm event for the Baltimore-Washington area, infiltrating into the bioretention area. Other areas with a different mean storm event will need to account for that in the design of the BMP.

Recommended minimum dimensions of the bioretention area are 15 feet wide by 40 feet in length. The minimum width allows enough space for a dense randomly distributed area of trees and shrubs to become established that replicates a natural forest and creates a microclimate. This enables the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet, with a length of twice the width. Any facilities with widths greater than 20 feet should have a length of twice the width. This length requirement promotes the distribution of flow and decreases the chances of concentrated flow.

FIGURE 2 BIORETENTION AREA SIZING



PLAN VIEW

BIORETENTION AREA
SIZING COMPUTATION

DEVELOPMENT	AREA (SQ FT)	"C"* FACTOR	C x AREA
PAVEMENT	23,800	0.90	21,400
GRASS	10,100	0.25	2,500
TOTALS	33,900		23,900

BIORETENTION AREA SIZE

1. WITH SAND BED (5% SUM OF C x AREA)
   = .05 x 23,900 = 1,195 OR SAY 1,200 SQ.FT.
2. WITHOUT SAND BED (7% SUM OF C x AREA)
   = .07 x 23,900 + 1,673 OR SAY 1,700 SQ. FT.

*SEE CHAPTER IV, PRINCE GEORGES COUNTY STORMWATER MANAGEMENT MANUAL

Source: PGDER, 1993

The maximum ponding depth of the bioretention area has been determined to be 6 inches. This depth provides for adequate storage and prevents excessive periods of time for standing water. Water left to stand for longer than four days restricts the type of plants that can be used due the water tolerance of most plants. Mosquitoes and other insects may also start to breed if water is standing for longer than four days.

The appropriate planting soil should be backfilled into the excavation bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture and have a clay content ranging from 10 to 25 percent. The soil should have infiltration rates greater than 0.5 inches per hour (in/hr), which is typical of sandy loams, loamy sands, or loams. Silt loams and clay loams generally have rates of less than 0.27 in/hr. The pH of the soil should be between 5.5 and 6.5. Pollutants (e.g., organic nitrogen and phosphorus) can be adsorbed by the soil and microbial activity can flourish within this pH range. Other requirements for the planting soil are a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts. In addition, criteria for magnesium, phosphorus, and potassium are 35 lbs/acre, 100 lbs/acre, and 85 lbs/acre, respectively. Soil tests should be performed for every 500 cubic yards of planting soil with the exception of tests run for pH and organic content, which is only required once per bioretention area.

A minimum planting soil depth of 4 feet should be used in a bioretention facility. This depth will provide adequate soil for the plants root system to become established in and prevent plant damage due to severe wind. Four feet of soil also provides adequate moisture capacity. To obtain the 4 foot depth, most sites will require excavation. Depths of greater than 4 feet may require additional construction practices (e.g., shoring measures). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached.

The bioretention area should be vegetated to resemble a terrestrial forest community ecosystem, that is dominated by trees and has discrete soil zones. A terrestrial forest community also has a mature canopy and a distinct sub-canopy of understory trees, a shrub layer and herbaceous ground covers. Three species of both trees and shrubs are recommended at a rate of 1,000 trees and shrubs per acre. For example, a 15' by 40' bioretention area (600 ft^2 or 1.4 percent of an acre) would require 14 trees and shrubs. The tree to shrub planting ratio should be 2:1 to 3:1. On average, the trees should be spaced 12 feet apart and the shrubs should be spaced 8 feet apart. In the metropolitan Washington, D.C. area trees and shrubs should be planted from mid-March through the end of June or from mid-September through mid-November. Planting periods in other areas of the US will vary. Vegetation should be watered at the end of each day for fourteen days following its planting.

Native species that are tolerant to pollutant loads and varying wet and dry conditions should be used in the bioretention area. These species can be determined from several published sources, including *Native Trees, Shrubs, and Vines for Urban and Rural America* (Hightshoe, 1988). The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures (e.g., provide a soil breach) to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities.

The optimal placement of vegetation within the bioretention area should be evaluated by the designer. Plants should be placed randomly to replicate a natural forest. Shade and shelter from the wind will be provided to the bioretention area if the designer places the trees on the perimeter of the area. Damaging flows to trees and shrubs can be minimized if they are placed away from the path of the incoming runoff. Certain species that are more tolerant to cold winds (e.g., evergreens) should be placed in areas of the site where these winds typically enter the site.

After placing the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted during the spring of the year. There are no restraints to the timing of mulch placement, except that it should immediately follow tree and shrub planting. Two to three inches of commercially available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to provide protection from erosion. Depths greater than 3 inches should not be applied because it would negatively impact the cycling of carbon dioxide and oxygen between the soil and the atmosphere. The mulch should be aged for at least six months, (one year is optimal), and applied uniformly over the site.

MAINTENANCE

Recommended maintenance for a bioretention area includes inspection and repair or replacement of the BMP components. Trees and shrubs should be inspected twice per year to determine their health and remove and replace any dead or severely diseased vegetation. Diseased vegetation that can be treated should be done on an as needed basis. Pruning and weeding may also be necessary to maintain the appearance of the BMP.

Mulch replacement is recommended when erosive conditions are evident or when the aesthetics of the bioretention area are declining. Spot mulching may be adequate when there are random void areas; however, once every two to three years the entire area may require mulch replacement. This activity should be performed during the spring. The previous layer of mulch should be removed prior to application of the replacement mulch.

The application of an alkaline product, such as limestone, is recommended one to two times per year due to increasing acidity of the soil that results from slightly acidic precipitation and runoff. Prior to applying the limestone, the soils and organic layer should be tested to determine the pH and determine the quantity of limestone required. Testing should also be performed to determine concentrations of heavy metals and other toxic substances in the soil. Forest buffers and grass swales, which accept similar sources of runoff as the bioretention area, tend to accumulate toxins and heavy metals within five years of installation. This suggests the possibility of a similar accumulation at a bioretention area. Soil replacement may be required when toxic levels of heavy metals or other pollutants are reached which impairs plant growth and the effectiveness of the BMP (PGDER, 1993).

COSTS

Construction cost estimates for a bioretention area are slightly greater than the required landscaping for a new development. Recently constructed 400 ft^2 bioretention areas in Prince George's County cost approximately $500. These units are rather small and are on the low side for cost estimation purposes particularly if a larger unit is required. The cost estimate includes the cost for excavating 2 to 3 feet and vegetating the site with 1 to 2 trees and 3 to 5 shrubs. The estimate does not include the cost for the planting soil. Purchasing soils will increase the cost for a bioretention area. Retrofitting a site typically has higher costs with an average cost of $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and/or existing structures and the replacement of fill material with planting soil. Plans for retrofitting a commercial site in Maryland (Kettering Development) was estimated at $111,600, which included 15 bioretention areas. The final costs for the retrofit were much lower due to only six bioretention areas being constructed.

The use of bioretention can decrease the cost for stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the required amount of storm drain pipe from 800 to 230 feet with the use of bioretention. The drainage pipe costs were reduced by $24,000 or 50 percent of the total drainage cost for the site (PGDER, 1993). Landscaping costs that would be required at a development regardless of the installation of the bioretention area should also be considered when determining the net cost of the BMP.

The operation and maintenance costs for a bioretention facility will be comparable to typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils.

ENVIRONMENTAL IMPACTS

Bioretention provides stormwater treatment that enhances the quality of downstream water bodies. Runoff is temporarily stored in the BMP and released over a period of four days to the receiving water. The BMP is also able to provide shade and wind breaks, absorb noise, and improve an area's landscape.

REFERENCES

1. Prince George's County Department of Environmental Resources (PGDER), 1993. Design Manual for Use of Bioretention in Stormwater Management. Division of Environmental Management, Watershed Protection Branch. Landover, MD.

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5. Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices. Metropolitan Washington Council of Governments.

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STORM WATER BMP: CATCH BASIN CLEANING

DESCRIPTION

Catch basins are chambers or sumps, usually built at the curb line, which allow surface water runoff to enter the storm water conveyance system. Many catch basins have a low area below the invert of the outlet pipe intended to retain sediment. By trapping coarse sediment, the catch basin prevents solids from clogging the storm sewer and being washed into receiving waters. Catch basins must be cleaned out periodically to maintain their sediment trapping ability. The removal of sediment, decaying debris, and highly polluted water from catch basins has aesthetic and water quality benefits, including reducing foul odors, reducing suspended solids, and reducing the load of oxygen-demanding substances that reach surface water.

CURRENT STATUS

Catch basin cleaning is an easily implemented but often overlooked Best Management Practice. Frequently, the cleaning procedures deal with removal of debris from grate openings but do not extend down into the catch basin itself.

APPLICATIONS

Catch basin cleaning is applicable to any facility that has an on-site storm sewer system which includes catch basins and manholes.

LIMITATIONS

Limitations associated with cleaning catch basins include:

- Catch basin debris usually contains appreciable amounts of water and offensive organic material which must be properly disposed of.
- Catch basins may be difficult to clean in areas with poor accessibility and in areas with traffic congestion and parking problems.
- Cleaning is difficult during the winter when snow and ice are present.

PERFORMANCE

It is not possible, based on current data, to quantify the water quality benefits to receiving waters of catch basin cleaning. The rate at which catch basins fill with debris, as well as the total amount of material which can be removed by different frequencies of cleaning, are highly variable and cannot be readily predicted. Past studies have estimated that typical catch basins retain up to 57 percent of coarse solids and 17 percent of equivalent biological oxygen demand (BOD).

MAINTENANCE

A catch basin should be cleaned if the depth of deposits are equal to or greater than one-third the depth from the basin bottom to the invert of the lowest pipe or opening into or out of the basin. Catch basins should be, at a minimum, inspected annually. If a catch basin is found during the annual inspection to significantly exceed the one-third depth standard, it should be inspected and cleaned on a more frequent basis. If woody debris or trash is likely to accumulate in a catch basin, it should, at a minimum, be inspected and cleaned, if necessary, on a monthly basis.

In addition, data collected as part of a Nationwide Urban Runoff Program (NURP) project in Castro Valley Creek, California indicated that a typical catch basin, which were cleaned once per year or once every other year contained approximately 60 pounds of material each.

Catch basins can be cleaned either manually or by specially designed equipment. These include bucket loaders and vacuum pumps. Material removed from catch basins is usually disposed of in landfills.

COSTS

Catch basin cleaning costs will vary depending upon the method used, required cleaning frequency, amount of debris removed, and debris disposal costs. Cleaning costs for catch basins were estimated in three NURP program studies (Midwest Research Institute, 1982). These estimates are summarized in Table 1 below.

TABLE 1. CLEANING COST PER CATCH BASIN

LOCATION	METHOD	COST
Castro Valley, CA	Vacuum attached to street sweeper	$7.70
Salt Lake County, UT,	Vacuum attached to street sweeper	$10.30
Winston-Salem, NC	Vacuum attached to street sweeper	$6.30

SOURCE: Reference 1.

In communities equipped with vacuum street sweepers, a cleaning cost of $8 per basin cleaned is recommended for budgetary purposes (Southeastern Wisconsin Regional Planning Commission, 1991). Cleaning catch basins manually costs approximately twice as much as cleaning the basins with a vacuum attached to a sweeper. Therefore, a cost estimate of $16 per catch basin cleaned may be used for manual cleaning. It should be noted that costs vary depending on local market conditions.

ENVIRONMENTAL IMPACTS

Sediment and debris removed from catch basins must be disposed of in a proper manner to avoid negative environmental impacts.

REFERENCES

1. Midwest Research Institute, Collection of Economic Data from Nationwide Urban Runoff Program Projects–Final Report. Report to U.S. Environmental Protection Agency, March, 1982.

2. Minnesota Pollution Control Agency, Protecting Water Quality in Urban Areas, 1989.

3. Southeastern Wisconsin Regional Planning Commission, Cost of Urban Nonpoint Source Water Pollution Control Measures, Technical Report No. 31, June, 1991.

4. U.S. EPA, Results of the Nationwide Urban Runoff Program, December, 1983.

5. U.S. EPA, Catch Basin Technology Overview and Assessment, May, 1977.

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STORM WATER BMP: COVERINGS

Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

A simple yet effective Best Management Practice (BMP) is covering. Covering is the partial or total enclosure of raw materials, byproducts, finished products, containers, equipment, process operations, and material storage areas which, when exposed to rain and/or runoff, could contaminate stormwater. Tarpaulins, plastic sheeting, roofs, buildings, and other enclosures are examples of temporary or permanent covering that are effective in preventing stormwater contamination. The most prominent advantage of covering is that it is inexpensive in comparison to other BMPs.

CURRENT STATUS

A review of numerous NPDES group applications indicates that covering is a commonly implemented BMP. As more facilities identify potential sources of stormwater contamination, the use of coverings will increase significantly due to its effectiveness from a performance and cost perspective.

APPLICATIONS

Covering is appropriate for loading/unloading areas, raw material, byproduct and final product outdoor storage areas, fueling and vehicle maintenance areas, and other high risk areas.

LIMITATIONS

Limitations associated with covering as a BMP include:

- Temporary methods such as plastic sheeting can become torn or ripped, exposing the contaminant to precipitation and/or stormwater runoff.
- Costs may prohibit the building of complete enclosures.
- May pose health or safety problems for enclosures built over certain materials or activities.
- Requires frequent inspection.
- A structure with only a roof may not keep out all precipitation.

PERFORMANCE

It is difficult, based on data currently available, to quantify the mitigation of runoff contamination when covering is used. However, significant runoff water quality benefits are expected by simply reducing the contact between potential contaminants and precipitation or stormwater runoff. One source has estimated that 80 percent of the environmental damage from de-icing chemicals is caused by inadequate storage facilities.

DESIGN CRITERIA

Evaluate the integrity and durability of the covering, as well as its compatibility with the material or activity being enclosed. When designing an enclosure, one should consider materials access, handling and transfer. Materials that pose environmental and/or safety dangers because they are radioactive, pathogenic, flammable, explosive, or reactive require special ventilation and temperature considerations.

Covering alone may not protect exposed materials from stormwater contact. Placing material on an elevated impermeable surface or building curbing around the outside of the materials may be required to prevent contact with stormwater runoff from adjacent areas.

Practicing proper materials management within an enclosure or underneath a covered area is essential. For example, floor drainage within an enclosure should be properly designed and connected to a sanitary sewer. The local publicly owned treatment works should be consulted to determine if there are any pretreatment requirements, restrictions, or compatibility problems prior to discharge.

MAINTENANCE

Maintenance involves frequent inspection of the covering for rips, holes, and general wear. Inspecting coverings should be part of an overall preventive maintenance program.

COSTS

Covering costs vary in proportion to the degree of protection desired, and the required lifespan. The most inexpensive covering is plastic sheeting, but it is not suitable where a high degree of protection is desired for a long period. An enclosed building is the most expensive type of covering when materials for the structure, lighting, and ventilation are considered, but it offers the highest degree of protection for the longest period.

ENVIRONMENTAL IMPACTS

The impact from a covered area depends on the degree of complexity in the covering design. A simple plastic sheeting can possibly have a stormwater diversion, and allow for disposal of uncontaminated water to a storm sewer. A structure with a permanent roof may be less effective, if the material inside is not sufficiently protected from contact with runoff. An enclosed structure may need to have internal drainage. If this is the case, it must not be connected to the storm sewer, and may not be suitable connection to a sanitary sewer, if the stored material is considered hazardous. The internal drains would then need to be connected to some suitable containment area for later disposal.

REFERENCES

1. Minnesota Pollution Control Agency, Protecting the Water Quality in Urban Areas, 1989.

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This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: DUST CONTROL

DESCRIPTION

Dust controls are methods that prevent pollutants from entering stormwater discharges by reducing the surface and air transport of dust caused by industrial or construction activities. Control measures can prevent dust from spreading into areas of a facility where runoff may eventually transport the material to a storm sewer collection system or directly to a receiving waterbody.

Dust control for industrial activities normally involves mechanical systems designed to reduce dust emissions from in-plant, processing activities, and/or materials handling. These may include hoods, cyclone collectors, bag-type collectors, filters, negative pressure systems, or mechanical sweepers.

Dust control measures for construction activities include windbreaks, minimization of soil, spray-on adhesives, tillage, chemical treatment, and water spraying.

COMMON MODIFICATIONS

There are a number of temporary alternatives for dust control. However, another consideration is to eliminate the need for temporary dust control completely by permanent modification of the site. This could include such measures as covering exposed areas with vegetation, stone, or concrete.

APPLICATIONS

Dust control measures may be applied to any site where dust generation can cause damage to the site or adjacent properties. However, application of dust controls is especially critical in arid areas where reduced rainfall levels expose soil particles for transport by air and runoff into water bodies. Dust control measures should also be applied to any industrial activity where dust poses a threat of contamination to water bodies.

LIMITATIONS

Primary limitations of dust control include :

- Some temporary dust controls must be reapplied or replenished on a regular basis.
- Some controls are expensive (e.g., chemical treatment) and may be ineffective under certain conditions.
- Some controls may cause an increase in the amount of mud being tracked off-site.
- Typical windbreaks are not as effective as chemical treatment or mulching and seeding, and may require land space that might not be available at all locations.
- Industrial dust control is typically labor and equipment intensive and may not be effective for all sources of pollution (e.g. street sweepers).
- More elaborate industrial dust control systems require trained personnel to operate them, an require the implementation of a preventive maintenance and repair program to ensure operational readiness.

PERFORMANCE

The decision on which dust control measures to implement must take into consideration the performance objectives required for a particular site. Some examples of performance objectives include:

- Prevent wind and water-based erosion of disturbed areas
- A reduction of employee respiratory problems.
- Rapid implementation at low cost and effort.
- Little or no impact on the environment.
- Permanent control of the dust problem.

Based on the objectives simply sweeping the impervious areas for larger particles on a routine basis may provide an efficient and reliable method of dust control that can be quickly implemented. Other controls might include vegetative windbreaks which would provide a much more permanent and environmentally safe alternative to chemical use.

DESIGN CRITERIA

The main goals of the dust control project design is to limit dust generation and reduce the amount of soil or dust particulate exposed. However this must also take into consideration the performance objectives established for the particular project. Additionally, some project sites may require solutions to both industrial and dust control problems. Realistically it may not be practical or possible to develop a design that meets all of the project goals and objectives at one time. Therefore it may be more appropriate to develop a phased design approach that utilizes a combination of temporary, permanent, or mechanical measures for dust control.

TEMPORARY MEASURERS

- Vegetative Coverings: Temporary seeding and mulching may be applied to cover bare soil and prevent wind erosion.
- Adhesives: Use spray-on adhesives according to Table 1 below. It is recommended using these adhesives only if other methods cannot be used as many of them are difficult to work with and form fairly impenetrable surfaces.
- Wetting: This is generally done as an emergency treatment. The site is sprinkled with water until the surface is wet and repeated as necessary. If this method is to be employed, it is recommended that a temporary gravel rock entrance be created to prevent carry-out of mud onto local streets.
- Tillage: This practice roughens the soil and brings clods to the surface. It is an emergency measure that should be used before wind erosion starts. Plowing should begin on the windward side of the site using chisel-type plows spaced about 12 inches apart, spring-tooth harrows, or similar plows.
- Barriers: Solid board fences, snow fences, burlap fences, crate walls, bales of hay, and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times the barrier height are effective in controlling wind erosion.

Calcium Chloride: This material is applied at a rate that will keep the surface moist. Pretreatment may be necessary due to varying site and climatic conditions.

TABLE 1: DESIGN OF ADHESIVE MEASURERS

Type of Emulsion	Water Dilution	Nozzle Type	Application Rate (gallons per acre)
Anionic Asphalt	7 to 1	Coarse	1,200
Latex	12.5 to 1	Fine	235
Resin and Water	4 to 1	Fine	300

SOURCE: Reference L

PERMANENT MEASURERS

- Permanent Vegetation: Seeding and sodding should be done to permanently stabilize exposed areas against wind erosion. It is recommended that existing trees and large shrubs remain in place to the greatest extent possible during site grading processes.

- Stone: The purpose of this method is to place coarse gravel or crushed stone over highly erodible soils.

- Topsoiling: This method is recommended when permanent vegetation cannot be established on a site. Topsoiling is a process in which less erosive soil material is placed on top of highly erodible soils.

- Cyclone Collectors. Cyclone collectors separate dry dust and particulate pollutants in the air by centrifugal force.

- Bag Collectors/Fabric Filters. Bag collectors or fabric filters remove dust by filtration. Storage of collected dust should be carefully considered so that it does not become a source of fugitive dust.

- Negative Pressure Systems. These systems minimize the release of dust from an operation by maintaining a small negative pressure or suction to confine the dust to a particular operation.

- Water Spraying. This temporary mechanical method confines and settles the dust from the air by dust and water particle adhesion. Water is sprayed through nozzles over the problem area.

- Street Sweepers. Two kinds of street sweepers are common in mechanical dust collection systems. The brush system has proven to be an efficient method at an industrial facility generating dust on a daily basis. It has proven to be extremely dependable and picks up the majority of the dust. Vacuum sweepers are presumed to be more efficient because the pollutants typically associated with contaminating stormwater are the smaller particles which may be left behind by a brush street sweeper. However, no performance data are as yet available to verify that vacuum sweepers are more efficient than brush sweepers.

MAINTENANCE

Typically, all dust control measures require periodic and diligent maintenance. For example, mechanical equipment should be operated according to the manufacturers recommendations and inspected regularly as part of an industrial site's preventive maintenance program. Temporary dust control measures, such as chemical spraying, watering, etc. require periodic renewal. Permanent solutions such as vegetation, wind barriers, impervious services also require upkeep and maintenance in order to remain effective.

COSTS

The costs associated with dust control measures are generally lower for vegetative and barrier methods, and increases significantly for chemical and mechanical treatments. For example, an industrial facility purchased a mechanical brush sweeper for approximately $35,000.

ENVIRONMENTAL IMPACTS

There are several negative environment impacts which are related to the dust control BMPs. These include :

- If over-application of a chemical treatment to control dust occurs, excess chemicals could be exposed to both wind and rain erosion with potential for both surface and groundwater contamination.

- Oil should never be used to control dust because of the high potential for polluting stormwater discharges.

- When using mechanical measures such as street sweepers, disposal is a major problem and could involve parameter testing of dust particulate. RCRA regulations may be applicable to this situation.

REFERENCES

1. City of Eagan, Minnesota, Erosion Control Manual, 1984

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This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: EMPLOYEE TRAINING

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

In-house training programs are designed and implemented to teach employees about stormwater management, potential sources of contaminants, and Best Management Practices (BMPs). Employee training programs should instill all personnel with a thorough understanding of their Stormwater Pollution Prevention Plan (SWPPP). This includes identification of BMP's, processes and materials they are working with, safety hazards, practices for preventing discharges, and procedures for responding quickly and properly to toxic and hazardous material incidents.

CURRENT STATUS

Typically, most industrial facilities have an employee training program. Usually these address such areas as health and safety training, or fire protection. The effort required to modify these programs to include discussion of stormwater management and BMP implementations should be reasonable.

APPLICATIONS

Employee training program implementation can be achieved through posters and bulletin boards designed to raise awareness of stormwater management, potential contaminant sources, and prevention of surface water runoff contamination. Field training programs where employees are shown areas of potential stormwater contamination and associated pollutants, followed by a discussion of site-specific BMPs by trained personnel, would also be beneficial for implementing the program.

LIMITATIONS

Limitations of an employee training program include:

- Lack of employee motivation
- Lack of incentive to become involved in BMP implementation
- Lack of commitment from senior management

PERFORMANCE

Quantitative performance will vary between facilities because performance is dependent on employee participation and commitment from senior management to reduce point and nonpoint sources of pollution. Employee training programs that teach identification of potential sources of contaminants, are highly recommended for implementation at all facilities. Support of these programs should given the highest priority, by senior management.

DESIGN CRITERIA

Specific design criteria for implementing an employee training program include:

- Meetings should be held at intervals frequent enough to ensure adequate understanding of SWPPP goals and objectives.
- A strong commitment by, and periodic input from, senior management.
- Transmission of knowledge from past spill causes and solutions to prevent future spills.
- Making employees aware of internal reporting procedures relative to BMP monitoring and spill reporting procedures.
- Operating manuals and standard procedures.
- Implementation of spill drills to minimize potential contamination of stormwater runoff from toxic pollutants.

MAINTENANCE

An employee training program should be an on-going yearly process. There should be, at a minimum, annual meetings to discuss SWPPPs. These meetings could be held in conjunction with other training programs. Figure 1 below illustrates a sample employee training tracking worksheet.

EMPLOYEE TRAINING

Worksheet
Completed by: ____________
Title: ____________
Date: ____________

Instructions: Describe the employee training program for your facility below. The program should, at a minimum, address spill prevention and response, good housekeeping, and material management practices. Provide a schedule for the training program and list the employees who attend training sessions.

Training Topics	Brief Description of Training Program/Materials (e.g., film, newsletter course)	Schedule for Training (list dates)	Attendees
Spill Prevention and Response			
Good Housekeeping			
Material Management Practices			
Other Topics			

SOURCE: Reference 2.

FIGURE 1: SAMPLE WORKSHEET FOR TRACKING EMPLOYEE TRAINING

COSTS

Costs for implementing an employee training program are highly variable. It is anticipated that most stormwater training program costs will be directly related to labor and associated overhead costs. however, the example shown in Table 1 below can be used to estimate what the annual costs might be for an in-house training program at your facility. Figure 2 can be used as a worksheet to calculate the estimated cost for an employee training program.

TABLE 1: EXAMPLE OF ANNUAL EMPLOYEE TRAINING COSTS

Title	Quantity		Avg. Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)
Stormwater Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
					TOTAL ESTIMATED ANNUAL COST				$12,600

Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with payroll expenses, building expenses, etc.

SOURCE: EPA

Title	Quantity		Avg. Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)	
____	____	x	____	x	____	x	____	=	____	(A)
____	____	x	____	x	____	x	____	=	____	(B)
____	____	x	____	x	____	x	____	=	____	(C)
____	____	x	____	x	____	x	____	=	____	(D)
					TOTAL ESTIMATED ANNUAL COST (Sum of A+B+C+D)				____	

SOURCE: Reference 2

FIGURE 2: SAMPLE ANNUAL TRAINING COST WORKSHEET

REFERENCES

1. U.S. EPA, NPDES BMP Guidance Document, December, 1979.

2. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September, 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: FLOW DIVERSION

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Structures which collect and divert runoff (such as gutters, drains, sewers, dikes, berms, swales, and graded pavement), are used in two ways to prevent the contamination of storm water and receiving water bodies. First, flow diversion structures may be used to channel storm water away from industrial areas so that storm water does not mix with on site pollutants. Second, they may also be used to carry contaminated runoff directly to a treatment facility.

Storm water conveyance systems can be constructed from many different materials, including concrete, clay tiles, asphalt, plastics, metals, rip-rap, and compacted soils covered with vegetation. The type of material used depends upon the design criteria used for conveyance of storm water runoff. These conveyances can be temporary or permanent.

Some advantages of storm water conveyance systems used for flow diversion purposes are:

- Direct storm water flows around industrial sites.
- Prevent temporary flooding of industrial site.
- Require low maintenance.
- Provide erosion-resistant conveyance of storm water runoff.
- Can typically be installed at any time.
- Provide long-term control of storm water flows.

COMMON MODIFICATIONS

Flow diversion structures can be modified by incorporating them with other pollution control best management practices. For example, diverted flow can be fed into an infiltration drain field system, diverted to an infiltration basin, diverted to a constructed wetland treatment facility, or diverted to an onsite treatment facility for discharge under the NPDES program. Another common modification is to construct a temporary flow diversion to determine its effectiveness. If the diversion structure is proven effective, it could then be converted to a permanent structure.

APPLICATIONS

Storm water diversions work well at most industrial sites. Storm water can be directed away from industrial areas by collecting it in a channel or drain system. Diversions can be used to collect storm water from the site and direct it down slope where it can be kept separate from runoff that has not been in contact with those areas. When potentially contaminated storm water is collected in a conveyance system, it can be directed to a treatment facility.

A good example of the utilization of a diversion structure is The Isle La Plume Wastewater Treatment Plant in La Crosse, WI The area immediately surrounding the facility has been regraded so that storm water runoff can be directed into the process tanks where it is treated right along with other wastewater. Figure 1 below illustrates this storm water runoff control method.

PERFORMANCE

Properly designed storm water diversion systems are very effective in preventing storm water from being contaminated or in routing contaminated flows to a proper treatment facility. For example, at the Denver Stapleton International Airport, flow diversion techniques intercept 99 percent of the glycol used and prevent its introduction to Sand Creek, the local receiving waterbody. At the La Crosse, WI Wastewater Treatment Plant, it is estimated that approximately one-third of the storm water runoff from the facility is diverted into their treatment process.

DESIGN CRITERIA

Planning for flow diversion structures should consider the typical volume and rate of storm water runoff present. Also, the patterns of storm water drainage should be considered so that the channels may be located to efficiently collect and divert the flow. When deciding on the type of material for the conveyance structure, consider the resistance of the material to erosion, its durability and compatibility with any pollutants it may carry.

Diversion systems are most easily installed during facility construction. Existing grades should be used to limit costs. Positive grades should be provided to allow for continued movement of runoff through the conveyance system. (Note: care must be exercised to limit velocities which could potentially increase erosion.) A typical diversion swale is shown in Figure 2 Below.

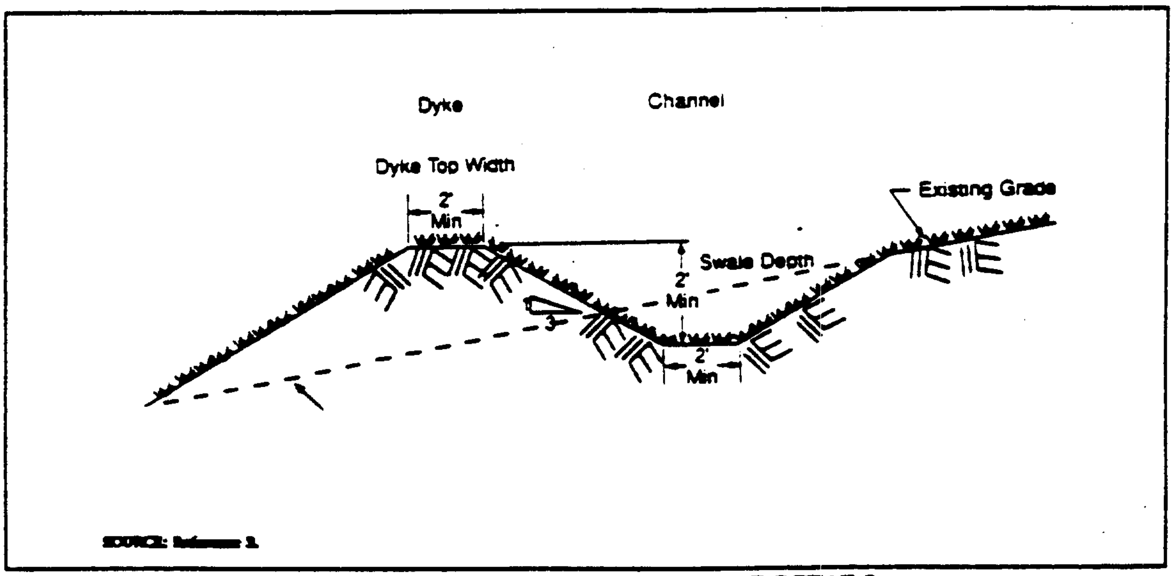

FIGURE 2: TYPICAL DIVERSION SWALE DETAILS

MAINTENANCE

A maintenance program should be established to ensure proper functioning of the system. Storm water diversion systems should be inspected to remove debris within 24 hours after a significant rainfall event since heavy storms may clog or damage them. Flow diversion structures should also be inspected on an annual basis to ensure that they meet their hydraulic design requirements for proper performance.

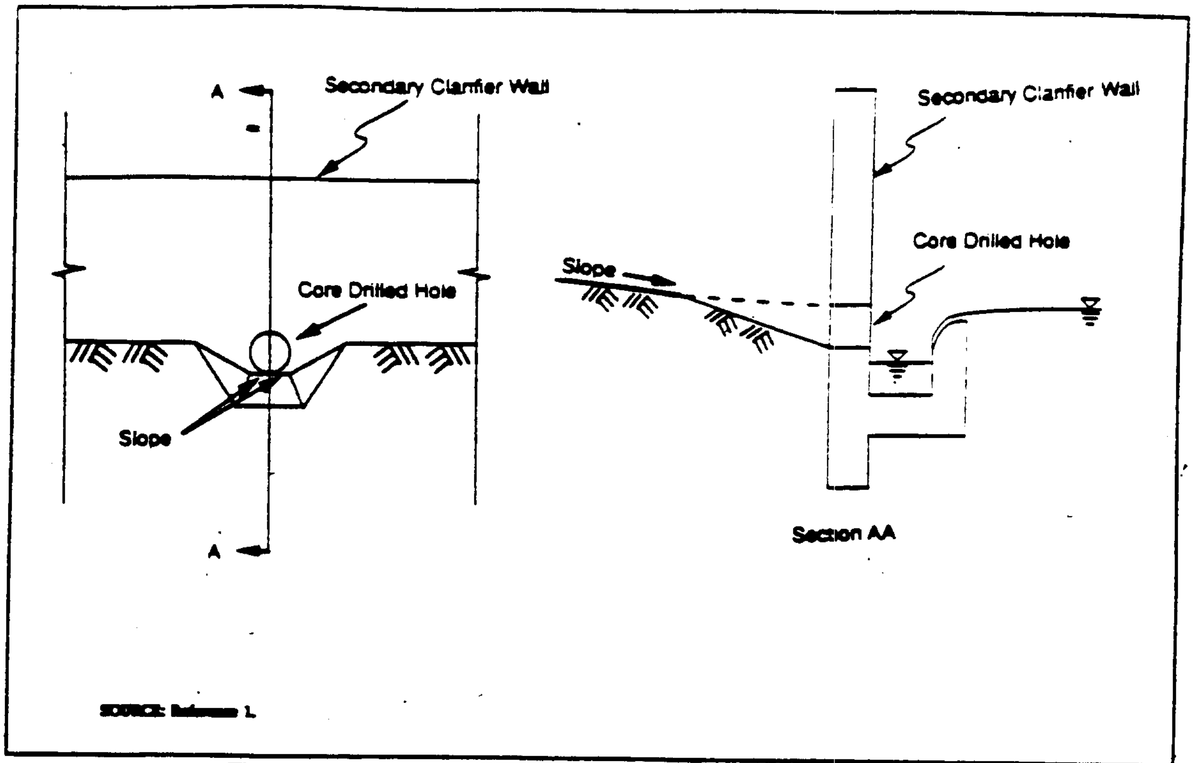

FIGURE 1: STORM WATER RUNOFF CONTROL MEASURERS

At the Denver Stapleton International Airport, the terminal area, aprons, and support facility areas (0.5 square miles), where activities resulting in storm water contamination are concentrated, are served by four individual large diameter storm sewers which collect storm water, snow melt, fuel spills, de-icing agents, and wash down flows. These storm sewers have hydraulic diversion structures in place which convey storm water flows to a 9 mgd detention basin. The basin contents are pumped to a sanitary sewer interceptor where it is then transferred to a local treatment facility.

Another concept being adapted into the new regional airport in Denver is based on centralized de-icing areas for use by all airlines. All de-icing area flows will be diverted to an on-site glycol recovery system or diverted to detention basins for discharge to the local treatment facility.

LIMITATIONS

Storm water flow diversion structure limitations include:

- Once flows are concentrated, they must be routed through stabilized structures, or treatment facilities in order to minimize erosion prior to discharging to receiving waters.
- May increase flow rates.
- May be impractical if there are space limitations.
- May not be economical especially for small facilities or after a site has been constructed.
- May require maintenance after heavy rains.

COSTS

Costs vary depending on the type of flow diversion structure used. For example, if vegetated swales are to be used for flow diversions, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) reported that, in 1991, costs may vary between $8.50 to $50 per lineal foot, depending upon swale depth in feet and bottom width. Capital costs for the Stapleton International Airport flow diversion system, including basins, diversion structures in each of the four main storm sewers, and additional flow diversion modifications made by airport staff were $6 million in 1988. Clearly the cost will be determined by the scope of the project and design requirements..

ENVIRONMENTAL IMPACTS

Environmental impacts include:

- Erosion problems due to concentrated flows.
- Potential groundwater contamination if conveyance channels have high infiltration capacities.
- Undersized water treatment facilities may result in discharges that have not been adequately treated.

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STORMWATER BMP: HIGHWAY ICE AND SNOW REMOVAL AND MINIMIZATION OF ASSOCIATED ENVIRONMENTAL EFFECTS FROM THESE PROCEDURES

OWM MTB
Excellence in compliance through optimal technical solutions
MUNICIPAL TECHNOLOGY BRANCH

INTRODUCTION

The United States is critically dependent on the nation's road system to support the rapid, reliable movement of people, goods, and services. The widespread expectation holds that even in the face of winter storms, roads and highways will be maintained to provide safe travel conditions. In many states, this requires substantial planning, training, manpower, equipment, and material resources to clear roads and streets throughout the winter.

The dependency on deicing chemicals has increased since the 1940s and 1950s to provide "bare pavement" for safe and efficient winter transportation. Sodium chloride (salt) is one of the most commonly used deicing chemicals. Concern about the effects of sodium chloride on the nation's environment and water quality has increased with this chemical usage. Automobile and highway bridge deck corrosion has also become a concern. However, in most cases sodium chloride is the most cost effective deicing chemical. Such concerns have led to major research efforts by the Strategic Highway Research Program (SHRP), the highway community, industry, government, and academia. This ongoing research is exploring many different areas in an effort to maintain the safest roads possible in the most economical way while protecting the environment.

This fact sheet summarizes research addressing water pollution and associated effects from deicing chemicals, and describes the methods used to control snow and ice on roadways while minimizing impacts on the environment. Due to the broad nature of this topic, sources for research and alternative methods are listed and can be referenced for more detail. This fact sheet emphasizes methods and practices for snow removal which are feasible and cost effective for local governments to implement consistent with sound environmental quality goals.

BACKGROUND

Salt was first used on roads in the United States for snow and ice control in the 1930s (Salt Institute, 1994). Beginning in the late 1940s and 1950s, the "bare pavement" policy was gradually adopted by highway agencies as the standard for pavement condition during inclement weather providing safer travel conditions on roadways. The "bare pavement" policy became a useful concept for roadway maintenance because it was a simple and self-evident guideline for highway crews. However, this policy should be implemented with the application of the minimum amount of salt needed rather than the maximum (Lord, 1988). A common perception that "more is better" led to practices of high application rates of salt. Dispersion of city populations into suburbs, higher travel speeds, and growing dependence upon automobiles for commuting and commerce increased the need for snow and ice removal for safer roadways (Lord, 1988). In the 1960s, the use of salt as a deicing chemical became widespread in the United States because it is readily available, it is effective on ice and snow, and it is the lowest cost alternative (Salt Institute, 1994).

In the late 1950's, damage to roadside sugar maples (a salt intolerant species) in New England gave rise to concern about the widespread use of salt. Shortly thereafter, contamination to drinking water from wells located near unprotected salt storage areas heightened this concern (Lord, 1988). Runoff of road salts also became recognized as causing additional environmental damage in many areas. Other adverse effects of the increased use of salt included the pitting and "rust out" of automobiles and corrosion of highway structures, especially bridge decks (Lord, 1988).

These environmental concerns have spawned a number of research programs. The goal of this research has been to minimize the environmental effects of deicing while still providing a cost effective means of clearing roadways for safe travel conditions. Early in the 1960s, research began on alternative deicing chemicals, reduced chemical use, improved operational practices, pavement heating, pavement modification, and mechanical approaches (Lord, 1988). More recently, a "Snow and Ice Control" study was conducted by the Strategic Highway Research Program (SHRP). SHRP is a unit of the National Research Council that was authorized by Section 128 of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (SHRP-H-381, 1994). The snow and ice control research included five major initiatives: snowplows, snow fences, road weather information systems, pretreatment, and deicing chemicals (SHRP, 1991).

INITIATIVES TO CONTROL SNOW AND ICE ON ROADWAYS WHILE MINIMIZING ASSOCIATED ENVIRONMENTAL EFFECTS

Improved Operational Practices

Clearing roadways after winter storms accounts for a large portion of the highway maintenance budget for many northern states. According to the Salt Institute's 1991 *Snowfighters Handbook*, snow removal in 33 snow belt states accounted for 16.2 percent of total maintenance costs and 3.6 percent of all highway expenditures (Salt Institute, 1991). To ensure public safety, minimize environmental effects, and minimize costs, a well planned and operated snow and ice removal program is essential.

To aid highway management personnel in improving operational practices, the Salt Institute initiated a "sensible salting" program in 1967 (Lord, 1988). These guidelines have evolved with technology to include the following: planning; personnel training; equipment maintenance; spreader calibration; proper storage; proper maintenance around chemical storage areas; and environmental awareness (Salt Institute, 1994). Further information on the "sensible salting" program can be obtained from the Salt Institute located in Alexandria, Virginia. While all of these guidelines reflect key concerns, proper storage is considered one of the most effective in source control of deicing chemicals (EPA, 1974).

In a 1988 paper by Lord, the estimated annual loss of uncovered stockpiled salt in the United States due to rainfall was 400,000 tons, which is approximately 5 percent of the 8 million tons of salt used annually in the United States. An estimate of $30 per ton of salt equates to a monetary loss of $12 million dollars each winter (Lord, 1988). Rock salt may be purchased in bulk for approximately $15 to $20 per ton. Including transportation, these costs increase to $35 to $70 per ton (Lord, 1988). Monetary loss calculations by Lord used a unit cost estimate for salt of $30 per ton which is between estimates including and excluding transportation. Guidelines for siting and design of deicing chemical storage facilities are provided in the *Manual for Deicing Chemicals: Storage and Handling* (EPA-670/2-74-033, 1974).

Another source, the Regional Groundwater Center (1995), estimated that 10 million tons of salt are used each winter in the United States to melt snow and ice on roads and surface streets (Regional Groundwater Center, 1995, Salt Institute, 1994). The cost for salt is currently estimated at $17 to $20 per ton excluding transportation costs (Jesperson, 1995). To minimize environmental impacts associated with briny runoff due to rain and an uncovered stockpile of salt, proper storage facilities must be implemented.

One of the most effective measures for reducing chemical application has been the use of a calibrated spreader using the optimal application rate. Salt application rates range from 300 to 800 pounds per two-lane mile, depending on road, storm, and temperature conditions (Salt Institute, 1994). Automatic controls on spreaders are recommended to ensure a consistent and correct application rate. The spreader should be calibrated prior to and periodically during the snow season, regardless of whether automatic or manual controls are used. Uncalibrated controls and poor maintenance are often responsible for excessive salt use (Salt Institute, 1994). Guidelines for the calibration of spreaders and determination of application rates are given in the Salt Institute's *Snowfighters Handbook* (1991) and in the EPA document entitled *Manual for Deicing Chemicals: Application Practices* (EPA-670/2-74-045, 1974).

Road Weather Information Systems

The United States and Canada spend over $2 billion dollars each year on snow and ice control (SHRP, 1993). In an effort to reduce these costs and maximize efforts, the SHRP sponsored research using road weather information systems (RWIS) for highway snow and ice control. Components of the RWIS include meteorological sensors, pavement sensors, site-specific forecasts, temperature profiles of roadway, other available weather information (including a weather advisor), communications, and planning (SHRP, 1993).

The RWIS can be used to maximize icing and plowing efforts by pinpointing and prioritizing roadways which need attention. It is also designed to eliminate unnecessary call-outs and provide better scheduling of crews based on knowledge of the probable extent and severity of the winter storms. Research indicated that the use of the RWIS technologies can improve efficiency and effectiveness as well as reduce the costs of highway winter maintenance practices (SHRP, 1993). It was concluded in this report that road weather information system technology has the potential for improving service. This conclusion led to the recommendation that every agency that regularly engages in snow and ice control should consider acquiring some form of road weather information systems; at a minimum, forecast services should be used. The SHRP also pointed out that additional research beyond the scope of the original RWIS project would be helpful (SHRP, 1993). Additional information about RWIS and intelligent and localized weather prediction are provided in the following SHRP manuals: *Road Weather Information Systems, Volumes 1 and 2* (SHRP-H-350 and SHRP-H-351); and *Intelligent and Localized Weather Prediction* (SHRP-H-333).

Alternative Deicing Chemicals

The most commonly used salts for deicing are sodium chloride (NaCl) and calcium chloride (CaCl) (Salt Institute, 1994). Approximately 10 million tons of salt are used each year at a cost of approximately $17 to $20 a ton (Jesperson, 1995). The eastern and north-central sectors of the country use more than 90 percent of this salt each year (Lord, 1988). Salt has proven to be a very effective and feasible deicing chemical. However, the importance of snow and ice removal programs, public safety, economic concerns, and environmental factors have led to research utilizing alternative deicing chemicals.

An acceptable alternative to salt as a deicer must have an effective melting range similar to salt, lack detrimental effects, and be cost-comparable. Some alternative deicers evaluated include formamide, urea, urea-formamide mixture, tetrapotassism phosphate (TKPP), ethylene glycol, ammonium acetate, and calcium magnesium acetate (Lord, 1988). The only alternative that warranted further consideration was calcium magnesium acetate (CMA). CMA is made from delometric limestone treated with acetic acid. While CMA does not overcome all the undesirable characteristics of salt, it is an effective deicing chemical (although more material does need to be applied to result in the same deicing achieved with salt). Since CMA has less potential to effect the environment and is not as corrosive as salt, it is a frequently used deicing chemical. However, the cost of CMA was estimated to exceed salt by a factor of 10 to 20 (Lord, 1988). Efforts have been made to find a more effective production technology to lower the cost of CMA, but these efforts have had limited success (Lord, 1988). Alternative deicers can cost anywhere from $200 to $700 a ton (Jesperson, 1995). Therefore, salt is still the most cost effective deicing agent. Another study performed by the Michigan Department of Transportation also found salt to be the most cost effective deicing agent of those evaluated. Those evaluated included sodium chloride (road salt), CMA, CMS-B (also known as Motech), CG-90 Surface Saver (a patented corrosion-inhibiting salt), Verglimit (patented concrete surface containing calcium chloride pellets), and calcium chloride (MDOT, 1993).

In 1992, the SHRP published a handbook to standardize testing procedures for evaluating deicing chemicals (SHRP, 1992). Parameters evaluated include fundamental properties (e.g., ice melting potential, fundamental thermodynamic factors), physicochemical characteristics, deicing performance (e.g., ice melting, ice penetration, ice undercutting), materials compatibility, and additional engineering parameters. This handbook is a valuable tool for the on-going research and technology of evaluating deicing chemicals. Additional information on these testing procedures is provided in the *Handbook of Test Methods for Evaluating Chemical Deicers* (SHRP-H-332, 1992).

Pretreatment

Limited experience (mainly in Scandinavian and other European countries) has shown that applying a chemical freezing-point depressant on a highway pavement prior to, or very shortly after, the start of accumulation of frozen precipitation minimizes the formation of an ice-pavement bond (SHRP, 1994). Liquid salt solution has been practiced in Scandinavia and has proven successful for pretreatment (SHRP, 1994). The anti-icing or pretreatment practice reduces the task of clearing the highway and requires smaller chemical amounts than are generally required under conventional deicing practices (e.g., applying after snow or ice have begun to accumulate). When properly implemented, pretreatment practices may reduce costs and be more effective than conventional practices. However, most state highway agencies generally have not adopted pretreatment due to uncertainty regarding how to implement this practice and which conditions most favor it. Other concerns with pretreatment practices include the imprecision with which icing events can be predicted, the uncertainty about the condition of the pavement surface, and the public's perception of wasted chemicals. Some early attempts to utilize pretreatment practices in the United States have failed because of these uncertainties (SHRP, 1994).

The technological improvements in weather forecasting and in assessment of pavement surface conditions, as previously mentioned, offer the potential for successful implementation of pretreatment. Research during the winters of 1991-92 and 1992-93 by the SHRP indicated that a 40 percent and 62 percent reduction, respectively, in chemical usage was possible using pretreatment (SHRP, 1994). The success of pretreatment depends on accurate RWIS, a technology which is still evolving. Development of spreaders specifically designed or retrofitted to distribute prewetted solid material or liquid chemicals, calibration and evaluation of spreaders, training of maintenance personnel, and effective communication are also items that need further attention to ensure the success of a pretreatment program (SHRP, 1994). Additional information on pretreament is available in the SHRP manual entitled, *Development of Anti-Icing Technology* (SHRP-H-385, 1994).

Mechanical and Design Approaches

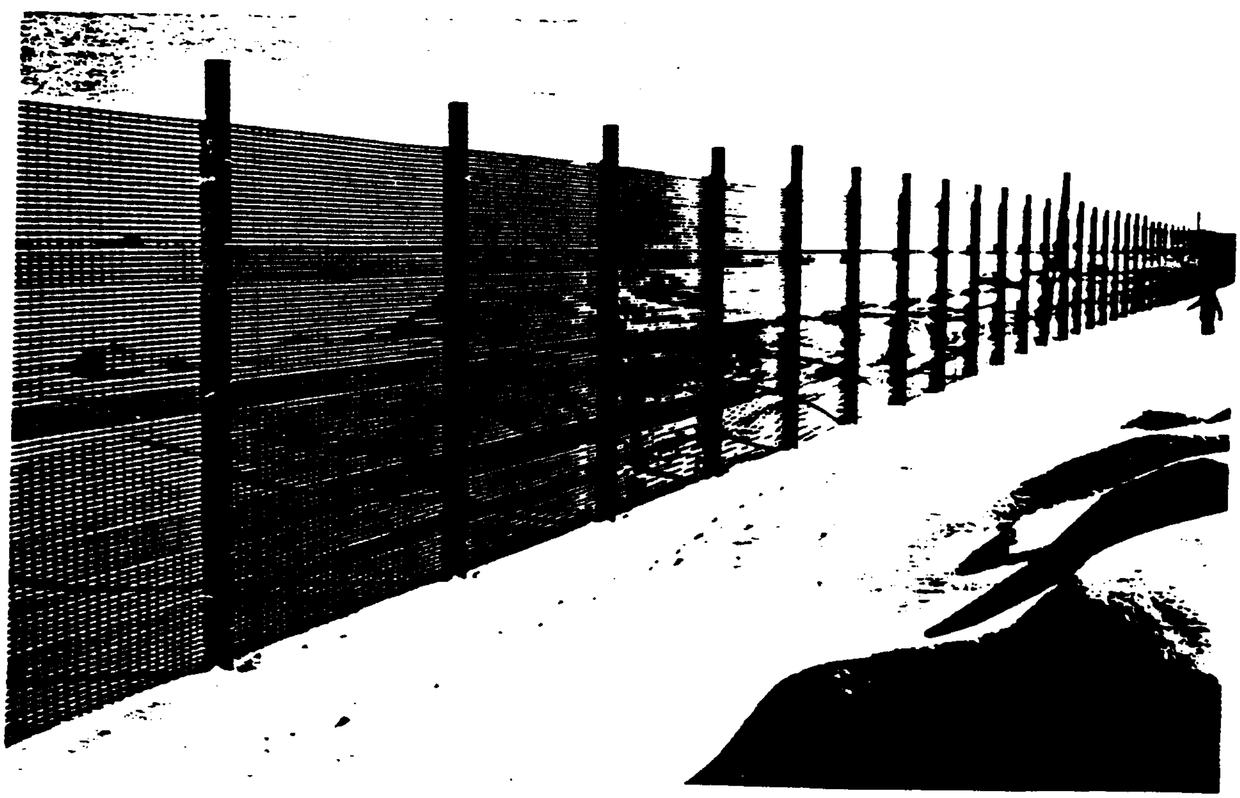
Many mechanical and design approaches have been and are being evaluated in an effort to improve snow and ice control practices. Some of these attempts have been very successful, while others have had limited success or need additional research. Pavement heating, pavement coatings, mobile thermal deicing equipment, snow fences, and snowplows are examined in this section. This is not an inclusive list of mechanical and design approaches to improve snow and ice control procedures.

Pavement heating and pavement coatings are two approaches to snow and ice removal that have had limited success due to cost or feasibility. Pavement heating systems are costly to install, and operational costs exceed salt on the order of 15 to 30 times (Lord, 1988). Mobile thermal deicing equipment has also been evaluated and determined to be impractical. Pavement coatings involve using hydrophobic or icephobic coatings to reduce the adhesion of ice and snow to the roadway. Pavement coatings are required to weaken or prevent bonding, while not decreasing traction in no snow conditions. They are also required to persist in extremely harsh conditions. Pavement coatings were generally unsuccessful because they were unable to meet these goals (Lord, 1988 and EPA, 1976). A 1976 EPA Manual, *Development of a Hydrophobic Substance to Mitigate Pavement Ice Adhesion* (EPA-600/2-76-242) describes this research.

Snow fences minimize costs associated with snow clearing, reduce the formation of compacted snow, and reduce the need for chemicals. Mechanical snow removal costs approximately 100 times more than trapping snow with fences (SHRP, 1991). However, the snow fence must be properly positioned and designed. A 4 foot picket fence in contact with the ground and improperly positioned was common 20 years ago (SHRP, 1991). Properly designed and positioned, taller fences are more effective than the traditional low picket fence. Lightweight plastics allow the construction of portable fences up to 8 feet tall (SHRP, 1991). A 15 foot tall snow fence used at Prudhoe Bay, Alaska is shown in Figure 1. To minimize improper positioning and design of snow fences, the SHRP provided publications such as *Design Guidelines for the Control of Blowing and Drifting Snow* (SHRP-H-381, 1994), *Snow Fence Guide* (SHRP-W/FR-91-106, 1991), and a 21 minute video entitled *"Effective Snow Fences"*.

Snowplow designs in the United States have evolved empirically, with scant regard to physical properties of the material being handled and with little consideration to aerodynamic and hydrodynamic principles involved in the flow of fluidizing snow. Consequently, the energy expended in displacing snow is disproportionate to the work performed, and the low cast distance requires unnecessary rehandling of the snow (Lord, 1988). The SHRP funded research at two universities to improve development of plow blade design and cutting edges for the plow blades (SHRP, 1991).

FIGURE 1. SNOW FENCE (15 FT TALL) LOCATED AT PRUDHOE BAY, ALASKA

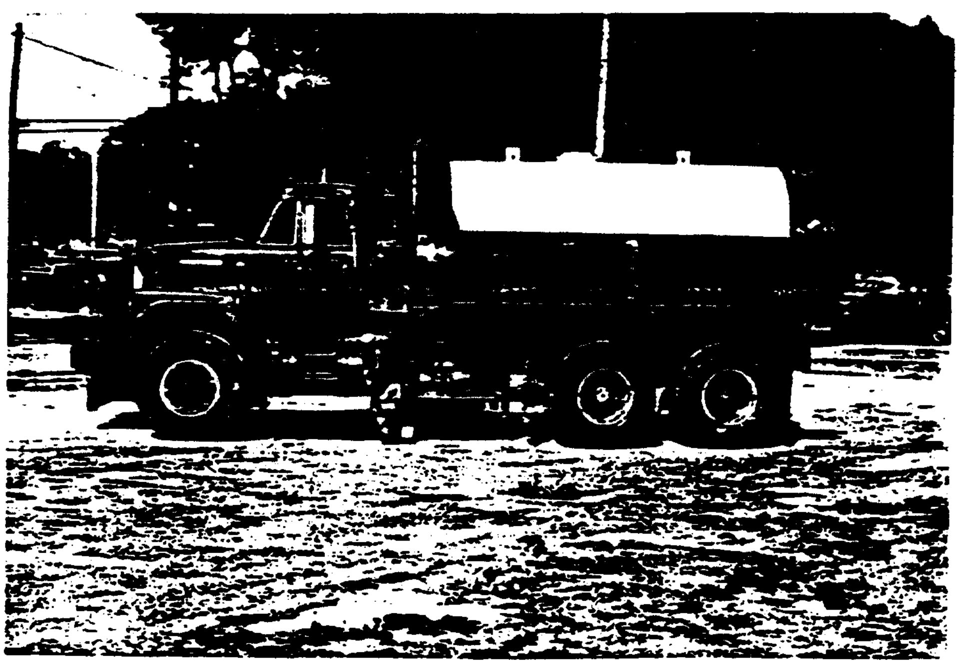


Source: Design Guidelines for the Control of Blowing and Drifting Snow, SHRP-H-381, 1994

The first research project, conducted by the University of Wyoming Department of Mechanical Engineering, focused on developing an improved snowplow blade. The objective of this design was to produce a plow that minimizes energy needed to throw snow clear of the roadway. The plow design, based on analytical methods and laboratory scale experiments, showed a 20 percent improvement in efficiency over conventional plows. The plow underwent testing in West Yellowstone, Montana during the winter of 1990-1991 (SHRP, 1991). Research for additional technological advances in plow design is ongoing.

Another research project, conducted by the University of Iowa Institute of Hydraulic Research, evolved to improve snowplow efficiency by improving cutting edges of plow blades based on mechanics of ice cutting (SHRP, 1993). Laboratory tests were performed with a hydraulic ice cutting ram to determine the effects of the geometry on the cutting edge of a snow plow blade on the force required to remove ice from a highway pavement surface. Results of this research indicate that changes in the cutting edge geometry result in substantially improved ice cutting, although the cutting edge performance may benefit from further studies (SHRP, 1993). An Iowa Department of Transportation "plowing truck" is shown in Figure 2. Figure 3 shows a plowing truck which is cutting ice. Additional information can be obtained in the SHRP manual entitled, *Improved Cutting Edges for Ice Removal* (SHRP-H-346, 1993).

FIGURE 2. PLOWING TRUCK USED BY THE IOWA DEPARTMENT OF TRANSPORTATION



Source: Improved Cutting Edges for Ice Removal, SHRP-H-346, 1993

FIGURE 3. A PLOWING TRUCK CUTTING ICE

Source: Improved Cutting Edges for Ice Removal, SHRP-H-346, 1993

SUMMARY OF FINDINGS

The importance of snow and ice control in terms of public safety, environmental effects, and costs have prompted significant breakthroughs in technology. Technological breakthroughs and on-going research have increased and will continue to increase the effectiveness of snow and ice removal programs across the United States. However, these advances should be supplemented by additional research and testing in the future.

To date, one of the most important advances to these programs has been improving operational practices. These operational practices include guidelines on the following: planning, personnel training, equipment maintenance, spreader calibration, proper storage of deicing chemicals, proper maintenance around chemical storage areas, and an increased environmental awareness. Using proper storage facilities for deicing chemicals and proper application rates has significantly reduced improper and overuse of these chemicals. Best management practices for snow and ice removal should implement improved operational procedures supplemented by technological advances if they are feasible and cost effective.

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STORMWATER BMP: HANDLING AND DISPOSAL OF COLLECTED STORMWATER AND SEDIMENT CONTROL SOLIDS/RESIDUALS

INTRODUCTION

The total watershed has become increasingly important in defining modern urban stormwater management. Not long ago, stormwater management programs often provided little more than local storm drainage, with scant regard for downstream effects. Today, a broad range of "best management practices" (BMPs) have evolved because of increasing concern about comprehensive watershed protection. These practices are intended to protect aquatic and terrestrial habitat, wetlands and cultural resources by preventing or controlling erosion, sedimentation, and pollution runoff.

As technology has evolved to afford better environmental protection, operations and maintenance requirements have increased. Many modern stormwater BMPs are designed to capture and retain solids. The continued effectiveness of such BMPs depends on periodic inspection and removal of these "residuals".

This fact sheet summarizes the nature of the residuals problem, discusses the regulatory framework and presents the management options available, along with typical unit costs and practical considerations. In addition to the available literature, the following draws on the experience of a number of practitioners at both the state and local levels.

POLLUTION FROM URBAN RUNOFF

Urban runoff carries a wide variety of pollutants from many sources and activities. Oil and salt on roads, automobiles, atmospheric deposition, chemicals used in homes and offices, erosion from construction sites, industrial plants, pet wastes, wastes from processing and salvage facilities, and chemical spills are all typical sources of pollutant runoff. The quality of runoff water tends to worsen as urbanization increases. This is caused by an increase in the density of sources and a decrease in natural systems for capturing pollutants. Urbanization reduces the coverage of trees and other vegetation which once intercepted rainfall. Natural paths, such as stream banks, become channels. The erosive conditions increase the amount of sediment carried by runoff. Natural dips or depressions that had formed temporary ponds for rainwater storage may be lost by grading and filling for development. As asphalt and concrete replace vegetation, the quantity of runoff increases and it reaches surface water faster. When the land loses its ability to absorb and store rainwater, the groundwater table drops and stream flows decrease during dry weather.

Urban runoff can affect water quality in various ways depending on the type of pollutant in the runoff, the quantity and concentration of the pollutant, and the nature of the receiving waters. Some of the major pollutants include sediment (organic and inorganic), nutrients, bacteria, oil and grease, and heavy metals. Other activities, parameters, and pollutants which may affect water quality include the disturbance of stream habitats due to construction and erosion, impervious surfaces, temperature, toxic substances, chlorides, and trash/debris. Urban runoff can also cause loss of property and vegetation through erosion.

URBAN BEST MANAGEMENT PRACTICES

BMPs are an integral part of an urban stormwater management program. For new development, BMPs intended for an erosion and sediment control plan during the site development stage can be designed with long-term runoff management as part of the objective. Some BMPs are designed for long-term control; others are retrofit projects intended to correct problems resulting from the lack of stormwater management. Goals of a BMP are to reduce the erosive effects of runoff and minimize the pollutants in urban runoff, including toxic pollutants which may effect downstream waters. Selection of the proper BMPs or combination of BMPs is critical to achieve this goal. BMP selection criteria include: the site's physical condition and development; runoff control benefits provided by each BMP option; the pollutant removal capability of each BMP option under several design scenarios; the environmental and human health advantages of each BMP option; the ultimate use of the receiving water body; and the long-term maintenance cost of the BMP.

Urban BMPs can generally be grouped in the following categories: detention basins, retention/infiltration devices, vegetative controls, and pollution prevention. Detention basins are widely used and are very effective in reducing suspended solid particles by temporarily holding the stormwater runoff and allowing the sediments to settle. Dry ponds, wet ponds, and extended detention dry ponds are examples of detention basins. Detention basins can reduce suspended solids concentrations by 50 to 95 percent. In addition, since detention basins delay the amount of runoff released into receiving waters, downstream flooding and streambank erosion from high flows are reduced and stress on the physical habitat is lessened.

Infiltration devices allow runoff to percolate into the ground, thereby reducing the amount of pollutants released into the receiving water. Infiltration basins, infiltration trenches and dry wells, and porous pavement are some examples of infiltration devices. The filtration and adsorption mechanism traps many pollutants (e.g., suspended solids, bacteria, heavy metals, and phosphorus) in the upper soil layers and prevents them from reaching groundwater. Infiltration devices can remove up to 99 percent of some runoff pollutants, depending on the percolation rate and area, soil type, pollutants present, and available storage volume. Retention devices are also used as pretreatment devices to treat runoff before it enters the stormwater collection system or infiltrates into the ground. Sand filters and oil/grit separators are examples of these devices. There has been limited success with some of these devices. Negative aspects of oil/grit separators are their limited ability to remove pollutants caused by low average detention times, and the resuspension and release of settled material during later storms.

Vegetative BMPs are used to decrease the velocity of stormwater runoff. This promotes infiltration and settling of suspended solids and also prevents erosion. Basin landscaping, filter strips, grassed swales, and riparian reforestation are examples of vegetative BMPs. Vegetative BMPs also remove organic material, nutrients, and trace metals. For maximum effectiveness, vegetative controls should be used as a first line of defense in removing pollutants in combination with other BMPs.

Pollution prevention is a source reduction program usually classified as a non-structural BMP. Local governments and industries establish pollution prevention programs to reduce the generation and exposure of pollutants that accumulate on streets, parking lots, and other surfaces, and eventually wash into streams and lakes. Examples of pollution prevention controls include land use planning, zoning strategies, street sweeping, good housekeeping practices, public education/awareness, and community involvement. A combination of a pollution prevention program and a structural urban BMP within the framework of a watershed management plan is usually required.

OPERATION AND MAINTENANCE OF URBAN BMPS

Proper operation and maintenance (O&M) procedures for all structural BMPs are essential to ensure their continued effectiveness. These O&M procedures may include the following: periodic inspections; pipe, pump, and structure maintenance; erosion control; nuisance control; general housekeeping; and debris and sediment removal. Periodic inspections are important to ensure that the structure operates in the manner originally intended. Inspections of municipal BMPs are usually performed by the local jurisdiction under state inspection criteria. Ideally, these inspections occur annually during wet weather to assess the BMP's effectiveness.

Erosion control may be necessary for some types of BMPs. Corrective measures such as regrading and revegetation may be necessary. Nuisance control is probably the most frequent maintenance item demanded by the local residents. Control of insects, weeds, odors, and algae may be needed with some BMPs. Some general housekeeping maintenance practices include grass cutting, vegetation control, and litter/debris removal.

For the BMP to achieve maximum pollutant removal it is necessary to periodically remove the stormwater residuals and sediment solids from the system. The removal of collected stormwater and sediment control solids/residuals is very site specific. However, it is possible to provide a general discussion for each structural BMP category (i.e., detention basins, retention/infiltration devices, and vegetative controls). O&M procedures for removing and handling stormwater solids/residuals from BMPs should be planned in the design stages of the BMP.

Detention Basins

Wet ponds will eventually accumulate enough sediment to significantly reduce storage capacity of the permanent pool. This loss of capacity can reduce both the appearance and the pollutant removal efficiency of the pond. The best available estimate is that approximately one percent of the storage volume capacity associated with the two year design storm can be lost annually (MWCOG, 1987). Even more storage capacity can be lost if the pond receives large sediment input during the construction phase. A sediment clean-out cycle of 10 to 20 years is frequently recommended in the Washington, D.C. metropolitan area (APWA, 1981; MWCOG, 1983b). According to the Center for Watershed Protection, stormwater ponds should require sediment clean-out on a 15 to 25 year cycle (Schueler and Yousef, 1994). Most ponds are now designed with a forebay to capture the majority of sediments decreasing the solids load to the wet pond. A common forebay sizing criterion is that it should constitute at least 10 percent of the total pool volume (Schueler and Yousef, 1994). This forebay could lose 25 percent of its capacity within 5 to 7 years based on a 0.5 inch/year muck deposition rate and the assumption that a forebay traps 50 percent of all muck deposited in the pond (Schueler and Yousef, 1994). However, using a forebay, the sediment removal frequency for the main pond may be extended to 50 years (Schueler and Yousef, 1994).

To clean out a larger wet pond, dragline or hydraulic dredge methods may be necessary. Dipper, clamshell, or bucket dredges are mechanical dredge methods, which are sometimes used on ponds which are not large enough to warrant a hydraulic dredge method. With smaller wet ponds, the pond level may be drawn down to a point where the residuals can begin to dry in place. After the material is dried, a front end loader can be used to remove it from the pond bottom.

Dry ponds and extended detention dry ponds also accumulate significant quantities of sediments over time. This sediment gradually reduces available stormwater management storage capacity within the pond and also reduces pollutant removal efficiency. Sediment accumulation can make dry ponds unsightly. In addition, sediment may tend to accumulate around the control device of the dry extended detention ponds. This sediment deposition increases the risk that either the orifice or the filter medium will become clogged, and also gradually reduces storage capacity reserved for pollutant removal in the lower stage. Therefore, in an extended detention dry pond it is recommended that sediment be removed from the lower stage every 5 to 10 years (MWCOG, 1987). Sediment removal from these systems is relatively simple if access is available for the equipment. Therefore, it is essential that access be included in the pond design. Front-end loaders or backhoes can be used to remove the accumulated sediment.

Retention/Infiltration Devices

Infiltration basins are usually located in smaller residential watersheds that do not generate large sediment loads or are equipped with some kind of sediment trap. Even when the sediment loads are low, they still have a negative impact on the basin's performance. The sediment deposits reduce the storage capacity reserved for exfiltration and may also clog the surface soils. Methods to remove sediment are different from those utilized for detention basins. Removal should not begin until the basin has thoroughly dried out, preferably to the point where the top layer begins to crack. The top layer should then be removed using lightweight equipment, being careful not to unduly compact the basin surface. The remaining soil can then be deeply tilled with a rotary tiller or disc harrow to restore infiltration capacity. Vegetated areas disturbed during sediment removal should be revegetated immediately to prevent erosion.

Infiltration trenches require that the pretreatment inlets of underground trenches be checked periodically and cleaned out when sediment depletes more than 10 percent of the available trench capacity. This can be done using a vacuum pump or manually. Inlet and outlet pipes should also be checked for clogging and vandalism. Dry wells should also be checked periodically for clogging. Performance of sand filter systems may be sustained through frequent inspections and replacement of the filter media every 3 to 5 years depending on the pollutant load. Accumulated trash and debris should be removed from the sand filters every 6 months or as necessary. Sand filter systems are usually cleaned manually (Parsons ES, 1995). Sediment is removed from porous pavement using vacuum sweeping. It has been recommended that the porous pavement be vacuum swept four times per year, followed by high-pressure jet hosing, to keep the pores open in the asphalt (MWCOG, 1987).

Ideally, oil/grit separators should be cleaned out after every storm event to prevent re-entry of any residuals or pollutants into the storm sewer system during the next storm event. However, due to the O&M costs and manpower requirements associated with this cleaning schedule, less frequent cleaning usually occurs at a point when an oil/grit separator is no longer operating effectively. The Metropolitan Washington Council of Governments recommends that oil/grit separators be cleaned out at least twice a year (MWCOG, 1987). As with all BMPs, the cleaning frequency depends upon the pollutant load which is site specific. Oil/grit separators can be cleaned out using several methods. One method to clean an oil/grit separator is to pump out the contents of each chamber. The turbulence of the vacuum pump in the chamber produces a slurry of water and sediment that can then be transferred to a tanker truck. The other method involves carefully siphoning or pumping out the liquid from each chamber (without creating a slurry). If needed, chemicals can then be added to help solidify the residuals. The solidified solids/residuals can then be removed manually from the separator.

Vegetative Controls

Vegetative controls (basin landscaping, filter strips, grassed swales, and riparian reforestation) rely on various forms of vegetation to enhance pollutant removal, habitat value, or appearance of a development site. These controls should be used in combination with other BMPs. Some natural systems require periodic sediment removal. For example, accumulated sediments deposited near the top of a filter strip will periodically need to be removed manually to keep the original grade.

PROPERTIES OF STORMWATER SOLIDS/RESIDUALS

Stormwater solids/residuals have properties that are very site specific. It is difficult to precisely estimate "typical" stormwater or sediment residual properties by the BMP employed or even by site classification such as residential, commercial, or industrial. A recent study by Schueler and Yousef reviewed bottom sediment chemistry data from 37 wet ponds, 11 detention basins, and two wetland systems, as reported from 14 different researchers. This research covered a broad range of geography, although nearly 50 percent of the sites were located in Florida or the Mid-Atlantic states. These stormwater ponds had been in use from 3 to 25 years. Sampling and analysis was restricted to mean dry weight concentrations of the surface sediments that comprise the muck layer, which is usually the top 5 centimeters (Schueler and Yousef, 1994). Properties of stormwater solids/residuals presented in this 1994 study and in three other technical papers, discussed in the next paragraph, are presented in the following sections. A summary of this data is presented in Table 1.

A 1982 study performed at Marquette University, Milwaukee, Wisconsin, obtained urban runoff residuals from a field-assembled sedimentation basin in Racine, Wisconsin, swirl and helical bend solids separators in Boston, Massachusetts, and an in-line upsized storm conduit in Lansing, Michigan. The residual samples from Racine and Boston were obtained from individual storm events, while the Lansing samples represent a six month accumulation of residuals. All of the sample locations were primarily residential (EPA - Marquette University, 1982). Results from the sampling are shown in Table 1. Also shown in Table 1 are the findings documented in two other technical papers (EPA - Rexnord, Inc., 1982, and Field and O'Shea, 1992).

In a 1994 paper on Pond Muck (pond sediment), Schueler and Yousef indicate that the properties of the solids/residuals from all BMPs are similar except for oil/grit separators. Analyzed properties mentioned in the paper include the following: nutrients, trace metals (cadmium, copper, lead, zinc, nickel, chromium), hydrocarbons, and priority pollutants. A noted exception, was that grassed swale soils tend to have about twice as much phosphorus and lead as detention ponds. Only one sand filter had been sampled, but these characteristics appeared similar to other BMPs (Schueler and Yousef, 1994). Characteristics of solids/residuals from BMPs are discussed in the following sections, with the exception of oil/grit separators which warrant a separate subsection.

Solids

Solids from stormwater and sediment BMPs can consist of organic and inorganic material. According to Schueler and Yousef (1994), the muck layer of a pond has a high organic matter content. An average of nearly 6 percent volatile suspended solids was reported. Pond muck solids have a very soupy texture with an average total solids content of 43 percent, although this parameter was reported from only 15 out of the 50 site locations. It was also described as having a distinctive grey to black color. These residuals have a low density averaging approximately 1.3 g/cm3. These solids/residuals also consist of poorly-sorted sands and silts dominating the muck layer (Schueler and Yousef, 1994).

According to a 1982 EPA study at Marquette University, total solids concentration of residuals samples from a sedimentation basin in Racine, Wisconsin ranged from 233 to 793 mg/l, with 104 to 155 mg/l being volatile. Urban runoff residual samples from swirl and helical bend solids separators in Boston, Massachusetts ranged from a total solids concentration of 344 to 1,140 mg/l, with 107 to 310 mg/l being volatile. The six month accumulated samples from the in-line upsized storm conduit in Lansing, Michigan had a total solids concentration of 161,000 mg/l with 25,800 mg/l being volatile (EPA - Marquette University, 1982). A 1992 paper by Field and O'Shea reported estimated annual residual/sludge volumes for urban storm runoff in the United States ranging from 27 to 547 million cubic meters (35 to 715 million cubic yards) at an average total solids content ranging from 0.5 to 12 percent (Field and O'Shea, 1992).

TABLE 1
PROPERTIES OF URBAN STORMWATER SOLIDS/RESIDUALS

Properties of Residuals	Wet Ponds[1]	Sedimentation Basin[2]	Swirl and Helical Bend Solids Separators[3]	In-Line Upsized Storm Conduit[4]	Urban Stormwater Runoff Residuals[5]
<u>Solids</u>					
VSS	6%	104-155 mg/l	107-310 mg/l	25,800 mg/l	90 mg/l
TSS	43%	233-793 mg/l	344-1,140 mg/l	161,000 mg/l	415 mg/l
<u>Nutrients</u>					
Phosphorus	583 mg/kg	< 5 mg/l	< 5 mg/l	0.3-2,250 mg/l	502 - 1,270 mg/kg
TKN	2,931 mg/kg	< 5 mg/l	< 5 mg/l	0.3-2,250 mg/l	1,140 - 3,370 mg/kg
<u>Heavy Metals</u>					
Zinc	6 - 3,171 mg/kg	-	-	-	302 - 352 mg/kg
Lead	11 - 748 mg/kg	-	-	-	251 - 294 mg/kg
Chromium	4.8 - 120 mg/kg	-	-	-	168 - 458 mg/kg
Nickel	3 - 52 mg/kg	-	-	-	69 - 143 mg/kg
Copper	2 - 173 mg/kg	-	-	-	251 - 294 mg/kg
Cadmium	ND - 15 mg/kg	-	-	-	-
Iron	-	6.1 - 2,970 mg/l	6.1 - 2,970 mg/l	6.1 - 2,970 mg/l	-
Hydrocarbons	2,087 - 12,892 mg/kg	-	-	-	-
PCBs	-	0.19 - 24.6 µg/l	-	0.19 - 24.6 µg/l	-

[1]Schueler and Yousef, 1994
[2]EPA - Marquette University, 1982 (Racine, Wisconsin)
[3]EPA - Marquette University, 1982 (Boston, Massachusetts)
[4]EPA - Marquette University, 1982 (Lansing, Michigan)
[5]Field and O'Shea, 1992

Nutrients

The muck layer is enriched with nutrients. In the 1994 paper by Schueler and Yousef, phosphorus concentrations were reported for 23 studies. The phosphorus concentrations ranged from 110 to 1,936 mg/kg, with an average concentration of 583 mg/kg. Nearly all of the nitrogen found in pond muck is organic in nature. Total kjeldahl nitrogen (TKN) concentrations were reported for 20 studies and ranged from 219 to 11,200 mg/kg, with an average concentration of 2,931 mg/kg. Nitrate was found to be present in very small quantities. This either indicates that some denitrification is occurring in the sediments or perhaps that less nitrate is initially trapped in the muck layer. The nitrogen to phosphorus ratio in this pond study averages 5 to 1. In comparison, the nitrogen to phosphorus ratio for incoming stormwater usually averages about 7 to 1. Ponds appear to be more effective in trapping phosphorus than nitrogen. Another explanation for the lower ratio is that the decay rate for nitrogen in the muck layer is thought to be more rapid than for phosphorus (Schueler and Yousef, 1994).

A 1982 EPA report and a 1992 paper by Field and O'Shea reported urban sludge nutrient concentrations ranging from 502 to 1,270 mg/kg total phosphorus as P and 1,140 to 3,370 mg/kg TKN. These nutrient concentrations were reported as being lower than nutrients found in combined sewer overflows (CSOs) and raw primary sludges (EPA - Rexnord, Inc., 1982 and Field and O'Shea, 1992). Another 1982 EPA report presented the concentration of individual nutrients [total phosphorus, TKN, ammonia-nitrogen (NH_3), nitrite-nitrogen (NO_2), and nitrate-nitrogen (NO_3)] in stormwater sediment samples from Boston, Massachusetts and Racine, Wisconsin as never exceeding 5 mg/l. Urban stormwater sediment samples taken from Lansing, Michigan were between 0.3 and 2.250 mg/l for individual nutrients (total phosphorus, TKN, NH_3, NO_2, and NO_3) (EPA - Marquette University, 1982).

Heavy Metals

According to the Northern Virginia Planning District Commission (NVPDC), sediment toxicity has been measured and analyzed in the Northern Virginia area (Guliea, 1995). One of these studies by Dewberry and Davis, 1990, is entitiled "Investigation of Potential Sediment Toxicity From BMP Ponds". This report analyzed sediments from 21 ponds in Northern Virginia under various land use conditions. Many of these ponds are owned and maintained by a property owner or a homeowners' association. Testing was performed for the presence of metals and to determine if the metals concentration is classified as toxic. The Extraction Procedure (EP) toxicity test was used by Dewberry and Davis in the analysis. Conclusions of this report indicate that the stormwater sediments tested were not hazardous and could be safely disposed of on-site or in a landfill. Sediments should be tested further for there use as backfill material or topsoil maintenance (Dewberry and Davis, 1990).

NVPDC had noted that while the 1990 study by Dewberry and Davis determined the material to be non-hazardous, characteristics of stormwater sediments are very site specific. In every jurisdiction in Northern Virginia, it is the responsibility of the owner/operator of the BMP to maintain and operate the system. However, this may vary from state to state. In addition, it is also recommended to plan and design a BMP for on-site disposal of the material (Guilea, 1995).

Trace metal levels are typically 5 to 30 times higher in the muck layer of a pond than in the parent soil below the muck layer (Schueler and Yousef, 1994). Trace metal levels were also reported to follow a relatively consistent pattern and distribution. The zinc concentration in the muck layer was the highest followed by lead. Zinc and lead concentrations were much greater than chromium, nickel, and copper concentrations which were approximately equal. Cadmium had the lowest concentration in the muck layer. In the 1994 Schueler and Yousef study, 50 ponds and wetlands were examined and found to have zinc concentrations ranging from 6 to 3,171 mg/kg (dry weight). Lead and chromium concentrations ranged from 11 to 748 mg/kg, and from 4.8 to 120 mg/kg, respectively. Nickel and copper concentrations ranged from 3 to 52 mg/kg, and from 2 to 173 mg/kg, respectively. Cadmium concentrations ranged from being non-detectable to 15 mg/kg (Schueler and Yousef, 1994).

Field and O'Shea indicate that median concentrations of zinc, lead, copper, nickel, and chromium in urban runoff sludges and residuals were reported as 316, 268, 263, 131, and 189 mg/kg, respectively (Field and O'Shea, 1992). In the 1982 study at Marquette University, iron was found as the highest concentration of metals in all of the samples ranging in concentration from 6.1 to 2,970 mg/l. Lead and zinc concentrations ranked second and third, respectively (EPA - Marquette University, 1982).

As with all pond parameters, trace metal concentrations are site specific. Ponds that primarily service roadways and highways are enriched with trace metals which are presumably associated with automotive loading sources (e.g., cadmium, copper, lead, nickel, and chromium). On the other hand, stormwater ponds that service primarily residential areas have the lowest trace metal concentrations (Schueler and Yousef, 1994). In general, the muck layer is highly enriched with metals; however, in most cases it should not be considered an especially toxic or hazardous material. For example, none of over 400 muck layer samples from any of the 50 pond sites examined in the referenced 1994 study exceeded EPA's current land application criteria for metals (Schueler and Yousef, 1994).

Hydrocarbons

There is limited data on hydrocarbon and poly-aromatic hydrocarbon (PAH) concentration in the muck layer of ponds. It was reported that the concentration of total PAH and aliphatic hydrocarbons in the muck layer of a 120 year old London basin were 3 to 10 times greater, respectively, than the base "parent" sediments. Minor degradation of the hydrocarbons trapped in the muck layer appeared to have occurred in the basin in recent years. On the other hand, hydrocarbons were rarely detected in the muck of Florida ponds. Hydrocarbon concentrations were reported for 2 out of the 50 sites in the 1994 report by Schueler and Yousef. These concentrations were reported for a industrial and residential site as 12,892 and 2,087 mg/kg, respectively (Schueler and Yousef, 1994).

Bacteria

Urban stormwater solids may contain high levels of bacteria and viral strains, including fecal streptococcus and fecal coliform from animal and human wastes. These bacteria have the potential to be spread from land application of stormwater residuals or landfill sites unless the proper precautions are taken. Measures which reduce their concentration in the sludge and minimize any sludge-vector contact include the following: stabilization of the solids; immediate covering of landfill trenches after disposal of these solids; the treatment of these bacteria in the solids by pasteurization, heat treatment, irradiation, etc; and public and animal access control away from the site (Field and O'Shea, 1992).

Other Pollutants

Other pollutants which may be toxic include pesticides and polychlorinated biphenyls (PCBs). Toxic wastes may also be present in fertilizers, herbicides, and household substances such as paints and cleaning materials. All of these pollutants may find their way into stormwater solids/residuals. In the 1982 report from Marquette University, PCBs were observed in measurable concentrations in the Racine, Wisconsin and the Lansing, Michigan samples. These concentrations ranged from 0.19 to 24.6 μg/l. Of eight pesticides surveyed only three (DDT, DDD, and Dieldrin) were observed in measurable concentrations (EPA - Marquette University, 1982).

Oil/Grit Separators

As previously mentioned, the stormwater and sediment solids collected by an oil/grit separator contain unique characteristics compared to other stormwater BMPs. The metal content of trapped sediments in an oil/grit separator may be 5 to 20 times higher than in other BMPs, especially if this separator services a gas station. Priority pollutant and hydrocarbon levels are also much higher. These higher levels reflect the fact that most oil/grit separators service areas that may discharge higher pollutant levels such as at gas stations or industrial sites, and are designed to trap lighter fractions of oil which may not be trapped by other BMPs. Other BMPs, such as detention basins, usually drain larger watersheds that dilute the influence of higher hydrocarbon or metal concentrations like those seen from gas stations or industries. Therefore, it is doubtful if solids from other BMPs would approach metal and hydrocarbon concentrations as high as those recorded with oil/grit separators (Schueler and Yousef, 1994).

STORMWATER SOLIDS/SLUDGE HANDLING ALTERNATIVES
Centralized Treatment (Bleed/Pump Back To The Dry Weather Treatment Plant)

Centralized treatment involves temporary storage of stormwater solids followed by its regulated release into a sanitary sewer during dry weather flow conditions. Advantages of this residuals handling alternative include the possible achievement of flow equalization through the timed addition of urban storm runoff to the dry weather influent, and the use of a central, pre-existing treatment facility and transportation system. Disadvantages of this system include: the deposition of large amounts of grit in the sewer system; the potential for exceeding the capacity of the dry weather treatment facility; any impacts to the treatment plant operation and efficiency which may arise due to differences in the characteristics of sanitary wastewater and urban storm runoff residuals; and additional cost for treatment (Field and O'Shea, 1992). The problems associated with bleed/pump back solids stormwater/sediment solids are similar to those evaluated with regard to CSO sludges.

Huibregste determined that "Centralized Treatment" was generally not practical (Huibregtse et al, 1977). In addition to the disadvantages already listed, some problems which may be associated with this type of system include: difficulties in effectively equalizing flow to the dry weather treatment plant due to the high solids/low volume characteristic of sludges; and difficulties maintaining sludge quality. Significant increases in heavy solids and toxic substance loadings will have an impact on treatment plant operation and effluent quality. The addition of large amounts of gritty solids can grossly overload solids handling facilities at treatment plants, and have a negative impact on overall sludge quality. Moreover, the addition of these stormwater and sediment residuals to the treatment system will increase the quantity of sludge which must be handled (Field and O'Shea, 1992). In a 1982 EPA report, research indicated that the number of days required for bleed/pump back of the residuals without overloading the dry weather treatment facility ranged from 2.8 to 3.9. This was considered an unacceptable bleed/pump back period, considering the likelihood of overlapping rainfall events (Huibregste et al, 1977).

Stormwater Solids Handling at Satellite Treatment Facilities

Another handling alternative for urban stormwater and sediment solids is treatment at a satellite facility. Average characteristics of urban storm runoff differ substantially from those of sanitary wastewater. For the treatment of stormwater runoff, biological processes are generally not employed due to its low organic and nutrient content as well as the intermittent and varying quantity and quality of the storm flow. The major differences affecting treatment process design include urban runoff's high grit content, low organic content, intermittent nature, and short flow duration (Field and O'Shea, 1992).

Evaluation of several CSO sludge handling processes by Huibregste found the most effective unit processes to be: conditioning through chemical treatment; gravity thickening; stabilization through lime addition; dewatering through vacuum or pressure filtration; and disposal through land application or landfill (Huibregste et al, 1977). In a 1982 report by Huibregste a cost analysis was performed specifically for the handling and disposal of urban storm runoff residuals. This cost analysis compared the following six alternative sludge handling scenarios for either swirl or sedimentation concentrated solids: (1) gravity thickening, vacuum filtration and landfill; (2) gravity thickening, vacuum filtration and landspreading; (3) gravity thickening, pressure filtration and landfill; (4) gravity thickening, pressure filtration and landspreading; (5) gravity thickening and landspreading; or, (6) landspreading. These cost estimates by Huibregste et al, 1982, are presented in terms of dollars per acre for residuals handling in an urban storm runoff area of 15,000 acres. These estimates were updated to July 1995 dollars and are presented in Table 2. As shown on Table 2, the most cost effective solids handling scenario based on annual costs is lime stabilization, gravity thickening, pressure filtration, and landfilling.

A 1982 EPA report from Marquette University concluded that of those options evaluated the most cost-effective means for handling and disposal of urban stormwater runoff residuals is gravity thickening followed by lime stabilization and landspreading or landfilling (EPA - Marquette University, 1982). This conclusion was based on urban stormwater studies from Boston, Massachusetts, Racine, Wisconsin, and Lansing, Michigan involving solids sampling, characterization, analysis, and treatability. The characterization study included analyses for nine metals, eight pesticides and PCBs, solids, nutrients, and organics. The treatability study included bench scale sedimentation tests, centrifugation tests, lime stabilization tests and capillary suction time tests (EPA - Marquette University, 1982). Other bench scale studies were performed by Carr in 1982 that evaluated the effectiveness of three dewatering alternatives for stormwater runoff residuals from sedimentation basins and swirl concentrators. These dewatering alternatives were gravity thickening, centrifugation, and capillary suction. Data from these studies indicated that the most effective method for concentrating urban stormwater runoff residuals was gravity thickening (Carr et al, 1982).

These bench scale studies identified some effective treatment methods for urban stormwater runoff residuals. However, characteristics of urban stormwater residuals are very site specific. Testing and analysis may be necessary to determine what level of treatment is necessary to dispose of these residuals.

On-Site Handling of Stormwater Solids/Sludge

The third alternative for handling/disposal of stormwater runoff residuals is on-site handling. This option may be used after the residuals have been analyzed and determined to be a non-hazardous material. During the design stage of a BMP, a dedicated area on the site should be set aside for land application or land disposal of the residuals. The area for this material should be carefully selected to prevent residuals from flowing back into the BMP during rainfall. On-site handling of this material is usually very cost effective as it avoids transportation costs and landfill tipping fees.

The stormwater runoff residuals must first be removed from the BMP. Alternatives for removing solids from various BMPs were discussed previously. After the solids are removed from the BMP, they will usually require dewatering. Dewatering is accomplished by spreading the material out on the ground and occasionally turning it. A front-end loader can be used for this. This material is then either land applied or land disposed. Land application involves spreading the material to the land at approved application rates. This material cannot be applied to a direct food chain crop and would probably be applied to a meadow or vegetated area. There is very little nutrient value associated with stormwater residuals. Land disposal consists of piling the material on an approved location at the site.

In some cases it may not be feasible to land apply or land dispose of the material on-site. This may be due to limited space on-site initially or limited space due to the accumulation of material. In any case, after the material is removed from the BMP it should be dewatered on-site if this is feasible. This will cut down on the volume of material to be transported. The material can then be loaded using a front-end loader and transported to either a landfill or another site for land application or land disposal.

TABLE 2

COST ESTIMATE ($/acre) FOR RESIDUALS HANDLING IN AN URBAN STORMWATER RUNOFF AREA OF 15,000 ACRES (1)

Sludge Handling Method	Sedimentation			Swirl Concentration		
	Capital	O&M	Annual	Capital	O&M	Annual
Lime Stabilization Gravity Thickening Vacuum Filtration Landfill	475	71	134	507	64	130
Lime Stabilization Gravity Thickening Vacuum Filtration Landspreading	507	76	171	531	67	155
Lime Stabilization Gravity Thickening Pressure Filtration Landfill	492	60	124	550	49	117
Lime Stabilization Gravity Thickening Pressure Filtration Landspreading	522	64	156	569	50	139
Lime Stabilization Gravity Thickening Landspreading	—	—	—	394	87	166
Lime Stabilization Landspreading	308	104	186	1025	856	1194

Note: (1) Huibregste et al. 1982. Costs have been updated to July 1995 dollars using the ENR.

REGULATIONS (CURRENT AND PENDING) AND LIABILITIES

Traditional point sources of water pollution are regulated by the EPA and individual states under the National Pollutant Discharge Elimination System (NPDES) permit program. This program was established by section 402 of the Clean Water Act, and establishes permit requirements for certain municipal and industrial stormwater discharges. However, the regulations governing the handling and disposal of stormwater runoff residuals is not as well defined.

Most states have regulations for runoff quality control. To adhere to these regulations, many local governments have implemented drainage and flood control regulations. Some local governments have also adopted localized stormwater quality and erosion/sediment control regulations which require BMPs. To help local governments implement and properly operate these BMPs, states issue guidance documents for local jurisdictions which are responsible for inspecting, maintaining, and ensuring proper operation of stormwater BMPs. Some states will also periodically inspect a local jurisdiction's stormwater management program.

In reality, many local jurisdictions do not have the manpower to inspect all BMPs regularly. BMPs which are not maintained do not perform efficiently. If not maintained, pollutants removed by the BMPs can be released back into the stormwater. An oil/grit separator is a good example of this. Some BMPs, such as detention basins, were installed by local jurisdictions in the 1980s and are now requiring or have not yet required cleaning/dredging for the first time. This is a learning experience for many jurisdictions that have not yet had to (or are doing it for the first time) dredge this material or handle/dispose of it.

Stormwater and sediment solids/residuals should initially be tested prior to disposal. If they are not hazardous, they will usually require dewatering prior to disposal. Some disposal methods for this material can be landfilling, land application, land disposal, and even incineration (e.g, non-hazardous solids from oil/grit separators). Historically, and in most cases, the disposal of sediments removed from BMPs has posed no special regulatory or legal difficulty. Many municipalities and industries have disposed of such sediments in the same way that they would have any uncontaminated soil (Jones et al, 1994). In fact, after drying, stormwater sediment has been mixed with other soil and reused as backfill on construction projects (Jones et al, 1994) as well as cover for landfills (Cox, 1995).

If the residuals/solids from a BMP are determined to be hazardous, they must be managed according to the Resource Conservation and Recovery Act of 1976 (RCRA) requirements. Wastes can be defined by RCRA as hazardous because they either have certain characteristics or contain constituents specifically listed in the RCRA regulations. Certain characteristics include ignitability, corrosivity, explositivity, or toxicity. In nearly all cases involving stormwater BMP solids, sediments could be classified as a hazardous waste because they contained listed chemicals rather than because the sediments are hazardous by characteristic (Jones et al, 1994). Simply because a chemical regulated by RCRA is detected in BMP sediments, does not render the sediment a hazardous waste. If no sample containing greater than ten percent of the listed chemical (by volume), or if contact with precipitation/runoff is unlikely, the sediment would not be classified as hazardous (Jones et al, 1994). Hazardous waste material must be disposed or handled according to RCRA regulations which would either require treatment to lessen the concentration of the hazardous constituent or disposal in a hazardous waste landfill.

EXAMPLES/CASE STUDIES

The following BMP residual management programs have been implemented by several municipalities, states, and a company which cleans oil/grit separators for various clients. This section is not inclusive, but is presented to illustrate how some states, municipalities, and industries manage the solids/sediments from BMPs.

Waste Reduction, Disposal, and Recycling Services

A Baltimore, Maryland firm cleans oil/grit separators for many commercial areas and industries. They use a three man crew and two trucks to clean these BMPs. A liquid tanker truck is used to pump the oil and water out of the separator. This mixture is transported to their facility in Baltimore for treatment (Schorr, 1995).

The solids in the oil/grit separator are further solidified using chemical addition. Once the material is solidified, it is shoveled out of the separator into 55 gallon drums. A composite sample is taken from each drum. This material is analyzed for toxicity, ignitibility (flash test), and PCBs. If the material is determined to be non-hazardous, the drums are taken back to their Baltimore facility. The material is then loaded into roll-off dumpsters and transported to an incinerator where they receive a certificate of destruction for the material (Schorr, 1995).

As each cleaning and maintenance job is site specific, this firm charges by the hour. The cost for cleaning is $202/hr for the three employees and two trucks. In addition, disposal of the liquid waste is $0.35/gallon, charge for the chemical that aids in solidification is $9.95/bag, drum purchase cost is $25/drum, drum disposal cost is $100, analytical charge is $145, and transportation charge is $250. It was emphasized that these oil/grit separators should be cleaned periodically. Cleaning schedules of oil/grit separators are site specific. For example, a typical commercial building may be cleaned one time per year, whereas, an industry may have its oil/grit separators cleaned approximately every three months (Schorr, 1995).

If the material is determined to be hazardous, it is dealt with in an appropriate method depending on the hazardous constituent of the waste. A copy of the analytical results are faxed to the generator. Additional testing is usually required to determine what constituent(s) is present in the sediment to classify it as a hazardous material (Schorr, 1995).

A hazardous material is handled on a case-by-case basis. Additional analytical testing and handling of the hazardous material will increase costs. In most cases, treatment to lower the hazardous chemical concentration to a non-hazardous level is preferred over landfilling in a hazardous waste landfill. For example, a sediment that contained a high hydrocarbon content, which may occur at a service station, would be spread out on an approved site for a period of time sufficient to allow the concentration to decrease in the sediment (Schorr, 1995).

Prince George's County, Maryland

In Prince George's County, Maryland, BMPs such as wet ponds have been in service long enough that they are just beginning to require dredging. In some cases, on-site disposal of the sediment was planned for in the design of the BMP. However, if on-site disposal is not an alternative then locating a site for disposal of the material is a major operation. Residual sand and gravel material from the BMP is transported to construction-sites for use or is disposed of on-site (Coffman, 1995).

Oil/grit separators are being phased out in Prince George's County for the following reasons all of which pertain to residuals management: sometimes the landfill will not accept the material; they require frequent maintenance and cleaning; the material is difficult to dewater; and the material is expensive to dewater, haul, and landfill (when the landfill accepts the material). In addition, the county does not have the personnel to routinely inspect and enforce the cleaning of oil/grit separators. As an alternative to this BMP, the county is focusing on pollution prevention and is also evaluating bioretention (Coffman, 1995).

Fairfax County, Virginia

Fairfax County has very few wet ponds. The wet ponds in the county are large lakes which can properly function up to 100 years without dredging (Henry, 1995). The county has not dredged a wet pond since 1991. A small mini-dredge is used for dredging wet ponds. For the smaller ponds, the lake level is lowered and attempts are made to dry the sediment material. After this, a clamshell or bucket dredge is used to remove the material. Material is either disposed of on-site or in a landfill. Sediments from dry ponds are dried on-site and removed using a front-end loader. This material is either landfilled or disposed of on-site (Henry, 1995).

Montgomery County, Maryland

Montgomery County has wet ponds and dry ponds, the majority of which have not required dredging. The State of Maryland has determined that the sediment from these ponds are a non-hazardous material. Thus, the material can be disposed of either on-site or in a landfill. The state law requires that BMPs be inspected annually. In practice, this typically does not occur because of resource limitations. The county has recently hired two more people to help with these inspections, but there are many BMPs in the county and the county does not anticipate achieving the annual inspection goal (Brush, 1995).

Typical oil/grit separators require much maintenance attention, and Montgomery County is trying to phase them out. The county has many sand filters proposed to replace the oil/grit separators, but information on their maintenance is not available due to the limited experience with cleaning and maintaining these filters (Brush, 1995).

State of Florida

The State of Florida does not have a specific regulation stating that each jurisdiction must dredge or remove material from BMPs periodically. They have issued a "Guidance Manual" as a supplement to the regulations which are considered inadequate for handling stormwater sediments for BMPs. Most BMPs were implemented in 1982, and are just to the point where they require dredging (Cox, 1995).

The guidance manual recommends testing of all BMP sediments, using the Toxicity Characteristics Leaching Procedure (TCLP), before disposal. The state has performed numerous analytical studies on this material, and in no cases was BMP sediment from any location determined to be hazardous. However, oil/grit separators were not tested as part of this study. Materials considered to be non-hazardous must have the appropriate laboratory TCLP paperwork before most landfills in Florida will accept it. Some cities and counties avoid this testing by sending BMP residuals to construction/debris landfills which are not as stringent. This practice is not supported by the state (Cox, 1995).

Even if a material is considered not hazardous using the TCLP test, the State of Florida also has a clean soil criterion. This is to protect community exposure from a material with elevated concentrations of a material which might not be classified hazardous. If a material does not pass the clean soil criterion, (e.g., if metal concentrations are high, but not hazardous) then it can only be used in an area where public access is controlled. Material such as this can be used as a landfill cover because public access is limited to most landfills. If the material does pass the TCLP and clean soil criterion then it can be used or disposed of in any manner. A beneficial use of the material is to blend it with soil as a conditioner (Cox, 1995).

Sediments from dry ponds in Florida are removed using a front-end loader and a dump truck. It is then recommended that a TCLP test be conducted on this material before either disposing on-site, landfilling, or disposing of in another manner. Wet ponds are dredged, however, these ponds are sometimes directly connected to a waterway so caution is taken to ensure solids are not resuspended in this operation. This material is usually spread out on the site to allow drying and disposed of on-site. If on-site disposal is not an alternative, then the sediments are usually transported to a landfill (Cox, 1995).

State of Delaware

The State of Delaware has followed Florida's lead as far as handling and disposal of stormwater BMP residuals. The State of Delaware has not conducted testing of stormwater BMP sediments, but considers the material as non-hazardous based on Florida's research and other research/reports. The state also has a stormwater management program in which local jurisdictions are required to inspect BMPs on an annual basis (Shaver, 1995).

The state's stormwater management plan includes BMP construction guidelines for ease of maintenance for the BMP and on-site disposal of the stormwater residuals. Oil/grit separators are not a BMP alternative in the State of Delaware. In addition to detention basins, sand filters are commonly used. The cleaning schedule for a sand filter is site specific, but three to four times a year is a general estimate. Three people are used to clean a "typical" Delaware Filter manually and shovel out the material which takes approximately 4 hours. Labor cost to clean the filter is approximately $120. The material is then transported to the landfill for disposal as this sediment was tested and not considered a hazardous material (Shaver, 1995).

State of Maryland

The State of Maryland conducted a four year study on oil/grit separators with the Metropolitan Washington Council of Governments. This study evaluated material from oil/grit separators in Maryland to determine if it was hazardous. The study also evaluated maintenance of oil/grit separators, as well as disposal of the residuals/solids from an oil/grit separator. Results from the study indicated that the solids from oil/grit separators were not hazardous, therefore, this material could be disposed of at a landfill after dewatering. However, as this material is site specific it was recommended that it be tested prior to sending to a landfill (Pencil, 1995).

Inspections of BMPs are required of all local jurisdictions. Every three years, the state reviews stormwater programs and procedures utilized by the local jurisdiction. The state has noted that many BMPs are not being properly maintained. This is due to cost and manpower requirements associated with regularly inspecting all BMPs by the local jurisdiction. Many homeowners' associations have BMPs on their property. Maintenance of these BMPs is another area of concern for the state because many homeowner's associations do not implement proper O&M procedures to maintain the BMP on their property (Pencil, 1995).

Sediments from wet ponds and dry ponds, as long as they are not hazardous, are usually dewatered and then disposed of on-site or landfilled. It is a common practice to spread this material out on a site for use as a soil amendment (Pencil, 1995).

SUMMARY OF FINDINGS

Data is available for solids content, nutrients, heavy metals, and other pollutants such as PCBs for many urban stormwater BMP solids/residuals. However, the data on stormwater residual's PAH and hydrocarbon concentrations is limited. Additional sampling and analysis would be beneficial to further examine these parameters.

Inspection and maintenance programs are the key to success for all BMPs. Guidelines for inspection and frequency of inspection are provided by most states for local jurisdictions. However, manpower requirements associated with enforcing the guidelines on the state level and inspection of these BMPs on the local level do not seem to be adequate. BMPs located on private property are not usually properly maintained or inspected. A possible solution to this lack of maintenance is to put a maintenance requirement in the deed for the land. This would require all owners of that property to properly maintain the BMP.

Difficulties in maintaining oil/grit separators and disposing of the residuals have resulted in some jurisdictions phasing their use out. Oil/grit separators require frequent maintenance and cleaning, the material is difficult to dewater, and the material is expensive to dewater, haul, and dispose of in a landfill (when the landfill accepts the material). Also, if oil/grit separators are not properly maintained then pollutants removed by the BMP can be released back into the stormwater.

Since many wet ponds and dry ponds were implemented in the 1980's, they have not required dredging or handling of the dredge material. Some local jurisdictions planned for on-site disposal of the material in the BMP design which is very cost effective because it avoids transportation charges. Local jurisdictions which did not plan for on-site disposal in the design of these BMPs are searching for disposal options for this material. Testing of stormwater sediment in many studies have indicated that this material is non-hazardous. Therefore, in most situations it can be disposed of on-site (land application or land disposal), in a landfill, or in an incinerator.

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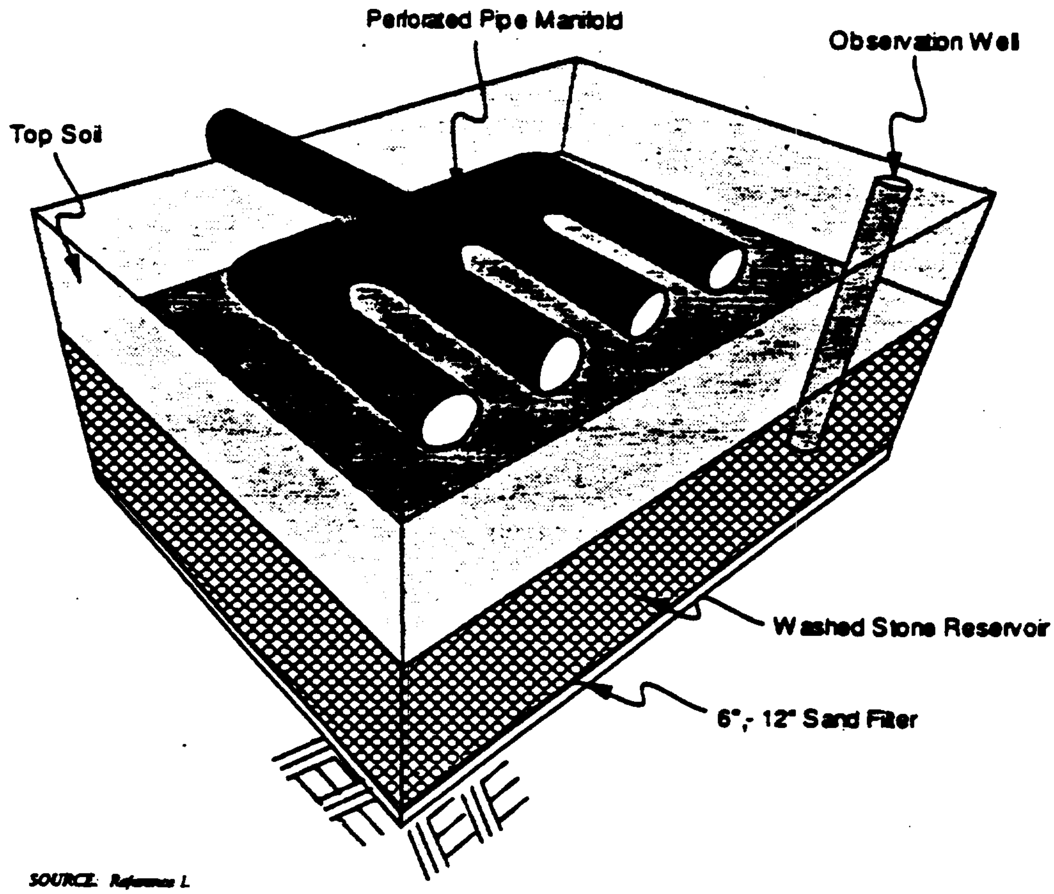
MUNICIPAL TECHNOLOGY BRANCH

STORM WATER BMP: INFILTRATION DRAINFIELDS

DESCRIPTION

Infiltration drainfield structures are constructed to aid in stormwater runoff collection and are designed to allow stormwater to infiltrate into the subsoils. Runoff is diverted into a storm sewer system which passes through a pretreatment structure such as an oil and grit separator. The oil and grit chamber effectively removes coarse sediment, oils, and grease. Stormwater runoff continues through a manifold system into the infiltration drainfield. The manifold system consists of perforated pipe which distributes the runoff evenly throughout the infiltration drainfield. The runoff then percolates through the aggregate sand filter, the filter fabric and into the subsoils. A schematic of a typical system is illustrated in Figure 1 below.



SOURCE: Reference L

FIGURE 1: TYPICAL INFILTRATION DRAINFIELD SCHEMATIC

COMMON MODIFICATIONS

Common design modifications include the installation of porous pavement surrounded by a grass filter strip over the infiltration drainfield or insertion of an emergency overflow pipe in the oil and grit pretreatment chamber. The overflow pipe allows runoff volumes exceeding design capacities to discharge directly to a trunk storm sewer system. Infiltration drainfields are very similar to infiltration trenches and basins.

CURRENT STATUS

Currently there is little information on infiltration drainfields. However. in general the same principals that apply to infiltration basins and infiltration trenches will apply to design of infiltration drainfields. The Environmental Protection Agency is currently evaluating the following issues related to the design and operation of infiltration drainfields:

- Is the oil and grit separator the most effective pretreatment system to protect infiltration capacity?
- What is the pollutant removal capacity of infiltration drainfields with various pretreatment systems?
- Is the performance of infiltration drainfields better than infiltration basins and trenches during subfreezing weather and snow melt runoff conditions?
- What level of maintenance is required to ensure proper performance?

APPLICATIONS

Infiltration drainfields are most applicable on sites with a relatively small drainage area (less than 15 acres). They can be used to control runoff from parking lots, rooftops, impervious storage areas, or other land uses. Infiltration drainfields should not be used in locations that receive a large sediment load that could clog a pretreatment system, which in turn, would plug the infiltration drainfield and reduce its effectiveness.

Soils should have field-verified permeability rates of greater than 0.5 inches per hour and there should be a 4-foot minimum clearance between the bottom of the system and bedrock or the water table.

LIMITATIONS

The use of infiltration drainfields may be restricted in regions with colder climates, arid regions, regions with high wind erosion rates (increased windblown sediment loads), and areas where sole source potable aquifers could be contaminated. Some specific limitations of infiltration drainfields include:

- High maintenance when sediment loads to the drainfield are heavy.
- High costs of excavation, fill material, engineering design, and pretreatment systems.
- Short life span if not well maintained.
- Not suitable for use in regions with clay or silty soils.
- Not suitable for use in regions where groundwater is used locally for human consumption.

- Systems require sufficient time between storm events to allow the soil to dry out, or anaerobic conditions may develop in underlying soils which could clog the soil and reduce the capacity and performance of the system.

PERFORMANCE

The effectiveness of infiltration drainfields depends upon their design. When runoff enters the drainfield, many of the pollutants are prevented from entering surface water. However, any water that bypasses the pretreatment system and drainfield will not be treated. Pollutant removal mechanisms include absorption, straining, microbial decomposition in the soil below the drainfield, and trapping of sediment, grit, and oil in the pretreatment chamber.

Currently there is little monitoring data on the performance of infiltration drainfields. However, some monitoring data is available on porous pavements which incorporate many similar design criteria as infiltration drainfields. An estimate of porous pavement pollutant removal efficiencies range between 82 and 95 percent for sediment, 65 percent for total phosphorus, and 80 to 85 percent for total nitrogen.

Some key factors that increase performance and pollutant removal efficiencies include:

- Good housekeeping practices in the tributary drainage area.
- Sufficient drying time (24 hours) between storm events.
- Highly permeable soils and subsoils.
- Pretreatment system incorporated.
- Sufficient organic matter in subsoils.
- Proper maintenance.
- Use of a sand layer on top of a filter fabric at the bottom of the drainfield.

DESIGN CRITERIA

Infiltration drainfields, along with most other infiltration BMPs (infiltration basins, trenches, etc.) have demonstrated relatively short life spans in the past. Failures have generally been attributed to poor design, poor construction techniques, subsoils with low permeability and lack of adequate preventive maintenance. Some design factors which can significantly increase the performance and reduce the risk of failure of infiltration drainfields and other infiltration processes are shown in Table 1 below.

MAINTENANCE

Routine maintenance of infiltration drainfields is extremely important. The pretreatment grit chamber should be checked at least four times per year and after major storm events. Sediment should be cleaned out when the sediment depletes more than 10 percent of the available capacity. This can be done manually or by vacuum pump. Inlet and outlet pipes should also be inspected at this time.

The infiltration drainfield should contain an observation well. The purpose of the monitoring well is to provide information on how well this system is operating. It is recommended that the observation well be monitored daily after runoff-producing storm events. If the infiltration drainfield does not drain after three days, it usually means that the drainfield is clogged. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to a monthly or quarterly basis.

TABLE 1: INFILTRATION DRAINFIELD DESIGN CRITERIA

Design Criteria	Guidelines
Site Evaluation	• Take soil borings to a depth of at least 4 feet below bottom of stone reservoir to check for soil permeability, porosity, depth to seasonally high water table, and depth to bedrock. • Not recommended on slopes greater than 5 percent and best when slopes are as flat as possible. • Minimum infiltration rate 3 feet below bottom of stone reservoir: 0.5 inches per hour. • Minimum depth to bedrock and seasonally high water table: 4 feet. • Minimum setback from water supply wells: 100 feet. • Minimum setback from building foundations: 10 feet downgradient, 100 feet upgradient. • Drainage area should be less than 15 acres.
Design Storm Storage Volume	• Literature values suggest this parameter is highly variable and dependent upon regulatory requirements. One typically recommended storage volume is the stormwater runoff volume produced in the tributary watershed by the 6-month, 24-hour duration storm event.
Drainage Time for Design Storm	• Minimum: 12 hours. • Maximum: 72 hours. • Recommended: 24 hours.
Construction	• Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction. • As needed, divert stormwater runoff away from site before and during construction. • A typical infiltration cross-section consists of the following: 1) a stone reservoir consisting of coarse 1.5 to 3-inch diameter stone (washed); 2) 6 to 12-inch sand filter at the bottom of the drainfield; and 3) filter fabric.
Pretreatment	• Pretreatment is recommended to treat runoff from all contributing areas.
Dispersion Manifold	• A dispersion manifold should be placed in the upper portions of the infiltration drainfield. The purpose of this manifold is to evenly distribute stormwater runoff over the largest possible area. Two to four manifold extension pipes are recommended for most typical infiltration drainfield applications.

SOURCE: Reference 2.

COSTS

There is little information on the cost of infiltration drainfields. However, the construction costs for installing an infiltration drainfield that is 100 feet long, 50 feet wide, 8 feet deep and with 4 feet of cover can be estimated using the general information in Table 2 below.

TABLE 2: ESTIMATED COST FOR INSTALLING AN INFILTRATION DRAINFIELDS

Excavation Costs:	(2,220 cy) ($5.00/cy)	$11,100
Stone Fill	(1,296 cy) ($20.00/cy)	25,920
Sand Fill	(185 cy) ($10.00/cy)	1,850
Filter Fabric	Top and Bottom = 10,000 sf Sides = 1,600 + 800 = 2,400 sf Total = 12,400 sf + 10% = 13,640 sf (13,640 sf) (1 sy/9 sf) ($3.00/sy)	4,550
Perforated Manifold and Inlet Pipe	75' + 4(40') = 235' 40' (275) ($10.00/ft)	2,750
Observation Well	1 at $500 ea	500
Pretreatment Chamber	1 at $10,000	10,000
Miscellaneous (Backfilling, overflow pipe, sodding, etc.)		1,000
	SUBTOTAL	$57,670
Contingencies (Engineering, administration, permits, etc.) = 25%		14,420
	TOTAL	$72,090

Note: Unit prices will vary greatly depending upon local market conditions.

SOURCE: Reference 1.

ENVIRONMENTAL IMPACTS

One potential negative impact of infiltration drainfields is the risk of groundwater contamination. Studies to date do not indicate that this is a major risk. However, migration of nitrates and chlorides has been documented.

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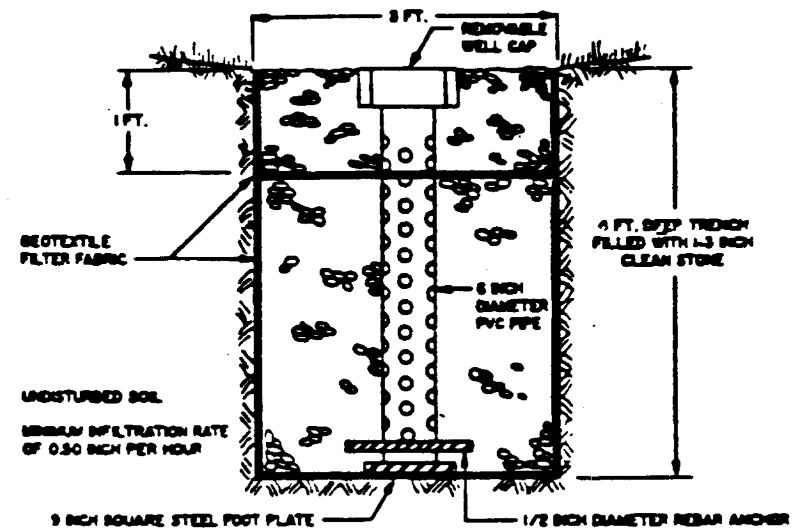
MUNICIPAL TECHNOLOGY BRANCH

STORM WATER BMP: INFILTRATION TRENCH

DESCRIPTION

Infiltration trenches are used to remove suspended solids, particulate pollutants, coliform bacteria, organics and some soluble forms of metals and nutrients from storm water runoff. An infiltration trench, as shown in Figure 1 below, is an excavated trench, 3 to 12 feet deep, backfilled with stone aggregate. A small portion of the runoff, usually the first flush, is diverted to the infiltration trench, which is located either underground or at grade. The captured runoff exits the trench by infiltrating into the surrounding soils. Filtration through the soil is the primary pollutant removal mechanism. Infiltration trenches also provide groundwater recharge and preserve base-flow in nearby streams.



SOURCE: Reference 6

FIGURE 1: TYPICAL INFILTRATION TRENCH

Infiltration trenches capture and treat small amounts of runoff, but do not control peak hydraulic flows. Infiltration trenches may be used in conjunction with another best management practice (BMP), such as a detention pond, to provide both water quality control and peak flow control (Schueler, 1992, Harrington, 1989). Runoff that contains high levels of sediments or hydrocarbons (oil and grease) that may clog the trench are often pretreated with other BMPs. Examples of pretreatment BMPs include grit chambers, water quality inlets, sediment traps, swales and vegetated filter strips (SEWRPC, 1991, Harrington, 1989).

COMMON MODIFICATIONS

The infiltration trench can be modified by substituting pea gravel for stone aggregate in the top 1 foot of the trench. The pea gravel improves sediment filtering and maximizes the pollutant removal in the top of the trench. When the modified trenches become clogged, they can generally be restored to full performance by removing and replacing only of the pea gravel layer with out replacing the lower stone aggregate layers. Infiltration trenches can also be modified by adding a layer of organic material (peat) or loam to the trench subsoil. This modification appears to enhance the removal of metals and nutrient through adsorption.

CURRENT STATUS

Infiltration trenches are often used in place of other BMPs where limited land is available. Infiltration trenches are most widely used in warmer, less arid regions of the U.S. However, recent studies conducted in Maryland and New Jersey on trench performance and operation and maintenance, have demonstrated the applicability of infiltration trenches in colder climates (Lindsey, et al, 1991).

LIMITATIONS

The use of infiltration trenches may be limited by a number of factors, including type of soils, climate, and location of groundwater tables. Site characteristics, such as the slope of the drainage area, soil type, and location of the water table and bedrock, may preclude the use of infiltration trenches. The surrounding area slope should be such that the runoff is evenly distributed in sheet flow as it enters the trench. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils such as clayey and silty soils or in areas with fill. The trench should be located above the water table so that the runoff can filter through the trench and into the surrounding soils and eventually into the groundwater. In addition, the drainage area should not convey heavy levels of sediments or hydrocarbons to the trench. For this reason, trenches serving parking lots should be preceded by appropriate pretreatment. Generally, trenches that are constructed under parking lots are also difficult to access for maintenance.

As with any infiltration BMP, the potential of groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. . In some cases the infiltration trench may not be suitable for sites that use or store chemicals or hazardous materials. In these areas other BMPs that do not interact with the groundwater should be considered. If infiltration trenches are selected, hazardous and toxic materials must be prevented from entering the trench. The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench.

An additional limitation is the climate. In cold climates, trench surface may freeze, thereby preventing the runoff from entering the trench and allowing the untreated runoff to enter surface water. The surrounding soils may also freeze reducing infiltration into the soils and groundwater. However, recent studies indicate if properly designed and maintained infiltration trenches can operate effectively in colder climates. By keeping the trench surface free of compacted snow and ice and by ensuring the part of the trench is constructed below the frost line, will greatly improve the performance of the infiltration trench during cold weather.

PERFORMANCE

Infiltration trenches function similarly to rapid infiltration systems that are used in wastewater treatment. Estimated pollutant removal efficiencies from wastewater treatment performance and modeling studies are shown in Table 1 below. Based on this data, infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the runoff (Schueler, 1987, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected especially in sandy soils (Schueler, 1992).

TABLE 1: TYPICAL POLLUTANT REMOVAL EFFICIENCY

Pollutant	Typical Percent Removal Rates
Sediment	90%
Total Phosphorus	60%
Total Nitrogen	60%
Metals	90%
Bacteria	90%
Organics	90%
Biochemical Oxygen Demand	70 - 80%

SOURCE: References 4 and 5

Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil will enhance metals and nutrient removal through adsorption.

LONGEVITY

There have been a number of concerns raised about the long term effectiveness of infiltration trench systems. In the past, infiltration trenches have demonstrated a relatively short life span with over 50 percent of the systems checked, having partially or completely failed after 5 years. A recent study of infiltration trenches in Maryland (Lindsey et al., 1991) found that 53 percent were not operating as designed, 36 percent were partially or totally clogged, and another 22 percent exhibited slow filtration. Longevity can be increased by careful geotechnical evaluation prior to construction. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons and other materials that may clog the trench. Regular maintenance including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

DESIGN CRITERIA

Prior to trench construction, a review of the design plans may be required by state and local governments. The design plans should include a geotechnical evaluation that determines the feasibility of using an infiltration trench at the site. Soils should have a low silt and clay content and have infiltration rates greater than 0.5 inches per hour. Acceptable soil texture classes include sand, loamy sand, sandy loam and loam. These soils are within the A or B hydrologic group. Soils in the C or D hydrologic groups should be avoided. Soil survey reports published by the Soil Conservation Service can be used to identify soil types and infiltration rates. However, sufficient soil borings should always be taken to verify site conditions. Feasible sites should have a minimum of 4 feet to bedrock in order reduce excavation costs. There should also be a least 4 feet below the trench to the water table to prevent potential ground water problems. Trenches should also be located at least 100 feet up gradient from water supply wells and 100 feet from building foundations. Land availability, the depth to bedrock and the depth to the water table will determine whether the infiltration trench is located underground or at grade. Underground trenches receive runoff though pipes or channels, whereas surface trenches collect sheet flow from the drainage area.

In general infiltration trenches are suitable for drainage areas up to 10 acres (SEWRPC, 1991, Harrington, 1989). However, when the drainage area exceed 5 acres, other BMPs should be carefully considered (Schueler, 1989 and 1992). The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. Runoff from unstabilized areas should be diverted away from the trench until vegetation is established.

The drainage area slope determines the velocity of the runoff and also influences the amount of pollutants entrained in the runoff. Infiltration trenches work best when the up gradient drainage area slope is less than 5 percent (SEWRPC, 1991). The down gradient slope should be no greater than 20 percent to minimize slope failure and seepage.

The trench surface may consist of stone or vegetation with inlets to evenly distribute the runoff entering the trench (SEWRPC, 1991, Harrington, 1989). Runoff can be captured by depressing the trench surface or by placing a berm at the down gradient side of the trench. Underground trenches are covered with an impermeable geotextile membrane overlain with topsoil and grass.

A vegetated buffer strip (20 to 25 foot wide) should be established adjacent to the infiltration trench to capture large sediment particles in the runoff. The buffer strip should be installed immediately after trench construction using sod instead of hydroseeding (Schueler, 1987). The buffer strip should be graded with a slope between 0.5 and 15 percent so that runoff enters the trench as sheet flow. If runoff is piped or channeled to the trench, a level spreader can be installed to create sheet flow (Harrington, 1989).

During excavation and trench construction, only light equipment such as backhoes or wheel and ladder type trenchers should be used to minimize compaction of the surrounding soils. Filter fabric should be placed around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric should overlap each side of the trench in order to cover the top of the stone aggregate layer (see Figure 1). The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate. Filter fabric that is placed 1 foot below the trench surface will maximize pollutant removal within the top layer of the trench and decrease the pollutant loading to the trench bottom.

The required trench volume can be determined by several methods. One method calculates the volume based on capture of the first flush, which is defined as the first 0.5 inches of runoff from the contributing drainage area (SEWRPC, 1991). The State of Maryland (MD., 1986) also recommends sizing the trench based on the first flush, but defines first flush as the first 0.5 inches from the contributing impervious area. The Metropolitan Washington Council of Governments (MWCOG) suggests that the trench volume be based on the first 0.5 inches per impervious acre or the runoff produced from a 1 inch storm. In Washington D.C., the capture of 0.5 inches per impervious acre accounts for 40 to 50 percent of the annual storm runoff volume. The runoff not captured by the infiltration trench should be bypassed to another BMP (Harrington, 1989) if treatment of the entire runoff from the site is desired.

Trench depths are usually between 3 and 12 feet (SEWRPC, 1991, Harrington, 1989). However, a depth of 8 feet is most commonly used (Schueler, 1987). A site specific trench depth can be calculated based on the soil infiltration rate, aggregate void space, and the trench storage time (Harrington, 1989). The stone aggregate used in the trench is normally 1 to 3 inches in diameter, which provides a void space of 40 percent (SEWRPC, 1991, Harrington, 1989, Schueler, 1987).

A minimum drainage time of 6 hours should be provided, to ensure satisfactory pollutant removal in the infiltration trench (Schueler, 1987, SEWRPC, 1991). Although trenches may be designed to provide temporary storage of storm water, the trench should drain prior to the next storm event. The drainage time will vary by precipitation zone. In the Washington, D.C. area, infiltration trenches are designed to drain within 72 hours.

An observation well is recommended to monitor water levels in the trench. The well can be a 4 to 6 inch diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench as shown in Figure 1 above. Inadequate drainage may indicate the need for maintenance.

MAINTENANCE

Maintenance should be performed as needed. The principal maintenance objective is to prevent clogging, which may lead to trench failure. Infiltration trenches and any pretreatment BMPs should be inspected after large storm events and any accumulated debris or material removed. A more through inspection of the trench should be conducted at least annually. Annual inspection should include monitoring of the observation well to confirm that the trench is draining within the specified time. Trenches with filter fabric should be inspected for sediment deposits by removing a small section of the top layer. If inspection indicates that the trench is partially or completely clogged, it should be restored to its design condition.

When vegetated buffer strips are used, they should be inspected for erosion or other damage after each major storm event. The vegetated buffer strip should have healthy grass that is routinely mowed. Trash, grass clippings and other debris should be removed from the trench perimeter. Trees and other large vegetation adjacent to the trench should also be removed to prevent damage to the trench.

COSTS

Construction costs include clearing, excavation, placement of the filter fabric and stone, installation of the monitoring well, and establishment of a vegetated buffer strip. Additional costs include planning, geotechnical evaluation, engineering and permitting. The Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991) has developed cost curves and tables for infiltration trenches based on 1989 dollars. The 1993 construction cost for a relatively large infiltration trench (i.e., 6 feet deep and 4 feet wide with a 2,400 cubic foot volume) ranges from $8,000 to $19,000. A smaller infiltration trench (i.e., 3 feet deep and 4 feet wide with a 1,200 cubic foot volume) is estimated to cost from $3,000 to $8,500 (1993).

Maintenance costs include buffer strip maintenance and trench inspection and rehabilitation. SEWRPC (1991) has also developed maintenance costs for infiltration trenches. Based on the above examples, annual operation and maintenance costs would average $700 for the large trench and $325 for the small trench. Typically, annual maintenance costs are approximately 5 to 10 percent of the capital cost (Schueler, 1987). Trench rehabilitation, may be required every 5 to 15 years. Cost for rehabilitation will vary depending on site conditions and the degree of clogging. Estimated rehabilitation cost run from 15 to 20 percent of the original capital cost (SEWRPC, 1991).

ENVIRONMENTAL IMPACTS

Infiltration trenches provide efficient removal of suspended solids, particulate pollutants, coliform bacteria, organics and some soluble forms of metals and nutrients from storm water runoff. Infiltration trenches also reduce the volume of runoff by providing a storage reservoir. The captured runoff infiltrates the surrounding soils and increases groundwater recharge and base-flow in nearby streams.

Negative impacts include the potential for groundwater contamination. Fortunately, most pollutants have a low potential to contaminate groundwater (Schueler, 1987). However, an EPA study (USEPA, 1991) found that chloride and nitrate, which are very soluble pollutants, can migrate from infiltration trenches into groundwater. In the future, federal or state agencies may require a groundwater injection permit for infiltration trench sites (Schueler, 1992).

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This fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC, 20460

STORM WATER BMP: INTERNAL REPORTING

DESCRIPTION

Internal reporting provides a framework for "chain-of-command" reporting of stormwater management issues. Typically, a facility develops a Stormwater Pollution Prevention Team (SWPPT) concept for implementing, maintaining, and revising the facility's Stormwater Pollution Prevention Plan (SWPPP). The purpose of identifying a SWPPT is to clarify the chain of responsibility for stormwater pollution prevention issues and provide a point of contact for personnel outside the facility who need to discuss the SWPPP.

CURRENT STATUS

The U.S. EPA first identified internal reporting as a Best Management Practice (BMP) in the late 1970s. Currently, internal reporting has evolved into development of an SWPPT for facilities implementing an SWPPP as part of their NPDES stormwater discharge permit. This SWPPT concept is a new and innovative part of the SWPPP.

IMPLEMENTATION

The key to implementing internal reporting as a BMP is to establish a qualified SWPPT. Where setting up an SWPPP is appropriate, it is important to identify key people on-site who are most familiar with the facility and its operations, and to provide adequate structure and direction to the facility's entire stormwater management program. Limitations involved in developing an internal reporting system are the potential lack of corporate commitment in designating appropriate funds, inadequate staff hours available for proper implementation, and a potential lack of motivation from SWPPT members that could inhibit the transfer of key stormwater pollution information.

PERFORMANCE

The performance and effectiveness of an internal reporting system is highly variable and dependent upon several factors. Key factors include:

- Commitment of senior management.
- Sufficient time and financial resources.
- Quality of implementation.
- Background and experience of the SWPPT members.

DESIGN CRITERIA

When establishing an internal reporting structure, it is important to select appropriate personnel to serve on the team. Both team and individual responsibilities should be designated with clear goals defined for proper stormwater management. Internal reporting should be tied to other baseline BMPs such as employee training, individual inspections, and record keeping to ensure proper implementation. Figure 1 below illustrates an example SWPPT organization chart.

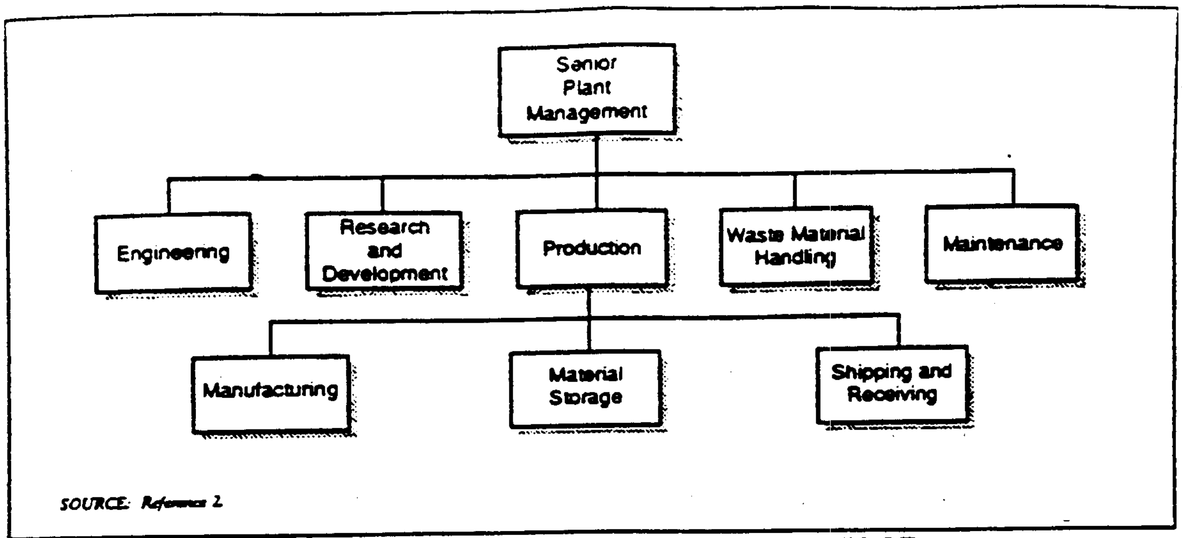


FIGURE 1: EXAMPLE SWPPT ORGANIZATION CHART

MAINTENANCE

To ensure that an internal reporting system remains effective, the person or team responsible for maintaining the SWPPP must be aware of any changes in plant operations or key team members to determine if modifications must be made in the overall execution of the SWPPP.

COSTS

Costs associated with implementing an internal reporting system are those associated with additional staff hours and related overhead costs. Annual costs can be estimated using the example shown in Table 1 below. Figure 2 can be used as a worksheet to calculate the estimated costs for an internal record keeping program.

TABLE 1: EXAMPLE OF ANNUAL INTERNAL REPORTING COSTS

Title	Quantity		Avg. Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)
Stormwater Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
SOURCE: EPA			TOTAL ESTIMATED ANNUAL COST						$12,600

Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with payroll expenses, building expenses, etc.

Title	Quantity		Avg. Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)	
________	____	x	____	x	____	x	____	=	____	(A)
________	____	x	____	x	____	x	____	=	____	(B)
________	____	x	____	x	____	x	____	=	____	(C)
________	____	x	____	x	____	x	____	=	____	(D)
					TOTAL ESTIMATED ANNUAL COST (Sum of A+B+C+D)				____	

SOURCE: Reference 2

FIGURE 2: SAMPLE ANNUAL INTERNAL REPORTING COST WORKSHEET

REFERENCES

1. U.S. EPA, NPDES BMP Guidance Document, June 1981.

2. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September, 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: MATERIALS INVENTORY

DESCRIPTION

A materials inventory system involves the identification of all sources and quantities of materials that may be exposed to direct precipitation or storm water runoff at a particular site. Significant materials are substances related to industrial activities such as process chemicals, raw materials, fuels, pesticides, and fertilizers. When these substances are exposed to direct precipitation or storm water runoff, they may be carried to a receiving waterbody. Therefore, identification of these substances and other materials helps to determine sources of potential contamination and is the first step in pollution control.

CURRENT STATUS

Most facilities already have in place a materials inventory system. However, the inventory of significant materials is not generally performed from a storm water contamination viewpoint. Modification of the existing materials inventory program to include storm water considerations should be minimal. The inventory should be incorporated into the Storm Water Pollution Prevention Plan (SWPPP).

APPLICATIONS

A materials inventory system is applicable to most industrial facilities. Inventory of exposed materials should be part of a baseline administrative program and is directly related to both record keeping and visual inspection Best Management Practices (BMP).

LIMITATIONS

Limitation of materials inventory system BMP include:

- It is an on-going process that continually needs updating.
- Qualified personnel are required to perform the materials inventory from a storm water perspective.
- Materials inventory records should be readily accessible.

PERFORMANCE

It is not possible to quantify water quality benefits to receiving waters of a materials inventory program since the program is intended to prevent pollution before it occurs. However, it is anticipated that an effective materials inventory program will result in improved storm water discharge quality.

DESIGN CRITERIA

Keeping an up-to-date inventory of all materials (hazardous and non-hazardous) on the site will help to limit material costs caused by overstocking, track how materials are stored and handled on site, and identify which materials and activities pose the greatest risk to the environment. The following basic steps should be used in completing a materials inventory:

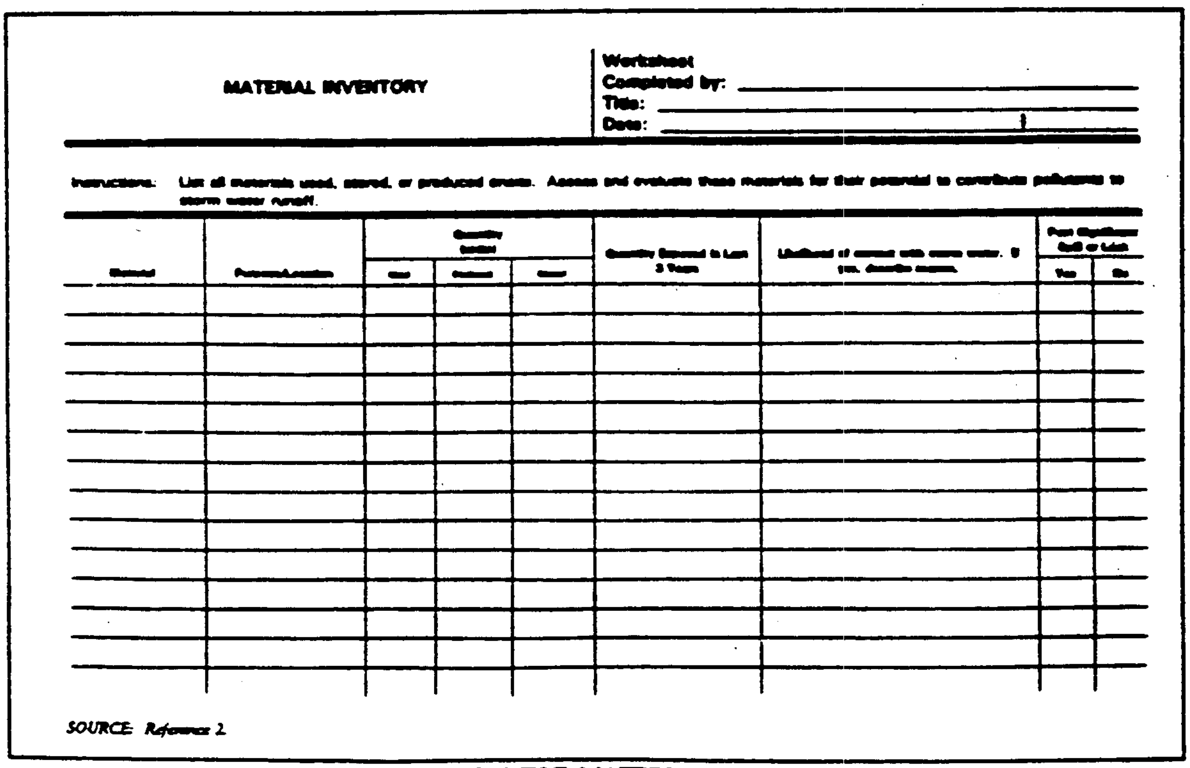
- Identify all chemical substances present in the work place. Walk through the facility and review the purchase orders for the previous year. List all chemical substances used in the work place and then obtain the material safety data sheets (MSDS) for each.

- Label all containers to show the name and type of substance, stock number, expiration date, health hazards, suggestions for handling, and first aid information. This information can usually be found on the MSDS. Unlabeled chemicals and chemicals with deteriorated labels are often disposed of improperly or unnecessarily.

- Clearly mark on the inventory hazardous materials that require specific handling, storage, use, and disposal considerations.

Improved material tracking and inventory practices, such as instituting a shelf life program, can reduce the wastes resulting from overstocking and the disposal of outdated materials. Careful tracking of all materials ordered may also result in more efficient materials use. Figure 1 below illustrates a simple material inventory tracking system.

Based on your materials inventory, describe the significant materials that were exposed to storm water during the past three years and/or are currently exposed. Other BMPs should then be evaluated and implemented or constructed to eliminate exposure of theses materials to storm water or that provide appropriate treatment before discharge to receiving waters. Figure 2 below illustrates a sample worksheet for evaluating exposed materials.



MATERIAL INVENTORY

Worksheet
Completed by: ______
Title: ______
Date: ______

Instructions: [illegible]

[illegible]	[illegible]	[illegible]			[illegible] 3 Years	[illegible]	[illegible]	
		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]

SOURCE: Reference 2

FIGURE 1: SAMPLE MATERIAL INVENTORY

DESCRIPTION OF EXPOSED SIGNIFICANT MATERIAL

Worksheet
Completed by: ____________
Title: ____________
Date: ____________

Instructions: Based on your material inventory, describe the significant materials that were exposed to storm water during the past three years and/or are currently exposed.

Description of Exposed Significant Material	Period of Exposure	Quantity Exposed (units)	Location (as indicated on the site map)	Method of Storage or Disposal (e.g., pile, drum, tank)	Description of Material Management Practice (e.g., pile covered, drum sealed)

SOURCE: Reference 2

FIGURE 2: EXPOSED MATERIAL WORKSHEET

MAINTENANCE

The key to a proper materials inventory system is continual updating of records. Maintaining an up-to-date materials inventory is an efficient way to identify what materials are handled on-site that may contribute to storm water contamination problems.

COSTS

The major cost of implementing a materials inventory system is the time required to implement a program that places emphasis on storm water quality. Typically, this is a small incremental increase if a materials inventory program already exists at the facility. Keeping an up-to-date inventory of all materials present on your site will help to keep material costs down by identifying waste and overstocking.

REFERENCE

1. U.S. EPA, NPDES Best Management Practices Guidance Document, December 1979.

2. U.S. EPA, Storm water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September, 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: NON-STORM WATER DISCHARGES

DESCRIPTION

Identifying and eliminating non-storm water discharges is an important and very cost-effective Best Management Practice (BMP). Examples of non-storm water discharges include process water, leaks from portable water tanks or pipes, excess landscape watering, vehicle wash water, and sanitary wastes. Non-storm water discharges are typically the result of unauthorized connections of sanitary or process wastewater drains that discharge to the storm sewer rather than to the sanitary sewer. Connections of non-storm water discharges to a storm water collection system are common, yet often go undetected. Another form of non-storm water discharge is wash water discharge to a storm drain. Typically these discharges are significant sources of pollutants, and unless regulated by an NPDES permit, are illegal.

CURRENT STATUS

Identifying and eliminating non-storm water discharges as a BMP have rarely been used at industrial facilities. Part of the problem is educational. Many facility operators are unaware of what constitutes a non-storm water discharge, and the potential impact. The new NPDES permit requirements for the presence of non-storm water discharges will greatly improve the implementation of this BMP.

APPLICATIONS

Identification of potential non-storm water discharges is applicable to almost every industrial facility that has not been tested or evaluated for the presence of such non-storm water discharges. Generally, a non-storm discharge evaluation includes:

- Identification of potential non-storm water discharges locations.
- Results of a physical site evaluation for the presence of non-storm water discharges.
- The evaluation criteria or test method used.
- The date of testing and/or evaluation.
- The on-site drainage points that were directly observed during the test and/or evaluation.

LIMITATIONS

Possible problems in identifying non-storm water discharges include:

- The possibility that a non-storm water discharge may not occur on the date of the test or evaluation.
- The method used to test or evaluate the discharge may not be applicable to the situation.
- Identifying an illicit connection may prove difficult due to the lack of available data on the location of storm drains and sanitary sewers, especially in older industrial facilities.

PERFORMANCE

The question of whether or not the elimination of non-storm water discharges is an effective BMP is answered by evaluating the environmental impact of these discharges. If a significant loading of pollutants is common from these discharges, then their elimination will be an effective BMP.

Several studies exist on the contents of non-storm water discharges. Pitt and Shawley (1982) reported that non-storm water discharges were found to contribute substantial quantities of many pollutants, even though the concentrations were not high. The long duration of the base flows offset the lower concentration leading to a substantial loading of pollutants. Gartner, Lee and Associates, Ltd. (1983) conducted an extensive survey of non-storm water discharges in the Humber River watershed (Toronto). Out of 625 outfalls, about 10 percent were considered significant pollutant sources. Further investigations identified many industrial and sanitary non-storm water discharges into the storm drainage system. For example, problems found in industrial areas included liquid dripping from animal hides stored in tannery yards and washdowns of storage yards at meat packing facilities. Therefore, it is anticipated that elimination of non-storm water discharges will be a highly effective BMP.

DESIGN CRITERIA

Key program criteria includes the identification and location of non-storm water entries into storm drainage systems. It is important to note that for any effective investigation of pollution within a storm water system, all pollutant sources must be included. For many pollutants, storm water may contribute the smaller portion of the total pollutant mass discharged from a storm drainage system. Significant pollutant sources may include dry-weather entries occurring during both warm and cold months and snowmelt runoff, in addition to conventional storm water associated with rainfall. consequently, much less pollution reduction benefit will occur if only storm water is considered in a control plan for controlling storm drainage discharges. The investigations may also identify illicit point source outfalls that do not carry storm water. Obviously, these outfalls also need to be controlled and permitted. Figure 1 below can be used as a sample worksheet to report non-storm water discharges.

NON-STORM WATER DISCHARGE

Worksheet
Completed by: ____________________
Title: ____________________
Date: ____________________

Date of Test or Evaluation	Outfall Directly Observed During the Test [illegible]	Method Used to Test or Evaluate Discharge	Describe Results from Test for the Presence of Non-Storm Water Discharge	Identify Potential Significant Sources	Name of Person Who Conducted the Test or Evaluation

SOURCE: Reference 4

FIGURE 1: SAMPLE WORKSHEET FOR RECORDING NON-STORM WATER DISCHARGES

There are four primary methods for investigating non-storm water discharges. These methods include:

- Sanitary and Storm Sewer Map Review. A review of a plant schematic is a simple way to determine if there are any unauthorized connections to the storm water collection system. A sanitary or storm sewer map, or plant schematic is a map of pipes and drainage systems used to carry process wastewater, non-contact cooling water, and sanitary wastes. These maps (especially as-built plans or record drawings of the facility) should be reviewed to verify that there are no unauthorized connections. A common problem is that sites often do not have accurate or current schematics or plans.

- Visual Inspection. The most simple method for detecting non-storm water connections in the storm water collection system is to observe all discharge points during periods of dry weather. Key parameters to look for are the presence of stains, smudges, odors, and other abnormal conditions.

- Sampling and Chemical Analysis. Sewer mapping and visual inspection are also helpful in identifying locations for sampling. Chemical tests are needed to supplement the visual or physical inspections. Chemical tests can help quantify the approximate components of the mixture at the outfall or discharge point. Samples should be collected, stored, and analyzed in accordance with standard quality control and quality assurance (QA\QC) procedures. Statistical analysis of the chemical test results can be used to estimate the relative magnitude of the various flow sources. In most cases, non-storm water discharges are made up of may separate sources of flow (such as leaking domestic water systems, sanitary discharges, ground water infiltration, automobile washwater, etc.). Key parameters that can be helpful in identifying the source of the no -storm water flows include, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), specific conductivity, temperature, fluoride, hardness, ammonia ammonium, potassium, surfactant fluorescence, pH, total available chlorine, and toxicity screening. It may be possible to identify the source of the non-storm water discharge by examining the flow for specific chemicals.

  Just as high levels of pathogenic bacteria are usually associated with a discharge from a sanitary, waste water sources, the presence of certain chemicals are generally associated with specific industries. Table 1 below includes a listing of various chemicals that may be associated with a variety of different activities.

- Dye Testing. Another method for detecting improper connections to the storm water collection system is dye testing. A dye test can be performed by simply releasing a dye (either pellet or powder) into either the sanitary or process wastewater system. Discharge points from the storm water collection system are them examined for color change.

MAINTENANCE

A maintenance program consists of annual inspections for non-storm water discharges, even if previous tests have been negative. New processes, building additions, and other plant changes, if they are not carefully reviewed during design, may result in future unauthorized connections to the storm water conveyance system.

TABLE 1: CHEMICALS COMMONELY FOUND INDUSTRIAL DISCHARGES

Chemical:	Industry:
Acetic acid	Acetate rayon, pickle and beetroot manufacture
Alkalies	Cotton and straw kiering, cotton manufacture, mercerizing, wool scouring, laundries
Ammonia	Gas and coke manufacture, chemical manufacture
Arsenic	Sheep-dipping, felt mongering
Chlorine	Laundries, paper mills, textile bleaching
Chromium	Plating, chrome tanning, aluminum anodizing
Cadmium	Plating
Citric acid	Soft drinks and citrus fruit processing
Copper	Plating, pickling, rayon manufacture
Cyanides	Plating, metal cleaning, case-hardening, gas manufacture
Fats, oils	Wool scouring, laundries, textiles, oil refineries
Fluorides	Gas and coke manufacture, chemical manufacture, fertilizer plants, transistor manufacture, metal refining, ceramic plants, glass etching
Formalin	Manufacture of synthetic resins and penicillin
Hydrocarbons	Petrochemical and rubber factories
Hydrogen peroxide	Textile bleaching, rocket motor testing
Lead	Battery manufacture, lead mining, paint manufacture, gasoline manufacture
Mercaptans	Oil refining, pulp mills
Mineral acids	Chemical manufacture, mines, Fe and Cu pickling, brewing, textiles, photoengraving, battery manufacture
Nickel	Plating
Nitro compounds	Explosives, and chemical works
Organic acids	Distilleries and fermentation plants
Phenols	Gas and coke manufacture, synthetic resin manufacture, textiles, tanneries, tar, chemical, and dye manufacture, sheep-dipping
Silver	Plating, photography
Starch	Food, textile, wallpaper manufacture
Sugars	Dairies, foods, sugar refining, preserves, wood process
Sulfides	Textiles, tanneries, gas manufacture, rayon manufacture
Sulfites	Wood process, viscose manufacture, bleaching
Tannic acid	Tanning, sawmills
Tartaric acid	Dyeing, wine, leather, and chemical manufacture
Zinc	Galvanizing, plating, viscose manufacture, rubber process

SOURCE: Reference 7.

COSTS

The above methods are mostly time-intensive and their cost are dependent on the amount of effort and level of expertise employed. Visual inspections are the least expensive of the three. Dye testing may be more cost effective for buildings that do not have current schematics of their sanitary and storm sewer systems. The cost of disconnecting illicit discharges from the storm water system will vary depending on the type and location of the connection and the type of corrective action needed.

The Full use of all of the applicable procedures is most likely necessary to successfully identify pollutant sources. Attempting to reduce costs, for example, by only examining a certain class of outfalls, or using inappropriate testing procedures, will significantly reduce the utility of the testing program and result in inaccurate conditions.

ENVIRONMENTAL IMPACTS

Eliminating non-storm water discharges can have significant impacts on improving water quality in the receiving waters.

REFERENCES

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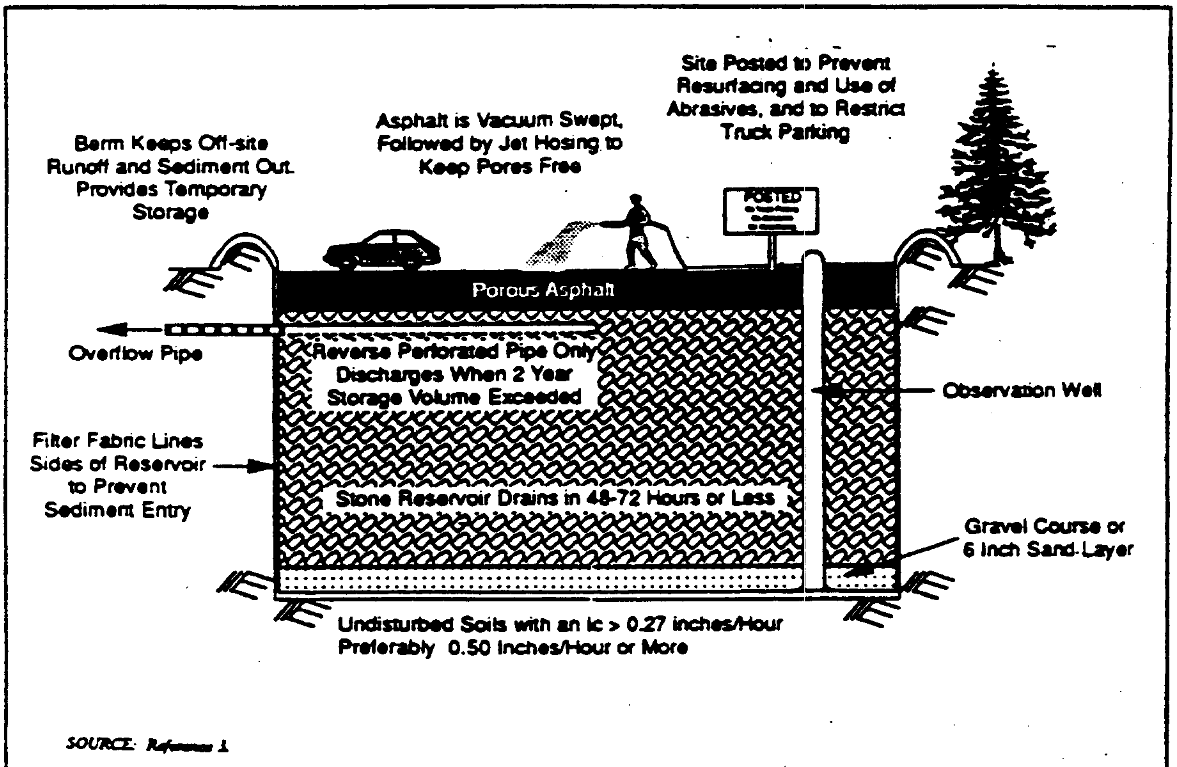
STORM WATER BMP: POROUS PAVEMENT

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Porous pavement is a specially designed and constructed pavement which allows stormwater to pass through it. The purpose of porous pavement is to reduce the speed and amount of runoff from a site, and to filter potential pollutants from the stormwater. There are two principal types of porous pavement: porous asphalt pavement, and pervious concrete pavement. Porous asphalt pavement consists of an open graded coarse aggregate bound together by asphalt with sufficient interconnected voids to provide a high rate of water percolation. Pervious concrete consists of specially formulated mixtures of Portland cement, uniform open graded coarse aggregate, and water. When properly handled and installed, pervious concrete has a high percentage of void space which allows rapid percolation of liquids through the pavement.

The porous pavement surface is typically placed over a highly permeable layer of open graded gravel and crushed stone. The void spaces in the aggregate layers provide a storage reservoir for runoff. A filter fabric is placed beneath the gravel and stone layers to prevent the movement of fine soil particles into these layers. Figure 1 below illustrates a common porous asphalt pavement installation.



SOURCE: Reference 1

FIGURE 1: TYPICAL POROUS PAVEMENT INSTALLATION

Porous pavement offers a number of advantages including:

Provides water quality improvement by removing pollutants.

- Reduces the need for curbing and storm sewer installation.
- Improves road safety by increasing skid resistance. (Tests have shown that there is up to 15 percent less hydro-planing and skidding on porous pavement surfaces.)
- Provides recharge to local aquifers.

COMMON MODIFICATIONS

A common modification for porous pavement design systems consists of varying the amount of storage to be provided in the stone reservoir located directly beneath the pavement, and adding perforated pipes near the top of the reservoir to discharge stormwater runoff after the reservoir has been filled to design capacity. Stone reservoirs may be designed to accept the first flush of stormwater runoff or provide enough storage to accommodate runoff from a chosen design storm for infiltration through the underlying subsoil. Pretreatment of off-site runoff is highly recommended. Another variation of pervious concrete is the use of a concrete block or brick system with individual blocks separated by a pervious material.

CURRENT STATUS

Currently there is little information on porous pavement. However, in general information about infiltration trenches and basins also applies to porous pavement. The following concerns are currently being evaluated by the EPA.

- Can pavement porosity be maintained over the long term, particularly with resurfacing needs and snow removal?
- What is the pollutant removal capability of porous pavement during subfreezing weather and snow removal conditions?
- What are the optimal relationships between porous pavement, groundwater, sandy soils, and high water table conditions?
- What are the costs of maintenance and rehabilitation options for restoration of porosity?

APPLICATIONS

Porous pavement is applicable as a substitute for conventional pavement on parking areas and low traffic volume roads provided that the grades, subsoils, drainage characteristics, and groundwater table conditions are suitable. Slopes should be very gentle to flat. Soils should have field-verified permeability rates of greater than 0.5 inches per hour, and there should be a 4-foot minimum clearance from the bottom of the system to bedrock or the water table. Additional areas for use of porous pavement include fringe overflow parking areas and taxiway and runway shoulders at airports.

LIMITATIONS

The use of porous pavement may be restricted in regions with extremely cold climates, arid regions or regions with high wind erosion rates (increased windblown sediment loads) and areas where sole source potable aquifers could be contaminated. The use of porous pavement is highly constrained, requiring deep permeable soils, restricted traffic, and adjacent land uses. Some specific disadvantages of porous pavement include:

- The lack of experience with this technology with most pavement engineers and contractors.

- Porous pavement has a tendency to become clogged if improperly installed or maintained.

- The high failure rate of porous pavement sharply limits the ability to meet watershed stormwater quality and quantity goals.

- Slight to moderate risk of groundwater contamination depending on soil conditions and aquifer susceptibility.

- Possible transport of hydrocarbons from vehicles and leaching of toxic chemicals from asphalt and/or binder surface.

- Some building codes may not allow for the installation of porous pavement.

- The possibility exists that anaerobic conditions may develop in underlying soils if the soils, are unable to dry out between storm events.

PERFORMANCE

Traditionally, porous pavement sites have had a high failure rate (75 percent). Failure has been attributed to poor design, inadequate construction techniques, low permeability soils, heavy vehicular traffic, and resurfacing with nonporous pavement materials.

Porous pavement pollutant removal mechanisms include absorption, straining, and microbiological decomposition in the soil underlying the aggregate chamber and trapping of particulate matter within the chamber. An estimate of porous pavement pollutant removal efficiency is provided by two long-term monitoring studies. These studies indicate long-term removal efficiencies of between 82 and 95 percent for sediment, 65 percent for total phosphorus, and 80-85 percent of total nitrogen. They also indicated high removal rates for zinc, lead, and chemical oxygen demand. Some key factors to increase pollutant removal and prevent failure include:

- Routine vacuum sweeping and high pressure washing.

- Maximum recommended drainage time of 24 hours.

- Highly permeable soils.

- Pretreatment of off-site runoff.

- Inspection and enforcement of specifications during construction.

- Organic matter in subsoils.

- Clean-washed aggregate.

- Use only in low-intensity parking areas.

- Restrictions on use by heavy vehicles.

- Limiting use of de-icing chemicals and sand.

DESIGN CRITERIA

Porous pavement, along with other infiltration BMPs (infiltration basins, trenches, etc.) have demonstrated relatively short life spans in the past. Failures have general been attributed to poor design, poor construction techniques, subsoils with low permeability, and lack of adequate preventive maintenance. Key design factors that can significantly increase the performance and reduce the risk of failure of porous pavements and other infiltration BMPs is shown in Table 1 below.

TABLE 1: DESIGN CRITERIA FOR POROUS PAVEMENT

Design Criteria	Guidelines
Site Evaluation	• Take soil borings to depth of at least 4 feet below bottom of stone reservoir to check for soil permeability, porosity, depth to seasonally high water table, and depth to bedrock.
	• Not recommended on slopes greater than 5 percent and best with slopes as flat as possible.
	• Minimum infiltration rate 3 feet below bottom of stone reservoir: 0.5 inches per hour.
	• Minimum depth to bedrock and seasonally high water table: 4 feet.
	• Minimum setback from water supply wells: 100 feet.
	• Minimum setback from building foundations: 10 feet downgradient, 100 feet upgradient.
	• Not recommended in areas where wind erosion supplies significant amounts of windblown sediment.
	• Drainage area should be less than 15 acres.
Traffic Conditions	• Use for low volume automobile parking areas and lightly used access roads.
	• Avoid moderate to high traffic areas and significant truck traffic.

SOURCE: Reference 2

TABLE 1: DESIGN CRITERIA FOR POROUS PAVEMENTS.

(CONTINUED)

Design Criteria	Guidelines
	• While the standard porous pavement design is believed to withstand freeze/thaw conditions normally encountered in most regions of the country, the porous pavement system is sensitive to clogging during snow removal operations. Therefore, the area should be posted with signs to restrict the use of sand, salt, and other deicing chemicals typically associated with snow cleaning activities.
Design Storm Storage Volume	• Literature values suggest this parameter is highly variable and dependent upon regulatory requirements. One typically recommended storage volume is the stormwater runoff volume produced in the tributary watershed by the produced in the tributary watershed by the 6-month, 24-hour duration storm event.
Drainage Time for Design Storm	• Minimum: 12 hours. • Maximum: 72 hours. • Recommended: 24 hours.
Construction	• Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction. • As needed, divert stormwater runoff away from planned pavement area to keep runoff and sediment away from site before and during construction. • A typical porous pavement cross-section consists of the following layers: 1) porous asphalt course, 2-4 inches thick; 2) filter aggregate course; 3) reservoir coarse of 1.5-3-inch diameter stone; and 4) filter fabric.
Porous Pavement Placement	• Pavement temperature: 240-260° F. • Minimum air temperature: 50° F. • Compact with one or two passes of a 10-ton roller. • Prevent any vehicular traffic on pavement for at least two days. Pretreatment•Pretreatment is recommended to treat runoff from all off-site areas. An example would be a 25-foot wide vegetative filter strip placed around the perimeter of the porous pavement where drainage flows onto the pavement surface.

SOURCE: Reference 2.

MAINTENANCE

Routine maintenance of porous pavements is extremely important. Maintenance should include vacuum sweeping at least four times per year, followed by high-pressure hosing to limit sediment clogging in the pores of the top layer. Potholes and cracks can be filled with typical patching mixes unless more than 10 percent of the surface area needs repair. Spot-clogging may be fixed by drilling half-inch holes through the porous pavement layer every few feet.

The pavement should be inspected several times during the first few months following installation and then annually thereafter. Inspections after large storms are necessary to check for pools of water. These pools may indicate clogging. The condition of adjacent pretreatment facilities should also be inspected.

COSTS

The costs of developing a porous pavement system 100 feet by 50 feet and with a 4 foot deep storage area can be estimated using the example in table 2 below.

Estimated costs for an average annual maintenance program of a porous pavement parking lot are approximately $200 per acre per year. This cost assumes four inspections, vacuum sweeping and jet hosing treatments per year.

TABLE 2: ESTIMATED COSTS FOR A POROUS PAVEMENT SYSTEM

1.	Excavation Costs:	740 cy x $5.00/cy	$ 3,700
2.	Filter Aggregate/Stone Fill	740 cy x $20.00/cy	14,800
3.	Filter Fabric	760 sy x $3.00/sy	2,280
4.	Porous Pavement	556 sy x $13.00/sy	7,228
5.	Overflow Pipes	200 ft x $12.00/ft	2,400
6.	Observation Well	1 at $200 ea	200
7.	Grass Buffer	833 sy x $1.50/sy	1,250
8.	Erosion Control	$1,000/lump sum	1,000
		SUBTOTAL	$32,858
9.	Contingencies (Engineering, Administration, etc.) = 25%		8,215
	SOURCE: Reference 4	TOTAL*	$41,073

* Costs for traditional pavement, including any storm sewers, curb and gutter should be subtracted from this amount to reflect the difference in total cost for implementing a porous pavement system. Unit costs will vary according to local market conditions.

ENVIRONMENTAL IMPACTS

One potential negative impact of porous pavement is the risk of groundwater contamination. Pollutants (such as nitrates and chlorides) not easily trapped, absorbed, or reduced may continue to move through the soil profile and into groundwater. This is not a desirable condition, as it could lead to contamination of drinking water supplies. Therefore, until more scientific data is available, it is advisable not to site porous pavement near groundwater drinking supplies.

REFERENCES

1. A Current Assessment of Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in a Coastal Zone, December 1991.

2. Field, Richard et al., An Overview of Porous Pavement Research, Water Resources Bulletin, Volume 18, No. 2, pp. 265-267, 1982.

3. Metropolitan Washington Council of Governments, Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, 1987.

4. Southeastern Wisconsin Regional Planning Commission, Costs of Urban Nonpoint Source Water Pollution Control Measures, Technical Report No. 31, June 1991.

5. U.S. EPA, Best Management Practices Implementation Manual, April 1981.

6. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September 1992.

7. Washington State Department of Ecology, Stormwater Management Manual for the Puget Sound Basin, February 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: PREVENTIVE MAINTENANCE

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Preventive maintenance involves the regular inspection and testing of plant equipment and operational systems. These inspections should uncover conditions such as cracks or slow leaks which could cause breakdowns or failures that result in discharges of chemicals to surface waters either by direct overland flow or through storm drainage systems. The purpose of the preventive maintenance program should be to prevent breakdowns and failures by adjustment, repair, or replacement of equipment before a major breakdown or failure can occur.

Preventive maintenance has been practiced predominantly in those industries where excessive down time is extremely costly. As a storm water best management practice BMP, preventive maintenance should be used selectively to eliminate or minimize the spill of contaminants to receiving waters. For many facilities this would simply be an extension of the current plant preventive maintenance program to include items to prevent storm water runoff contamination.

For sites that have storm drainage facilities, proper maintenance is necessary to ensure that they serve their intended function. Without adequate maintenance, sediment and other debris can quickly clog facilities and render them useless. Typically, a preventive maintenance program should include inspections of catch basins, storm water detention areas, and water quality treatment systems.

CURRENT STATUS

Most plants already have preventive maintenance programs that provide some degree of environmental protection. This program could be expanded to include stormwater considerations, especially the upkeep and maintenance of storage tanks, valves, pumps, pipes, and storm water management devices.

APPLICATIONS

Preventive maintenance procedures and activities are applicable to almost every industrial facility. Preventive maintenance should be part of a general good housekeeping program designed to maintain a clean and orderly work environment. Often the most effective first step towards preventing storm water pollution from industrial sites simply involves good common sense to improve the facility preventive maintenance and general good housekeeping methods.

LIMITATIONS

Primary limitations of implementing a preventive maintenance program include:

- Additional costs.
- Availability of trained preventive maintenance staff technicians.
- Management direction and staff motivation in expanding the preventive maintenance program to include storm water considerations.

PERFORMANCE

Quantitative data is not available on the effectiveness of preventive maintenance as a best management practice. However, it is clear that an effective preventive maintenance program can result in improved storm water discharge quality.

DESIGN CRITERIA

Elements of a good preventive maintenance program should include:

- Identification of equipment or systems which may malfunction and cause spills, leaks, or other situations that could lead to contamination of storm water runoff. Typical equipment to inspect include pipes, pumps, storage tanks and bins, pressure vessels, pressure release valves, process and material handling equipment, and storm water management devices.
- Once equipment and areas to be inspected have been identified at the facility, establish schedules and procedures for routine inspections.
- Periodic testing of plant equipment for structural soundness is a key element in a preventive maintenance program.
- Promptly repair or replace defective equipment found during inspection and testing.
- Keep spare parts for equipment that need frequent repair.
- It is important to include a record keeping system for scheduling tests and documenting inspections in the preventive maintenance program.
- Record test results and follow up with corrective action taken. Make sure records are complete and detailed. These records should be kept with other visual inspection records.

MAINTENANCE RECORDS

The key to properly tracking a preventive maintenance program is through the continual updating of maintenance records. Records should be updated immediately after preventive maintenance, or when any repair has been performed on any item in the plant. An annual review of these records should be conducted to evaluate the overall effectiveness of the preventive maintenance program. Refinements to the preventive maintenance procedures and tasking should be implemented as necessary.

COSTS

The major cost of implementing a preventive maintenance program that places emphasis on storm water quality is the staff time required to implement the program. Typically, this is a small incremental increase if a preventive for training and maintenance program already exists at the facility.

REFERENCES

1. U.S. EPA, NPDES best management practice Guidance Document, June 1981.

2. U.S. EPA, Storm water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September, 1992.

3. Washington State Department of Ecology, Storm water Management Manual for Puget Sound, February 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: RECORD KEEPING

DESCRIPTION

A record keeping system should be implemented for documenting spills, leaks, and other discharges such as hazardous substances. Keeping records and reporting events that occur on-site are effective ways of tracking the progress of pollution prevention efforts and waste minimization. Analyzing records of past spills can provide useful information for developing improved Best Management Practices (BMPs) to prevent future spills. Record keeping represents a good operating practice because it can increase the efficiency of a facility by reducing down time and increase the effectiveness of other prevention and treatment BMPs. Typical record keeping items include reported incidents and follow-up on results of inspections, and reported spills, leaks, or other discharges.

IMPLEMENTATION

Record keeping as a BMP should be an integral part of a BMP implementation program and should be incorporated into Stormwater Pollution Prevention Plans (SWPPP).If a separate record keeping system for tracking BMPs, monitoring results, etc., is not currently in place at a facility, existing record keeping structures could be easily adapted to incorporate this data. An ideal tool for implementation is the record keeping procedures laid out in an SWPPP. In many cases the record keeping system can be maintained on a personal or desk top computer using standard spreadsheet or data base management software.

LIMITATIONS

Limitations associated with a record keeping system are:

- It is an on-going process that continually needs updating.
- Qualified personnel required to complete the record keeping forms.
- Accessible of records.
- Security of confidential information.

PERFORMANCE

Record keeping performance as a BMP is highly variable. It depends on the time and commitment dedicated to implementing an effective system. The benefit of an effective record keeping system being incorporated into an overall SWPPP is improved stormwater discharge leaving facility grounds. The effectiveness of the record keeping system is often dependent on the following:

- The commitment of senior management to implementing and maintaining an effective record keeping system.
- The quality of the record keeping program.
- The background and experience of the assigned record keeping team.

DESIGN CRITERIA

Record keeping and reporting procedures for spills, leaks, inspections, maintenance, and monitoring activities should include the following. a sample worksheet for keeping records of spills and leaks is shown in Figures 1 below.

- The date, location, and time of material inventories, site inspections, sampling observations, etc.
- The individual(s) who performed site inspections, sampling observations, etc.
- The date(s) analyses were performed and the time(s) analyses were initiated, the individual or individual(s) who performed the analyses, analytical techniques or methods used, and results of such analysis.
- Quality assurance/quality control results.
- The date, time, exact location,and complete characterization of significant spills or leaks.
- Visual observation and sample collection exception records.
- All calibration and maintenance records of instruments used in stormwater monitoring.
- All original strip chart recordings for continuous monitoring equipment.

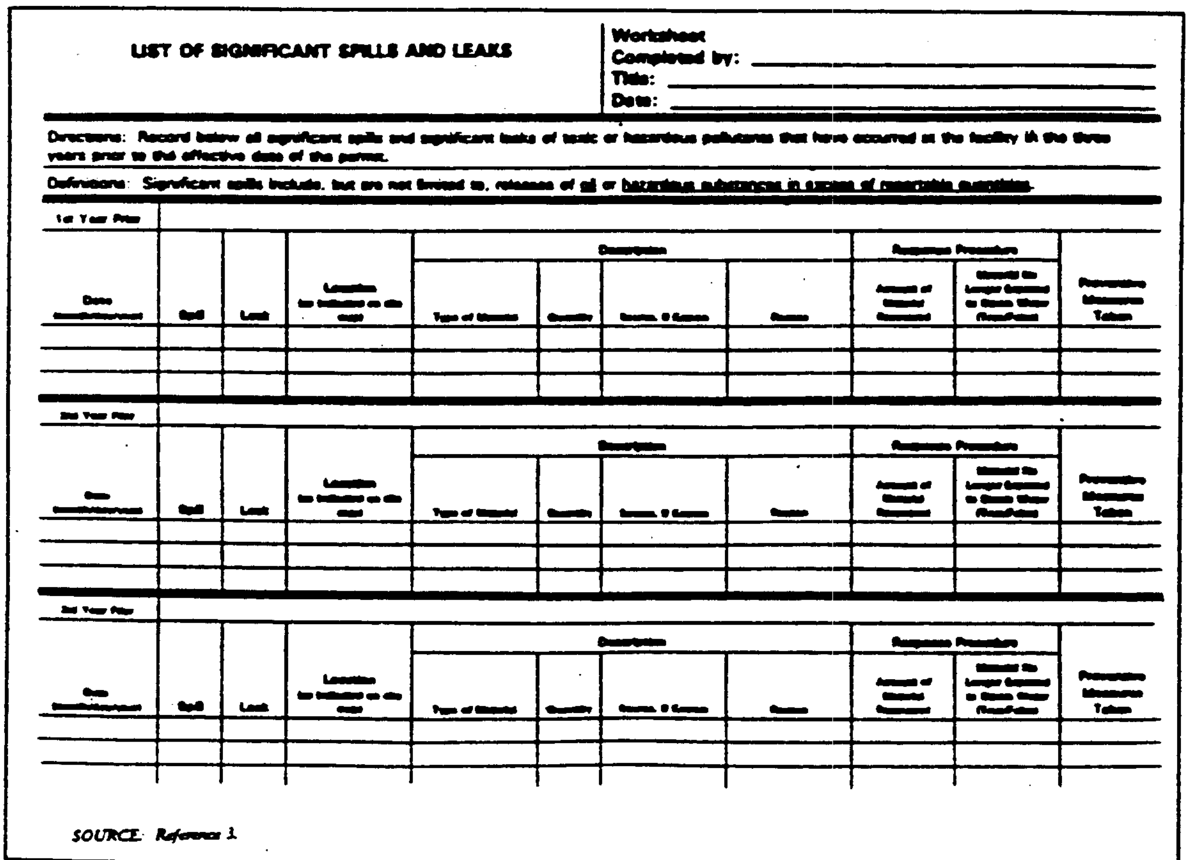


FIGURE 1: SAMPLE WORKSHEET FOR TRACKING SPILLS AND LEAKS

MAINTENANCE

The key to a proper maintenance program for record keeping is continual updating. Records should be updated with the correct name and address of the facility, name and location of receiving waters, number and location of discharge points, principal product and significant changes in raw material storage outside, and reports of monitoring results and spills at the site. It is recommended that all reports be maintained for a period of at least five years from the date of sample observation, measurement, or spill report. Some simple techniques used to accurately document and report results include:

- Field notebooks
- Timed and dated photographs
- Videotapes
- Drawings and maps
- Computer spreadsheet and database programs

COSTS

Costs associated with implementing a record keeping system are those associated with additional staff hours to initially develop the system and to keep records up to date, along with related overhead costs. Annual costs can be estimated using the example shown in Table 1 below. Figure 4 can be used as a worksheet to calculate the estimated annual cost for a record keeping system.

TABLE 1: EXAMPLE OF ANNUAL RECORD KEEPING COSTS

Title	Quantity		Avg. Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)
Stormwater Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
			TOTAL ESTIMATED ANNUAL COST						$12,600

Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with payroll expenses, building expenses, etc.

SOURCE: EPA

Title	Quantity		Avg. Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)	
________	____	x	____	x	____	x	____	=	____	(A)
________	____	x	____	x	____	x	____	=	____	(B)
________	____	x	____	x	____	x	____	=	____	(C)
________	____	x	____	x	____	x	____	=	____	(D)

TOTAL ESTIMATED ANNUAL COST (Sum of A+B+C+D) ____

SOURCE: Reference 1

FIGURE 2: SAMPLE ANNUAL RECORD KEEPING COST WORKSHEET

REFERENCES

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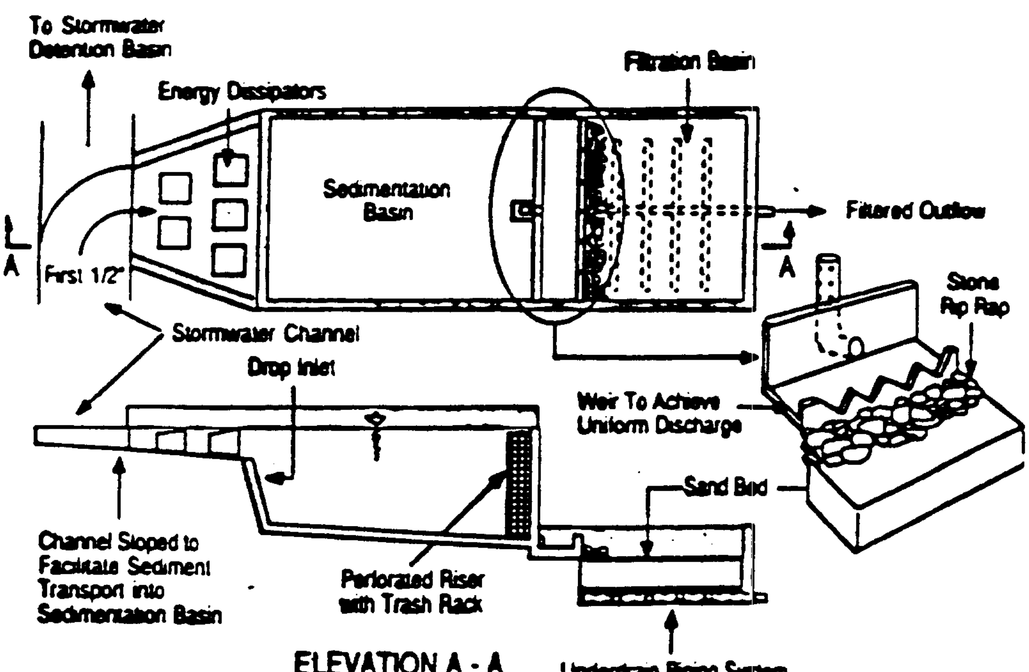
STORM WATER BMP: SAND FILTERS

MTB
Office of Wastewater Management
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Sand filters are most often designed for storm water quality control and generally provide limited storm water quantity management. A typical sand filter system consists of at least two chambers or basins with one designed for sedimentation and one for filtration. The first chamber, the sedimentation chamber, removes floatables and heavy sediments. The second chamber, the filtration chamber, removes additional pollutants by filtering the runoff through a sand bed. The treated filtrate normally is discharged through an underdrain system to a storm drainage system or directly to surface waters. Sand filters can achieve high removal efficiencies for sediment, biochemical oxygen demand (BOD) and fecal coliform bacteria. However, total metals removal is moderate and nutrient removal is often low.

There are three main sand filter designs currently in common use: the Austin sand filtration system (Figure 1a), the Washington, D.C. sand filter (Figure 1b) and the Delaware sand filter (Figure 1c). The primary differences in these designs are location (i.e., underground or surface and on-line or off-line), drainage area served, filter surface areas, land requirements, and quantity of runoff treated.

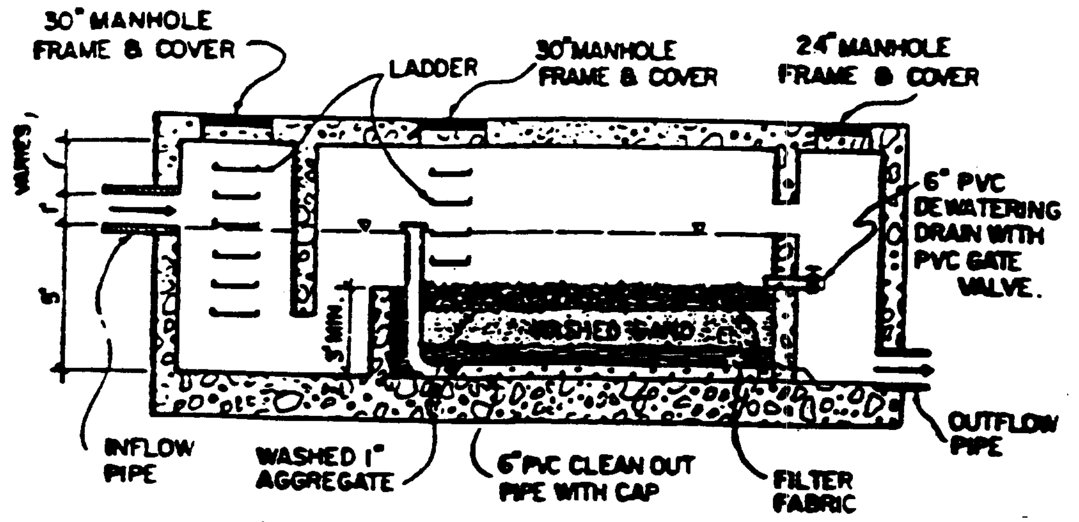


SOURCE: Reference 2

FIGURE 1a: TYPICAL AUSTIN SAND FILTER DESIGN

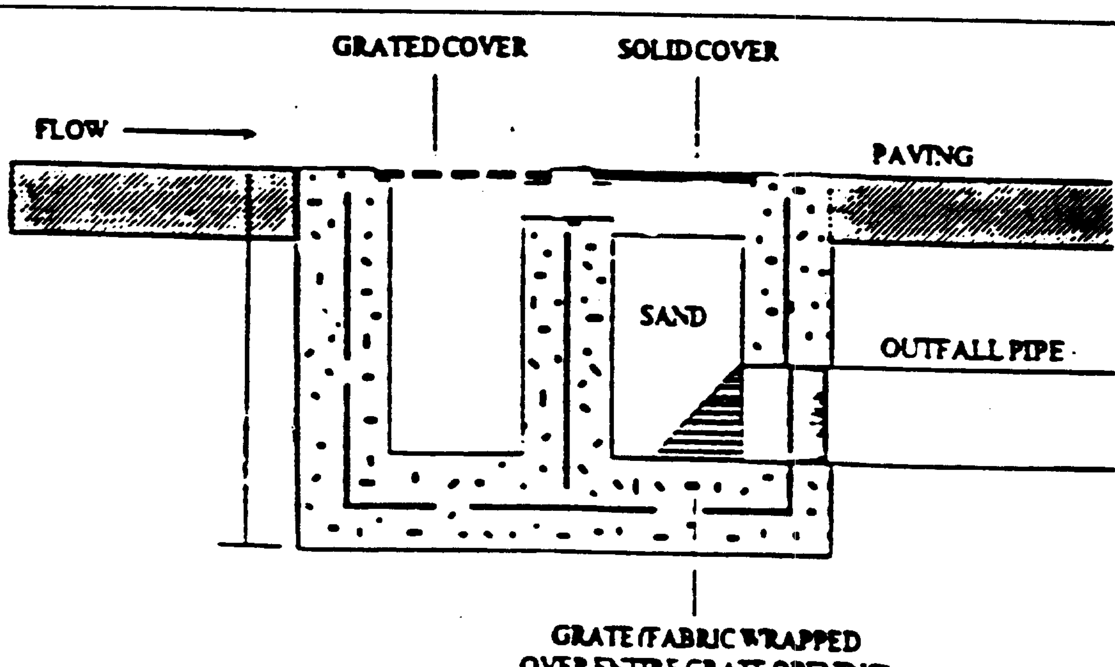
COMMON MODIFICATIONS

Modifications that may improve sand filter design and performance are being tested. One modification is the addition of a peat layer in the filtration chamber. The properties and characteristics of the peat may increase the microbial growth within the sand filter and improve pollutant (e.g., metals and nutrients) removal rates. Another design variation, which is included in the Washington, D.C. sand filter design, includes an underdrain that is extended above the sand filter layer. This allows for backwashing of the filter when it becomes clogged.



SOURCE: Reference 3

FIGURE 1b: TYPICAL WASHINGTON, DC SAND FILTER DESIGN



SOURCE: Reference 1

FIGURE 1c: TYPICAL DELAWARE SAND FILTER DESIGN

CURRENT STATUS

Sand filters are currently in use in the State of Delaware; and the Cities of Austin, Texas; Alexandria, Virginia; and Washington, D.C. Studies on the pollutant removal efficiencies are currently being performed for the Washington, D.C. and the Austin sand filters. However, additional evaluations need to be conducted in other locations and on alternative designs and media.

APPLICATIONS

In general, sand filters are preferred over infiltration practices, such as infiltration trenches, when groundwater contamination is of concern due to high ground water tables or in areas where underlying soils are unsuitable. In most cases, sand filters can be constructed with impermeable basin or chamber bottoms to collect, treat, and discharge runoff to a storm drainage system or directly to surface water without the contaminated runoff coming into contact with the groundwater.

The selection of the type of sand filter depends largely on the drainage area characteristics. For example, the Washington, D.C. and Delaware sand filter systems are well suited for highly impervious areas where land availability for structural controls is limited. Both the Washington, D.C. and Delaware sand filter designs are intended for underground installation. These sand filters are often used to treat runoff from parking lots, driveways, loading docks, service stations, garages, airport runways/taxiways, and storage yards. The Austin sand filtration system is more suited for larger drainage areas with both impervious and pervious surfaces. This system is located at grade and is often used at transportation facilities, large parking areas and commercial developments.

All three types of sand filters can generally be used as alternatives for water quality inlets, which are more frequently used to treat oil and grease contaminated runoff from drainage areas with heavy vehicle usage. In climatic zones where evaporation exceeds rainfall, the Austin sand filtration systems can also be used as an alternative to wet ponds for treatment of contaminated storm water runoff. In high evaporation zones, wet ponds will not likely be able to maintain the required permanent pool unless there is adequate baseflow from the groundwater.

LIMITATIONS

The size and characteristics of the drainage area as well as the pollutant loading will greatly influence the effectiveness of the sand filter system. In some cases other best management practices (BMPs), such as wet ponds, may be less costly for sites with large drainage areas and should also be considered if removal of nutrients and metals is required. Drainage areas with heavy sediment loads may result in frequent clogging of the filter. The lack of maintenance to the clogged filters will limit the performance. Certain climatic conditions may also limit the performance of the filters. For example, it is not known how well sand filters will operate in colder climates where sustained freezing conditions are encountered.

PERFORMANCE

Particulates are removed by both sedimentation in the sedimentation chamber and by filtration in the filtration chamber. The City of Austin has estimated pollutant removal efficiencies (Austin, 1988) based on preliminary findings of the City's storm water monitoring program. The estimates shown in Table 1 below, are average values for various sand filters serving several different size drainage areas.

As shown in Table 1, no removal of nitrate was observed in the preliminary findings. The removal of other dissolved pollutants was not monitored. Additional monitoring is currently being performed by the City of Austin to supplement the preliminary estimates.

LONGEVITY

There have been a number of concerns raised about the long term effectiveness of sand filter systems. Proper design and maintenance are critical factors in maintaining the useful life of any filter system. The life of the filter media may be increased by a number of methods including: stabilizing the drainage area so that sediments loadings in the runoff are minimized; placing a sedimentation chamber that removes sediments prior to the filtration chamber; providing adequate detention times for sedimentation and filtration to occur; and frequently inspecting and maintaining the sand filter to ensure proper operation. In some cases, replacement of the filter media may be required every 3 to 5 years. The useful life of the media will depend on the pollutant loading to the filter and the design and maintenance of the system.

TABLE 1: TYPICAL POLLUTANT REMOVAL EFFICIENCY

Pollutant	Typical Percent Removal
Fecal Coliform	76
Biochemical Oxygen Demand (BOD)	70
Total Suspended Solids (TSS)	70
Total Organic Carbon (TOC)	48
Total Nitrogen (TN)	21
Total Kjeldahl Nitrogen (TKN)	46
Nitrate as Nitrogen (NO_3-N)	0
Total Phosphorus (TP)	33
Iron (Fe)	45
Lead (Pb)	45
Zinc (Zn)	45

SOURCE: Reference 4

DESIGN CRITERIA

Typically the Austin sand filter system is designed to handle runoff from drainage areas up to 50 acres. The collected runoff is first diverted to the sedimentation basin, where heavy sediments and floatables are removed. There are two designs for the sedimentation basin: the full sedimentation system, as shown in Figure 1a, and a partial sedimentation system, where only the initial flow is diverted. Both systems are located off-line and are designed to collect and treat the first 0.5 inch of runoff. The partial system has the capacity to hold only a portion (at least 20%) of the first flush volume in the sedimentation basin, whereas the full system captures and holds the entire flow volume. Equations that are used to determine the sedimentation basin surface areas (A_s) in acres are shown in Table 2 below.

TABLE 2: SURFACE AREA EQUATION FOR THE AUSTIN SAND FILTER SYSTEM

Partial Sedimentation	Full Sedimentation
$A_s = (A_D)(H)/(1/D_s - 1/10)$	$A_s = (A_D)(H)/10$
$A_f = (A_D)(H)/10$	$A_f = (A_D)(H)/18$

Note:
D_s (feet) = depth of the sedimentation basin;
H (feet) = depth of rainfall, 0.042 ft (0.5 inches); and
A_D (acres) = impervious and pervious areas that provide contributing drainage.

SOURCE: Reference 4

Flow is conveyed from the sedimentation basin either through a perforated riser, gabion wall, or berm to the filtration basin. The filtration basin consists of an 18-inch layer of sand 0.02 to 0.04 inch in diameter that may be underlain with a gravel layer. Equations that are used to determine the filtration basin surface areas (A_f) in acres are also shown in Table 2. The filtrate is discharged from the filtration basin through underdrain piping 4 to 6 inches in diameter with 3/8-inch perforations. Filter fabric is placed around the underdrain piping to prevent sand and other particulates from being discharged.

Typically the Washington, D.C. sand filter system is designed to handle runoff from completely impervious drainage areas of 1 acre or less. The system, as shown in Figure 1b, consists of three chambers: a sedimentation chamber, a filtration chamber, and a discharge chamber. The reinforced concrete chambers are located underground. The sand filter system is designed to accept the first 0.5 inch of runoff. Coarse sediments and floatables are removed from the runoff within the sedimentation chamber. Runoff is discharged from the sedimentation chamber through a submerged weir, where it then enters the filtration chamber. The filtration chamber consists of a combination of sand and grave layers totaling 3 feet in depth with an underdrain system wrapped in filter fabric. The underdrain system collects the filtered water and discharges it to the third chamber, where the water is collected and discharged to a storm water channel or sewer system. An overflow weir is located between the second and third chambers to bypass excess flow. The Washington, D.C. sand filter is often constructed on-line, but can be constructed off-line. When the system is off-line the overflow between the second and third chambers is not included.

The Delaware sand filter, as shown in Figure 1c, is similar to the Washington, D.C. sand filter; both utilizing underground concrete vaults. However, the Delaware sand filter has two chambers: a sedimentation chamber and a filtration chamber. A 1-inch design storm was selected for the sizing of the sedimentation basin because it is representative of most frequent storm events. In Delaware, 92% of all storms are less than 1 inch in depth. Runoff enters the sedimentation chamber through a grated cover and then overflows into the filtration chamber, which contains a sand layer 18 inches in depth. Gravel is not normally used in the filtration chamber, although the filter can be modified to include gravel. Typical systems are designed to handle runoff from drainage areas of 5 acres or less. A major advantage of the Delaware sand filter is its shallow structure depth of only 30 inches, thereby reducing excavation requirements.

MAINTENANCE

All filter system designs must provide adequate access to the filter to perform the required inspection and maintenance. The sand filters should be inspected after all storm events to verify that they are working as designed. Since the D.C. and Austin sand filter systems can be relatively deep, they may be designated as confined spaces, therefore, require compliance with confined space entry safety procedures.

Typically, sand filters begin to experience clogging problems within 3 to 5 years (NVPDC, 1992). Accumulated trash, paper and debris should be removed from the sand filters every 6 months or as necessary to keep the filter clean. A record should be kept of the dewatering times for all sand filters to determine if maintenance is necessary. Corrective maintenance of the filtration chamber includes removal and replacement of the top layers of sand, gravel and/or filter fabric that have become clogged. The removed media may usually be disposed of in a landfill. The City of Austin has tests their waste media before disposal. Results thus far indicate that the waste media is not toxic and can be safely landfilled (Schueler, 1992). Sand filter systems may also require the periodic removal of vegetative growth.

COSTS

The construction cost for an Austin sand filtration system is approximately $17,750 (1993 dollars) for a 1-acre drainage area. The cost per acre decreases with increasing drainage area. For example the cost for a 15-acre site is approximately $3,300 (1993 dollars) per acre for a total of $49,500 (Austin, 1990b). The cost for precast Washington, D.C. sand filters with drainage areas of less than 1 acre ranges between $6,300 and $10,500. This is considerably less than the cost for the same size cast-in-place system of approximately $26,400 (D.C., 1992). Costs for the Delaware sand filter are similar to that of the D.C. system, except the excavation costs are generally lower, because of the filters shallower depth.

Annual costs for maintaining sand filter systems averages about 5 percent of the initial construction cost (Schueler, 1992). Media replacement is performed as needed. Currently the sand is being replaced in the D.C. filter systems about every 2 years. The cost to replace the gravel layer, filter fabric and top portion of the sand for D.C. sand filters is approximately $1,600 (D.C. 1992). The City hopes that improved maintenance procedures will extend the life of the filter media and reduce the overall maintenance costs.

ENVIRONMENTAL IMPACTS

The three types of sand filters achieve high removal efficiencies for sediment, BOD and fecal coliform bacteria and generally require less land than other BMPs, such as ponds or wetlands. Sand filters constructed with impermeable basin liners limit the potential for groundwater contamination. Sand filters generally do not provide storm water quantity control and, therefore, do not prevent downstream stream bank and channel erosion. Sand filters may also be of limited value in some applications because of their traditionally low nutrient removal and metals removal capabilities. Waste media from the filters does not appear to be toxic and is environmentally safe for landfill disposal.

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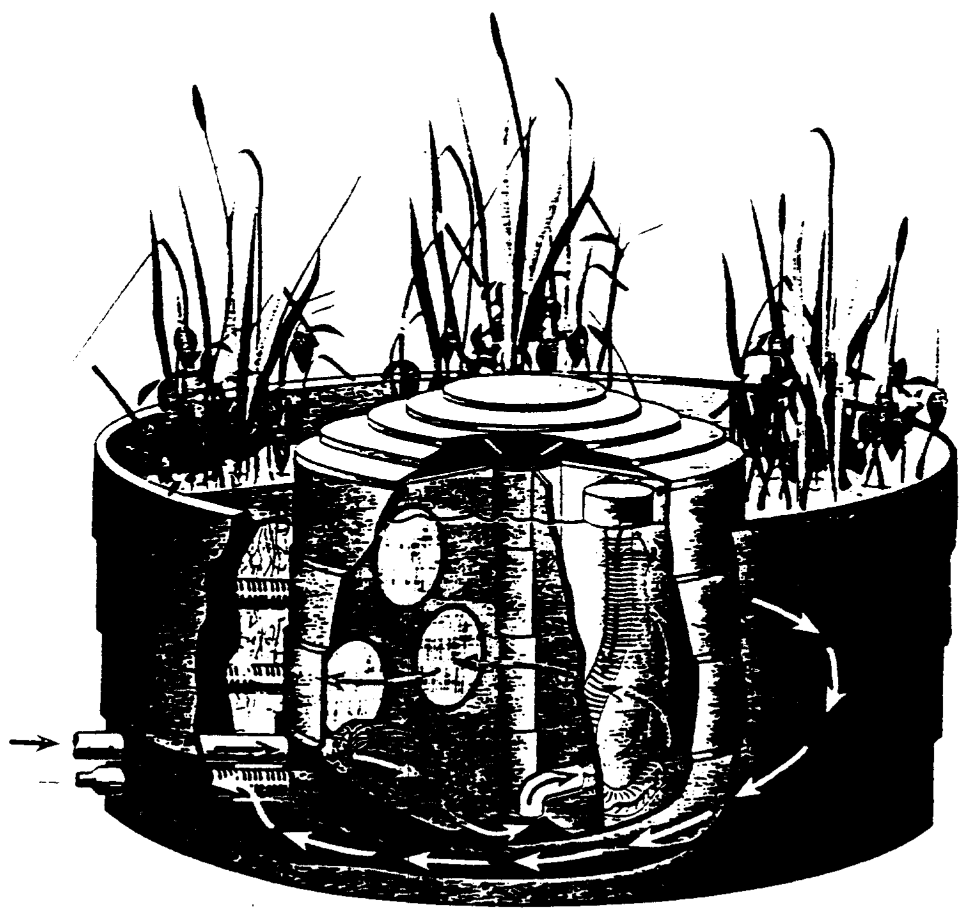
This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460

STORMWATER BMP:
STORMTREAT™ SYSTEM

DESCRIPTION

The STORMTREAT™ System (STS), developed in 1994, is a stormwater treatment technology consisting of a series of sedimentation chambers and constructed wetlands which are contained within a modular, 9.5-foot diameter recycled-polyethylene tank. The STS is shown in Figure 1. Influent is piped into the sedimentation chambers where pollutant removal processes such as sedimentation and filtration occur. Stormwater is conveyed from the sedimentation chambers to a fringing constructed wetland where it is retained for five to ten days prior to discharge. Unlike most constructed wetlands for stormwater treatment, the stormwater is conveyed into the subsurface of the wetland and through the root zone. It is within the root zone that greater pollutant attenuation occurs through processes such as filtration, adsorption, and biochemical reactions.

FIGURE 1 STORMTREAT™ SYSTEM



Source: StormTreat Systems, Inc.

COMMON MODIFICATIONS

The STS design allows for modifications when the system is installed in areas with high groundwater levels or in areas tidally affected. In areas with high groundwater, modifications to the discharge pipe work can be made so that runoff is discharged to a remote downgradient area with a lower water table level. In tidally influenced areas, a check valve can be installed to prevent flow from reentering the unit from its discharge point after the flow has discharged and allow discharge only during mid to low tide conditions. The valve would be adjusted for higher than normal flow velocities (those velocities used with a non-tidally influenced unit) so that the system maintains an average holding time of five to ten days.

The manufacturers of the system indicate that the STS could be used throughout the US, with only minor modifications to the system to make it effective in different geographical areas. In cold climates, where the 4 foot height unit would be installed above the frost line, modifications may be necessary to prevent the water within the tank from freezing. Adding a greenhouse to cover the system or insulating the subgrade tank may prove to be effective.

Modifications may also be necessary in an arid region due to insufficient water to support the wetland vegetation. In these areas the unit could be modified to discharge the flow at a slower rate which would increase the water retained in the bottom of the unit. Soils that retain water more efficiently could also be used. Alternately, the unit could have an alternate water supply for the extended dry periods.

CURRENT STATUS

An STS has been installed in Kingston, Massachusetts (MA) and has been operational since November 1994. The need for a stormwater treatment system in this area became evident as increased bacteria levels caused the closing of shellfish beds in the Jones River. Additional systems are planned for installation in Gloucester, MA, Harwich, MA, and Waltham, MA. Two systems will be installed in Gloucester to help mitigate impacts to the downstream shellfish beds which have also been identified as having high counts of fecal coliform bacteria. The system planned for installation in Harwich will treat polluted runoff from the town landing prior to discharge to Wychmere Harbor, a scenic boating harbor on Cape Cod. A system will be installed at GTE in Waltham during the Fall of 1995. The industrial complex is located in a sensitive watershed. The system will collect rooftop runoff and runoff from a parking lot. If these installed systems prove to be cost effective, there are additional needs in Massachusetts where 40 percent of the shellfish beds have been closed due to high levels of metals and bacteria.

APPLICATIONS

The STS has applications in a wide range of settings. The system's size and modular configuration make it adaptable to a wide range of site constraints and watershed sizes. Designers of the system indicate that the system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial and residential areas. The STS is an appropriate stormwater treatment technology for both coastal and inland areas.

LIMITATIONS

As discussed previously, the STS is relatively new and untested in different geographical locations. There may be possible limitations in these areas. Soil types surrounding the modular unit will not limit the system's effectiveness nor will high water tables.

PERFORMANCE

Preliminary monitoring results from four sets of samples collected in November 1994, December 1994, and February 1995 indicate removal rates of 94% for total coliform bacteria, 83% for fecal coliform bacteria, 95% for total suspended solids, and 90% for total petroleum hydrocarbons, as shown in Table 1. Preliminary nutrient removal rates have been determined to be 44% for total dissolved nitrogen, 89% for total phosphorus (TP), and 32% for ortho-phosphorus. Total nitrogen (TN) performance data are not available at this time; however, the manufacturer of the system indicates that they should be high based on the results of other wetland systems where particulates, and therefore TN, are removed. Removal rates are anticipated to increase as the wetland vegetation becomes more established and during warmer months. The pollutant removal rates achieved by the system for other pollutants are as follows: 65% for lead, 98% for chromium, and 90% for zinc.

TABLE 1 STORMTREAT™ MONITORING RESULTS

Pollutant	Percentage Removed
Total Coliform Bacteria	94
Fecal Coliform Bacteria	83
Total Suspended Solids	95
Chemical Oxygen Demand	75
Total Dissolved Nitrogen	44
Total Phosphorus	89
Ortho-phosphorus	32
Total Petroleum Hydrocarbons	90
Lead	65
Chromium	98
Zinc	90

DESIGN CRITERIA

The STS is a modular, 9.5-foot diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands. The sedimentation chambers are in the inner ring of the tank, which has a diameter of nearly 5.5 feet. The 9.5 feet diameter outer ring, which surrounds the sedimentation chambers, contains the wetland. The tank walls and bulkheads, which separate the sedimentation chambers, have a height of 4 feet.

The STS tanks are designed to withstand the hydrostatic pressures that result from the saturated soils surrounding the tanks. The STS unit connects to existing catch basins with PVC piping. Influent is conveyed through the PVC piping to the first of six internal sedimentation chambers. The 4 inch diameter inlet pipe is covered with a burlap sack that traps larger particles and debris. Synthetic screens and woven geotextiles placed within the bulkheads filter the flow as it passes into the succeeding chamber. Flow is conveyed through larger mesh sizes in the first series of sedimentation chambers, followed by smaller mesh sizes in the remaining sedimentation chambers. In addition to the filter screens, skimmers have been installed in the tanks. Skimmers replace the previously used screens and combination of screens and skimmers. The screens and skimmers perform the same pollutant removal mechanism; however, the screens require more maintenance than the skimmers. The skimmers float on the water surface within each chamber and have an opening 6 inches below the surface through which flow is conveyed to the following tank. Sediments which collect in the bottom of the chamber remain in that chamber until the unit is maintained. The skimmers prevent sediment from being conveyed to the subsequent chamber. The bulkhead separating the last two sedimentation chambers is fitted with an inverted elbow which traps oil and grease within the fifth chamber. The elbow is located approximately 10 inches from the chamber bottom.

Flow is conveyed from the sedimentation chamber through four, 4 inch diameter, PVC, slotted outlet pipes into the wetland portion of the STS. Stormwater flows subsurface through the length of the wetland, which has a length of 23 feet, width of 2.4 feet, and contains 3 feet of gravel and sand. The gravel used at the Kingston facility is 1/4 inch rice stone and 3/8 inch bluestone. The weight of the gravel provides the force that counteracts the buoyancy forces that would be present at a high water table site. The wetland has an approximate storage capacity of 760 gallons. The entire system has a capacity of 1,390 gallons.

Vegetation within the wetland will vary depending on the local, naturally occurring wetland vegetation and the maximum expected root depth of the plant. Bulrush and burreeds have been used in Massachusetts and have maximum root depths of 2.6 and 2 feet, respectively (USEPA, 1993). Mature vegetation should have roots that extend into the permanent 6 inches of water in the bottom of the tank. Insufficient root depth may result in a lack of water supply to the plants during the periods between storm events.

Effluent from the wetland is discharged through a 2 inch diameter pipe that is controlled by a valve. Flow rates and holding times can be varied by manipulating the outlet control valve. At the Kingston facility, the control valve is adjusted to provide for a recommended discharge rate of 0.2 gal/min. and a 5-day holding time in the wetland. The valve has an added benefit that in the event of an upstream toxic spill the valve can be closed and the pollutants will be trapped in the STS.

Tanks are available in one size but multiple tanks can be installed at a site to capture the volume of runoff from the site. The size of the tank was selected so that the prefabricated tanks could be transported without requiring conformance to oversized load regulations. The determination of the number of tanks needed for a site is based on three factors:

- Area of impervious drainage surfaces;
- Design storm to be treated; and
- Detention storage prior to the STS tanks.

To capture and treat the first 0.25 inches of runoff from a one acre, completely impervious drainage area, the designers of the system estimate that two tanks would be required when preliminary detention is provided and five tanks when it is not. For a design storm of 0.5 inches, four tanks are required with preliminary detention and ten tanks without preliminary detention. Preliminary detention may be provided in the drainage pipes and catch basins which convey flow to the STS. In some instances, settling tanks may be located upstream that detain the runoff. A typical site would require 100 ft^2 per tank, which includes sufficient space for the tank and access to the tank for maintenance.

MAINTENANCE

Anticipated maintenance of the STS is minimal. The system should be observed at least once a year to be sure that it is operating effectively. At that time the burlap sack that covers the influent line should be removed and replaced. If the system installed uses filters, these should be removed, cleaned, and reinstalled. Sediment should be removed from the system once every 2 to 3 years, unless the system has higher than normal sediment loads. After six months of operation the unit installed in Kingston, MA was found to have 2 inches of accumulated sediment. The sediment can be pumped from the tank by septic haulers or by maintenance personnel responsible for sediment removal from catchbasins. It is not anticipated that the sediment will be toxic and may be safely landfilled. However, sediment toxicity will depend on the activities in the contributing drainage area and testing of the sediment may be required to determine if it should be considered hazardous.

COSTS

The STS is a prefabricated unit that is easily installed in most locations. Installation time for a normal site (i.e., bedrock not encountered) is approximately four man-days. This time includes both site preparation and installation. The estimated cost for one installed tank is $3,600 to $4,000, which includes the site work, tank, skimmers, gravel, wetland plants, external PVC piping, and installation by the manufacturer. Costs of systems that have been installed or are planned for installation have been lower that the estimated costs due to the municipalities providing the site preparation at no charge. The higher end of the cost range may be encountered if complications with site preparation occur. Capital and installation costs decrease as the number of units on a site increases. The cost for a system installed by the manufacturer and consisting of four tanks is approximately $15,000. The four tank system would effectively treat a one acre, completely impervious drainage area with preliminary detention designed to capture the first 0.5 inches of runoff.

The estimated maintenance cost for removal of sediment from one tank ranges from $100 to $150. This cost is incurred every two to three years when sediment removal is necessary. Costs have not been determined for an annual site inspection and removing any debris and leaves from the wetland area. However, these costs should be minimal (i.e., one day of labor for one person).

ENVIRONMENTAL IMPACTS

Systems have been installed in Massachusetts due to the increased bacteria levels resulting in the closing of shellfish beds. Regulators and environmental groups in Massachusetts are concerned over the closing of 40 percent of the shellfish beds in the state and are utilizing stormwater management practices, including the STS, to improve the water quality in the downstream beds. The STS also protects the groundwater by removing pollutants prior to infiltration. The STS has shown high TPH, TP, metals, and suspended solids removal rates, which improves water quality. An additional benefit of the STS is the system's spill containment feature which results in capture of an upstream release, and therefore, lessens the impact from the spill on the environment.

REFERENCES

1. StormTreat Systems, Inc., date unknown. Technical Data for STORMTREAT™ System. Barnstable, Massachusetts (relocated to Hyannis, MA).
2. StormTreat Systems, Inc., 1995. STORMTREAT™ Systems Newsletter. Barnstable, Massachusetts (relocated to Hyannis, MA).
3. Horsley, Scott W. and Winfried Platz, January 4, 1995. Progress Report: Water Quality Monitoring at Elm Street Facility, Barnstable, Massachusetts (relocated to Hyannis, MA).
4. Horsley, Scott W., June 15, 1995. The STORMTREAT™ System - A New Technology for Treating Stormwater.
5. Horsley & Witten, Inc., 1995. Fact Sheet - Modeling of Water Flow Through the STORMTREAT™ System.
6. USEPA, July 1993. Subsurface Flow Constructed Wetlands for Wastewater Treatment: A Technology Assessment. EPA 832-R-93-001.

STORM WATER BMP: SPILL PREVENTION PLANING

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

A Spill Prevention Plan identifies areas where spills can occur on site, specifies materials handling procedures, storage requirements, and identifies spill clean-up procedures. The purpose of this plan is to establish standard operating procedures, and the necessary employee training to minimize the likelihood of accidental releases of pollutants that can contaminate stormwater runoff. Spill Prevention is prudent from both an economic as well as environmental standpoint because spills increase operating costs and lower productive

Storm water contamination assessment, flow division, record keeping, internal reporting, employee training, and preventive maintenance are associated BMPs that should be incorporate into a comprehensive Spill Prevention Plan.

CURRENT STATUS

Typically, most businesses and public agencies that generate hazardous waste and/or produce, transport, or store petroleum products are required by state and federal law to prepare spill control and cleanup plans. Therefore, a Spill Prevention and Response Plan may have already been developed in response to other environmental regulatory requirements. Existing plans should be re-evaluated and revised if necessary to address stormwater management issues.

APPLICATIONS

A Spill Prevention Plan is applicable to facilities that transport, transfer, and store hazardous materials, petroleum products, and fertilizers that can contaminate stormwater runoff. An important factor of an effective spill prevention plan is quick notification of the appropriate emergency response teams. In some plants each area or process may have a separate team leader and team of experts. Figure 1 below illustrates a sample spill prevention team roster for quick identification of team leaders and their responsibilities.

LIMITATIONS

Spill Prevention Planing can be limited by the following:

- Lack of employee motivation to implement plan.
- Lack of commitment from senior management.
- Key individuals identified in the Spill Prevention Plan may not be properly trained in the areas of spill prevention, response, and cleanup.

PERFORMANCE

Past experience has shown that the single most important obstacle to an effective Spill Prevention Plan is its implementation. Qualitatively, implementation of a well prepared Spill Prevention Plan should significantly decrease contamination of stormwater runoff.

POLLUTION PREVENTION TEAM

MEMBER ROSTER

Worksheet
Completed by: ______________
Title: ______________
Date: ______________

Leader: ______________ Title: ______________
Office Phone: ______________

Responsibilities: ______________

Members:

(1) ______________ Title: ______________
Office Phone: ______________

Responsibilities: ______________

(2) ______________ Title: ______________
Office Phone: ______________

Responsibilities: ______________

(3) ______________ Title: ______________
Office Phone: ______________

Responsibilities: ______________

SOURCE: Reference 1.

FIGURE 1: SAMPLE SPILL PREVENTION TEAM ROSTER

DESIGN CRITERIA

General guidelines for the preparation of a Spill Prevention Plan include:

- The first part of the plan should contain a description of the facility including the owner's name and address, the nature of the facility activity, and the general types of chemicals used in the facility.

- The plan should contain a site plan showing the location of storage areas for chemicals, location of the storm drains, tributary drainage areas with drainage arrows, and the location and description of any devices to stop spills from leaving the site such as collection basins.

- The plan should describe notification procedures to be used in the event of a spill such as phone numbers of key personnel, and appropriate regulatory agencies such as local Pollution Control Agencies and the local Sewer Authority.

- The plan should provide specific instructions regarding cleanup procedures.

- The owner, through an internal reporting procedure, should have a designated person with overall responsibility for spill response. Through an employee training program, key personnel should be trained in the use of this plan. All employees should have basic knowledge of spill control procedures.

- A summary of the plan should be written and posted at appropriate points in the building (i.e., lunch rooms, cafeteria, and areas with a high spill potential), identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.

- Cleanup of spills should begin immediately. No emulsifier or dispersant should be used.

- In fueling areas, absorbent should be packaged in small bags for easy use and small drums should be available for storage of absorbent and/or used absorbent. Absorbent materials shall not be washed down the floor drain or into the storm sewer.

- Emergency spill containment and cleanup kits should be located at the facility site. The contents of the kit should be appropriate to the type and quantities of chemical or goods stored at the facility.

Some structural methods to consider when developing a Spill Prevention Plan include:

- Containment diking-- Containment dikes are temporary or permanent earth or concrete berms or retaining walls that are designed to hold spills. Diking can be used at any industrial facility, but is most common for controlling large spills or releases from liquid storage and transfer areas. Diking can provide one of the best protective measures against the contamination of stormwater because it surrounds the area of concern and holds the spill, keeping spill materials separated from the stormwater outside of the diked area.

- Curbing-- Like containment diking, curbing is a barrier that surrounds an area of concern. Because curbing is usually small-scale, it cannot contain large spills like diking can. However, curbing is common at many facilities and small areas where liquids are handled and transferred.

- Collection basins. Collection basins are permanent structures where large spills or contaminated stormwater are contained and stored before cleanup or treatment. Collection basins are designed to receive spills, leaks, etc., that may occur and prevent these materials from being released to the environment. Unlike containment dikes, collection basins can receive and contain materials from many locations across a facility.

Once a hazardous material spill occurs and is contained, the material has to be cleaned up and disposed of to protect plant personnel from potential health and fire hazards, and to prevent the release of the substance to surface waters. Methods of cleanup, recovery, treatment, or disposal include:

- Physical. Physical methods for cleanup of dry chemicals include the use of brooms, shovels, sweepers, or plows.

- Mechanical. Mechanical methods for cleanup include the use of vacuum cleaning systems and pumps.

- Chemical. Chemical cleanup of material can be accomplished with the use of sorbents, gels, and foams. Sorbents are compounds that immobilize materials by surface absorption or adsorption in the sorbent bulk. Gelling agents interact with the spilled chemical(s) by concentrating and congealing to form a rigid or viscous material more conducive to mechanical cleanup. Foams are mixtures of air and aqueous solutions of proteins and surfactant-based foaming agents. The primary purpose of foams is to reduce the vapor concentration above the spill surface thereby controlling the rate of evaporation.

- Create a map of the facility site to locate pollutant sources and determine stormwater management opportunities. This site map should include all surface waterbodies on or next to the site, and should also identify, if any that are in place. Tributary drainage areas with identification of flow direction should also bed identified during this mapping phase. Table 1 contains a list of features that should be indicated on the site map.

- Conduct a material inventory throughout the facility.

- Evaluate past spills and leaks.

- Identify non-stormwater discharges and non-approved connections to stormwater facilities.

- Collect and evaluate stormwater quality data.

- Summarize the findings of this assessment.

TABLE 1: CRITERIA FOR DEVELOPING A SITE MAP

DEVELOPING A SITE MAP	Worksheet Completed by: ____________ Title: ____________ Date: ____________

Instructions: Draw a map of your site including a footprint of all buildings, structures, paved areas, and parking lots. The information below describes additional elements

- All outfalls and storm water discharges
- Drainage areas of each storm water outfall
- Structural storm water pollution control measures, such as:
  - Flow diversion structures
  - Retention/detention ponds
  - Vegetative swales
  - Sediment traps
- Name of receiving waters (or if through a Municipal Separate Storm Sewer System)
- Locations of exposed significant materials
- Locations of past spills and leaks
- Locations of high-risk, waste-generating areas and activities common on industrial sites such as:
  - Fueling stations
  - Vehicle/equipment washing and maintenance areas
  - Area for unloading/loading materials
  - Above-ground tanks for liquid storage
  - Industrial waste management areas (landfills, waste piles, treatment plants, disposal areas)
  - Outside storage areas for raw materials, by-products, and finished products
  - Outside manufacturing areas
  - Other areas of concern (specify:________________)

SOURCE: Reference 1.

MAINTENANCE

A facility Spill Prevention Plan should be reviewed at least annually and following any spills to evaluat the Spill Prevention Plan's level of success and how it can be improved. Other times for significant review of the plan should be when a new material is introduced to the plant as a result of a processing modification, or when a change has occurred in a materials handling procedure.

COSTS

If a facility already has a Spill Control and Cleanup Plan in-place, modifications, to address stormwater contamination concerns, will require minimal cost. If a facility will be developing a Spill Prevention Plan for the first time, initial cost will depend on the type of materials at the facility, facility size, and other related parameters. Costs for structural containment devices will also need to be identified for each facility.

ENVIRONMENTAL IMPACTS

Preventing or containing spills, especially toxic or hazardous materials, is important in reducing storm water contamination and in maintaining the water quality of the receiving water.

REFERENCES

1. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September 1992.
2. Washington State Department of Ecology, Stormwater Management Manual for Puget Sound, February 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: CONTAMINATION ASSESSMENT

DESCRIPTION

A Stormwater Contamination Assessment (SWCA) provides a review of a facility and site to determine what materials or practices may be a source of contaminants to the stormwater. The purpose of the assessment is to help target the most important pollutant sources for corrective and/or preventive action.

A SWCA program is closely related to other BMP's, such as materials inventory, non-stormwater discharges, record keeping, and visual inspections. To be effective these, and other BMP's should be incorporated into a comprehensive pollution prevention program.

APPLICATIONS

A SWCA program is applicable to any industrial facility which contains areas, activities, or materials which may contribute pollutants to stormwater runoff from the total site. An assessment for stormwater purposes may also be applicable in situations where a formal site assessment for hazardous waste purposes is being performed.

LIMITATIONS

Limitations associated with a contamination assessment program include:

- Assessments need to be performed by qualified personnel.
- A corporate commitment must exist to reduce the contamination sources once discovered.
- Assessments need to be periodically updated.

PERFORMANCE

It is not possible, based on currently available data, to quantify the water quality benefits to receiving waters of a stormwater contamination assessment program. Results are entirely based on the severity of the contamination uncovered, and the corrective actions taken. Qualitatively, implementation of a program that identifies areas of high pollutant concentrations and eliminate or reduces their potential pollutant capabilities will result in positive water quality benefits.

DESIGN CRITERIA

A SWCA program should include the following key activities:

- Assess potential pollutant sources and associated high risk activities such as loading and unloading operations, outdoor storage activities, outdoor manufacturing or processing activities, significant dust or particulate-generating activities, and on-site waste disposal practices.

Once you have completed the above steps in your pollutant source assessment, you have enough information to determine which areas, activities, or materials are a risk towards contributing pollutants to stormwater runoff from your site. An important benefit is that by using this information, you car effectively select other cost-effective BMPs to prevent or control pollutants.

IMPLEMENTATION

In addition to identifying problems within the storm sewer system, it is even more important to prevent problems from developing at all, and to provide an environment in which future problems can be avoided. Thus, an effective stormwater assessment program should include implementation activities to insure success and follow-up activities to measure results. Keys to a successful implementation program should include:

- Public education, on organized systematic program of disconnecting commercial and industrial stormwater entries into the storm drainage system.
- Tackling the problem of widespread septic system failure.
- Disconnecting direct sanitary sewerage connections.
- Rehabilitating storm or sanitary sewers to abate contaminated water infiltration.
- Developing zoning and other ordinances.

In extreme cases, it may be that while it was thought that a community had a separate sanitary sewer system and a separate storm sewer system, in reality the storm sewer system is acting as a combined sewer system. In these cases, consideration should be given to the economic and practical advantages of designating the storm sewer system a combined sewer and applying end-of-pipe treatment to the entire system.

A SWCA program needs to be periodically updated. Updating is especially important upon the introduction of new raw materials or changes in processes at the site.

It is also important to establish parameters for measuring the success of the correction program. If results do not meet expectation, then reassessment and appropriate changes to the correction program should be made.

COSTS

Costs for the initial assessment may be high. However, by pinpointing high potential areas or activities a SWCA program may reduce overall costs associated with a complete BMP implementation program. The costs associated with an assessment program for stormwater are small when compared to or a part of a larger overall hazardous waste site assessment.

ENVIRONMENTAL IMPACT

A comprehensive SWCA program can eliminate pollution sources that can significantly impair receiving water quality.

REFERENCES

1. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September 1992.

2. U.S. EPA, NPDES Best Management Practices Guidance Document, June 1981.

3. Pitt, Robert, Barbe, Donald; Adrian, Donald, and Field, Richard, Investigation of Inappropriate Pollutant Entries into Storm Drainage System -- A User's Guide, U.S. EPA, Edison, New Jersey, 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

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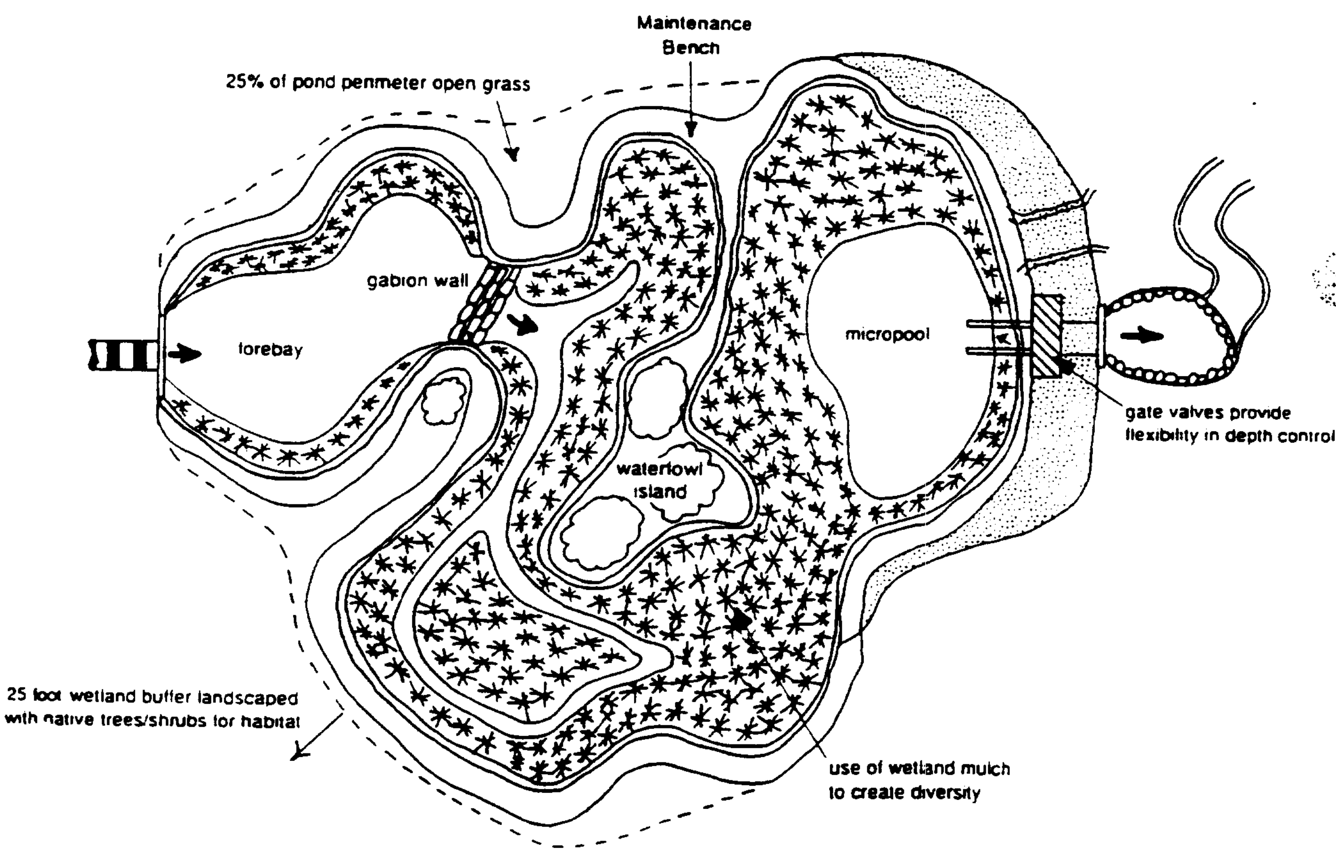
STORMWATER BMP:
STORMWATER WETLANDS

DESCRIPTION

Wetlands are those areas that are typically inundated with surface or ground water and support plants adapted to saturated soil conditions. A typical shallow marsh wetland is shown in Figure 1. Wetlands have been described as "nature's kidneys" due to the physical, chemical, and biological processes that occur in wetlands which result in transformation of some elements (e.g., nitrogen, sulfate) and filtration of others (Hammer, 1989). The natural pollutant removal capabilities of wetlands have brought increased attention to their usage as a stormwater best management practice (BMP).

FIGURE 1 SHALLOW MARSH WETLAND



Source: MWCOG, 1992.

Wetlands used for stormwater treatment can be constructed, incidental or natural. Incidental wetlands are those that were created as a result of previous development or human activities. The use of natural wetlands for stormwater treatment is discouraged by many and may not be an option. Some states, however, allow their usage but only in very restricted circumstances. For example, the State of Florida allows the use of natural wetlands that have been severely degraded or wetlands that are intermittently connected (flows when groundwater rises above ground level) to other waters (Livingston, 1994). Conversion of natural wetlands to stormwater wetlands are done on a case-by-case basis and require the appropriate state and federal permits (e.g., 401 water quality certification and 404 wetland permit).

Two types of constructed wetlands have been used successfully for wastewater treatment: the subsurface flow (SF) and the free water surface (FWS) constructed wetland. In the FWS wetland runoff flows through the soil lined basin at shallow depths. The wetland consists of a shallow pool planted with emergent vegetation (vegetation which is rooted in the sediment but the leaves are at or above the water surface). The SF wetland also has a basin, however, the basin contains a suitable depth of rock or gravel, through which the runoff is conveyed. The water level in a SF wetland remains below the top of the rock or gravel bed. Studies have indicated that the SF wetland is well suited for the diurnal flow pattern of wastewater, however, the peak flows from stormwater or combined sewer overflows (CSO) may be several orders of magnitude higher than the average flow. The cost for a gravel bed to contain the peak storm event would be very high, and therefore, preclude the use of SF wetlands for stormwater or CSO treatment. The remainder of this factsheet addresses the FWS constructed wetland or natural and incidental wetlands.

COMMON MODIFICATIONS

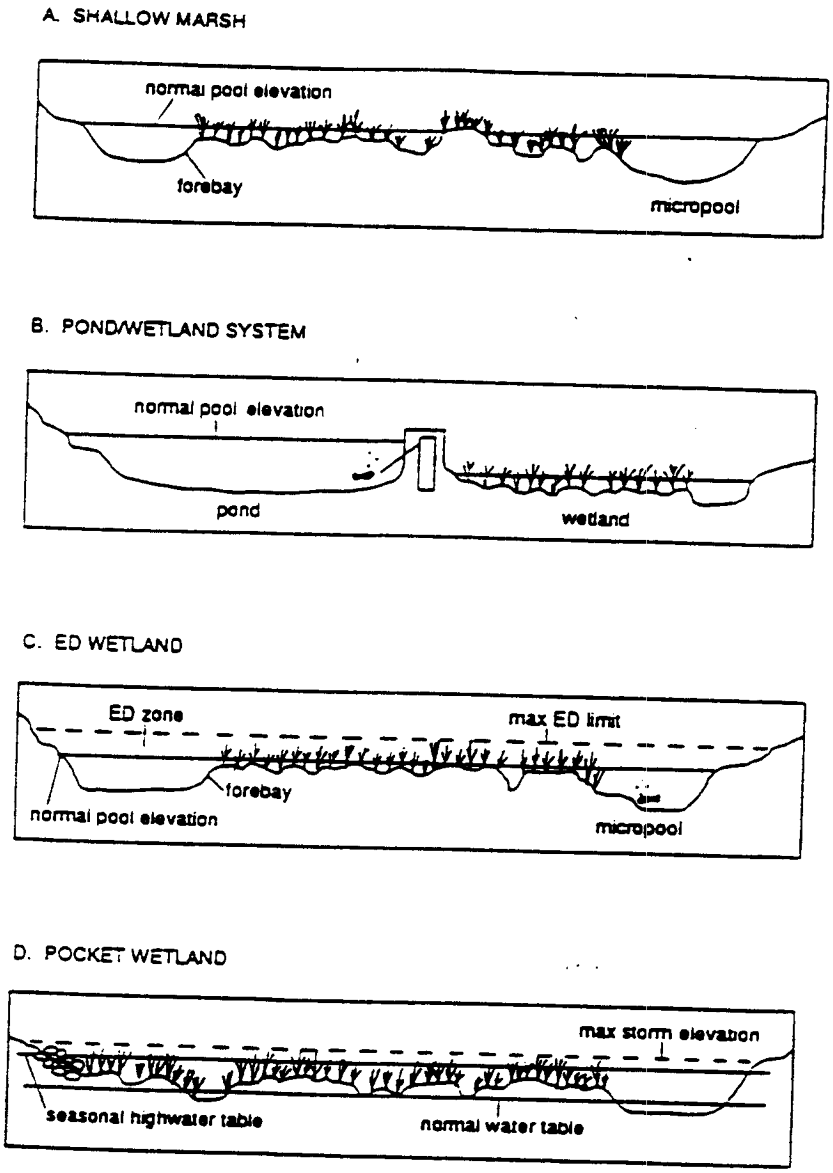
There are four basic designs of constructed wetlands: shallow marsh, pond/wetland system, extended detention (ED) wetland, and pocket wetland. The wetland designs, as shown in Figure 2, store runoff in a shallow basin vegetated with wetland plants. The selection of one design over the other will depend on various factors, including the land availability, level and reliability of pollutant removal, and size of contributing drainage area. The shallow marsh design requires the largest amount of land and a sufficient baseflow to maintain water within the wetlands. The marsh can be modified to include extra vertical runoff storage. This modified marsh system, known as the ED wetland, attenuates flows and relieves downstream flooding.

Another variation, the pond/wetland system, has two separate cells: one being a wet pond and the other a shallow marsh. The wet pond traps sediments and reduces velocities prior to runoff entry into the wetland. Land requirements for a pond/wetland system are less than for the shallow marsh system. Areas with insufficient land area for construction of a larger wetland system, may be appropriate sites for the fourth wetland design, a pocket wetland. Pocket wetlands have contributing drainage areas of 1 to 10 acres and usually will require excavation down to the water table in order to provide a reliable water source to the wetland. Unreliable water sources and fluctuating water levels result in low plant diversity and poor wildlife habitat value (MWCOG, 1992).

CURRENT STATUS

In the past the use of natural treatment processes occurring within wetlands has generally focused on the the treatment of wastewater. Wetlands for stormwater treatment have gained attention in recent years and many systems are now operational. Studies are ongoing to determine the effectiveness of wetlands, design modifications that improve their performance, and required maintenance to sustain their performance.

FIGURE 2 COMPARATIVE PROFILES OF FOUR STORMWATER WETLAND DESIGNS



Cross-sectional profiles of the four stormwater wetlands are not drawn to scale. In Panel A, the majority of the shallow marsh is devoted to shallow depths that support emergent wetland plants. The pond/wetland system (Panel B) is composed of deep and a shallow pool. In ED wetlands (Panel C), the runoff storage of the wetland is augmented by temporary, vertical ED storage. Pocket wetlands (Panel D) are excavated to the groundwater table to provide a more or less constant water elevation.

Source: MWCOG, 1992.

APPLICATIONS

Wetlands provide the benefit of stormwater quality control, with the option of achieving quantity control (e.g., extended detention wetland). Wetlands are one of the more reliable BMPs capable of removing pollutants and are adaptable to most locations in the US. Locations with existing wetlands used for stormwater treatment include, but are not limited to, Washington, California, Minnesota, Michigan, Illinois, Florida, Maine, Maryland, and Virginia. They have been used to treat runoff from agricultural, commercial, industrial, and residential areas.

LIMITATIONS

Urban settings and established communities may preclude the use of wetlands due to the large land requirement for the systems. The presence of trout, sculpins and other temperature sensitive fish species or aquatic insects located in downstream waters may also preclude the use of wetlands due to the stream warming that could occur within a wetland, especially during the warmer months. Communities may be opposed to a wetland due to their preconceived notion that wetlands will result in an infestation of mosquitoes and other nuisances. Communities may also be opposed due to the appearance of the wetlands. Wetlands, however, can be designed to be attractive and features (e.g., morphology, fish, and vegetation) can be added to decrease, if not eliminate, a problem with mosquitoes and other nuisances.

Limitations in pollutant removal may be experienced during the non-growing season and in localities with lower temperatures. Decreases in pollutant removal efficiency have been observed when wetlands are covered with ice or receive snowmelt runoff.

PERFORMANCE

Stormwater pollutant removal in wetlands is attributed to the physical, chemical, and biological processes that occur within the wetland. Chemical and physical assimilation mechanisms include sedimentation, adsorption, filtration, and volatilization. Sedimentation is the primary removal mechanism for pollutants such as suspended solids, particulate nitrogen, and heavy metals. The settling of the particulates is influenced by the velocity of the runoff through the wetland, the particle size, and turbulence. Sedimentation can be maximized by creating sheet flow conditions, slowing the velocities through the wetland, and providing morphology and vegetation conducive to settling. The vegetation and its root system will also decrease the resuspension of settled particles.

Adsorption is the process where pollutants attach to surfaces of suspended or settled sediments and vegetation. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Pollutants removed by adsorption include metals, phosphorus, and some hydrocarbons.

Wetland plants act as filters for pollutants such as trash, debris, and other floatables. Filtration can be enhanced by slow velocities, sheet flow, and sufficient quantities of vegetation. The plants also increase the pollutant removal achieved through sedimentation, adsorption, and microbial activity by providing for an increased detention and contact time and a surface for microbial growth.

Volatilization plays a minor role in pollutant removal from wetlands. Pollutants such as oils, hydrocarbons, and mercury can be removed from the wetland via evaporation or by aerosol formation under windy conditions.

Biological processes that occur in wetlands result in pollutant uptake by wetland plants and algae. Emergent wetland plants uptake settled nutrients and metals through their roots. The process creates new sites in the sediment for pollutant adsorption. During the fall the above ground parts typically die back and the plants may potentially release the nutrients and metals back into the water column (MWCOG, 1992). Recent studies, however, indicate that most pollutants are stored in the roots of aquatic plants, rather than the stems and leaves (CWP, 1995). Additional studies are required to determine the extent of pollutant release during the fall die back.

Microbial activity contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria and aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels in the top layer of wetland sediments. The low oxygen levels and the decomposed organic matter contribute to the immobilization of metals.

Soluble pollutants such as phosphorus and ammonia are partially removed by planktonic or benthic algae. The algae consume the nutrients and convert it into biomass. The biomass settles to the bottom of the wetland.

Evaluation of the removal effectiveness of wetlands is ongoing and limited data are currently available; however, some conclusions can be drawn from available preliminary data. The projected long term pollutant removal rates for constructed wetlands in the Mid-Atlantic Region as reported by MWCOG (1992) and Strecker (1995) are presented in Table 1. As shown, total suspended solids (TSS) and lead removal rates are anticipated to approach 75 percent. Lower removal rates are expected for nutrients and organic carbon. The removal rates will vary with the loadings to the wetland. Excessive pollutant loadings (e.g., suspended solids) may exceed the wetlands removal capabilities.

TABLE 1 PERFORMANCE OF STORMWATER WETLANDS (1)

Pollutant	Removal Rate
Total Suspended Solids	75 %
Total Phosphorus	45 %
Total Nitrogen	25 %
Organic Carbon	15 %
Cadmium (2)	70%
Copper (2)	40%
Lead	75%
Zinc	50%
Bacteria	2 log reduction

(1) Source: MWCOG, 1992
(2) Source: Strecker, 1995

Conclusions have been determined from studies performed on wetlands with regard to their effectiveness compared to other BMPs and construction practices that affect performance. Data indicate that the pollutant removal achieved with wetlands is similar to that achieved with conventional pond systems. Studies also indicate that constructed stormwater wetlands achieve higher pollutant removal rates than natural wetlands. This is likely due to the intricate design of the constructed systems and the continued monitoring and maintenance of the systems (MWCOG, 1992). The effectiveness of the wetland seems to improve after the first few years of use as the vegetation becomes established and organic matter accumulates in the wetland. During construction and excavation, many constructed wetlands lose organic matter in the soils. The organic matter provides exchange sites for pollutants, and therefore, plays an important role in pollutant removal. Replacing or adding organic matter after construction improves performance.

LONGEVITY

Well designed wetlands can function as designed for 20 years or longer. Accumulated sediments will gradually cause a decrease in storage and performance, and therefore, should be removed as necessary or the water level in the wetland should be raised (e.g., adjust outlet to increase discharge elevation). Sediment forebays will decrease the accumulation of sediments within the wetland and increase the wetlands longevity.

DESIGN CRITERIA

Required local, state and federal permits should be established prior to wetland design with the appropriate regulatory authorities. Required permits and certifications may include 401 water quality certifications, 402 stormwater NPDES permit, 404 wetland permits, dam safety permits, sediment and erosion control plans, waterway disturbance permits, forest clearing permits, local grading permits, and land use approvals.

Prior to construction, a site should be selected that is appropriate for a wetland. The site must have an adequate water balance and appropriate underlying soils. This requires that the baseflow from the drainage area or groundwater is sufficient to maintain a shallow pool in the wetland and support the vegetation. Certain species are more susceptible to damage during dry periods. Underlying soils that are type B, C, or D will have relatively insignificant infiltration losses. High infiltration rates may be experienced at sites with type A soils or at sites underlain by karst, limestone, or fractured bedrock. These sites may require geotextile liners or a 6 inch layer of clay. After any necessary excavation and grading of the wetland at least 4 inches of soil should be applied to the site. This material may be the soil previously excavated or sand and other suitable material. The soils are needed to provide a substrate that the vegetation can become established in and anchor to. The substrate should be soft for ease of insertion of the plants.

The Metropolitan Washington Council of Governments (MWCOG) has made recommendations for the design of wetlands that require the designer to meet several basic sizing criteria. The volume of the wetland is determined as the quantity of runoff generated by 90 percent of the runoff producing storms. This volume will vary throughout the US due to the different rainstorms experienced. In the Mid-Atlantic Region, for example, the 1.25 inch storm is used as the sizing criterion. The imperviousness of a watershed will impact the runoff volume generated. The following equations are used to determine the treatment volume (Vt):

(1) $Rv = 0.05 + 0.009 (I)$

where:

Rv = storm runoff coefficient

I = percent site imperviousness

(2) $Vt = [(1.25)(Rv)(A)/12](43{,}560)$

where:

Vt = treatment volume (ft^3)

A = contributing area (acres)

Sizing criteria for wetlands vary with some states having their own methods. For example, shallow wetland basins constructed in Maryland are designed to maximize the surface area. The surface area should be a minimum of 3 percent of the area of the watershed draining to it. The preferred design would include extended detention, the volume of which is determined by detaining the 1-year storm for 24 hours. The Washington State Department of Ecology sizes wetlands using the runoff generated from the 6-month, 24-hour rainfall event.

Criteria are also established by MWCOG for the water balance, maximum flow path, allocation of treatment volume, minimum surface area, allocation of the surface area, and extended detention. The water balance, as discussed previously, must be adequate during dry weather to provide a baseflow and maintain the vegetation. The flow path should be maximized to increase contact time between the plants and sediments and the runoff. The recommended length to width ratio is 2:1. A ratio of greater than 1:1 should prevent short circuiting where runoff escapes treatment. Suggested allocation of treatment volumes, as shown in Table 2, are provided to improve removal efficiency. The minimum surface area requirement for shallow marshes established by MWCOG is that the wetland to watershed area ratio be greater than 2 percent. The remaining three wetland designs can have wetland to watershed ratios greater than 1 percent.

TABLE 2 GUIDELINES FOR ALLOCATING WETLAND SURFACE AREA AND TREATMENT VOLUME

Target Allocations	Shallow Marsh	Pond/Wetland	ED Wetland	Pocket Wetland
Percent of Surface Area (%)				
Forebay	5	0	5	0
Micropool	5	5	5	0
Deepwater	5	40	0	5
Low Marsh	40	25	40	50
High Marsh	40	25	40	40
Semi-Wet	5	5	10	5
Percent of Treatment (%) Volume				
Forebay	10	0	10	0
Micropool	10	10	10	0
Deepwater	10	60	0	20
Low Marsh	45	20	20	55
High Marsh	25	10	10	25
Semi-Wet	0	0	50	0

Source: MWCOG, 1992
Deepwater - 1.5 to 6 feet below normal pool
Low Marsh - 6 to 18 inches below normal pool
High Marsh - 0 to 6 inches below normal pool
Semi-Wet - 0 to 2 feet above normal pool (includes ED)

The wetland surface area is allocated to four different depth zones: deepwater (1.5 to 6 feet), low marsh (18 to 6 inches below normal pool), high marsh (up to 6 inches below normal pool), and semi-wet areas (above normal pool). The allocation to the various depth zones will create a complex internal topography. This is important because various wetland plants have different depth requirements, therefore the internal complexity should maximize plant diversity and increase pollutant removal. Allocation guidelines established by MWCOG are shown in Table 2. The State of Maryland requires that 75 percent of the shallow marsh should have depths less than 12 inches and the remaining 25 percent should have depths ranging from 2 to 3 feet. The 75 percent portion is additionally broken down so that 25 percent ranges from 6 to 12 inches and the remaining 50 percent is 6 inches or less.

Extending detention within the wetland increases the time for sedimentation and other pollutant removal processes to occur and also provides for attenuation of flows. Up to 50 percent of the wetland treatment volume can be added into the wetland system for extended detention. The ED elevation should not, however, exceed 3 feet above the normal pool elevation. This will prevent large fluctuations in the water level that could potentially harm the vegetation. The ED volume should be detained between 12 and 24 hours.

Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. The forebays provide additional benefits of creating sheet flow, extending the flow path, and preventing short circuiting. The volume of the forebay should be at least 10 percent of the wetland treatment volume and have a depth of 4 to 6 feet. The State of Maryland recommends a depth of at least 3 feet. The forebay is typically separated from the wetland by gabions or an earthen berm (MWCOG, 1992).

Flow from the wetland should be conveyed though an outlet structure that is located within the deeper areas of the wetland. Discharging from the deeper areas using a reverse slope pipe prevents the outlet from becoming clogged. A micropool can be constructed where the outlet structure is to be located that will also prevent outlet clogging. The micropool should contain approximately 10 percent of the treatment volume and be 4 to 6 feet deep. An adjustable gate controlled drain capable of dewatering the wetland within 24 hours should be located within the micropool. A typical drain may be constructed with an upward facing inverted elbow with its opening above the accumulated sediment. The dewatering feature eases planting and follow-up maintenance (MWCOG, 1992).

Vegetation can be established by one of five methods: mulching, allowing volunteer vegetation to become established, planting nursery vegetation, planting underground dormant parts of a plant, and seeding. Donor soils from existing wetlands can be used to establish vegetation within a wetland. This technique, known as mulching, has the advantage of quickly establishing a diverse wetland community. However, the types of species that grow within the wetland is unpredictable with mulching. Another unpredictable technique is allowing the species to voluntarily become established. Wind and waterfowl provide volunteer species to wetlands. Volunteer species are usually well established within 3 to 5 years. Wetlands established with volunteers are usually characterized by low plant diversity with monotypic stands of exotic or invasive species. A higher diversity wetland can be established when nursery plants or dormant rhizomes are planted. Planting of the vegetation from a nursery should take place during the growing season and not during late summer and fall. Planting during the growing season gives the vegetation time to store up food reserves in the underground parts for the dormant period. Underground parts of vegetation are planted during the plants dormant period, usually October through April, but the months will vary in the US due to local climate. Another planting technique, the spreading of seeds, has not been very successful, and therefore, is not widely practiced as a principal planting technique.

Selection of plant types will vary for different locations and climates. The designer of the wetland should select five to seven plants that grow native to the area and design the depth zones in the wetland to be appropriate for the type of plant and its associated maximum water depth. Approximately half of the wetland should be planted. Of the five to seven species selected, three should be aggressive plants or those that become established quickly. Examples of aggressive species used in the Mid-Atlantic Region include softstem bulrush (*Scirpus validus*) and common three-square (*Scirpus americanus*). Aggressive plants as well as other native wetland plants are available from numerous nurseries. Most vendors require an advance order of 3 to 6 months.

After wetland excavation and grading the wetland should be inundated and allowed to stand until planting. Six to nine months later, the wetland is typically surveyed, drained, and staked. The wetland is surveyed two weeks prior to planting to ensure that depth zones are appropriate for plant growth. Revisions may be necessary to account for any depths different from that originally excavated. Staking the site ensures that the planting crew spaces the plants within the correct planting zone. Planting zones are used to avoid mixing species and creating competition within the planted areas. The State of Maryland recommends planting two aggressive or primary species in 4 monospecific areas and planting an additional 40 clumps (one or more individuals of a single species) per acre of each primary species over the rest of the wetland. Three secondary species are planted close to the edge of the wetland at an application rate of 10 clumps of 5 individual plants per acre of wetland, for a total of 50 individuals of each secondary species per acre of wetland. At least 48 hours prior to planting, the wetland should be drained. At the completion of planting and within 24 hours the wetland should be re-flooded.

The wetland design should include a buffer to separate the surrounding land uses from the wetland. Buffers may alleviate some of the potential nuisances associated with the wetland, such as accumulated floatables or odors. MWCOG recommends a buffer of 25 feet from the maximum water surface elevation, plus an additional 25 feet when wildlife habitat is of concern. An enhanced wildlife habitat can be obtained if during construction the removal of existing forested areas is minimized. If removal is necessary, the buffer area should be reforested. The reforestation also decreases the potential for a goose pond due to their preference for open areas.

MAINTENANCE

The use of wetlands for stormwater treatment is relatively new, and therefore, specific guidelines on their maintenance have not been established. The wetlands will require monitoring, reinforcement planting, sediment removal, and possibly plant harvesting. Access should be incorporated in the design to facilitate these maintenance activities. Monitoring the wetland during the first three years is crucial to the performance of the wetland. Inspections should be conducted twice per year for the first three years, and on an annual basis thereafter. Reinforcement planting may be required during this time period if the original plants do not flourish in the wetland. The inspector should determine sediment accumulation within the wetland and also take note of the species distribution/survival, water elevations, and outlet condition. Water elevations can be raised or lowered by adjusting the outlet's gate valve if it is determined that plants are not receiving an appropriate water supply. The forebay will likely require sediment clean-out every three to five years. The design of the forebay should allow for it to be drained so that a skid loader or backhoe can be used to remove the accumulated deposits (MWCOG, 1992). Mowing of the embankment and maintenance bench should occur twice per year. Other areas surrounding the wetland will not require mowing.

Numerous studies have been performed to determine the toxicity of pond sediments and whether landfilling or land application can be accomplished without having to meet hazardous waste requirements. Studies to date have not found sediments to be hazardous. Therefore, on-site land application of the sediments away from the shoreline will most likely be the most cost effective disposal method. On-site disposal is preferred over off-site disposal due to the cost savings associated with transportation and off-site disposal fees. Wetlands that receive flow from a drainage area containing industry and activities associated with hazardous waste may contain toxic levels in the sediments and testing may be required for these sediments prior to land application.

COSTS

Costs incurred for stormwater wetlands include those for permitting, design, construction and maintenance. The permitting costs vary depending on state and local regulations, but it has been estimated that permitting and design costs are between 15 and 25 percent of the construction cost. Construction costs for an emergent wetland range from $12,000 to $20,000 per acre of wetland and for a forested wetland range from $20,000 to $40,000 per acre of wetland. These costs include the costs for clearing and grubbing, erosion and sediment control, excavating, grading, staking, and planting. The cost for constructing the wetland is largely dependant upon the amount of excavation required at a site. Maintenance costs are estimated at 10 to 15 percent per year of the construction costs (Bowers, 1995).

ENVIRONMENTAL IMPACTS

Benefits associated with stormwater wetlands include increased downstream water quality, wetland creation, enhancement of wildlife habitat, and flood attenuation. Water quality is improved due to the partial removal of suspended solids, metals, nutrients, and bacteria. The creation of wetlands is typically looked upon as positive, particularly when the nation has lost considerable acres of wetlands within the past century. The wetlands provide an environment attractive to wildlife, such as sandpipers and herons. ED wetlands also attenuate runoff and alleviate downstream flooding.

Potential adverse impacts attributed with stormwater wetlands can occur upstream, in the wetland, and downstream of the wetland. There is potential for stormwater wetlands located in a large watershed (>100 acres) to experience degradation of upstream headwaters since they receive no effective hydrologic control (MWCOG, 1992). The wetland designer can incorporate upstream modifications to relieve this negative impact.

Concerns within the wetland are the potential for a fish barrier, habitation by undesirable species, and groundwater contamination. A fish barrier may be created by the wetland, which prohibits fish access to the full length of the stream. This may result in a lowering of fish diversity in the stream. Geese and mallards may become year round residents of the wetland if structural complexity is not included in the wetland design. Geese and mallards favor deep and open water areas. Forested buffer areas and a reduction of grassy areas will also deter the geese and mallards. The geese and mallards will increase the nutrient and coliform loadings to the wetland and will also likely be a nuisance to local residents. The issue of groundwater contamination resulting from migration of polluted sediments to the groundwater has been considered a potential negative environmental impact. However, studies to date indicate that there is little risk of groundwater contamination (MWCOG, 1992).

Stormwater wetlands can act as a heat sink, especially during the summer, and discharge warmer waters to downstream water bodies. The increased temperatures can negatively impact sensitive fish species and aquatic insects located downstream. Avoidance of the use of wetlands with temperature sensitive downstream species is recommended. Regardless of the sensitivity of downstream species, the designer should still take precautions in the design of wetlands to reduce the magnitude of warming in the wetland. The adverse impact can be minimized through careful design. Several possible remedies to each of the negative impacts (e.g., upstream degradation, stream warming, etc.) described are suggested in the publication *Design of Stormwater Wetland Systems* (MWCOG, 1992).

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STORM WATER BMP: VEGETATIVE COVERS

MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

This Best Management Practice (BMP) involves preserving existing vegetation or revegetating disturbed soil as soon as possible after land disturbance activities in order to control erosion and dust. Vegetative covers include sod, temporary and permanent seeding and other vegetative covers, as well as preservation of existing vegetation. Sod is a strip of permanent grass cover placed over disturbed areas to provide an immediate and permanent turf that both stabilizes the soil surface and eliminates sediment due to erosion, mud, and dust. Temporary vegetative cover involves planting grass seed immediately after rough grading to provide protection until establishment of final cover. Permanent vegetative cover is the establishment of perennial vegetation in disturbed areas. Preservation of natural vegetation (existing trees, vines, bushes, and grasses) provides a natural buffer zone during land disturbance activities.

Vegetative covers provide dust control and a reduction in erosion potential by increasing infiltration, trapping sediment, stabilizing the soil, and dissipating the energy of hard rain. Application of mulch may be required for seeded areas. Mulch is the application of plant residues or other suitable materials to the soil surface to protect the soil surface from rain impact and the velocity of stormwater runoff.

APPLICATIONS

Vegetative covers are applicable to all land uses. Soils, topography, and climate will be determinants in the selection of appropriate tree, shrub, and ground cover species. Local climatic conditions determine the appropriate time of year for planting. Temporary seeding should be performed on areas disturbed by construction left exposed for several weeks or more. Permanent seeding and planting is appropriate for any graded or cleared area where long-lived plant cover is desired. Some areas where permanent seeding is especially important are filter strips, buffer areas, vegetated swales, steep slopes, and stream banks. Design criteria for vegetative covers is included in Table 1 below.

LIMITATIONS

Limitations of vegetative covers as a BMP include:

- The establishment of vegetative covering must be coordinated with climatic conditions for proper establishment. For example, cold climate areas have limited growing seasons and arid regions require careful selection of species.

- The key to proper performance is implementation of a maintenance program to ensure healthy vegetative covering.

PERFORMANCE

Qualitatively, vegetative covers are clearly effective in controlling dust and erosion when properly implemented. The amount of runoff generated from vegetated areas is considerably reduced and is of better quality than from unvegetated areas. However, it is not possible, based on data currently available, to quantify the water quality benefits of the vegetative coverings as a BMP.

TABLE 1; DESIGN CRITERIA FOR VEGETATIVE COVERS

Measure	Extent and Material	Dimensions	Hydraulic	Avoid	Miscellaneous
Temporary Seeding	Place topsoil as needed to enhance plant growth. A loamy soil with an organic content of 1.5 percent or greater is preferred. Use rapid-growing annual grasses, small grains, or legumes. Apply seeds using a cyclone seeder, drill, cultipacker seeder, or hydroseeder.	Place topsoil, where needed, to a minimum compacted depth of 2 inches on 3:1 slopes or steeper, and of 4 inches on flatter slopes.	Divert channelized flow away from temporarily seeded areas to prevent erosion and scouring.	Heavy clay or organic soils as topsoil. Hand-broadcasting of seeds (not uniform), except in very small areas. Mowing temporary vegetation. High-traffic areas.	Use where vegetative cover is needed for less than 1 year. Use chisel plow or tiller to loosen compacted soils. As needed, apply water, fertilizer, lime, and mulch. Incorporate lime and fertilizer into top 4-6 inches of soil. Plant small grains 1 inch deep. Plant grasses and legumes 1/2-inch deep.
Permanent Seeding	Place topsoil as needed to enhance plant growth. A loamy soil with an organic content of 1.5 percent or greater is preferred. Where possible, use low maintenance local plant species. Apply seeds using a cyclone seeder, drill, cultipacker seeder, or hydroseeder.	Apply mulch to slopes 4:1 or steeper, if soil is sandy or clayey or if weather is excessively hot or dry. Place topsoil where needed.	Divert channelized flow away from seeded areas to prevent erosion and scouring.	Heavy clay or organic soils as topsoil. Hand-broadcasting of seeds (not uniform), except in very small areas. High traffic areas.	Use chisel plow or tiller to loosen compacted soils. As needed, apply water, fertilizer, lie, and mulch. Incorporate lime and fertilizer into top 4-6 inches of soil. Plant small grains 1 inch deep. Plant grasses and legumes 1/2-inch deep.

SOURCE: Reference L.

TABLE 1: DESIGN CRITERIA FOR VEGETATIVE COVERS (Continued)

Measure	Extent and Material	Dimensions	Hydraulic	Avoid	Miscellaneous
Mulching	Prefer Organic mulches such as straw (from wheat or oats), wood chips, and shredded bark. Commercial mats and fabrics may also be very effective. Chemical soil stabilizers or binders are less effective, but may be used to tack wood fiber mulches.	Application rates (per acre): straw, one to two tons; wood chips, five to six tons; wood fiber, 0.5 to one ton; bark, 35 cubic yards; asphalt (spray), 0.10 gallon per square yard. After spreading much, less than 25 percent of the ground surface should be visible.	–	–	Mulch may be applied by machine or by hand. Chemical mulches and wood fiber mulches, when used alone, often do not provide adequate soil protection. Use nets or mats in areas subject to water flow. Anchor mulch by punching into soil, or by applying chemical agents, nets, or mats. ?Secure nets and mats with 6 inches or longer. No. 8 gauge or heavier, wire staples placed at 3-foot intervals

SOURCE: Reference 1.

TABLE 1: DESIGN CRITERIA FOR VEGETATIVE COVERS
(Continued)

Measure	Extent and Material	Dimensions	Hydraulic	Avoid	Miscellaneous
Sodding	Sod should be machine-cut at a uniform thickness of 1/2 to 2 inches.		In waterways, select plant types able to withstand design flow velocity.	Gravel or nonsoil surfaces. Unusually wet or dry weather. Frozen soils. Mowing for at least two to three weeks.	Prior to laying sod, clear soil surface of debris, roots, branches, and stones bigger than 2 inches in diameter. Sod should be harvested, delivered, and installed within 36 hours. Lay sod with staggered joints along the contour. Lightly irrigate soils before sod placement during dry or hot periods. After placement, roll sod and wet soil to a depth of 4 inches. On slopes steeper than 3:1, secure sod with stakes. In waterways, lay sod perpendicular to water flow. Secure sod with stakes, wire, or netting.
Preservation of Natural Vegetation	Careful planning is required prior to start of construction.	Wherever possible, maintain existing contours.	Maintain existing hydraulic characteristics.	Activities within the drop line of trees. Concentrating flows at new locations.	Preservation of vegetation should be planned before any site disturbance begins. Proper maintenance is vitally important. Clearly mark areas to be preserved.

SOURCE: Reference 1.

MAINTENANCE

Areas should be checked following each rain to ensure that seed, sod, and mulch have not been displaced. Staking the sod or netting for seeded areas may be required.

Newly sodded areas need to be inspected frequently for the first new months to ensure the sod is maturing. Failures may be due to improper conditioning of the subsoil, lack of irrigation, improper staking, or improper placement of sod pieces.

Newly seeded areas need to be inspected frequently for the first few months to ensure the grass is growing at a proper rate and density. If the seeded area is damaged, determine the cause of the damage before repeating seed bed preparation and seeding procedures.

Once a vegetative cover has been established, it is important to water the sod frequently and uniformly. If the grass is to be mowed, keep grass to a height appropriate for the species selected and the intended use. Occasional soil tests should be collected and analyzed to determine if the soil is appropriately fertilized. Weed control should only be done if absolutely required. Spot seeding should be done to small and damaged areas.

COSTS

Cost estimates for sodding, seeding, and mulching are provided in Table 2 below. These costs were developed by the Southeastern Wisconsin Regional Planning Commission (1991). Please note that costs very depending on local conditions.

TABLE 2: INSTALLATION COSTS

Description	Unit	Material	Labor	Equipment	Indirect Cost	Total Cost	Year of Cost	Comments
Sodding								
Level								
>400 square yards	Square yard	$0.98	$0.85	$0.17	$0.56	$2.56	January 1989	--
100 square yards	Square yard	1.36	1.07	0.22	0.70	3.35		
50 square yards	Square yard	1.95	1.14	0.23	0.80	4.12		
Slopes								
400 square yards	Square yard	1.03	1.19	0.24	0.72	3.18		
Seeding								
Mechanical Seeding	Acre	$410.00	$435.00	$165.00	$290.00	$1,300.00	January 1989	--
	Square yard	0.08	0.09	0.03	0.06	0.26		
Fine Grade/Seed	Square yard	0.15	0.85	0.17	0.48	1.65		Includes fertilizer and lime
Push Spreader								
Grass Seed	1,000 square feet	$8.60	$0.67	$0.26	$1.22	$10.75	January 1989	--
Limestone	1,000 square feet	2.05	0.67	0.26	0.58	3.56		
Fertilizer	1,000 square feet	5.40	0.67	0.26	0.92	7.25		
Level Areas	Acre	578.21	149.30	80.63	251.00	1,059.14	Mid-1988	--
Sloped Areas	Acre	578.21	238.88	129.00	328.75	1,274.84		
Mulching								
Hay	Acre	$255.76	$74.65	$40.31	$118.50	$489.22	Mid-1988	--
	Square yard	--	--	--	--	0.58 0.25-1.00	1983	Average Typical range

NOTE: Total cost includes operation and maintenance, taxes, insurance and other contingencies.

SOURCE: Modified from Reference 4.

ENVIRONMENTAL IMPACTS

None for proper installation of vegetative covers. However, care must be taken to avoid contamination of run off and ground water from over use of fertilizers, weed control herbicides and other hazardous chemicals.

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5. U.S. EPA, Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices, September,1992.

6. Washington State Department of Ecology, Stormwater Management Manual for the Puget Sound Basin, February 1992.

This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: VEGETATED SWALES

DESCRIPTION

Vegetated swales are natural or man made, broad, shallow channels with a dense stand of vegetation covering the side slopes and main channel. Vegetated swales trap particulate pollutants (total suspended solids and trace metals), promote infiltration, and reduce the flow velocities of stormwater runoff. Figure 1 below illustrates an example of a vegetated swale.

Vegetated swales can serve as an integral part of an area's minor stormwater drainage system by replacing curbs and gutters and storm sewer systems in low-density residential, industrial, and commercial areas. The swale's advantages over a storm sewer system generally include reduced peak flows, increased pollutant removal, and lower capital costs. However, vegetated swales typically have a limited capacity to accept runoff from large storm, since high velocity flows can cause erosion of the swale or damage the vegetated cover.

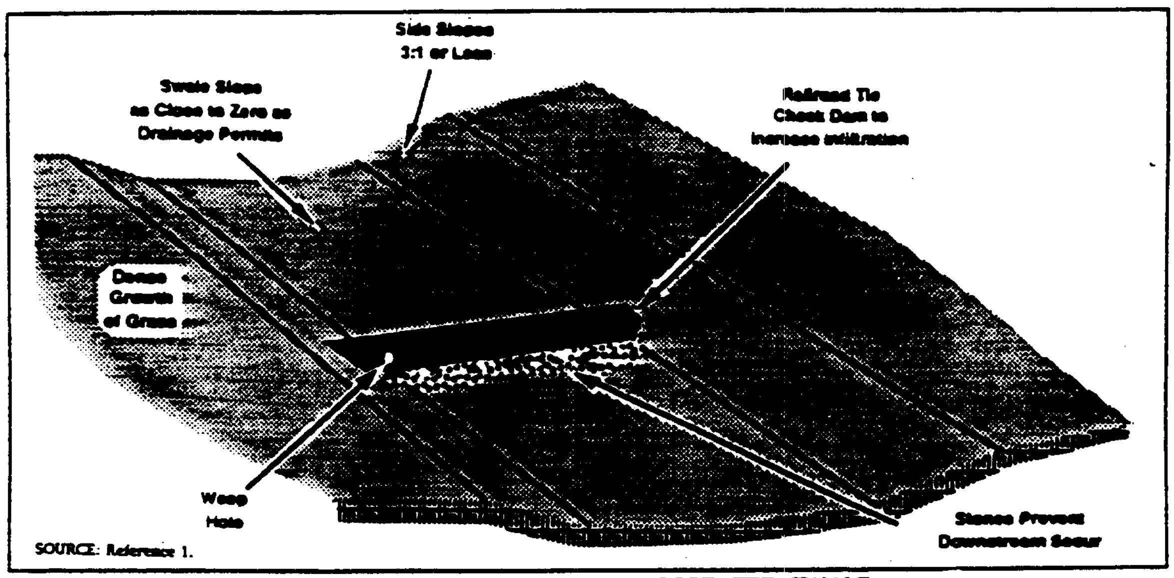


FIGURE 1: EXAMPLE OF A VEGETATED SWALE

COMMON MODIFICATIONS

The effectiveness of vegetated swales can be enhanced by adding check dams approximately every 50 feet to increase storage, decrease flow velocities, and promote particulate settling. Structures to skim off floating debris may also be added. Incorporating vegetated filter strips parallel to the top of the channel banks can also help to treat sheet flows entering the swale.

CURRENT STATUS

Vegetated swales are relatively easy to design and incorporate into a site drainage plan. While swales are not generally used as a stand alone Stormwater Best Management Practice (BMP), they are very effective when used in conjunction with other BMP's such as wet ponds, infiltration strips, wetlands, etc.

APPLICATIONS

Vegetated swales can be used in all regions of the country where climate and soils permit the establishment and maintenance of a dense vegetative cover. The suitability of a vegetated swale at a particular site depends on the area, slope, and imperviousness of the contributing water shed, as well as the dimensions, slope, and vegetative covering employed in the swale system.

GENERAL LIMITATIONS

The limitations of vegetated swales include:

- Vegetated swales are generally impractical in areas with very flat grades, steep topography, or wet or poorly drained soils.
- Swales provide minimal water quantity and quality benefits when flow volumes and/or velocities are high.
- Swales may pose a potential drowning hazards, create mosquito breeding areas, and cause odor problems.
- The use of vegetated swales may be limited by the availability of land.
- Many local municipalities prohibit the use of vegetated swales if peak discharges exceed five cubic feet per second (cfs) or flow velocities are greater than three feet per second (fps).
- Vegetative swales are generally impractical in areas with erosive soils or where a dense vegetative cover is difficult to maintain.
- Certain quantitative aspects of vegetated swales are not known at this time. These include whether pollutant removal rates of swales decline with age, the effect of slope on the filtration capacity of vegetation, the benefit of check dams, and the degree to which design factors can enhance the effectiveness of pollutant removal.

PERFORMANCE

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants, such as suspended solids and trace metals. For example, three grass swales in the Washington, DC, area were monitored by the Nationwide Urban Runoff Program (NURP). NURP found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height. A Durham, NC, project monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project monitored 11 storm and concluded that particulate concentrations of heavy metals (Cu,Pb,Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients. A conservative estimate is that properly designed vegetated swales may achieve a 25 to 50 percent reduction in particulate pollutants, including sediment and sediment-attached phosphorus, metals, and bacteria. Lower removal rates (less than 10 percent) can be expected for dissolved pollutants, such as soluble phosphorus, nitrate, and chloride.

The literature suggest that vegetated swales represent a practical and potentially effective technique for control of urban runoff quality. While limited quantitative performance data exists for vegetated swales, some known positive factors for pollutant removal are check dams, flatter slopes, permeable soils, dense grass cover, longer contact time, and smaller storm events. Negative factors include compacted soils, short runoff contact time, larger storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

The useful life of a vegetated swale system is directly proportional to the effectiveness and frequency of maintenance. If properly designed and regularly maintained, vegetated swales can last an indefinite period of time.

DESIGN CRITERIA

Although specific quantitative performance data for vegetated swales is limited, design criteria have been established for implementation of the vegetated swales and is presented below.

- Location. Vegetated swales are typically located along property boundaries, although they can be used effectively wherever the site provides adequate space. Swales can be used in place of curbs and gutters along parking lots.

- Soil Requirements. Gravelly and coarse sandy soils that cannot easily support dense vegetation should be avoided. If available, alkaline soils and subsoils should be used to promote the removal and retention of metals. Soil infiltration rates should be greater than one-half inch per hour, therefore, care must be taken to avoid compacting the soil during construction.

- Vegetation. Fine, close-growing, water-resistant grass should be selected for use in vegetated swales. Dense vegetation maximizes water contact, improving the effectiveness of the swale system. The vegetation should be selected on the basis of pollution control objectives and the ability to thrive in the conditions present in the conditions present at the site. Some examples of vegetation appropriate for swales include reed canary grass, grass-legume mixtures, and red fescue.

- General Channel Configuration. It is recommended that a parabolic or trapezoidal cross-section with side slopes no steeper than 3:1 be used, maximizing the wetted, channel perimeter. Recommendations for longitudinal channel slopes vary within the existing literature. For example, Shuler (1987) recommends a vegetated swale slope as close to zero as drainage permits. The Minnesota Pollution Control Agency (1989) recommends that the channel slope be less than 2 percent. The Stormwater Management Manual for the Puget Sound Basis (1992) specifies channel slopes between 2 and 4 percent; slopes of less than 2 percent can be used if drain tile is incorporated into the design, and slopes greater than 4 percent can be used if check dams are placed in the channel to reduce flow velocity.

- Drainage Area. The maximum flow rate (Q) to the swale can be calculated using the Rational Formula, depending on the size of the drainage area (A), the percentage of the drainage area that is impervious (C) and the rainfall intensity (I) for the design storm.

$$Q = CiA$$

A typical design storm used for sizing swales is a six-month frequency, 24- hour storm event. The exact intensity must be calculated for your location and is generally available from the US Geological Survey (USGS). Swales are generally not used where the maximum flow rate exceeds 5 cfs.

- Sizing Procedures. The width of the swale can be calculated using various forms of the Manning equation. However, this methodology can be simplified to the following rule of thumb: the total surface area of the swale should be 500 square feet for each acre that drains to the swale.

Unless a bypass is provided, the swale must be sized as both a treatment device and to pass the peak hydraulic flows. But to be most effective as a treatment device, the depth of the stormwater should not exceed the height of the grass in the swale.

Design Parameters. Based on limited research, swales can generally be designed using the following parameters:

1. Minimum grass height of 6 inches (Figure 2).

2. Maximum depth of stormwater during the design storm of 4 inches (Figure 2).

3. Maximum flow in the swale of 5 cfs.

4. Maximum velocity in the swale of 3 fps.

5. Channel slope between 2 and 5 percent.

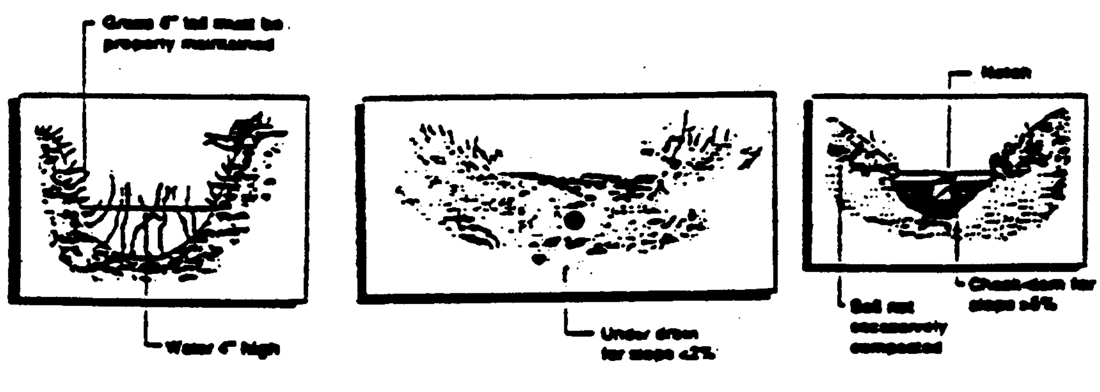
   - Slopes of less than 2 % can be used if the swale is drained to prevent ponding (Figure 2).

   - Slopes of more than 5 % can be used if check dams are placed in the swale to maintain channel velocity below 3 fps (Figure 2).

6. To provide maximum long term treatment effectiveness, the swale width should be calculated using a design flow of 0.2 cfs per acre of area draining into the swale. However, the minimum width is 18 inches.

7. If a by-pass is not provided, the channel width and/or height should be increased, if needed, to pass peak hydraulic flows.

8. In order to provide adequate treatment, the swale should have a minimum length of 200 feet. If a shorter length must be used, the width should be increased proportionally to maintain a treatment surface area of at least 500 square feet, as discussed above. However, the minimum length is 25 feet.



SOURCE: Reference 3.

FIGURE 2: DESIGN PARAMETERS

- Construction. The subsurface of the swale should be carefully constructed to avoid compaction of the soil. Compacted soil reduces the infiltration and inhibits growth of the grass. Damaged areas should be restored immediately to ensure that the desired level of treatment is maintained and to prevent further damage due to erosion of exposed soil.

- Check Dams. Check dams can be installed in swales to promote additional infiltration, increase storage, and reduce velocities. The check dam may be a railroad tie embedded into the swale with riprap placed on the downstream side of the tie to prevent a scour hole from forming. Earthen check dams are not recommended because of their potential to erode. Check dams should be installed every 50 feet if longitudinal slope exceeds 4 percent.

MAINTENANCE

The primary swale maintenance objectives are to maintain the hydraulic efficiency of the channel and maintain a dense, healthy grass cover. Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), Weed control, watering during drought conditions, reseeding bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should be removed periodically. Application of fertilizers and pesticides should be minimal, if required.

Research has not yet identified proper mowing strategies. However, mowings during the spring and summer should keep the grass at the 6" design height. In some commercial applications where 6" may cause an aesthetic problem the grass can be cut to 4" but the last mowing of the season should not be below 6". Mowing encourages growth thereby improving the removal of soluble pollutants. The final mowing should occur near the end of the growth season. Failure to remove the growth before the dormant season will cause a loss of pollutants back to the stormwater.

Any damage to the channel such as rutting must be repaired with suitable soil, properly tamped and seeded. The grass cover should be thick; if it is not reseeding as necessary.

Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (ie, silt, grass cuttings, etc.) must be disposed of in accordance with local or state requirements.

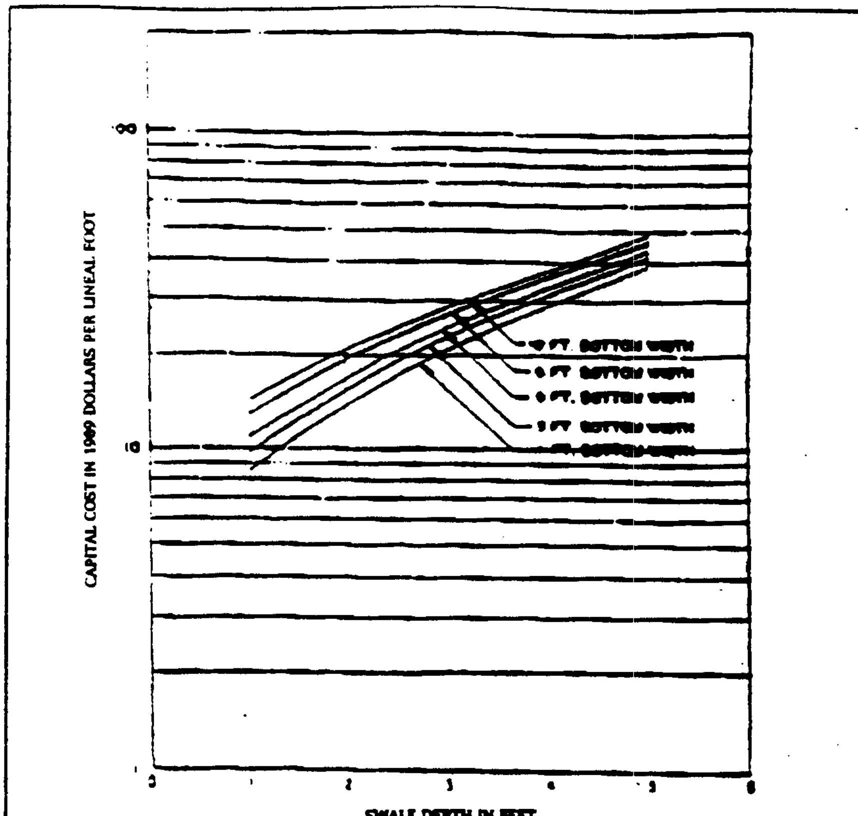
COSTS

Vegetated swales typically cost less to construct than curbs and gutters or underground storm sewers. Shuler (1987) reported that costs may vary from $4.90 to $9.00 per lineal foot for a 15-foot wide channel (top width).

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) reported that costs may vary from $8.50 to $50.00 per lineal foot depending upon swale depth and bottom width (1991). The SEWRPC cost estimates are higher than other published estimates because they include the cost of activities such as clearing, grubbing, leveling, filling, and sodding, which may not be included in many of the reported costs. Construction costs depend on specific site considerations and local costs for labor and materials. The Table 1 below shows estimates capital cost of a vegetated swale.

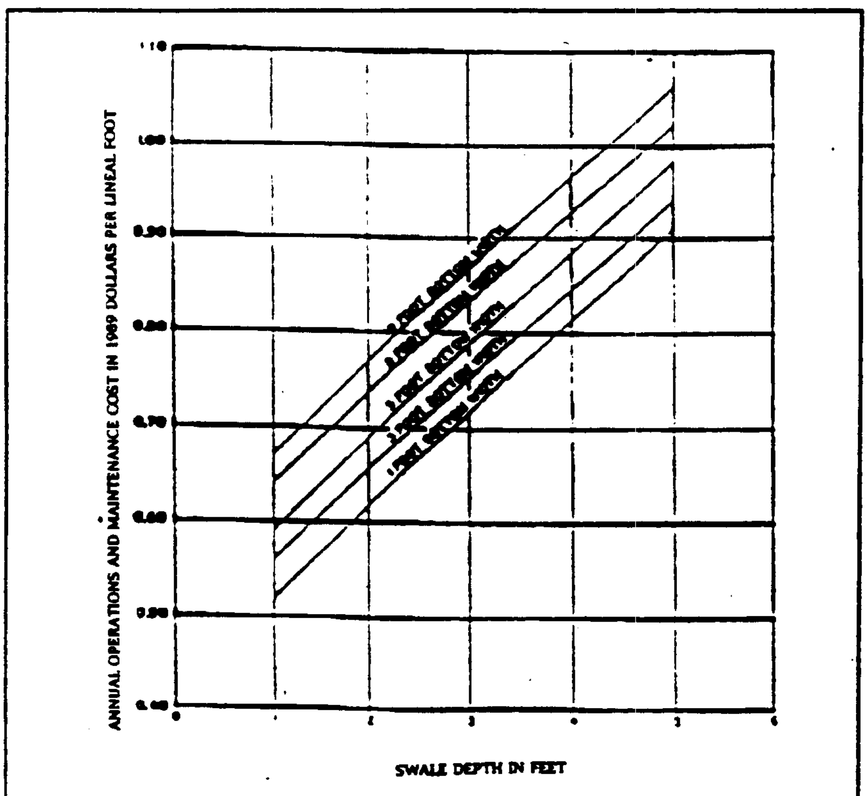
Annual costs associated with maintaining vegetated swales are approximately $0.58 per lineal foot for a 1.5-foot deep channel, according to SEWRPC (1991). Estimated average annual operating and maintenance costs of vegetated swales can be estimated using Table 2 below.

TABLE 1: ESTIMATED CAPITAL COSTS



SOURCE: Reference 4.

TABLE 2: ESTIMATED O & M COSTS



SOURCE: Reference 4.

ENVIRONMENTAL IMPACTS

Negative environmental impacts of vegetated swales may include:

- Leaching from culverts and fertilized lawns may increase the presence of trace metals and nutrients in the runoff.
- Infiltration through the swale may affect local groundwater quality.
- Standing water in vegetated swales can result in potential safety, odor, and mosquito problems.

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1. U.S. EPA, A Current Assessment of Best Management Practices; Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone, December 1991.

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This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: VISUAL INSPECTIONS

EPA MTB
Office of Wastewater Enforcement & Compliance
MUNICIPAL TECHNOLOGY BRANCH

DESCRIPTION

Visual inspection is the process by which members of a Stormwater Pollution Prevention Team (SWPPT) visually inspects stormwater discharge from material storage and outdoor processing areas to identify contaminated stormwater and its possible sources.

An example of a visual inspection is examination within the first hour of a storm event that produces significant stormwater runoff for the presence of floating and suspended materials, oil and grease, discolorations, turbidity, odor, or foam. Another example would be to examine a raw materials storage area where materials are stored in 55-gallon drums and look for leaks, discolorations, or other abnormalities that may cause a pollutant to contaminate stormwater runoff.

CURRENT STATUS

The U.S. EPA has recognized visual inspections as a baseline Best Management Practice (BMP) for over 10 years. Its implementation across the country, however, has been sporadic. Stormwater Pollution Prevention Plan (SWPPP) development will increase implementation of visual inspections in the future as facility management recognizes it to be an effective BMP from a water quality and cost savings perspective.

LIMITATIONS

Limitations associated with visual inspections include:

- Inspections are limited to those areas clearly visible to the human eye
- Visual inspections need to be performed by qualified personnel
- Lack of a corporate commitment to actively implement inspections on a routine basis
- Inspectors need to be properly motivated to perform a thorough visual inspection.

PERFORMANCE

The performance of visual inspections as an effective tool in reducing stormwater runoff contamination is highly variable and dependent upon site-specific parameters such as industrial activity occurring at the facility, maintenance procedures, and employees. Currently there is no quantitative data regarding the effectiveness of visual inspections as a BMP.

DESIGN CRITERIA

Visual inspections should be performed routinely for the presence of non-stormwater discharges. Flows during a dry period should be observed to determine the presence of any dry weather flows, stains, sludges, odors, and other abnormal conditions.

Visual inspections should be made of all stormwater discharge outlet locations during the first hour of a storm event that produces a significant amount of stormwater runoff. In geographic locations with a high frequency of storm events, inspections should be performed at least once per month. Inspection for the presence of floating and suspended materials, oil and grease, discolorations, turbidity, foam, and odor should be performed.

The inspection frequency interval is a key design criterion in a visual inspection program. To determine the inspection frequency, experienced personnel should evaluate the causes of previous incidents and assess the probable risks for occurrence in the future. Conditions in the stormwater discharge permit may also dictate inspection frequency.

Another key design criterion is proper record keeping of an inspection. Record keeping should include the date of the inspection, the names of the personnel who performed the inspection, and the observations made during the inspection. Records should be forwarded to appropriate personnel through an internal reporting system. Remedial modifications to a facility can then be implemented based on documented inspections.

Visual inspections of a facility should focus on the following key areas:

- Storage facilities
- Transfer pipelines
- Loading and unloading areas
- Pipes, pumps, valves, and fittings
- Internal and external inspection for tank corrosion
- Wind blowing of dry chemicals
- Tank support or foundation deterioration
- Deterioration of primary or secondary containment facilities
- Damage to shipping containers
- Wind blowing of dry chemicals and dust particles
- Integrity of stormwater collection system
- Leaks, seepage, and overflows from sludge and waste disposal sites

IMPLEMENTATION

A visual inspection BMP program should be incorporated within the facility's record keeping and internal reporting BMP structure. Estimates of outfall flow rates, and noting the presence of oil sheens, floatables, coarse solids, color, odors, etc. will probably be the most useful indicators of potential problems. Specific parameters to look for in completing a visual inspection include:

- Odor--The odor of a discharge can vary widely and sometimes directly reflects the source of contamination. Industrial discharges will often cause the flow to smell like a particular spoiled product, oil, gasoline, specific chemical, or solvent. As an example, for many industries, the decomposition of organic wastes in the discharge will release sulfide compounds into the air above the flow in the sewer, creating an intense smell of rotten eggs. In particular, industries involved in the production of meats, dairy products, and the preservation of vegetables or fruits, are commonly found to discharge organic materials into storm drains. As these organic materials spoil and decay, the sulfide production creates this highly apparent and unpleasant smell. Significant sanitary wastewater contributions will also cause pronounced and distinctive odors.

- Color--Color is another important indicator of inappropriate discharges, especially from industrial sources. Industrial discharges may be of any color. Dark colors, such as brown, gray, or black, are most common. For instance, the color contributed by meat processing industries is usually a deep reddish-brown. Paper mill wastes are also brown. In contrast, textile wastes are varied. Other intense colors, such as plating-mill wastes, are often yellow. Washing of work areas in cement and stone working plants can s\cause cloudy discharges. Potential sources causing various colored contaminated waters from industrial areas can include process waters (slug or continuous discharges), equipment and work area cleaning water discharged to floor drains, spills during loading operations (and subsequent washing of the material into the storm drains).

- Turbidity--Turbidity of water is often affected by the degree of gross contamination. Industrial flows with moderate turbidity can be cloudy, while highly turbid flows can be opaque. High turbidity is often a characteristic of undiluted industrial discharges, such as those coming from some continual flow sources, or some intermittent spills. Sanitary wastewater is also often cloudy in nature.

- Floatable matter--A contaminated flow may also contain floatables (floating solids or liquids). Evaluation of floatables often leads to the identity of the source of industrial or sanitary wastewater pollution, since these substances are usually direct products or byproducts of the manufacturing process, or distinctive of sanitary wastewater. Floatables of industrial origin may include substances such as animal fats, spoiled food products, oils, plant parts, solvents, sawdust, foams, packing materials, or fuel, as examples.

- Deposits and Stains--Deposits and stains (residue) refer to any type of coating which remains after a non-stormwater discharge has ceased. They will cover the area surrounding the stormwater discharge and are usually of a dark color. Deposits and stains often will contain fragments of floatable substances and, at times, take the form of a crystalline or amorphous powder. These situations are illustrated by the grayish-black deposits that contain fragments of animal flesh and hair which often are produced by leather tanneries, or the white crystalline powder which commonly coats sewer outfalls due to nitrogenous fertilizer wastes.

- Vegetation--Vegetation surrounding a stormwater discharge may show the effects of the wastewater. Industrial pollutants will often cause a substantial alteration in the chemical composition and Ph of the discharge water. This alteration will affect plant growth, even when the source of contamination is intermittent. For example, decaying organic materials coming from various food product wastes would cause an increase in plant life. In contract, the discharge of chemical dyes and inorganic pigments from textile mills could noticeably decrease vegetation, as these discharges often have a very acidic Ph. In either case, even when the cause of industrial pollution is gone, the vegetation surrounding the discharge will continue to show the effects of the contamination.

  In order to accurately judge if the vegetation surrounding a discharge is normal, the observer must take into account the current weather conditions, as well as the time of year in the area. Thus, flourishing or inhibited plant growth, as well as dead and decaying plant like, are all signs of pollution or scouring flows when the condition of the vegetation just beyond the discharge disagrees with the plant conditions near the discharge. It is important not to confuse the adverse effects of high stormwater flows on vegetation with highly toxic flows. Poor plant growth could be associated with scouring flows occurring during storms.

Structural Damage--Structural damage is another readily visible indication of industrial discharge contamination. Cracking, deterioration, and spalling of concrete or peeling of surface paint, occurring at an outfall are usually caused by severely contaminated discharges, usually of industrial origin. These contaminants are usually very acidic or basic in nature. For instance, primary metal industries have a strong potential for causing structural damage because their batch dumps are highly acidic. Poor construction, hydraulic scour, and old age may also adversely affect the condition of structures.

Implementation of visual inspections should be assigned to qualified staff such as maintenance personnel or environmental engineers. Figure 1 provides a sample visual evaluation worksheet which can be used to record the results of the inspections.

Outfall # _______ Photograph # _______ Date: ____________

Location: ____

Weather: air temp.: ___ °C rain: Y N sunny cloudy

Outfall flow rate estimate: ____ L/sec

Known industrial or commercial uses in drainage area? Y N
describe: ____

PHYSICAL OBSERVATIONS:

Odor: none sewage sulfide oil gas rancid-sour other:_____

Color: none yellow brown green red gray other:_______

Turbidity: none cloudy opaque

Floatables: none petroleum sheen sewage other:______ (collect sample)

Deposits/stains: none sediment oily describe:________ (collect sample)

Vegetation conditions: normal excessive growth inhibited growth
extent: ______________________________________

Damage to outfall structures:
identify structure: ______________________________
damage: none / concrete cracking / concrete spalling / peeling paint / corrosion
other damage: ___________________________________
extent: ______________________________________

SOURCE: Reference 4.

FIGURE 1: VISUAL INSPECTION WORKSHEET

MAINTENANCE

Maintenance involved with visual inspections as a BMP include developing a schedule for performing visual inspections and follow-up to make sure the inspections are performed on schedule. Continual record updates need to be performed with each inspection, and properly routed through the internal reporting structure of a SWPPT.

COSTS

Costs are those associated with direct labor and overhead costs for staff hours. Annual costs can be estimated using the example in Table 1 below. Figure 2 can be used as a worksheet to calculate the estimated annual cost for implementing a visual inspection program.

TABLE 1: EXAMPLE OF ANNUAL VISUAL INSPECTION PROGRAM COSTS

Title	Quantity		Avg. Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)
Stormwater Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
					TOTAL ESTIMATED ANNUAL COST				$12,600

Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with payroll expenses, building expenses, etc.

SOURCE: EPA

Title	Quantity		Avg. Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Est. Annual Cost ($)	
______	____	x	____	x	____	x	____	=	____	(A)
______	____	x	____	x	____	x	____	=	____	(B)
______	____	x	____	x	____	x	____	=	____	(C)
______	____	x	____	x	____	x	____	=	____	(D)
					TOTAL ESTIMATED ANNUAL COST (Sum of A+B+C+D)				____	

SOURCE: Reference 3.

FIGURE 2: SAMPLE ANNUAL VISUAL INSPECTION PROGRAM COST WORKSHEET.

ENVIRONMENTAL IMPACTS

Visual inspections is an effective way to identify a variety of problems. Correcting these problems can have a significant impact on improving water quality in the receiving water.

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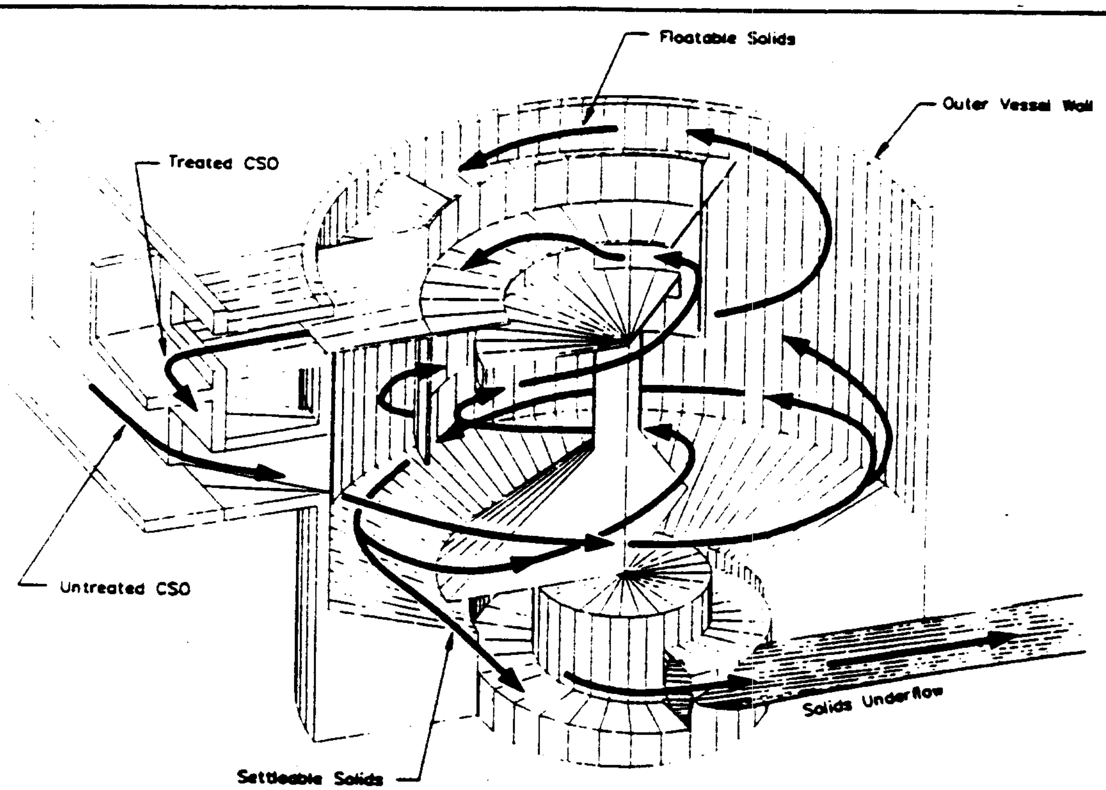
This BMP fact sheet was prepared by the Municipal Technology Branch (4204), US EPA, 401 M Street, SW, Washington, DC 20460.

STORM WATER BMP: VORTEX SOLIDS SEPARATOR

DESCRIPTION

A vortex solids separator is a wastewater treatment technology with no moving parts which uses velocities imparted from vortex swirling to assist the settling and removal of concentrated solids. During a storm event, flow enters the cylindrical unit tangentially and induces a swirling vortex which concentrates solids in the underflow and reduces their concentration in the clarified liquid. A general view of the vortex solid separator and liquid flow paths is shown in Figure 1 below.



SOURCE: Reference 19

FIGURE 1: GENERAL VIEW OF THE VORTEX SOLID SEPARATOR

Vortex units are most often applied to combined sewer overflow (CSOs), but can also be used to treat storm water runoff. In CSO treatment applications, the concentrated solids are removed from the bottom of the unit and conveyed via the sanitary sewer to a wastewater treatment plant (WWTP). In separate storm water applications, the concentrated underflow would likely go to a holding tank or pond. Effluent exits the top of the unit and is discharged to the receiving water. Vortex units may be used on-line or off-line, and in combination with other Best Management Practices (BMPs) such as storage tanks or detention ponds.

CURRENT STATUS

This fact sheet contains general information only, and should not be used as the basis for designing a vortex solids separators for storm water applications . While the basic vortex separator technologies used for CSO applications are well established, actual operating experience for storm water applications is limited. The three types of vortex solids separators currently being actively marketed in the United States are listed below. While all three types use the same basic principal, this fact sheet will discuss some of the differences in design and performance of the different units. The technology for storm water applications is evolving rapidly. The equipment manufacturers and the municipal operators should be contacted for the current state of the art information.

- The EPA Swirl Concentrator.
- The Fluidsep.
- The Storm King.

The design specifications for the EPA Swirl Concentrator were developed by the U.S. Environmental Protection Agency (EPA) in the early 1970s. Currently, there are 20 full-scale EPA Swirl Concentrator units in the U.S. and four in Japan (EPA, 1977). All of these units were designed for CSO treatment. However, the EPA Swirl Concentrator design was extensively tested during a study for separated storm water treatment in West Roxbury, Massachusetts in the early 1980s (EPA, 1982, 1984).

Fluidsep is a patented design that is licensed by a German firm, but is available in the U.S. There are 13 full-scale Fluidsep units operating in the U.S. and Europe, with additional units planned for construction. Fluidsep has been consistently used for CSO applications and has not been tested on separated storm-sewer systems.

Storm King, a patented unit, is available in the U.S. from H.I.L. Technology, Inc. There are no full-scale Storm King units in operation in the U.S. at this time. However, there are more than 100 Storm King treatment units in operation in Europe and Canada, almost exclusively on CSOs. Full-scale Storm King units have been selected by the City of Columbus to treat CSOs. Storm water treatment by the Storm King has been limited to a pilot study in Bradenton, Florida and a full-scale unit in Surrey Heath, England.

APPLICABILITY

Vortex separators are most effective where the separation of gritty materials, heavy particulates or floatables from wet-weather runoff is required. The technology is particularly well suited to locations where there is limited land availability which may preclude the use of other BMPs such as settling basins or detention ponds. Vortex separators can also be applied as satellite units to treat smaller subareas of the collection system, minimizing the high cost of conveyance systems needed for centralized treatment facilities. Units can be designed to remove solids and capture floatables. However, solids with poor settleability are not effectively removed in vortex solids separators.

LIMITATIONS

The use of vortex solids separators as a wet-weather treatment option may be limited by the poor net solids removal (10-34 percent). In some cases this level of solids removal may not meet the treatment objectives for a potential location. There is even less information on the ability of vortex solids separators to remove pollutants other than solids. Pollutants such as nutrients and metals that adhere to fine particulates or are dissolved will not be significantly removed by the vortex separator.

Site constraints, including the availability of suitable land, appropriate soil depth and stability to structurally support the unit, may also limit the applicability of the vortex separator. The slope of the site or collection system may dictate the use of an underground unit, which can result in extensive excavation. For above-ground units, pumping may be required. Maintaining and operating these pumping facilities will increase the capital costs as well as the energy, operations and maintenance cost of the vortex solids separator.

DESIGN

Regardless of the type of vortex separator selected, the type and quantity of pollutants to be removed must first be determined. The settleability characteristics and the quantity of flow to be treated will then established for proper design to achieve the desired treatment level. The settling characteristics of particulates anticipated in the influent are the basis of the design of all unit types.

The performance of each unit is based on the vortex separation mechanism. Each unit type has its own design criteria to achieve solids/liquids separation. The design of the EPA Swirl Concentrator is based on settleability studies developed in the 1970s. This information is available in the public domain from EPA design manuals (USEPA, 1977). Design of the Storm King units is based on pilot-scale treatability studies. Pilot-scale testing is conducted at each installation to select the appropriate full-scale unit design that best suits the intended application. The Fluidsep design is based on modeling of particulate settleability determined during site-specific studies, including flow gauging and rainfall measurements.

PERFORMANCE

Vortex separators designed primarily for removing grittier material, may have difficulty removing the less settleable solids often found in storm water runoff. For CSO applications, average total mass solids removals varied between 38%, at the EPA Swirl Concentrator facility in Washington, D.C., to 61%, at the Storm King pilot-study facility in Columbus, Georgia. For storm water runoff applications, average total mass solids removal was observed to be approximately 26%, at the pilot-scale Swirl Concentrator demonstration test in West Roxbury, Massachusetts. Average performance characteristics for the three different types of separators in shown in Table 1 below. This data is for CSO applications only.

Solids are removed in the underflow by flow splitting even if there is no concentration of particulates in the underflow from the vortex unit. The removal of solids in the underflow may account for a large portion of the total mass solids removed in the unit. To discount the solids removed by the underflow without concentration by the unit, net solids removals were determined. Net solids removals exclude from the total solids removal, the solids removed by the underflow by flow-splitting. Net solids removals for CSO applications, as shown in Table 1, were observed to a low of 7% for Tengen, Germany and a high of 34%, for Columbus, Georgia. The average net mass solids removal for separate storm water applications was observed to be a high of 17% for the EPA Swirl Concentrator tested at West Roxbury, Massachusetts and a low of 12% for the Storm King unit tested at Bradenton, Florida. However, the data for storm water runoff applications is not considered sufficient to allow for the evaluation of performance between unit designs and is not included in Table 1.

MAINTENANCE

Vortex separators do not have any moving parts, and are therefore not maintenance intensive. However, wash downs are required following every CSO event to prevent odors. To accomplish this, some

TABLE 1: AVERAGE VORTEX PERFORMANCE CHARACTERISTICS FOR CSO APPLICATIONS

Unit Type	Location	Effluent Hydraulic Flow (MGD)	Solids Reduction	Solids Removal	Total Net Treatment Removal	Factor
Swirl	Washington, DC	10	24	38	12	1.7
Fluidsep	Tengen, Germany	11	47	54	7	1.2
Storm King	James Bridge, UK	7.5	39	53	14	1.7
Storm King	Columbus, GA	4.3	23	61	34	2.6

SOURCE: References 10, 11, 20, and 21

units have been designed to be self-cleansing. This may not be necessary for storm water treatment applications. Pretreatment

BMPs such as bar screens or street sweeping can be used to decrease the quantity of wastes reaching the vortex separators, but it is not required. Maintenance would be required for pretreatment and pumping equipment.

COSTS

The capital cost for vortex solids separator treatment facilities are dependant on site-specific characteristics. Commonly, vortex solids separators are used with other treatment technologies such as automatic bar screens, and disinfection. The capital cost for vortex solids separator treatment facilities in the U.S. varies between $3,000 and $5,250 per acre of drainage basin (1993 dollars). Typically the capital cost for installed vortex solids separator units without pretreatment is approximately $4,900 per million gallons of flow treated (1993 dollars).

Total costs of vortex units often include predesign costs, capital costs and operation and maintenance (O&M) costs. Foe example, predesign study costs for the Storm King are typically $20,000 (1993 dollars). Predesign costs for the Fluidsep, range between $25,000 and $100,000 (1993 dollars). There are no predesign study costs associated with the EPA Swirl Concentrator, because published settleability curves are used for the basis of design.

Vortex solids separator units do not generally require significant energy expenditures unless pumping is required. Operating expenses primarily include labor for wash down or energy costs for automatic wash down or bar screens. However some installations such as the Storm King unit in Surry Heath, England, do not have a sanitary or foul sewer line for disposing of collected solids. These facilities must collect its residuals in a collection zone or holding tank. The frequency for pumping out the collected residuals will be dependent on the amount of material collected per storm, the number of storm events and the size of the holding zone or tank. The Surry Heath facility is estimating the holding zone will require pump out every 2-3 years. The cost for periodic emptying and disposal of the collected residuals is estimated to be between $300-450 per cleaning (1993 dollars).

ENVIRONMENTAL IMPACTS

Improvements can often be observer in water quality or in the health of the ecosystem. For example, the Washington, D.C. CSO Abatement Program, which includes EPA Swirl Concentrators and upstream storage, has resulted in decreased oxygen demands in the receiving water. Fish have returned to the once oxygen-depleted water. Much of the improved receiving water quality is attributable due to a combination of the upstream storage, and the bar screens, disinfection, and operation of the vortex units.

For CSO applications the vortex solid separators must be washed down after each storm events to prevent objectionable odors. Odor control for some storm water applications and for residual storage facilities may also be required. Collected residuals from storm water applications have not evaluated. However, collected residuals should be evaluated for toxicity and metals content before disposal.

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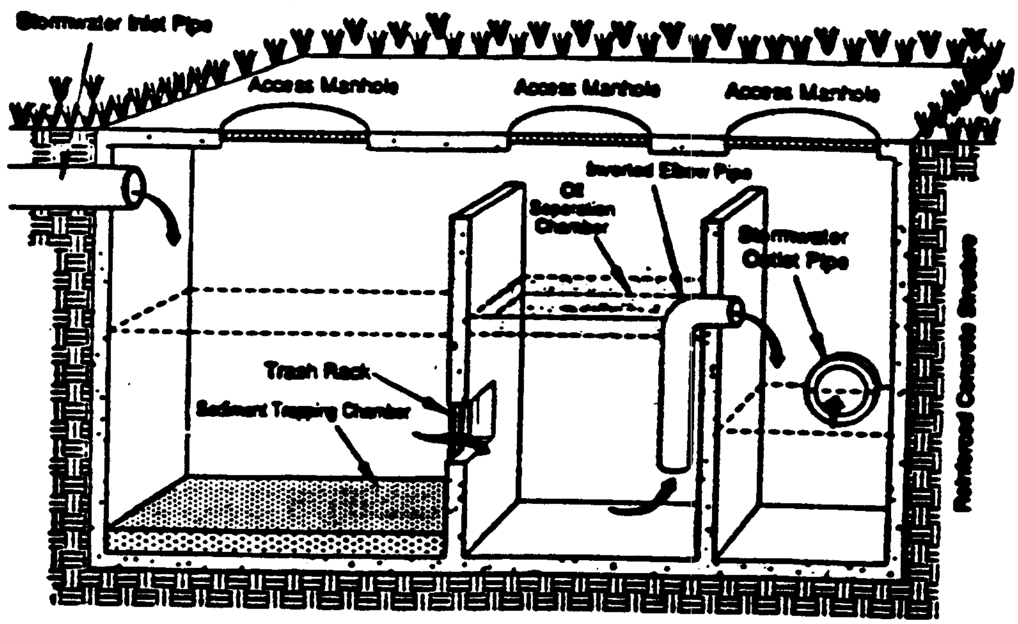
STORM WATER BMP: WATER QUALITY INLETS

DESCRIPTION

Water quality inlets (WQIs) consist of a series of chambers that allow sedimentation of coarse materials, screening of larger or floating debris, and separation of free oil (as opposed to emulsified or dissolved oil) from storm water. They capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs). A typical WQI, as shown in Figure 1 below, consists of a sediment chamber, an oil separation chamber and a discharge chamber. WQIs are also commonly called oil/grit separators or oil/water separators. WQIs can be purchased as a pre-manufactured unit or can be constructed on site.



SOURCE: Reference 3

FIGURE 1: PROFILE OF A TYPICAL WATER QUALITY INLET

COMMON MODIFICATIONS

The design of WQIs can be modified to improve their performance. Possible modifications include (1) an additional orifice and chamber that replace the inverted pipe elbow, (2) the extension of the second chamber wall up to the top of the structure, or (3) the addition of a diffusion device at the inlet. The diffusion device is intended to dissipate the velocity head and turbulence and distribute the flow more evenly over the entire cross-sectional area (API, 1990). Suppliers of pre-manufactured units (i.e., Highland Tank & Mfg., Jay R. Smith Mfg., etc.) can also provide modifications of the typical design for special conditions.

CURRENT STATUS

WQIs are widely used in the U.S.; however, recent studies indicate that the lack of regular maintenance adversely affect their performance. There is also some concern that, because the collected residuals contain hydrocarbon by-products, the residuals may be considered too toxic for conventional landfill disposal. Maintenance requirements and residual disposal, should be carefully evaluated in selecting a WQI. Possible alternatives to the WQI include sand filters, oil absorbent materials, and other innovative BMPs (i.e., Stormceptor System).

APPLICATIONS

WQIs are often used where land requirements and cost prohibit the use of larger BMP devices, such as ponds or wetlands. WQIs are also used to treat runoff prior to discharge to other BMPs. WQIs can be adapted to all regions of the country (Schueler, 1992), and are typically located in small, highly impervious areas, such as gas stations, loading areas or parking areas. Sites with high automotive related uses can be expected to have higher hydrocarbon concentrations than other land uses (MWCOG, 1993). Increased maintenance and residual disposal, due to these higher hydrocarbon concentrations from these areas, must be carefully evaluated before selecting a WQI for these applications.

LIMITATIONS

Two major constraints limit the effectiveness of WQIs. Theses constraints are (1) the size of the drainage area and (2) the activity within the drainage area. WQIs are generally recommended for drainage areas of 1 acre or less (Berg, 1991, NVPDC, 1992). Construction costs often become prohibitive for larger drainage areas. High sediment loads interfere with the ability of the WQI to effectively separate oil and grease from the runoff. Therefore, WQIs should not accept runoff from disturbed areas unless the runoff has been pretreated to reduce the sediment loads to acceptable levels.

WQIs are also limited by maintenance requirements and pollutant removal capabilities. Maintenance of underground WQIs can be easily neglected because the WQI is often "out of sight and out of mind." Regular maintenance is essential to ensuring effective pollutant removal. Lack of maintenance will often result in resuspension of settled pollutants. WQIs are most effective in removing heavy sediments and floating oil and grease. WQIs have demonstrated limited ability to separate dissolved or emulsified oil from runoff. WQIs are also not very effective at removing pollutants such as nutrients or metals, except where the metals are directly related to sediment removal.

PERFORMANCE

More than 95 percent of all WQIs operate as designed during their first 5 years. Very few structural or clogging problems or problems with the separation of the pollutants and water are experienced during that period. However, WQIs have a very poor record of pollutant removal due to a lack of regular clean-outs and the resuspension of the sediments (Schueler, 1992). The efficiency of oil and water separation in a WQI is inversely proportional to the ratio of the discharge rate to the unit's surface area (API, 1990). Due to the small capacity of the WQI, the discharge rate is typically very high and the detention time is very short, which can result in minimal pollutant settling. The average detention time in a WQI is less than 0.5 hour (MWCOG, 1993).

The WQI achieves slight, if any, removal of nutrients, metals and organic pollutants other than free petroleum products (Schueler, 1992). Grit and sediments are partially removed by gravity settling within the first two chambers. A WQI with a detention time of 1 hour may expect to have 20 to 40 percent removal of sediments.

The Metropolitan Washington Council of Governments (MWCOG) performed a long-term study to determine WQI performance and effectiveness. Monitoring of more than 100 WQIs indicated that less than 2 inches of sediments (mostly coarse-grained grit and organic matter) were trapped in the WQIs. Hydrocarbon and total organic carbon (TOC) concentrations of the sediments averaged 8,150 and 53,900 mg/kg, respectively. The mean hydrocarbon concentration in the WQI water column was 10 mg/L. The study also indicated that sediment accumulation did not increase over time, suggesting that the sediments become re-suspended during storm events (MWCOG, 1993). Although the design of the WQI effectively separates oil and grease from water, re-suspension of the settled matter appears to limit removal efficiencies. Actual removal occurs when the residuals are removed from the WQI (Schueler 1992).

DESIGN CRITERIA

Prior to WQI design, the site should be evaluated to determine if another BMP would be more cost-effective in removing the pollutants of concern. WQIs should be used where no other BMP is feasible. The site should be near a storm drain network so that flow can be easily diverted to the WQI for treatment (NVPDC, 1992). Construction activities within the drainage area should be completed and the drainage area should be revegetated so that the sediment loading to the WQI is minimized. Upstream sediment control measures should be installed to decrease the sediment loading.

WQIs are most effective for small drainage areas. Drainage areas of 1 acre or less are often recommended. WQIs are typically used in an off-line configuration (i.e., portions of runoff are diverted to WQI), but they can be used as an on-line unit (i.e., receive all runoff). Generally off-line units are designed to handle the first 0.5 inches of runoff from the drainage ares. Upstream isolation/diversion structures can be used to divert the water to the off-line structure (Schueler, 1992). On-line units receive higher flows that will likely cause increased turbulence and resuspension of settled material; thereby reducing WQI performance.

Chamber Design

Structural loadings should be considered in the WQI design (Berg, 1991). WQIs are available in pre-manufactured units or can be cast-in-place. Reinforced concrete should be used to construct below-grade WQIs. The WQIs should be water tight to prevent possible ground water contamination. The first and second chambers are generally connected by an opening covered by a trash rack or by a PVC or other suitable material pipe (Berg, 1991). If a pipe is used it should also be covered by a trash rack or screen. The opening or pipe between the first and second chambers should be designed to pass the design storm with out surcharging the first chamber (Berg, 1991). The design storm will vary depending on geographical location and is generally definite by local regulations.

When the combined length of the first two chambers exceeds 12 feet, the chambers are typically designed with the length of the first and second chamber being 2/3 and 1/3 of the combined length respectively. Each of the chambers should have a separate manhole to provide access for cleaning and inspection.

The State of Maryland design standards indicate that the combined volume of the first and second chambers should be determined based on 40 cubic feet per 0.10 acre draining to the WQI. In Maryland, this is equivalent to capturing the first 0.133 inch of runoff from the contributing drainage area. The combined volume includes the volume of the first and second chamber up to the top of the interior walls and the volume of the permanent pool (Berg, 1991).

Permanent pools within the chambers help prevent the possibility of sediment resuspension. The first and second chambers should have permanent pools with 4-foot depths. If possible, the third chamber should also contain a permanent pool (NVPDC, 1992).

In the standard WQI, an inverted elbow is installed between the second and third chamber. The elbow should extend a minimum of 3 feet into the second chamber's permanent pool in order to retain oil (NVPDC, 1992). The elbow should be capable of passing the design storm to prevent frequent discharge of accumulated oil. The size of the elbow or number of elbows can be adjusted to accommodate the design flow (Berg, 1991).

MAINTENANCE

WQIs should be inspected after every storm event to determine if maintenance is required. At a minimum each WQI should be cleaned at the beginning of each change in season (Berg, 1991). The required maintenance will be site-specific due to variations in sediment and hydrocarbon loading. Maintenance should include clean-out and disposal of the sediments and removal of trash and debris. The clean-out and disposal techniques should be environmentally acceptable and in accordance with local regulations. Since WQI residuals contain hydrocarbon by-products they may require disposal as a hazardous waste. Many WQI owners contract with waste haulers to collect and dispose of these residuals. Since WQIs can be relatively deep, they may be designated as confined spaces. Caution should be exercised to comply with confined space entry safety regulations in the event that entry into the WQI is required.

COSTS

The construction costs for WQIs will vary greatly depending on the size and depth required. The construction costs (in 1993 dollars) for cast-in-place WQIs range from $5,000 to $16,000, with the average WQI costing around $8,500 (Schueler, 1992). For the basic design and construction of WQIs, the pre-manufactured units are generally less expensive than those cast-in-place (Berg, 1991).

Maintenance costs will also vary greatly depending on the size of the drainage, the amount of the residuals collected, and the clean-out and disposal methods available (Schueler, 1992). The cost of residuals removal, analysis and disposal can be major maintenance expense, particularly if the residuals are toxic and are not suitable for disposal in a conventional landfill.

ENVIRONMENTAL IMPACTS

WQIs can effectively trap trash, debris, oil and grease, and other floatables that would otherwise be discharged to surface waters (Schueler, 1992). The 1993 MWCOG study found that pollutants in the WQI sediments were similar to those pollutants found in downstream receiving water sediments (the tidal Anacostia River). This information suggests that downstream sediment contamination is linked to contaminated runoff (MWCOG, 1993). A properly designed and maintained WQIs can be an effectively BMP for reducing hydrocarbon contamination in receiving water sediments.

WQIs generally provide limited hydraulic and residuals storage. Due to the limited storage, WQIs do not provide adequate storm water quantity control. The WQI residuals require frequent removal and may require disposal as a hazardous waste. The 1993 MWCOG study found that the residuals from WQIs typically contain many priority pollutants, including polyaromatic hydrocarbons, trace metals, pthalates, phenol, toluene, and possibly methylene chloride (MWCOG, 1993). During periods of high flow, the residuals may be resuspended and released from the WQI to surface waters.

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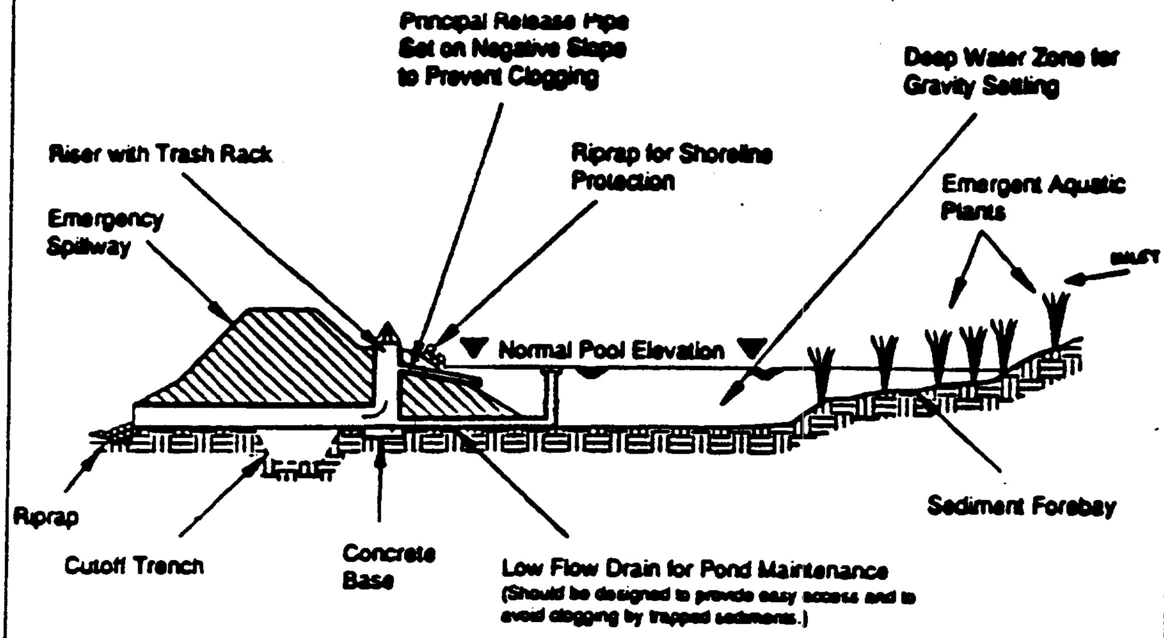
STORM WATER BMP: WET DETENTION PONDS

DESCRIPTION

Wet detention ponds provide both retention and treatment of contaminated storm water runoff. A typical wet detention pond is shown in Figure 1 below. A wet detention pond maintains a permanent pool of water where pollutant removal is achieved through physical, biological and chemical processes. Storm water runoff is detained in the pond until runoff from the next storm event mixes with and displaces some of the treated water before discharge to receiving waters. Discharge from the pond is controlled by a riser and an inverted release pipe.



SOURCE: Reference 2

FIGURE 1: TYPICAL LAYOUT OF A WET DETENTION POND

Wet detention ponds remove sediment, organic matter and metals by sedimentation and remove dissolved metals and nutrients through biological uptake. Effective pollutant removal can be achieved if the pond is properly designed and maintained (SEWPRC, 1991).

COMMON MODIFICATIONS

A typical wet pond may be enhanced with the addition of a sediment forebay, as shown in Figure 1, or by constructing shallow ledges along the edge of the permanent pool. Runoff passes through the sediment forebay where the heavier sediments drop out of suspension, while additional removal of lighter sediments occurs in the permanent pool. The shallow, peripheral ledges contain aquatic plants that trap pollutants as they enter the pond. Biological activity also increases due to the aquatic plants, and results in increased nutrient removal. Perimeter wetland areas can also be created that will aid in pollutant removal. The ledges also act as a safety precaution from accidental drowning and provide easy access for maintenance to the permanent pool.

Storm water quality control is achieved in the permanent pool, which is designed by either the eutrophication method or the solids settling method (Hartigan, 1988). Several models are available for both methods. The solids settling method accounts for pollutant removal through sedimentation, whereas the eutrophication method accounts for dissolved nutrient removal that occurs as a result of biological processes. Equations for the Walker eutrophication model are shown in Table 2 below. The solids settling method indicate that two-thirds of the sediment, nutrients and trace metal loads are removed by sedimentation within 24 hours. Theses projections are supported by the results of the EPA's 1993 National Urban Runoff Program (NURP) studies. However, other studies indicate that a hydraulic residence time (HRT) of 2 weeks is required to achieve significant phosphorus removal (MD, 1986). This longer HRT is similar to the HRT determined by the eutrophication method. In some cases, the HRTs calculated by the eutrophication method are up to three times greater than HRTs calculated by the solids settling method. These longer HRTs appear to be due to the slower reaction rates associated with the biological removal of dissolved nutrients. This results in a permanent pool that is approximately three times larger than the permanent pool calculated by solids settling models (Hartigan, 1988). Other design methods, such as sizing the permanent pool to collect a specific volume of runoff from the drainage area, have been tried with varying degrees of success, and are not described in this fact sheet.

TABLE 2: WALKER EUTROPHICATION MODEL

$$K2 = (0.056)(QS)(F)^{-1}/(QS + 13.3) \qquad (1)$$

$$R = 1+(1-(1+4N)^{0.5})/(2N) \qquad (2)$$

where:

K2	= Second order decay rate (m^3/mg-yr)
QS	= Mean overflow rate (m/yr) = Z/T
F	= Inflow ortho P/total P ratio
Z	= Mean depth (m)
T	= Average HRT (yr)
R	= Total P retention coefficient = BMP efficiency
N	= (K2)(P)(T)
P	= Inflow total P (ug/L)

SOURCE: Reference 3

Other key factors to be considered in the pond design are the volume and area ratios. The volume ratio, VB/VR, is the ratio of the permanent pool storage (VB) to the mean storm runoff (VR). The area ratio, A/As, is the ratio of the contributing drainage area (A) to the permanent pool surface area (As). Both ratios are considered important in the design of the pond and are correlated with treatment efficiencies. Larger VBs and smaller VRs provide for increased retention and treatment between storm events. Low VB/VR ratios result in poor pollutant removal efficiencies. The eutrophication model indicates that the VB/VR ratio should equal 4.0 for maximum efficiency (Hartigan, 1988). However, design standards for the State of Maryland set VB/VR equal to 2.5 (Hartigan, 1988). The area ratio is also an indicator of pollutant removal efficiency. Data from previous studies, indicates that area ratios less than 100 typically have better pollutant removal efficiencies (MD, 1986). A VB/VR of 4.0 is equivalent to a 2 week HRT assuming an average of 100 storm events per year (Hartigan, 1988). This can be determined using the formula VB/[(VR)(N)] = HRT, where N is the average number of storm events per year and HRT is expressed in years. A different VB/VR ratio will change the HRT. For example, in Maryland a VB/VR ratio equal to 2.5 is equivalent to a 9 day HRT (Hartigan, 1988).

One way to increase the HRT is to increase the depth of the permanent pool. However, the permanent pool depth should not exceed 20 feet. The optimal depth ranges between 3 and 9 feet for most regions, given a 2 week HRT (Hartigan, 1988). Ponds with shallower depths will have shorted HRTs. It is important to maintain a sufficient permanent pool depth in order to prevent the resuspension of trapped sediments (NVPDC, 1992). Conversely, thermal stratification and anoxic conditions in the bottom layer might develop if permanent pool depths are too great. Stratification and anoxic conditions may decrease biological activity. Anoxic conditions may also increase the potential for the release of phosphorus and heavy metals from the pond sediments (NVPDC, 1992).

In general, pond designs are unique for each site and application. Ponds should always be designed to complement the natural topography (NVPDC, 1992). The pond should be constructed with adequate slopes and lengths. While, a length-to-width ratio is usually not used in the design of wet detention ponds for storm water quantity management, a 2:1 length-to-width ratio is commonly used when water quality is of concern. In general, high length-to-width ratios (greater than 2:1) will decrease the possibility of short-circuiting and enhance sedimentation within the permanent pool. Baffles or islands can also be added within the permanent pool to increase the flow path (Hartigan, 1988). Shoreline slopes between 5:1 and 10:1 are common and allow easy access for maintenance, such as mowing and sediment removal (Hartigan, 1988). In addition, wetland vegetation is difficult to establish and maintain on slopes steeper than 10:1. Ponds should be wedge-shaped so that flow enters the pond and gradually spreads out. This minimizes the potential for zones with little or no flow (Urbonas, 1993).

The design of the wet pond embankment is another key factor to be considered. Proper design and construction of the embankments will prolong the integrity of the pond structure. Subsidence and settling will likely occur after an embankment is constructed. Therefore, during construction the embankment should be overfilled by at least 5% (SEWPRC, 1991). Seepage through the embankment can also affect the stability of the structure. Seepage can generally be minimized by adding drains, anti-seepage collars and core trenches. The embankment side slopes can be protected from erosion by using minimum side slopes of 2:1 and by covering the embankment with vegetation or rip-rap. The embankment should also have a minimum top width of 6 feet to ease maintenance.

Normal flows will be discharged through the wet pond outlet, which consists of a concrete or corrugated metal riser and barrel. The riser is a vertical pipe or inlet structure that is attached to the base with a watertight connection. Risers are typically placed in or adjacent to the embankment rather than in the middle of the pond. This provides easy access for maintenance and prevents the use of the riser as a recreation spot (e.g., diving platform for kids) (Schueler, 1988). The barrel is a horizontal pipe attached to the riser that conveys flow under the embankment.

Typically, flow passes through an inverted pipe attached to the riser, as shown in Figure 1, with higher flows will pass through a trash rack installed on the riser. The inverted pipe should discharge water from below the pond water surface to prevent floatables from clogging the pipe and to avoid discharging the warmer surface water. Clogging of the pipe could result in overtopping of the embankment and damage to the embankment (NVPDC, 1992). Flow is conveyed through the near horizontal barrel and discharged to the receiving stream. Rip-rap, plunge pools, or other energy dissipators should be placed at the outlet to prevent scouring and minimize erosion. Rip-rap also provides a secondary benefit of reaeration of the pond discharges.

The design and construction of the riser and barrel should consider the design storm and the material of construction. Generally, the riser and barrel are sized to meet the storm water management design criteria (e.g., to pass a 2-year or a 10-year storm event). In many installations the riser and barrel are designed to convey multiple design storms (Urbonas, 1993). The riser and barrel should be constructed of reinforced concrete rather than corrugated metal pipe to increase the life of the outlet. The riser, barrel and base should also have sufficient weight to prevent flotation (NVPDC, 1992).

In most cases, emergency spillways should be included in the pond design. Emergency spillways should be sized to safely pass flows that exceed the design storm flows. The spillway prevents pond water levels from overtopping the embankment, which could cause structural damage the embankment. The emergency spillway should be located so that downstream buildings and structures will not be negatively impacted by a spillway discharges. The pond design should include a low flow drain, as shown in Figure 1. The drain pipe should be designed for gravity discharge and should be equipped with an adjustable gate valve.

MAINTENANCE

Wet detention ponds function more effectively when they are regularly inspected and maintained. Routine maintenance of the pond includes mowing of the embankment and buffer areas and inspection for erosion and nuisance (e.g., borrowing animals, weeds, odors) problems (SEWPRC, 1991). Trash and debris should be routinely removed to maintain an attractive appearance and also to prevent the outlet from becoming clogged. In general, wet detention ponds should be inspected after every storm event. The embankment and emergency spillway should also be routinely inspected for structural integrity, especially after major storm events. Embankment failure could result in severe downstream flooding.

When any problems are observed during routine inspections, necessary repairs should be made immediately. Failure to correct minor problems may lead to larger more expensive repairs or even pond failure. Typically, maintenance includes repairs to the embankment, emergency spillway, inlet and outlet, removal of sediment and control of algal growth, insects and odors (SEWPRC, 1991). Large vegetation or trees that may weaken the embankment should be removed. Periodic maintenance may also include the stabilization of the outfall area (e.g., add rip-rap) to prevent erosive damage to the embankment and the stream bank. In most cases sediments removed from wet detention ponds are suitable for landfill disposal. However, where available, on-site disposal od removed sediments will reduce maintenance costs.

COSTS

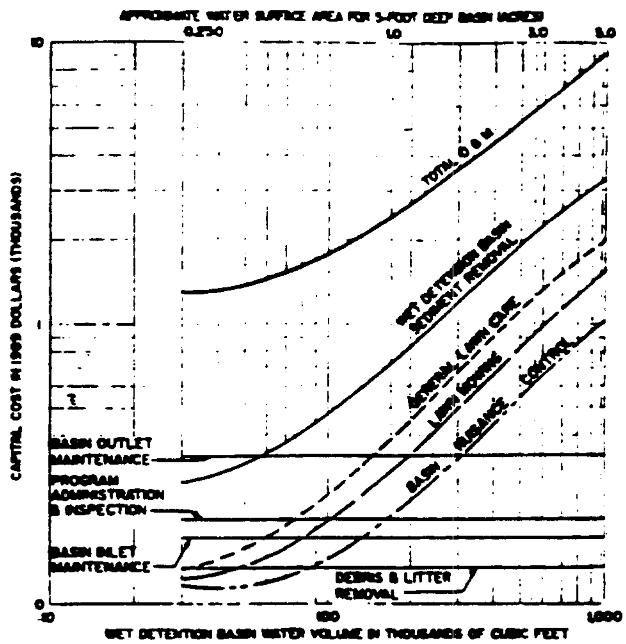
The total cost for a pond includes permitting, design and construction and maintenance costs. Permitting costs may vary depending on state and local regulations. Typically, wet detention ponds are less costly to construct in undeveloped areas than retrofitting into developed areas. This is due to the cost of land and the difficulty in finding suitable sites in developed areas. The cost of relocating of pre-existing utilities or structures is also a major concern in developed areas. The construction costs for wet detention ponds in 1989 for undeveloped areas are shown in Figure 2 below. These costs include mobilization and demobilization of heavy equipment, site preparation (e.g., clearing and excavation), site development (e.g., seeding and inlet construction) and contingencies (e.g., engineering and legal fees) (SEWPRC, 1991). Several studies have shown the construction cost of retrofitting a wet detention pond into a developed area may be 5 to 10 times the cost of constructing the same size pond in an undeveloped area.

Operation and maintenance costs in 1989 are presented in Figure 3 below (SEWPRC, 1991). Annual maintenance costs can generally be estimated at 3 to 5 percent of the construction costs (Schueler, 1992). Maintenance costs include the costs for regular inspections of the pond embankments, grass mowing, nuisance control, debris and liter removal, inlet and outlet maintenance and inspection, and sediment removal and disposal. Sediment removal costs can be decreased by as much as 50 percent if an on-site disposal areas are available (SEWPRC, 1991).

ENVIRONMENTAL IMPACTS

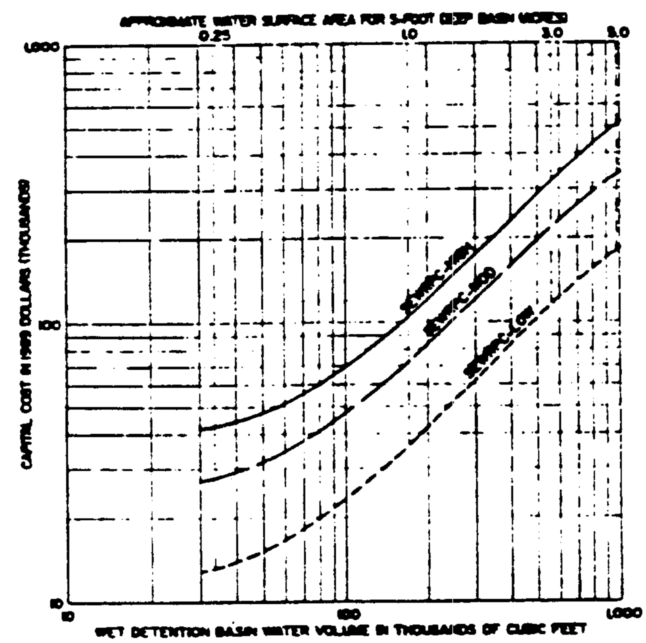
Wet detention ponds provide both storm water quantity and quality benefits. Benefits obtained from the use of wet detention ponds include decreased potential for downstream flooding and stream bank erosion. Water quality is also improved due to the removal of suspended solids, metals, and dissolved nutrients. In general, the positive impacts from a wet detention ponds will exceed any negative impacts from a pond, assuming the pond is properly designed and maintained.

TABLE 3: CONSTRUCTION COSTS (1989)



SOURCE: Reference 4

TABLE 4: OPERATIONS AND MAINTENANCE COSTS (1989)



SOURCE: Reference 4

However, wet detention ponds that are improperly designed, sited or maintained may have potential adverse affects on water quality, groundwater, cold water fisheries, or wetlands. Improperly designed or maintained ponds may result in stratification and anoxic conditions that can promote the resuspension of solids and the release of nutrients and metals from the trapped sediments. During construction, precautions should be taken to prevent damage to wetland areas. Ponds should also not be sited in areas where warm water discharges from the pond will adversely impact cold water fishery. The potential groundwater contamination should be carefully evaluated. However, studies to date indicate that wet detention ponds do not significantly contribute to groundwater contamination (Schueler, 1992).

Treatment within a pond can be enhanced through extending the detention time in the permanent pool. This allows for a more gradual release of collected runoff from a design storm over a specified time (Hartigan, 1988). This results in increased pollution removal as well as control of peak flows.

CURRENT STATUS

Wet detention ponds have been widely used throughout the U.S. for many years to treat of storm water runoff. Many of these ponds have been monitored to determine their performance. EPA Region V is currently performing a study on the effectiveness of 50 to 60 wet detention ponds. Other organizations, such as the Washington, D.C., Council of Governments (Wash COG) have also conducted extensive evaluations of wet detention pond performance (Schueler, 1992). Wet detention ponds provide the benefit of both storm water quantity and quality control. In general, a higher level of nutrient removal and better storm water quantity control can be achieved in wet detention ponds than can be achieved with other best management practices (BMPs), such as infiltration trenches or sand filters. However, proper maintenance is essential to maintaining these higher levels of treatment.

LIMITATIONS

Wet detention ponds must be able to maintain a permanent pool. Therefore, ponds should not be constructed in areas where there is insufficient precipitation or on soils that are highly permeable. In wetter regions, a small minimum drainage area may be adequate, where as, in more arid regions, a larger drainage areas may be required in order to ensure sufficient water to maintain the permanent pool. In some cases, soils that are highly permeable may be compacted or overlaid with clay blankets to make the bottom less permeable. Land constraints, such as small sites or highly developed areas, may also preclude the use of a pond. In addition, the local climate (i.e., temperature) may affect the biological uptake in the pond. With out proper maintenance, the performance of the pond will drop off sharply. Regular cleaning of the forebays is particularly important. Maintaining the permanent pool is also important in preventing the resuspension of trapped sediments. In most cases no specific limitations have been places on disposal of sediments removed from wet detention ponds. Studies to date indicate that pond sediments are likely to meet toxicity limits and can be safely landfilled (Schueler, 1992). Some states have allowed sediment disposal on-site, as long as the sediments are deposited away from the shoreline, preventing their reentry into the pond.

PERFORMANCE

The primary pollutant removal mechanism in a wet detention pond is sedimentation. Suspended pollutants, such as metals, nutrients, sediments, and organics, are partly removed by sedimentation. Other pollutant removal mechanisms include algal uptake, wetland plant uptake and bacterial decomposition (Schueler, 1992). Dissolved pollutant removal occurs as a result of biological and chemical processes (NVPDC, 1992).

The removal rates of conventional wet detention ponds (i.e., without the sediment forebay or peripheral ledges) are well documented and are shown in Table 1 below. The wide range in the removal rates is a result of varying hydraulic residence times (HRTs), which is further discussed in the Design Criteria section. Increased pollutant removal by biological uptake and sedimentation is correlated with increased HRTs. Proper design and maintenance also affect pond performance.

Studies have shown that more than 90 percent of the pollutant removal occurs during the quiescent conditions (i.e., the period between the rainfall events) (MD, 1986). However, some removal occurs during the dynamic period (i.e., when the runoff enters the pond).

TABLE 1: REMOVAL EFFICIENCIES FROM WET DETENTION PONDS

Parameter	Percent Removal	
	Schueler, 1992[1]	Hartigan, 1988[2]
Total Suspended Solid	50 - 90	80 - 90
Total Phosphorus	30 - 90	
Soluble Nutrients	40 - 80	50 - 70
Lead	70 - 80	
Zinc	40 - 50	
Biochemical Oxygen Demand or Chemical Oxygen Demand	20 - 40	

[1] hydraulic residence time varies
[2] hydraulic residence time of 2 weeks

SOURCE: Reference 1
SOURCE: Reference 2

DESIGN CRITERIA

Well designed and properly maintained ponds can function as designed for 20 years or more. Concrete risers and barrels have a longer life than corrugated metal pipe risers and barrels and are recommended for most permanent ponds (Schueler, 1992). The accumulation of sediments in the pond will reduce the storage capacity and cause a decline in performance. Therefore, the bottom sediments in the permanent pool should be removed every 2 to 5 years or as necessary. The design of the pond should allow easy access to the forebays for frequent sediment removal.

All local, state and federal permit requirements should be established prior to starting the pond design. Depending on the location of the pond, required permits and certifications may include wetland permits, water quality certifications, dam safety permits, sediment and erosion control plans, waterway permits, local grading permits, land use approvals, etc.(Schueler, 1992). Since many states and municipalities are still in the process of developing or modifying storm water permit requirements, the applicable requirements should be confirmed with the appropriate regulatory authorities.

Prior to designing the pond, a site should be selected that is able to support the pond environment. The cost effectiveness of locating a pond at that site should also be carefully evaluated. The site must have adequate base-flow from the groundwater or from the drainage area to maintain the permanent pool. Typically, underlying soils with permeability between 10^{-5} and 10^{-6} cm/sec will be adequate so that a permanent pool can be maintained. In addition, the pond should be located where the topography of the site allows for maximum storage at minimum construction costs (NVPDC, 1992). Land constraints to avoid include existing utilities (e.g., electric or gas) that would be costly to relocate and excavation of bedrock that would require expensive blasting operations.

The design of wet detention ponds should serve two functions: storm water quantity control and storm water quality control. Storm water quantity requirements are typically met by designing the pond to control post-development peak discharge rates to pre-development levels. Various routing models (i.e., Soil Conservation Service TR-20 or EPA SWMM) can be used to calculate the required storm water storage. Usually the pond is designed to control multiple design storms (e.g., 2- and/or 10-year storms) and safely pass the 100-year storm event. However, the design storm may vary depending on local conditions and requirements.

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3. Hartigan, J.P, 1988. "Basis for Design of Wet Detention Basin BMPs" in Design of Urban Runoff Quality Control. American Society of Engineers.

4. Southeastern Wisconsin Regional Planning Commission (SEWPRC), 1991. Costs for Urban Nonpoint Source Water Pollution Control Measures. Technical Report No. 31.

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United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA 832-F-99-010 September 1999

EPA

Storm Water Management Fact Sheet
Employee Training

DESCRIPTION

In-house employee training programs are established to teach employees about storm water management, potential sources of contaminants, and Best Management Practices (BMPs). Employee training programs should instill all personnel with a thorough understanding of their Storm Water Pollution Prevention Plan (SWPPP), including BMPs, processes and materials they are working with, safety hazards, practices for preventing discharges, and procedures for responding quickly and properly to toxic and hazardous material incidents.

APPLICABILITY

Typically, most industrial facilities have employee training programs. Usually these address such areas as health and safety training and fire protection. Training on storm water management and BMPs can be incorporated into these programs.

Employees can be taught through 1) posters, employee meetings, courses, and bulletin boards about storm water management, potential contaminant sources, and prevention of contamination in surface water runoff, and 2) field training programs that show areas of potential storm water contamination and associated pollutants, followed by a discussion of site-specific BMPs by trained personnel.

ADVANTAGES AND DISADVANTAGES

Advantages of an employee training program are that the program can be a low-cost and easily implementable storm water management BMP. The program can be standardized and repeated as necessary, both to train new employees and to keep its objectives fresh in the minds of more senior employees. A training program is also flexible and can be adapted as a facility's storm water management needs change over time.

Obstacles to an employee training program include:

- Lack of commitment from senior management.
- Lack of employee motivation.
- Lack of incentive to become involved in BMP implementation.

KEY PROGRAM COMPONENTS

Specific design criteria for implementing an employee training program include:

- Ensuring strong commitment and periodic input from senior management.
- Communicating frequently to ensure adequate understanding of SWPPP goals and objectives.
- Utilizing experience from past spills to prevent future spills.
- Making employees aware of BMP monitoring and spill reporting procedures.
- Developing operating manuals and standard procedures.

- Implementing spill drills.

IMPLEMENTATION

An employee training program should be an on-going, yearly process. Meetings about SWPPPs should be held at least annually, possibly in conjunction with other training programs. Figure 1 illustrates a sample employee training worksheet. Worksheets such as these can be used to plan and track employee training programs. Program performance depends on employees' participation and on senior management's commitment to reducing point and nonpoint sources of pollution; therefore, performance will vary among facilities. To be effective these programs need senior management's support

COSTS

Costs for implementing an employee training program are highly variable. Most storm water training program costs will be directly related to labor and associated overhead costs. Trainers can reduce costs by using free educational materials available on the subject of storm water quality.

Figure 2 can be used to estimate the annual costs for an in-house training program. Table 1 provides an example of how this worksheet can be used to estimate annual costs.

REFERENCES

1. U.S. EPA, 1979. *NPDES BMP Guidance Document.*

2. U.S. EPA, Pre-print, 1992. *Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices*. EPA 832-R-92-006.

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EMPLOYEE TRAINING			Worksheet Completed by: ______ Title: ______ Date: ______
Instructions: Describe the employee training program for your facility below. The program should, at a minimum, address spill prevention and response, good housekeeping, and material management practices. Provide a schedule for the training program and list the employees who attend the training sessions.			
Training Topics	**Brief Description of Training Program/Materials (e.g., film, newsletter, course)**	**Schedule for Training (list dates)**	**Participants**
Spill Prevention and Response			
Good Housekeeping			
Material Management Practices			
Other Topics			

Source: U. S. EPA, 1992.

FIGURE 1 SAMPLE WORKSHEET FOR TRACKING EMPLOYEE TRAINING

TABLE 1 EXAMPLE OF ANNUAL EMPLOYEE TRAINING COSTS

Title	Number		Average Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Estimated Annual Cost ($)
Stormwater Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
							Total Estimated Annual Cost $12,600		

*Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with costs other than salary of employing a person, expenses, etc

Title	Number		Average Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Estimated Annual Cost ($)	
______	______	x	______	x	______	x	______	=	______	(A)
______	______	x	______	x	______	x	______	=	______	(B)
______	______	x	______	x	______	x	______	=	______	(C)
______	______	x	______	x	______	x	______	=	______	(D)
							Total Estimated Annual Cost (Sum of A+B+C+D)		______	

Source: U.S. EPA, 1992.

FIGURE 2 SAMPLE ANNUAL TRAINING COST WORKSHEET

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United States Environmental Protection Agency
Office of Water Washington, D.C.
832-F-99-046
September 1999

EPA

Storm Water Management Fact Sheet
Visual Inspection

DESCRIPTION

Visual inspection is a Best Management Practice (BMP) in which members of a Storm Water Pollution Prevention Team visually examine material storage and outdoor processing areas, the storm water discharges from such areas, and the environment in the vicinity of the discharges, to identify contaminated runoff and its possible sources.

In a visual inspection, storm water runoff may be examined for the presence of floating and suspended materials, oil and grease, discoloration, turbidity, odor, or foam; and storage areas may be inspected for leaks from containers, discolorations on the storage area floor, or other indications of a potential for pollutants to contaminate storm water runoff.

Visual inspections may indicate the need to modify a facility to reduce the risk of contaminating runoff.

APPLICABILITY

The U.S. EPA has recognized visual inspection as a baseline BMP for over 10 years. Its implementation, however, has been sporadic. Implementation may increase as more facilities develop Storm Water Pollution Prevention Plans. Implementation may also increase as facility management recognizes visual inspection to be effective both in protecting water quality and in reducing costs.

ADVANTAGES AND DISADVANTAGES

Visual inspections are an effective way to identify a variety of problems. Correcting these problems can improve the water quality of the receiving water.

Limitations associated with visual inspections include the following:

- Visual inspections are effective only for those areas clearly visible to the human eye.
- The inspections need to be performed by qualified personnel.
- To be effective, inspections must be carried out routinely. This requires a corporate commitment to implementing them.
- Inspectors need to be properly motivated to perform a thorough visual inspection.

KEY PROGRAM COMPONENTS

Visual inspections for signs of storm water contamination should be performed routinely. Flows should be observed during dry periods to determine the presence of any stains, sludge, odors, and other abnormal conditions.

Visual inspections should also be made at all storm water discharge outlet locations during the first hour of a storm event, once runoff has reached its maximum flow rate. Inspectors should examine the discharge for the presence of floating and suspended materials, oil and grease, discoloration, turbidity, foam, or odor.

Inspection frequency interval may be determined by the storm water discharge permit, by storm frequency, or by the potential risk from the site. Inspections should be made at least once a month in areas with frequent storms; inspections may be less frequent where storms are less frequent. Finally, inspection frequency may be based in part on the history of previous spills and leaks. Experienced personnel should evaluate the causes of previous accidents, assess the risks for future accidents, and determine an inspection schedule based on these risks.

Proper records of inspection results must be kept. The record for each inspection should include the date of the inspection, the names of the personnel who performed the inspection, and their observations.

Visual inspections of a facility should focus on the following key areas:

- Storage facilities.
- Transfer pipelines.
- Loading and unloading areas.
- Pipes, pumps, valves, and fittings.
- Tanks (including internal and external inspection of the tank for corrosion and inspection of its support or foundation for deterioration).
- Primary or secondary containment facilities.
- Shipping containers.

In addition, a visual inspection should include assessing the integrity of the storm water collection system; checking for leaks, seepage, and overflows from sludge and waste disposal sites; and ensuring that dry chemicals and dust from industrial areas is not exposed to wind or other elements that may move them into the runoff.

IMPLEMENTATION

A visual inspection BMP program should be incorporated into every storm water discharger's record keeping and internal reporting structure.

Outfall flow rates and the presence of oil sheens, floatables, coarse solids, color, and odors will probably be the most useful indicators of potential problems. Specific parameters to look for in completing a visual inspection include the following:

- Odor: Discharge odors can vary widely. Some may indicate the source of contamination. Industrial discharges may smell like a particular spoiled product, oil, gasoline, a specific chemical, or a solvent. For example, the decomposition of organic wastes in a discharge will release sulfide compounds, creating an intense smell of rotten eggs. Significant sanitary wastewater contributions will also cause pronounced and distinctive odors.
- Color: Color may indicate inappropriate discharges, especially from industrial sources. Industrial discharges may be any color. Dark colors, such as brown, gray, or black, are most common. For instance, flow contaminated by meat processing industries is usually a deep reddish-brown. Paper mill wastes (plating-mill wastes) are often yellow. Wash water from cement and stone working plants can cause cloudy discharges. Contamination from industrial areas may come from process waters (slug or continuous discharges); from equipment and work area wash water discharged to floor drains; or from spills washed into storm drains.
- Turbidity: Turbidity is often affected by the degree of gross contamination. Industrial flows can be cloudy (moderately turbid) or opaque (highly turbid). Undiluted industrial discharges, such as those coming from continual flow sources or intermittent spills, are often highly turbid. Sanitary wastewater is also often cloudy in nature.

- Floatable matter: A contaminated flow may also contain floatable solids or liquids. Identifying floatables can aid in finding the source of the contamination, because these substances are usually direct products or byproducts of the manufacturing process or the sanitary system. Examples of floatables of industrial origin are animal fats, spoiled food products, oils, plant parts, solvents, sawdust, foams, packing materials, and fuel.

- Deposits and Stains: Deposits and stains (residues) are any type of coating that remains after a non-storm water discharge has ceased. Deposits or stains usually are of a dark color and usually cover the area surrounding the storm water discharge. They often contain fragments of floatable substances, and, at times, take the form of a crystalline or amorphous powder. For example, contamination from leather tanneries often produces grayish-black deposits containing fragments of animal flesh and hair. Another characteristic example is the coating of white crystalline powder formed on sewer outfalls by nitrogenous fertilizer wastes.

- Vegetation: Storm water discharges often affect surrounding vegetation. Industrial pollutants often cause a substantial alteration in the chemical composition and pH of the discharge water, which can affect plant growth even when the source of contamination is intermittent. For example, nutrients from various food product wastes increase plant growth. In contrast, the discharge of chemical dyes and inorganic pigments from textile mills may decrease vegetation, as these discharges are often very acidic. In either case, even when the pollution source is gone, the vegetation surrounding the discharge will continue to show the effects of the contamination.

  In order to accurately judge if the vegetation surrounding a discharge is normal, the observer must take into account recent weather conditions, as well as the time of year. Increased or inhibited plant growth near storm water discharges, as well as dead and decaying plants, is often a sign of pollution. However, it is important to distinguish whether plant damage is caused by contamination or by the physical effects of increased flows, such as scour. This can be done by chemically analyzing the flow or by confirming its source through additional visual inspections.

- Structural Damage: Structural damage is also a sign of industrial discharge contamination. Cracked or deteriorated concrete or peeling surface paint at an outfall usually indicates the presence of severely contaminated discharges. Contaminants causing this type of damage are usually very acidic or basic and are usually of industrial origin. For instance, discharges from primary metal industries may cause structural damage because their batch dumps are highly acidic.

The effectiveness visual inspections in reducing storm water runoff contamination is highly variable and dependent upon site-specific parameters. These factors include inspectors' motivation level, the types of industrial activity occurring at the facility, and the facility's maintenance procedures. Because familiarity with facility operations is essential in performing effective visual inspections, the inspections should be assigned to qualified staff such as maintenance personnel or environmental engineers. Figure 1 provides a sample visual evaluation worksheet that can be used to record the results of the inspections.

COSTS

Costs for performing the visual inspection BMP are minimal and consist of direct labor and overhead costs for staff hours spent on training, planning inspections, inspecting, and completing follow up activities. Annual costs can be estimated using the example in Table 1. Figure 2 can be used as a worksheet to calculate the estimated annual cost for implementing a visual inspection program.

Outfall # ____________			Photograph # ____________			Date: ____________	
Location: ______________________________________							
Weather: air temp.: _______ °C			rain: Y N		sunny	cloudy	
Outfall flow rate estimate: _____ L/sec							
Known industrial or commercial uses in drainage area?				Y N			
Describe: ____							
PHYSICAL OBSERVATIONS							
Odor:	none	sewage	sulfide	oil	gas	rancid-sour	other: _________
Color:	none	yellow	brown	green	gray	other: _________	
Turbidity:	none	cloudy	opaque				
Floatables:	none	petroleum sheen		sewage	other: __________ (collect sample)		
Deposits/stains:		none	sediment	oily	describe: __________ (collect sample)		
Vegetation conditions:		normal	excessive growth		inhibited growth		
	extent: ____________________________________						
Damage to outfall structures:							
	identify structure: ______________________________						
	damage:	none / concrete cracking / concrete spalling / peeling paint / corrosion					
	other damage: _______________________________						
	extent: ____________________________________						

Source: Pitt, et. al, 1992.

FIGURE 1 VISUAL INSPECTION WORKSHEET

REFERENCES

1. California Environmental Protection Agency, 1992. Staff Proposal for Modification to Water Quality Order No. 91-13 DWQ Waste Discharge Requirements for Dischargers of Storm Water Associated with Industrial Activities, Draft Wording, Monitoring Program and Reporting Requirements.

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3. U.S. EPA, 1981. *NPDES BMP Guidance Document.*

4. U.S. EPA. Pre-print, 1992. *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices.* EPA 832-R-92-006.

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TABLE 1 EXAMPLE OF VISUAL INSPECTION PROGRAM COSTS

Title	Quantity		Average Hourly Rate ($)		Overhead* Multiplier		Estimated Yearly Hours on SW Training		Estimated Annual Cost ($)
Storm Water Engineer	1	x	15	x	2.0	x	20	=	600
Plant Management	5	x	20	x	2.0	x	10	=	2,000
Plant Employees	100	x	10	x	2.0	x	5	=	10,000
					TOTAL ESTIMATED ANNUAL COST				**$12,600**

*Note: Defined as a multiplier (typically ranging between 1 and 3) that takes into account those costs associated with payroll expenses, building expenses, etc.

Source: U.S. EPA, 1992.

Title	Quantity		Average Hourly Rate ($)		Overhead Multiplier		Estimated Yearly Hours on SW Training		Estimated Annual Cost($)
____________	_______	x	________	x	_______	x	____________	=	_______ (A)
____________	_______	x	________	x	_______	x	____________	=	_______ (B)
____________	_______	x	________	x	_______	x	____________	=	_______ (C)
____________	_______	x	________	x	_______	x	____________	=	_______ (D)

Source: U.S. EPA, 1992.

FIGURE 2 SAMPLE INSPECTION PROGRAM COST WORKSHEET

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ECONOMIC ANALYSIS OF THE STORM WATER PHASE II PROPOSED RULE: INITIAL FINAL DRAFT

August 1,1997

U.S. Environmental Protection Agency
Office of Wastewater Management
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EXECUTIVE SUMMARY

This Economic Analysis (EA) includes the U.S. Environmental Protection Agency's (EPA) analysis of the national compliance costs and benefits, including monetized and non-monetized benefits, associated with the proposed phase II storm water regulation. A comparison of costs and benefits is also included. This EA also includes analyses for Executive Order 12866 for Regulatory Impact Analysis (RIA), the Regulatory Flexibility Act of 1980, the Small Business Regulatory Enforcement Fairness Act of 1996, Executive Order 12898 for Environmental Justice, the Unfunded Mandate Reform Act of 1995, and the Paperwork Reduction Act of 1995. The findings of these analyses are summarized in the following sections.

The proposed phase II storm water regulation has been developed pursuant to Section 402(p)(6) of the Federal Water Pollution Control Act (hereinafter referred to as the Clean Water Act [CWA]) and will serve as the final regulatory component in a phased program designed to control contaminated discharges associated with storm water runoff. Specifically, the phase II regulation will address contaminated storm water discharges from small municipal separate storm sewer systems (MS4s) and construction activities at small construction sites (sites disturbing greater than or equal to 1 acre and less than 5 acres). Existing phase I regulations currently address contaminated storm water discharges from medium and large municipalities, [1] construction activities at sites disturbing five acres or greater, and specified industrial activities (40 C.F.R. §122.26).

OPTIONS FOR IMPLEMENTING THE STORM WATER PHASE II PROGRAM

The proposed phase II storm water regulation has been developed pursuant to the requirements of CWA §402(p)(6) and is based on the findings of the Phase II Storm Water Report to Congress,[2] public and expert comments and testimony, other technical data and literature, and input from members of the Storm Water Phase II Federal Advisory (FACA) Subcommittee. EPA worked with the FACA Subcommittee for more than 18 months to develop the proposed phase II regulation.

[1] Phase I also provides authority to regulate municipalities that contribute to water quality impacts.

[2] *Storm Water Discharges Potentially Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program: Report to Congress*. U.S. EPA, Office of Water, March 1995, EPA 833-K-94-002. The Storm Water Phase II Report to Congress includes the recommendations of the *Clinton Clean Water Initiative*.

Working with the FACA Subcommittee, EPA considered numerous alternative approaches and requirements for each of the basic components of the proposed regulation, including the structural approach to implementing the program, the scope of coverage of the proposed regulation, and substantive requirements applicable to each category of phase II sources, including waivers. Major alternatives to the basic program components included:

- Structuring the phase II program as a National Pollutant Discharge Elimination System (NPDES) permit-based program, a non-NPDES program, or a program that allows use of NPDES permits as well as other mechanisms (e.g., permit-by-rule)
- Designating *all* small municipal storm sewer systems (MS4s) as sources subject to the phase II regulation; designating only those small MS4s that meet specified criteria (e.g., census-designated urbanized area); or allowing the permitting authority to determine which small MS4s require phase II regulation
- Designating all land-disturbing construction sites not subject to phase I (i.e., under 5 acres) as sources subject to the phase II regulation (a variation provided for an exemption based on de minimis impact); those construction activities involving clearing, grading, or excavating greater or equal to 1 acre and less than 5 acres of land; or use of a local ordinance or state plan under which all construction- related sources of runoff pollution would have to be controlled to the greatest extent feasible
- Designating certain industrial or commercial activities not expressly subject to phase I (e.g., facilities that maintain, fuel, clean or rehabilitate two types of machinery, heavy industrial equipment and school buses) as sources subject to the phase II regulation
- Determining and defining those best management practices considered minimum measures for small MS4s (e.g., public education and outreach, public involvement, illicit discharges, construction site storm water discharge control, post-construction storm water management in new and re-development, pollution prevention/good housekeeping, evaluation and assessment)

EPA also examined providing exemptions or waivers for situations where there is no exposure of industrial materials to storm water, there exists a watershed plan or total maximum daily load (TMDL) that adequately addresses pollutants of concern, rainfall or erosion is limited, and storm water results in no impact on water quality.

Consideration of alternatives by the EPA and the FACA Subcommittee was an iterative process, one that started with a broad range of issues and worked toward acceptable specific alternatives within each program component. One result of this process is that the alternatives discussed in this EA tend to be distinguished by differences in the components of the proposed regulation (e.g., scope of coverage for small MS4s or small construction sites) rather than differences in the overall regulatory approach (e.g., NPDES versus non-NPDES). Where the FACA Subcommittee's recommendations to EPA reflect some agreement on a particular issue, this is reflected in the alternatives considered and the proposed regulation.

In cases where agreement was not reached by the FACA Subcommittee, EPA considered the numerous options presented and selected those that best satisfy the objectives of the phase II program. These objectives include the general goals of protecting water quality, providing sufficient flexibility to the permitting authority to focus on priority phase II sources within the relevant watershed, and achieving compatibility with the phase I program. Additional specific objectives include a desire for a single comprehensive program, the need for the program to be effectively enforced, an emphasis on public participation, the ability of the program to address all phase II sources, and efficient utilization of existing programs.

In addition to considering alternative approaches to specific components of the phase II proposed rule, EPA also worked with the FACA Subcommittee to combine these components into several distinct phase II regulatory options. Major regulatory alternatives addressed in this RIA include:

- No regulation of phase II sources (Status Quo)
- The final phase II rule promulgated on August 7, 1995 (60 FR 40230)
- An NPDES Permit/Partnership approach (Plan B)
- A flexible NPDES storm water program.

The proposed phase II regulation is based on the flexible NPDES program alternative. This alternative has evolved through several iterations to incorporate aspects of each of the other alternatives that best achieve the objectives of the storm water program. A primary characteristic of the proposed rule is the flexibility it offers both the permitting authority and small MS4s and small construction sites. A summary of the proposed phase II rule is provided in Exhibit ES-1.

EVALUATION OF NATIONAL COMPLIANCE COSTS

EPA developed detailed cost estimates for the incremental requirements imposed under the proposed phase II regulation and applied these estimates to the potentially regulated universe of phase II sources. Where necessary, simplifying assumptions were made to facilitate the analysis and to overcome data limitations. These assumptions were designed to be "conservative," that is, where uncertain of costs

Exhibit ES-1. Overview of Proposed Phase II Storm Water Regulation

Scope of Coverage	Regulates Small Municipalities (Population under 100,000): MS4s located in an incorporated place, county or other place under jurisdiction of a governmental entity and within a census-designated urbanized area. The permitting authority would be required to evaluate those small MS4s located in an incorporated place, county or other place under jurisdiction of a governmental entity and outside an urbanized area with a population density of greater than 1,000 people per square mile and a population greater than 10,000. These MS4s would be designated as phase II sources where they meet criteria that indicate the potential to result in significant water quality impacts. The permitting authority would be required to designate any incorporated place, county or other place under jurisdiction of a governmental entity that contributes substantially to the storm water pollutant loadings of a physically inter-connected MS4 regulated under an NPDES permit. Small Construction Sites: Discharges from construction activities that disturb greater than or equal to 1 acre and less than 5 acres, unless otherwise waived from certain program requirements. Sites disturbing less than 1 acre are also regulated if part of a larger common plan of development or sale.
Requirements	Small Municipalities (Population under 100,000): Each small MS4 would be required to obtain coverage under a NPDES permit. Permit would require that the small MS4 develop, implement, and enforce a storm water management program designed to reduce pollutants to the maximum extent practicable and protect water quality. Each small MS4 would be required to specify in their permit application or notice of intent to be covered under a general permit the best management practices that will be used in their storm water management program and measurable goals for six specified minimum control measures. These minimum measures include: public education and outreach, public involvement/ participation, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new development and re-development, and pollution prevention/good housekeeping for municipal operations. Small Construction Sites: Obtain coverage under a NPDES permit. Small construction site operators would be required to seek such permits under the phase I storm water requirements. General permit requirements under phase I include storm water pollution prevention planning, soil and erosion control, notice of intent, notice of termination, and municipal notification. The permitting authority could reference qualifying soil and erosion control measures.
Exemptions/Waivers	Storm water discharges from industrial facilities do not require a NPDES permit where owner or operator achieves and certifies no exposure of industrial materials or activities to storm water. Applicable to phase I and phase II. Not applicable to large or small construction sites, or individually designated sources. Permitting authority could authorize small construction sites to discharge subject to a general permit without submitting an NOI. Permit authority could waive regulation of a MS4 when the total population served by the MS4 is less than 1,000 people. The waiver may be provided if there are no water quality violations and no substantial contribution of pollutants to physically inter-connected and regulated MS4s. Permitting authority could waive requirements applicable to construction site disturbing 1 to 5 acres where waste load allocations (TMDL) addresses pollutants of concern; a comprehensive watershed plan addresses pollutants of concern; rainfall energy factor less than 2 during construction; or annual soil loss less than 2 tons per acre per year.
Other	Persons can petition the permitting authority to subject an MS4 to NPDES coverage. Permitting authority may designate other sources based on the potential for water quality impacts or significant contribution of pollutants.

EPA chose to be conservative by estimating higher, rather than lower, costs. EPA's approach for estimating costs for small MS4s involved:

- Identifying and characterizing the requirements of the proposed phase II regulation
- Applying cost data collected under the phase I storm water program for common program elements that represent incremental phase II requirements
- Developing minimum, mean, and maximum per capita costs for each of the six minimum measures required under the proposed phase II regulation
- Applying per capita costs to the potential universe of phase II municipalities for the first permit cycle
- Developing total and per capita cost estimates for the second and third permit cycles excluding certain first permit cycle costs (e.g., illicit connections) assumed completed during first permit cycle
- Developing other municipal costs (e.g., submittal of an application, record keeping, and reporting) from data previously developed under the phase I program.

EPA's approach for estimating costs for small construction sites involved:

- Identifying and characterizing the requirements of the proposed phase II regulation
- Developing an estimate of construction starts involving sites equal to or greater than 1 acre but less than 5 acres based on building permit data collected by the U.S. Bureau of the Census and then estimating the number of building permits issued on individual construction sites
- Determining the number of construction starts subject to incremental costs associated with the proposed phase II regulation through reviewing data on existing storm water requirements imposed by NPDES-authorized States on small sites
- Determining the fraction of starts where soil and erosion control is an incremental phase II cost based on a survey of local soil and erosion control programs
- Developing cost estimates for development of the storm water pollution prevention plan based on cost data from the phase I construction general permit
- Developing unit cost estimates for soil and erosion controls based on the control appropriate for small sites and applying these cost estimates to 21 scenarios in order to estimate the range of expected costs
- Developing cost estimates for the submittal of a notice of intent, notice of termination and notification to the local municipality based on cost data from the phase I construction general permit.

Exhibit ES-2. Summary of Major Cost Assumptions

Assumption	Potential Impact on Analysis
Estimated expenditures from large and medium sized municipal storm sewer systems (MS4s) were used to extrapolate the costs of minimum measures to phase II municipalities.	Potentially overstates the costs because phase II communities are smaller and do not have as many structures to maintain, systems to map, or connections to inspect for illicit discharges. Also, potentially understates per capita costs because smaller populations are required to finance public meetings, information packets, etc.
Not all phase II municipalities were expected to incur incremental costs for the minimum measures because many communities are already conducting regular maintenance of infrastructure and have storm water ordinances already in effect.	Potentially overstates costs. It is unknown what phase II communities are currently doing to control storm water discharges or what they may do before promulgation of a final phase II rule. Coastal communities will have some CZARA §6217 requirements that will need to be implemented prior to promulgation of the phase II rule.
Construction cost analysis includes Coastal Zone Act Reauthorization Amendments (CZARA) §6217 sites and does not take credit for soil and erosion controls that will be required in coastal counties prior to promulgation of the final phase II rule.	Overstates construction costs by including soil and erosion control costs in the analysis. Costs for storm water pollution prevention plans, notice of intent, and notice of termination are included in the analysis because they are required by the construction general permit but not the CZARA §6217 program.
Construction starts were estimated to increase 2.1 percent annually.	This assumption most likely over estimates the construction costs because the growth rate for construction starts fluctuates yearly and does not necessarily increase each year.
Distributing construction starts by size categories based on data collected from Prince George's County, Maryland.	Data may either under or over estimate the number of building permits issued for single-family homes occurring in developments greater than 5 acres. This will either over- or understate construction costs (i.e., there will be more, or less, single-family construction starts occurring on land disturbing less than 5 acres of land).
Use of general National Pollutant Discharge Elimination System permit.	The cost analysis assumes that municipalities, industrial facilities, and construction sites will apply for general permits. This may underestimate costs because some could apply for an individual permit. Phase II MS4s have the option to join together, if possible, or to request inclusion with an existing phase I MS4 permittee. If either of these occur on a widespread bases the municipal costs may be overstated.
Overlap with phase I requirements.	Whenever the phase II rule requires activities similar to phase I, such as permit conditions, the default was to use cost estimates developed for the phase I permits. This may overstate costs.
The number of starts were reduced by 15 percent annually to account for the construction waiver.	EPA estimates the number of construction sites that will apply for a waiver from the construction requirements of the phase II rule to range from 5 to 25 percent. The true number of sites which will be able to utilize the waiver is unknown, therefore, the 15 percent reduction may either under or overstate costs.
Construction cost off-set.	Potentially understates costs. Treating increases in the value of residential dwellings due to location near storm water ponds as a cost off-set may understate compliance costs for the construction industry.

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Major assumptions used in developing the cost estimates for small municipalities and small construction sites are summarized in Exhibit ES-2. In general, these assumptions tend to overstate rather than understate costs associated with the phase II regulation. For example, cost data drawn from phase I may overstate costs incurred by phase II sources because phase I sources must implement BMPs across a significantly larger spectrum of facilities, structures, and people. A second example is the inclusion of sites that may be subject to Coastal Zone Act Reauthorization Amendment (CZARA) requirements. CZARA requires coastal communities to implement management measures to address nonpoint source runoff from several specific types of activities, including construction activities in urban areas. By including construction sites potentially subject to these requirements, this analysis potentially overstates costs.

Exhibit ES-3 presents a summary of the estimated annual range of total annual costs imposed under the proposed phase II regulation and other major options considered. The range of values for each option includes the costs for compliance, which encompasses the paperwork requirements.

Exhibit ES-3. Summary of Total Annual Low-High Cost Estimates (Millions of 1997 Dollars)

	Status Quo	August 7, 1995 Final Rule	Plan B	September 30, 1996 Draft Proposed Rule	February 13, 1997 Draft Proposed Rule	Proposed Phase II Rule
Construction	$0	$270–$2,719	$225–$2,015	$153–$1,282	$17–$165	$17–$165
Municipal	$0	$632–$1,787	$350–$1,489	$94–$271	$94–$271	$94–$271
Industrial	$0	$1,218–$74,825	$0	$46–$2,632	$46–$2,632	$0
Total Cost	$0	$2,120–$79,331	$575–$3,504	$293–$4,185	$157–$3,068	$111–$436

Because the phase II proposed rule provides a significant degree of flexibility to the permitting authority and regulated phase II sources, the actual costs of implementing the proposed storm water phase II rule are highly dependent on how the program is implemented by the permitting authority and regulated phase II sources. To some extent, this flexibility is reflected in the broad ranges of costs. EPA believes that because of the significant flexibility provided by the proposed rule, the low to middle ranges of costs are most representative of the actual costs likely to be incurred. For example, in the municipal cost analysis, the maximum per capita estimate was driven by one municipality. The estimate for this municipality was viewed as an outlier and after it was removed from the data set, the maximum values approached the minimum values.

SOCIAL COSTS

The social costs of a proposed regulation include the costs imposed on the regulated community to achieve compliance with the proposed,[3] as well as the State and Federal costs of administering the regulation. Under the proposed phase II regulation, no compliance requirements have been deemed to require capital expenditure, however, EPA has included opportunity costs on the estimated total annual compliance cost for MS4s.

EPA estimated the cost to the Federal and State governments for administering the proposed regulation. The main component of this administrative cost category is the cost of labor and material resources for administering the municipal permit program (processing applications, reviewing storm water pollution prevention plans, reviewing municipal reports, and issuing permits) and for administering the construction program (Notice of Intent [NOI] and Notice of Termination [NOT] tracking).

EPA estimated unit costs for administrative function in the following areas:

- Incorporation of 401 certification into permits and revising storm water goals in non NPDES-authorized States;
- Permit application and issuance for municipalities including processing of applications, developing and issuing permits, reviewing the storm water pollution prevention plans, and reviewing the reports required of small regulated MS4s;
- NOI and NOT tracking for construction general permits; and
- Repermitting municipal sources.

Exhibit ES-4 presents the range of estimated social costs associated with the proposed storm water phase II regulation. The cost accounts have been separated to indicate the costs associated with information collection assessed pursuant to the Paperwork Reduction Act, as well as non-Paperwork Reduction Act compliance costs. Paperwork costs include applications, report preparation and generation, and record keeping. Non-paperwork compliance costs include items such as soil and erosion controls and public outreach activities.

[3] In this EA, this cost has been adjusted for the increase in property value of residential dwellings located around constructed ponds.

Exhibit ES-4. Estimated Total Annual Social Costs for the Proposed Storm Water Phase II Rule (Millions of 1997 $)

Social Cost Categories	Low Value	High Value
Total Annual Cost to Regulated Community for Compliance		
– Construction		
- PRA Costs	$26.0	$52.7
- Non PRA Costs	$81.0	$912.3
- Construction Cost Off-Set (negative cost)	-$90.0	-$800.0
– Municipalities		
- PRA Costs	$0.9	$2.1
- Non PRA Costs	$94.1	$269.3
Annual Opportunity Costs	$16.0	$46.2
Annual Unemployment Costs	$0.0	$0.0
Annual Costs for Administering the Proposed Regulation		
– Federal Costs		
- PRA Costs	$0.5	$1.3
- Non PRA Costs	$0.1	$0.4
– State Costs		
- PRA Costs	$2.4	$6.1
- Non PRA Costs	$0.4	$3.8
Estimated Total Annual Social Cost	$131.4	$494.2

Source: Exhibit 6-3

EVALUATION OF BENEFITS

Estimates of total annual monetized benefits associated with the phase II regulation were derived from an aggregate, "top-down" approach. This means that the underlying data and assumptions were geared to a national scale (e.g., national value of the commercial fishery, nationwide beach visit data). This approach was selected because research indicated that, given the variability of local situations and the scarcity of data on both local conditions and on extrapolation methods. A bottom-up approach is not feasible at this time. Nevertheless, information from more geographically-confined studies provided important data that support the benefit analysis. In addition, local and regional experiences also provided verification of some of the impacts and benefits that are estimated at a national level.

One consequence of the approach used to estimate total annual monetized benefits is that, unlike the cost analysis, the benefits analysis does not provide monetized estimates of the benefits associated with each phase II regulatory alternative.

Total annual monetized benefit estimates were derived using an approach in which the benefits of discrete, large-scale changes in water quality beyond present day conditions were estimated and then a share of those benefits was apportioned to the storm water phase II rule. To allocate water quality impacts to storm water runoff, data from the 1994 *National Water Quality Inventory* was used.[4] Prior to selecting these data for use in the analysis a comprehensive review of data sources and other analyses to identify sources that would meet three necessary criteria was used. The data source must provide information on a national level, address both coastal and interior water bodies, and provide comprehensive information on the contribution of storm water runoff to water quality impairment. The *Inventory* was the only national, comprehensive source of data on degrees and sources of water use impairment that addressed storm water runoff as well as other sources of water quality problems. Other data sources exist, such as the Clean Water Act Effects Model but they are limited in scope and coverage and could not provide a national benefits estimate.

The share of water quality improvement benefits attributed to phase II was based on the following approach. First, the maximum benefits obtainable after all non-CSO storm water impairments were reversed was estimated.[5] The benefits analysis identified numerous areas where controls on storm water runoff would have positive financial impacts on society through avoided costs or enhanced value or income. These include: enhanced commercial fisheries, avoided treatment costs, avoided water storage replacement costs, avoided navigational dredging costs, avoided damages from floatables, avoided flood damage and cleanup costs, and avoided streambank erosion. Similarly, the benefits analysis identified the following recreational benefits: enhanced opportunities for swimming, enhanced opportunities for fishing, reduced illness from consuming contaminated seafood, reduced illness from swimming in contaminated waters, enhanced opportunities for boating, and enhanced opportunities for other, non-contact recreation.

Exhibit ES-5 presents the range of total annual monetized benefits associated with controlling water impairments resulting from storm water discharges. This exhibit includes the estimated maximum total annual monetized benefit that could be attained by controlling discharges from storm water phase I and phase II sources and sanitary sewer overflows.

[4] This report is also known as the 305(b) Report to Congress.

[5] This includes discharges from storm water phase I sources, storm water phase II sources, and sanitary sewer overflows. This does not include combined sewer overflows.

Exhibit ES-5. Total Annual Monetized Storm Water Benefits (Thousands of 1997 $)

	Lower bound	Upper Bound
Financial Benefits	$165,800	$478,300
Recreational Benefits	$83,900	$551,900
Health Benefits	$3,873	$7,900
Total	$253,573	$1,038,100

Source: Exhibit 10-4.

After estimating maximum potential storm water control benefits, the share of storm water impairments that are attributable to sanitary sewer overflows and to phase I storm water sources, were estimated and removed. Finally, to account for the fact that any control will not be 100 percent effective, EPA estimated the effectiveness of the phase II storm water best management practices and applied these estimates to the total annual phase II monetized benefits. Due to the uncertainty regarding the rate of effectiveness of different best management practices and other related issues such as allocating benefits between other EPA Wet Weather Programs, EPA developed 3 scenarios to estimate phase II total annual monetary benefits.

Scenario 1 includes the following assumptions:

- When monetary benefits resulting from controlling sanitary sewer overflows and storm water pollutants overlap, 2/7 of the benefits should be attributed to sanitary sewers and 5/7 to storm water
- Municipal benefits were distributed 50:50 between phase I and phase II sources
- Construction benefits were split 40 percent for phase I sources and 60 percent for phase II sources
- EPA also determined that 100 percent of all benefits that can be attributed to industrial sources are phase I benefits
- EPA estimated the total monetized benefits if the storm water controls were 90 percent effective in removing or prohibiting storm water pollutants. This number is based on effective installation combined with monthly inspections. Ninety percent effectiveness is consistent with the maximum effectiveness of a properly installed silt fence. Silt fences are a low cost and commonly used best management practice at construction sites.

Scenario 2 includes the following assumptions:

- When monetary benefits result from controlling sanitary sewer overflows and storm water pollutants overlap that 2/7 of the benefits should be attributed to sanitary sewers and 5/7 to storm water

- Municipal benefits were distributed 50:50 between phase I and phase II sources

- Construction benefits were split 50:50 between phase I and phase II sources

- EPA also determined that 100 percent of all benefits that can be attributed to industrial sources are phase I benefits

- EPA estimated storm water benefits if the controls were 60 percent effective in prohibiting storm water contamination or in the removal of storm water pollutants. EPA believes that once the phase II permittees adopt and implement storm water best management practices the effectiveness of the practices will vary. The effectiveness will vary because permittees are not required to implement specific practices and the effectiveness between properly installed practices varies. Therefore, EPA suggests that the effectiveness of phase II storm water controls may be as little as 60 percent if controls are not properly installed and inspected.

Scenario 3 includes the following assumptions.

- EPA decided to split the benefit categories that overlap all wet weather programs (combined sewers, sanitary sewers, and storm water) based on total suspended solids (TSS). EPA has determined the benefits split should be as follows for these categories: 1 percent for sanitary sewer overflows, 3 percent for combined sewer overflows, and 96 percent for storm water.

- Municipal benefits were distributed 50:50 between phase I and phase II sources.

- Construction benefits were split 40:60 between phase I and phase II sources.

- It was determined that 100 percent of all benefits that can be attributed to industrial sources are phase I benefits.

- Total monetized benefits were estimated as if the storm water controls were 80 percent effective in removing or prohibiting storm water pollutants. Eighty percent effectiveness is consistent with the TSS removal efficiency goal of the CZARA program.

Exhibit ES-6. Summary of Total Annual Monetized Benefits from Implementation of the Proposed Phase II Storm Water Rule (Millions of 1997 $)

Benefits Category	Scenario 1 Annual Value	Scenario 2 Annual Value	Scenario 3 Annual Value
Financial Benefits	$83 - $265	$42 - $130	$71 - $226
Recreational Benefits	$35 - $228	$22 - $149	$31 - $202
Health Benefits	$1 - $3	$1 - $2	$2 - $4
Total	$119 - $495	$65 - $281	$104 - $431

Source: Exhibit 10-8.

Although this analysis identified and monetized significant benefits associated with the proposed phase II storm water regulation, it did not address all benefits associated with the proposed regulation since not all such benefits can be readily monetized. For example, the benefits of storm water runoff controls in protecting habitats and wildlife are not addressed in the estimates provided above. Hydromodification is addressed in the benefits analysis, but it is extremely difficult to estimate the monetized benefit from controlling sources on a large-scale basis.

COMPARISON OF COSTS AND BENEFITS/COST-EFFECTIVENESS

As discussed above, EPA was able to develop a partial monetary estimate of expected annual benefits for the storm water phase II proposed rule for financial benefits, recreational benefits, and health benefits. Summing the annual monetized benefits, for each of the scenarios, across these categories results in total annual monetized benefits ranging from approximately $66 million to $495 million (1997 $) annually for the proposed rule. This estimate of benefits understates the true value of storm water controls because it omits numerous mechanisms by which society is likely to benefit from reduced storm water pollution, such as improved aesthetic quality of waters, benefits to wildlife and to threatened and endangered species, option existence values, cultural values, tourism benefits, biodiversity benefits, and reduced siting costs for reservoirs.

Exhibit ES-7 presents a comparison of the estimated total annual monetized benefits with the total annual costs associated with the proposed storm water phase II regulation. Because EPA is uncertain of the exact total annual monetized benefit the benefits for each scenario has been compared to total annual costs. The net annual social benefits (social benefits less social costs) for the three benefits scenarios range from a low of negative $63.1 million in Scenario 2 to a high of negative $0.2 million in Scenario 1.

Exhibit ES-7. Comparison of Total Annual Monetized Benefits to Total Annual Costs for the Proposed Phase II Storm Water Rule (Millions of 1997 $)

Benefit Categories	Scenario 1 Value	Scenario 2 Value	Scenario 3 Value
Financial Benefits	$ 83.6 - $264.5	$42.1 - $130.5	$71.5 - $226.2
Recreational Benefits	$ 34.6 - $227.6	$22.8 - $149.4	$30.8 - $202.3
Health Benefits	$ 1.2 - $ 2.5	$0.8 - $ 1.6	$1.5 - $ 3.2
	$ 119.4 - $ 494.6	$ 65.7 - $ 281.5	$103.8 - $ 431.7
Cost Categories	Value	(Low- High)	
Compliance Costs		$ 112.0 - $ 437.0	
Opportunity Costs		$ 16.0 - $ 46.2	
Administration Costs		$ 3.4 - $ 11.6	
Total Monetized Costs		$ 131.4 - $ 494.8	
Net Monetized Benefits	$ (12.0) - $ (0.2)	$ (65.7) - $ (213.3)	$ (27.9) - $ (63.1)

Source: Exhibit 11-1.

EPA believes that there are several aspects of the storm water phase II rule that inherently encourage the selection of cost-effective practices. EPA structured the proposed storm water phase II rule to allow NPDES permitting authorities to develop specific programs that reflect the most cost-effective approach given regional and watershed-specific conditions. In addition, given the flexibility provided in this rule would allow regulated entities to select the most cost-effective storm water best management practice because it is in their economic interest to do so.

The proposed phase II storm water regulation has been structured to protect water quality through completing the phased storm water program while providing a maximum amount of flexibility to those affected by the program. In developing this proposed regulation, EPA has combined those provisions deemed most important by the Agency and stakeholders on the FACA Subcommittee, and has worked to achieve an approach that will be cost effective. Among the options considered, the proposed regulation would impose the lowest estimated costs on the regulated community and those agencies responsible for implementing the rule while achieving significant benefits. In addition, the flexibility provided under the proposed phase II regulation promotes efficient implementation. EPA believes these factors support the regulatory approach proposed.

REGULATORY FLEXIBILITY ANALYSIS

In compliance with the Regulatory Flexibility Act of 1980 (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), EPA analyzed the potential for the proposed phase II storm water regulation to have a significant economic impact on a substantial number of small entities. In identifying small entities potentially affected by the rule, EPA used the definitions of small businesses, municipalities, and nonprofit organizations established by the RFA and the Small Business Administration (SBA). Criteria for determining whether an impact is significant are established by EPA guidelines.

Based on data from the 1990 U.S. Census, EPA identified a total of 3,614 small municipalities subject to the proposed rule. In addition, 11 American Indian reservations are potentially affected. EPA identified 187,610 construction firms in SIC 15 with annual sales within applicable SBA size standards (between $0 and $17 million). However, it is not possible to distinguish which of these business are not involved in site development (and thus not subject to the proposed rule). The proposed rule does not apply to any nonprofit organizations.

EPA conducted screening analyses of the potential economic impact of the proposed rule on the identified small entities. For municipalities, EPA conducted a "revenue test." This test calculates total annual compliance cost as a percentage of total annual municipal revenues. EPA calculated total annual compliance cost based on mean costs ($2.69 per capita and $555 per municipality) and the population reported in the 1990 Census. EPA estimated annual revenues based on data from the 1992 Census of Governments, using state-specific estimates of annual revenue per capita for municipalities in three population size categories (fewer than 10,000, 10,000–25,000, and 25,000–50,000). EPA performed the revenue test for American Indian reservations using these same sources but adjusted the per capita revenue estimates.[6]

EPA conducted a "sales test" to evaluate the potential economic impact of compliance costs on small businesses. This test compares annual compliance cost as a percentage of total sales. Because the available data are not amenable to this calculation, EPA approximated the sales test by estimating

[6] Revenue per capita for tribal governments was not available. Therefore, EPA used the state-specific municipal per capita revenue estimates by size category and adjusted these estimates downward based on the ratio of per capita income on the reservation to per capita income for the state. EPA then multiplied the adjusted estimates of per capita revenue by the reservation population and conducted the screening analysis in the same manner as for municipalities (assuming annual compliance costs of $2.69 per capita and $555 per reservation).

compliance costs for single-family homes under various scenarios and comparing those costs with the median sale price of a single-family home. However, it is unlikely that the compliance costs will be borne by businesses developing construction sites and building and selling new single-family homes because they are able to pass regulatory costs on to buyers.

Based on criteria established for use in implementing the RFA and SBREFA, EPA does not expect the proposed phase II storm water rule to have a significant economic impact on a substantial number of small entities. The results of a revenue test for municipalities indicate that mean estimated compliance costs represent greater than 1% of estimated revenues for only 62 (or 1.7%) of the affected small municipalities, and greater than 3% of estimated revenues for only 4 (or 0.1%) small municipalities. Thus, the rule may be presumed not to have a significant economic impact on a substantial number of small entities (a Category 1 rule). A doubling of the estimated per capita portion of compliance costs does not change this potential classification. In addition, only a small number of Native American reservations are affected, which also does not change the potential classification.

EPA's approximation of a "sales test" for site developers and building contractors suggests that mean compliance costs will not exceed 1% of sales for a construction business that builds and sells typical single-family homes (the one exception is for homes built on sites between 4 and 5 acres, when the sales test ratio is estimated based on the median home price and including soil and erosion costs). In addition, as described above, these costs will most likely be passed on to the homebuyer. Indeed, EPA's analysis indicated that the potential increase in monthly mortgage payments may range from $0.79 to $13.51, which is relatively small compared to average monthly payments ranging from $900 to $1,500. Thus, a "pass through" of costs to home buyers appears feasible. These results suggest that the rule may be classified as Category 1 for building contractors as well.

ENVIRONMENTAL JUSTICE

Executive Order 12898 established a federal policy for incorporating environmental justice into federal agency missions by directing agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. EPA ensured consideration of environmental justice concerns during the Phase II rulemaking by selecting a balanced FACA membership and specifically inviting a representative of the Environmental Justice Information Center to participate on the storm water phase II FACA subcommittee. Together, the FACA and EPA examined the potential impact of the proposed storm water phase II rule on low-income and minority populations, and worked to develop a proposed rule that would advance environmental justice.

Three aspects of the proposed storm water phase II regulation will promote environmental justice. First, the proposed rule would result in improvements in water quality in the areas around small municipalities and certain industries that impact water quality. These improvements will benefit all persons living in or using these areas, including minority populations and low-income populations. Second, the proposed rule would provide a high degree of flexibility to the NPDES permitting authority to address high priority contaminated storm water discharges based on community input and public participation. This ability to focus program requirements on priority needs or areas should serve as an additional tool to address environmental justice concerns. Finally, the proposed phase II regulation will promote environmental justice through its substantive requirements. The proposed regulatory language would specify that required public education and outreach programs required of small MS4s should be tailored to address the concerns of all communities, particularly minority and disadvantaged communities. In addition, the proposed regulatory language would specify that compliance with required public involvement and participation requirements should include efforts to engage all economic and ethnic groups.

UNFUNDED MANDATES

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) establishes requirements for Federal Agencies to assess the effects of their regulatory actions on State, local and tribal governments and the private sector. UMRA requires EPA to:

- Identify the Federal law under which the rule is being promulgated
- Describe EPA's consultation with representatives of State, local, and tribal governments
- Identify regulatory alternatives
- Qualitatively and quantitatively assess the anticipated costs and benefits of the proposed rule
- Assess costs imposed on the economy and unemployment impacts, and
- Select the least costly, most-cost effective, or least burdensome alternative.

EPA has completed each of these requirements as presented specifically in Chapter 5 and generally throughout this EA. As discussed in Chapter 2, the phase II storm water regulation is required by § 402(p)(6) of the CWA, which requires that the phase II program must, at a minimum, establish priorities, establish requirements for State storm water management programs, and establish expeditious deadlines. This provision also provides that the program may include performance standards, guidelines, guidance, management practices, and treatment requirements, as appropriate.

In developing the proposed phase II regulation, EPA has taken numerous steps to obtain the input of representatives of State, local, and Tribal governments. EPA solicited public comments on alternative approaches to the phase II program in a *Federal Register* notice published on September 9, 1992 (See 57 *FR* 41344). Forty-three and 24 percent of the 130 comments received were from municipalities and State or Federal agencies, respectively. In addition, EPA held public and expert meetings in 1993 to assist in developing and analyzing options for identifying unregulated storm water sources and possible controls. Finally, EPA established the Urban Wet Weather Flows Federal Advisory Committee (FACA), which included a Storm Water Phase II Subcommittee. The balanced membership of the Storm Water Subcommittee included representatives from States, municipalities, and Indian Tribes, as well as the industrial and commercial sectors, agriculture, environmental groups, and public interest groups. EPA worked with the Storm Water Subcommittee for over 18 months in developing and refining options for the proposed phase II program.

Working with the FACA Subcommittee EPA considered several distinct regulatory options, which are discussed generally above and in detail in Chapter 3. Compliance cost estimates for these options are presented in Chapter 4 and low and high cost estimates for each option are presented above in Exhibit ES-3. Also, as summarized above and discussed in Chapters 7-10, EPA assessed the benefits of the proposed phase II regulation. Chapter 10 indicates the monetized benefits. The monetized benefits for three likely benefits scenarios are summarized in Exhibit ES-6 and the comparison of benefits to costs for the proposed phase II storm water rule are indicated in Exhibit ES-7.

For several reasons, EPA does not believe that this proposed rule will have a significant effect on the economy or upon unemployment. First, the proposed rule does not address industries involved in production, but rather small municipalities and small construction sites. Second, flexibility within the proposed rule will allow municipalities to tailor proposed phase II requirements to their needs and financial position. Finally, discussions with representatives within the construction industry indicate that construction costs are likely to be passed on to consumers. EPA believes that these same reasons will result in the proposed rule having minimal or no unemployment impacts.

Finally, as indicated in Exhibit ES-3, the proposed storm water phase II regulation would be the least costly alternative. As previously stated, the net annual social benefits (social benefits less social costs), for the three benefits scenarios, range from negative $0.2 million in Scenario 1 to negative $63.1 million in Scenario 3.

PAPERWORK REDUCTION

The Paperwork Reduction Act of 1995 requires EPA to assess the paperwork burden imposed on the regulated entities for the proposed storm water phase II rule. Within this EA, EPA has estimated the paperwork burden and costs for three permitting cycles, or 15 years. The average annual burden and cost for requirements directed by the Paperwork Reduction Act of 1995 are estimated to be approximately 2.1 million hours and $75.5 million for each year in the first permit cycle and approximately 2.0 million hours and $60.9 million for each year in the second and third permit cycles. Exhibit ES-8 indicates the estimated annual hourly burden and cost for those entities affected by the proposed storm water phase II rule.

Exhibit ES-8. Estimated Total Annual Paperwork Burden

Paperwork Requirement for:	First Permit Cycle		Second and Third Permit Cycles	
	Total Hourly Burden(thousands)	Estimated Annual Cost (millions)	Total Hourly Burden (thousands)	Estimated Annual Cost (millions)
Small Construction Sites	1,700	$52.0	1,700	$52.0
Small MS4s	106	$2.7	72	$1.9
Federal Government	48	$14.0	43	$1.3
State Governments	263	$6.8	219	$5.7
Annual Total	2,117	$75.5	2,034	$60.9

Note: The costs associated with the paperwork requirements have been included in the range of estimated costs in Exhibit ES-3.

PHASE I INDUSTRIAL NO EXPOSURE

The proposed storm water rule includes a provision which will allow phase I industrial establishments to certify that if they have no exposure of significant materials or industrial activities to storm water they can petition EPA for an exemption from the requirements of the storm water phase I rule. This provision is included in the phase II proposed storm water rule but is only applicable to phase I industrial establishments. Therefore, EPA has decided not to factor the costs savings associated with this exemption into the costs analysis for the phase II rule. Rather, the cost savings associated with this exemption will be addressed separately in a later version of this EA.

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RESEARCH REPORT

Enforceable State Mechanisms for the Control of Nonpoint Source Water Pollution

October 1997

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ENFORCEABLE STATE MECHANISMS FOR THE CONTROL OF NONPOINT SOURCE WATER POLLUTION

Environmental Law Institute

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Enforceable State Mechanisms for the Control of Nonpoint Source Water Pollution

ELI Project #970300

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Executive Summary

This study examined the laws of the fifty states, Puerto Rico, and the District of Columbia to identify and analyze enforceable mechanisms for the control of nonpoint source water pollution. An enforceable mechanism consists of a *standard* applicable to an identified entity or entities; a *sanction* such as a civil, criminal, or administrative penalty, loss of a license, and performance of required remedial action, but not mere loss of an incentive; and a *process*, either explicit or implied, for applying the standard and imposing the sanction.

The study found many enforceable mechanisms in state law, and also found that there is great variability in such authorities. In the absence of any federal legislative or regulatory norm, the states have exhibited great diversity in their legislation.

Standards are often supplied by a mixture of agriculture laws, forestry laws, fish and game laws, nuisance prohibitions, general water pollution discharge prohibitions, land use planning and regulation laws, and criminal laws. Also, many state authorities are watershed-based, or targeted solely upon critical areas, buffers, or particular impaired waters. In addition, state laws also often delegate standard setting, implementation, or enforcement duties to units of local government or conservation districts.

Because of this great variation in approach, it is not possible to quantify nonpoint authorities or to classify them in mutually exclusive categories. Moreover, because these laws operate together, it is necessary to understand each state's entire program in order to assess its potential for using an enforceable mechanism to deal with particular conduct in a particular place. For example, a state may address in its forestry law conduct that is addressed in another state by a soil and water conservation district law. Or a state may address agricultural activities in riparian buffer zones or critical areas in ways that it does not address similar activities that are located at greater distances from identified waters, while another state imposes similar requirements across all agricultural lands.

Some general observations emerge from the study.

First, nearly all of the states have some general statutory authority to deal with nonpoint source discharges that can be shown to result in water pollution. These "general discharge prohibition" authorities come in different forms, but most are parts of states' water pollution control laws. Careful scrutiny of these laws is essential in assessing their utility in controlling nonpoint source pollution. For example, in about half the states, water pollution control provisions superficially resemble the federal Clean Water Act's prohibition of the discharge of a pollutant without a permit, 33 U.S.C.

1311(a), but unlike the federal act can be applied to nonpoint source pollution because they lack the limitation in 33 U.S.C. 1362(12) that defines "discharge of a pollutant" as "from any point source."

General discharge prohibition laws come in two major types. One type prohibits the discharge of any substance (or pollutant, or waste) without a permit. This is broad authority and can serve either as the basis for adopting a permitting program by regulation or for enforcement against discharges in appropriate case-by-case settings. Some states with this type of authority have adopted explicit statutory or regulatory exemptions for agriculture or forestry activities. The definition of "waste" or "pollutant", if these terms are used rather than "any substance" in such provisions may present difficulties in controlling nonpoint discharges of sediments or properly applied agricultural chemicals in some states.

Even more states have provisions that simply prohibit the causing of "pollution," or causing or contributing to the exceedance of water quality standards. In these states, however, the difficulty of proving a direct link between a particular discharge and the condition of a waterbody can be substantial, or at least expensive absent ongoing and extensive monitoring. Nevertheless, these provisions allow states to impose sanctions and obtain compliance in relatively clear-cut cases. Provisions in state public health and penal codes and fish and game laws, typically enforced as petty criminal offenses, also may prohibit specific kinds of discharges that detrimentally affect public waters, cause nuisances, impair public health, or kill fish. Again, these require proof of a detrimental effect directly traceable to the operation in question before enforcement action may be taken.

The general discharge prohibitions primarily operate as back-up enforcement authorities, used when voluntary and incentive measures fail, or when no other authority exists in a given area. However, in some states they serve as the basis for the imposition of direct regulatory requirements upon nonpoint source dischargers. More states apply enforceable mechanisms to require operating standards and practices through targeted laws, such as erosion control laws, forest practices laws, and agricultural conservation laws.

Enforceable erosion and sediment control laws provide one significant area of control. Some of these programs are statewide in application, many are delegable to local governments or conservation districts. However, most of these programs exempt agriculture or at least normal agricultural activities; some exempt both agriculture and forestry. Thus, where these laws exist, and where they have coverage beyond simple NPDES stormwater permitting, they are usually directed at disturbance of earth for development or land conversion activities.

Forest practices laws play a role in establishing enforceable nonpoint source pollution controls in about a dozen states - primarily on the west coast and in New England - which have forestry laws with enforceable statewide standards. These states require the preparation and approval of harvest plans incorporating state standards or prescribed best management practices (BMPs). Other states regulate forest practices through erosion and sediment control laws. Even more common are forestry-related requirements establishing riparian buffer zones, limiting percentage of vegetation that may be removed near a waterway, special rules for timber operations in wetlands, and similar targeted requirements. While these approaches all rely on prescriptive enforceable requirements, another approach has been adopted by a handful of states. These do not require the enforceable implementation of particular standards statewide, but have instead adopted a "bad actor" authority that allows them to issue orders to halt particular logging operations that are actively discharging pollution.

Another approach with some relevance to forest sources of nonpoint source pollution is the increasing number of states that now require licensing of loggers and/or professional foresters. While licensing does not itself limit nonpoint source pollution, it can serve as a means to have timber operations designed and supervised properly, and assures familiarity of operators with BMPs.

Agriculture is the most problematic area for enforceable mechanisms. Many laws of general applicability, as noted above, have exceptions for agriculture. Where state laws exist, they often defer to incentives, cost-sharing, and voluntary programs. Nevertheless, about a fifth of the states have some statewide sediment requirements applicable to agriculture, often administered by local governments or soil and water conservation districts. Even more states (about a fourth) authorize individual soil and water conservation districts, as a matter of local option, to adopt enforceable "land use regulations" for the control of erosion and sedimentation. But most of these require approval by landowner referendum, with approval requiring a super-majority (ranging from 66 to 90 percent) in order for such regulations to become effective.

Enforceable regulation of agricultural nutrients presents a mixed picture. Enforceable authorities most commonly include concentrated animal feeding operation (CAFO) regulations similar to the federal requirements, but with variations on the number of animals, or with the addition of siting requirements. Some states have adopted "accepted agricultural practice" requirements, or nutrient regulations, that are enforceable. Most states have laws regulating fertilizers, but only to ensure content and efficacy: only a few have provisions that address misapplication of fertilizers or water pollution resulting from such application. Finally, a number of states have enforceable provisions allowing districts or agencies to order abatement of agricultural pollution. Several of these laws provide that abatement cannot be ordered unless state or federal cost-share money is provided to help pay for the required action.

In the context of both forestry and agriculture, states have in many different ways contrived mechanisms to make BMPs either enforceable or at least something more than voluntary by linking them to other enforcement mechanisms. There are at least five such approaches. Some laws, such as state comprehensive forest practices laws, make BMPs directly enforceable in connection with required plans and permits. Another approach makes BMPs enforceable, but only after the fact when a "bad actor" is causing pollution. A third approach makes BMPs the basis for an exemption from a regulatory program. For example, a law may provide that compliance with BMPs will allow a forestry operation not to need a permit under a critical areas program, or a farm not to comply with an erosion and sediment control law. Another approach makes compliance with BMPs a defense to a regulatory violation; such provisions include those that prohibit a state from taking action under a water pollution control statute against a farm that is implementing BMPs, whether or not the operation is causing pollution. Finally, a substantial number of states make compliance with agricultural BMPs a defense to nuisance actions.

Pesticide discharges are regulated indirectly by most states. Most states provide for state registration of pesticides, and for licensing of dealers and various classes of applicators (with typical exemptions for farmers applying pesticides to their own or neighbors' property). States typically have the ability to prohibit or restrict uses in areas where there is evidence of damage or harm. Some states have broad prohibitions of causing harm anywhere, but in most states these provisions do not cover "use" or application of pesticides, but only transport, storage, and disposal. Several states have prescribed responses if contamination is shown by state monitoring of waters or groundwaters.

Several other sources of nonpoint source pollution are subject to enforceable mechanisms. Onsite sewage disposal systems (septic tanks) are usually locally regulated by building codes and health officials. However, a significant number of states have adopted requirements at the state level and delegated administration to local governments. Only a small number of the state laws explicitly require the owner to maintain the proper functioning of the system. There are often special requirements in coastal areas for the construction and maintenance of such systems. Hydromodification, including drainage and stream alteration activities, is subject to a great deal of state regulation, some of which addresses nonpoint source impacts of the activity. Less explicit state law speaks to highways and certain other state agency activities, but some mechanisms exist there as well.

With respect to most of the issues described above, the most sophisticated state enforceable requirements appear to be arising on a targeted watershed basis. There are typically more explicit operating requirements and clearer enforcement authorities in the context of watershed protection areas, estuaries and coastal waters, wild and scenic rivers, and targeted impaired waters. This presents both a greater level of complexity for understanding state enforceable mechanisms and an opportunity for further work, research, and analysis. Federal decisionmakers can assist in the development of state enforceable authorities by undertaking studies of the effectiveness of these authorities in particular watersheds and with respect to particular impaired waters.

This report demonstrates the great diversity of state legislation imposing enforceable mechanisms. It identifies the kinds of responses that state and federal decisionmakers can draw upon in filling gaps and dealing with remaining water quality problems in the nonpoint source context.

Chapter One:

✲

Introduction

After 25 years of federal and state efforts under the federal Clean Water Act, nonpoint source pollution remains a significant problem. The Act's enforceable provisions are directed at discharges from point sources - regulating the discharge of pollutants to surface waters from pipes, outlets, and other discrete conveyances. In contrast to this enforcement approach, nonpoint source water pollution - polluted runoff - is addressed primarily through non-regulatory means under the Act.

Yet water pollution from nonpoint sources remains a substantial contributor to the impairment of waters across the nation. Various approaches have been used to control such pollution, including assistance to states from federal planning and grant programs under the Clean Water Act (e.g., 33 U.S.C. §§ 1288, 1329). Common strategies at the state level include watershed and land use planning, development of voluntary best management practices (BMPs), technical assistance programs, cost-sharing for implementation of prevention and control measures, and - the focus of this study - some enforceable mechanisms, including regulation and liability provisions.

State adoption of enforceable mechanisms has occurred largely in the absence of any direct federal requirement or mandate. But the federal Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) provided impetus to most coastal states to identify enforceable mechanisms applicable to activities causing or contributing to nonpoint source pollution in the coastal zone. 16 U.S.C. §§ 1455(d)(16), 1455b. The implementation of urban and industrial stormwater permitting by the states under the 1987 Water Quality Act has also resulted in some states taking a more comprehensive approach to sedimentation and polluted runoff beyond simply meeting the federal requirements. Acting independently, some states have adopted innovative programs or employed older pollution control authorities to control nonpoint source pollution. There is much activity, ferment, and interest in this area.

The Environmental Law Institute has examined what enforceable mechanisms the states have available to them, the scope of the existing mechanisms used by the states, and the general limitations and impediments that accompany some of these mechanisms, in order to inform the nation's policy decisions on the remaining nonpoint problem. This report summarizes the Institute's findings.

STATE LAW: DIVERSE AND CHANGING

It is important to recognize at the outset that both the existence and scope of legally enforceable measures vary widely among the states. Absent explicit federal requirements in the area, such variation is not only to be expected, but somewhat desirable as it provides an opportunity to assess alternative approaches.

Some states have attempted to achieve broad coverage over polluting activities in their enforceable nonpoint source control mechanisms, while many others have taken aim at specific problems. Still other states have little in the way of an articulated enforceable scheme, although even these generally have some statutory enforcement authorities that could be used to address particularly damaging discharges from nonpoint sources. It is fair to say that no state is entirely without any enforceable authority relevant to nonpoint source discharges. While some states have few such authorities, others have adopted a bewildering array of enforceable tools applicable to specific watersheds, specific activities, and specific effects on the environment. These are frequently paired with equally bewildering arrays of exemptions and exclusions.

Understanding what enforceable mechanisms exist is important -- both in order to structure federal and state programs that can improve and maintain the nation's water quality, and to operate fairly in addressing the respective responsibilities of point and nonpoint source dischargers for water quality improvement.

The task of understanding state enforceable controls is quite difficult because no two states have adopted anything like the same set of laws. And even when the laws appear quite similar, they often have varying definitions, enforcement mechanisms, and procedures. In more than one instance, even laws that use identical words can have quite different scopes because of minor changes in the wording of the relevant definitions. These variations, along with the widely varying complements of laws enacted by each state, make state-to-state comparisons of particular laws difficult. One state may address nonpoint source silvicultural discharges through its broad sediment control statute, while another may reach the same conduct through a forest practices law, a combination of watershed-specific laws, or a water pollution control statute that covers some forms of nonpoint discharges as well as point source discharges.

This extreme variability also has another lesson for the policymaker: state programs can only be understood whole. The mere compilation of a list of authorities does not reveal their interconnection, whether and how they can be used in practice given institutional and procedural constraints, or how programs delegated to counties, localities, or watershed districts can be evaluated in relation to apparently similar state programs that are not so decentralized. As a result, even this study - looking at numerous authorities across all of the states - necessarily gives an incomplete picture of the individual capacity of any one state.

Any research effort examining the states is also faced with rapidly changing information. There is more than the typical amount of flux in the many state laws that affect nonpoint source discharges. This is true for at least three reasons:

First, state legislatures typically respond to new and urgent problems. As new pollution problems are identified as important, or are elevated in importance as older problems are being solved, legislative responses become more likely. This is clearly the case with respect to such nonpoint source issues as animal waste (particularly with respect to siting issues), silvicultural practices affecting rivers and watersheds, biological effects such as *Pfiesteria piscicida*, impacts of suburban development, the cost of providing additional levels of treatment at publicly owned treatment works, and new interest in the recovery of river corridors. States are often the first line responders to the emergence of new problems or the ascendancy of older ones.

Second, state action is beginning to be affected by the CZARA-driven upgrades to nonpoint source programs in the coastal states. The "conditional approvals" given by the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) to many of these programs will require states to seek new "enforceable mechanisms" or to demonstrate the utility of such existing mechanisms over the course of the next several years if their programs are to remain compliant and eligible for continued nonpoint source grant funding under the Clean Water Act and coastal zone funding under the Coastal Zone Management Act. A prior wave of modest enforceable nonpoint control mechanisms was launched by the stormwater permitting programs under the 1987 Water Quality Act. While many states simply implemented the requirements of the program, others took the initiative to add additional land use and sediment controls in implementing legislation.

Third, state action is beginning to be affected by the impact of judicial and EPA requirements for states to establish and implement Total Maximum Daily Loads (TMDLs) for their impaired waters. This task will require both better understanding of pollution sources in affected waterbodies, and development of effective state responses in requiring pollution prevention and controls. 33 U.S.C. § 1313(d).

Indeed, greater investment in the assessment of impaired waters in state biennial reports under 33 U.S.C. 1315(b) is also playing a role in the evolution of state nonpoint source authorities. These state assessments and improved technical tools and capacity, including the use of biological indices, are beginning to reveal the locations and scale of pollution problems only guessed at in prior decades. The identification of particular impaired waters can lead to political pressures at the state level to adopt control and abatement measures.

In sum, this area is one in which state laws are changing. At the same time, however, many of the laws that create enforceable duties for nonpoint source dischargers are quite old. As described below, some are the legislative codifications of centuries-old common law nuisance principles. Others are broad provisions in state clean water laws enacted in the 1960s and 70s that apply to nonpoint sources, but that may not have been implemented to their fullest extent by regulations or enforcement programs. Still others are state laws, such as planning and zoning laws, that have relevance to pollution-causing activities, but that were not originally drafted with pollution prevention effects in mind. This mixture of new laws and new implementation opportunities for older laws constitutes the complement of enforceable mechanisms available in most states.

This study is a snapshot of state laws at one time, taken with the knowledge and expectation that changes are continuing. The picture that emerges is intended to inform the broader discussion and to help lead to the development of effective approaches as states continue to make laws in this area.

RESEARCH APPROACH

Scope

This study examined the laws of the fifty states, Puerto Rico, and the District of Columbia. It did not examine tribal laws, nor the laws of individual cities or municipalities. However, to the extent to which duties and enforceable mechanisms were created by state law and delegated to political subdivisions, these state laws were examined.

It is necessary to define the scope of the study with respect to "nonpoint" source pollution because of the increasing overlap of this category with sources regulated under the point source (NPDES) provisions of the Clean Water Act. These areas of overlap have arisen, in part, as a result of decisions by Congress to expand the regulatory reach of the Clean Water Act incrementally -- primarily by bringing more categories into the point source permitting program.

The municipal and industrial stormwater program is the most significant of these potential overlaps. Section 402(p) of the Clean Water Act, 33 U.S.C. 1342(p), enacted in 1987, established a two-phase program. Under the first phase, NPDES permits (individual, general, or multi-sector or "group" permits) are required for stormwater discharges from municipal separate storm sewers serving populations greater than 100,000, and stormwater discharges from certain industrial activities including, initially, construction sites of five acres or larger. Permits may also be required case-by-case if a stormwater discharge is determined to violate a water quality standard or is a significant contributor of pollutants to the waters of the United States. The second phase will cover stormwater discharges from smaller metropolitan areas, smaller construction sites, light industry, and other activities. Obviously, not all earth-disturbing activities resulting in runoff are captured by the stormwater permitting program, and many such activities are regulated, if at all, by the states under other authorities. Because state authorities often cover both activities subject to stormwater permitting and other activities, this study attempted to include the general state authorities that appeared to cover these other activities, even if many also clearly fall within the § 402(p) universe.

A similar problem was presented by enforceable mechanisms dealing with agricultural sources of animal wastes. Large concentrated animal feeding operations (CAFOs) are regulated as point sources under the Clean Water Act, 33 U.S.C. 1362(14). Many states, accordingly, regulate these operations through amendments to their water pollution control regulations corresponding to 40 CFR 122.23 and 40 CFR Part 122, App. B. Such point source regulation is not within the scope of this study. This study focuses on state nonpoint source authorities affecting animal wastes that appear to have a different reach from the federal CAFO regulations.

Finally, section 401 of the Clean Water Act, 33 U.S.C. 1241, presents a related issue. That section requires states to certify whether an activity to be authorized under a federal license or permit will comply with adopted state water quality standards. If the state denies such certification, the federal license or permit may not be issued. Because all states are required to apply this authority, a state-by-state analysis was not undertaken. However, it should be noted that this authority is used by some states to address some forms of nonpoint source pollution, although the provision's applicability to nonpoint source discharges remains in some dispute, *see Oregon Natural Desert Association v. Thomas*, 940 F. Supp. 1534 (D. Ore. 1996) *appeal pending* (401 applies to nonpoint discharges).

In summary, this study examines state laws that cut across areas that are also subject to federal regulations or requirements, but focuses on state laws that do more than simply implement the federal requirements in order to highlight state actions that differ from mere conformance to federal requirements.

Enforceable Mechanism

"Enforceable mechanism" is defined narrowly for purposes of this study. The definition is designed to identify only those authorities that can impose an obligation upon an uncooperative discharger as completely as upon one that is cooperative. In consequence, the term is not identical to the term "enforceable policies and mechanisms" as defined in CZARA and interpreted in the guidance documents issued by EPA and NOAA for that program. In particular, the loss or recoupment of incentives for nonpoint source dischargers participating in voluntary programs is not deemed an "enforceable mechanism" for purposes of this study.

For purposes of this study an enforceable mechanism consists of a *standard* applicable to an identified entity or entities; a *sanction* such as a civil, criminal, or administrative penalty, loss of a license, and performance of required remedial action (but not mere loss of an incentive); and a *process*, either explicit or implied, for applying the standard and imposing the sanction. For example, the standard may be a provision that "no person" shall "discharge a pollutant so as to cause or contribute to a violation of water quality standards," while the sanction and process may include administrative or civil actions leading to penalties, cessation of the discharge, abatement, cost recovery, criminal fines and jail terms, or other remedies.

An enforceable mechanism is not limited to "regulatory" or permit-based regimes similar to the NPDES program. Indeed, mere liability for a clearly defined action is sufficient. Thus, the availability of injunctive relief and damages, or provisions for summary abatement and cost recovery, or the power to issue binding cease-and-desist orders qualify as enforceable mechanisms.

Study Methodology

The researchers developed a template identifying categories of state laws that affect activities that generate nonpoint source pollution. This template was developed to guide research that necessarily ranged across numerous titles of any state's legislation - from the criminal code to the public health code, from the environmental code to the agricultural code. The template's categories were based on prior state studies conducted by the Environmental Law Institute, on a review of the required CZARA management measures and a preliminary sampling of program submissions by coastal states under that law, and on the researchers' professional judgment.

The template was then used to guide a broad review of the state legislative codes for all fifty states, Puerto Rico and the District of Columbia. State laws were reviewed in their published and codified form, supplemented by some computer-assisted research. CZARA program submissions were also reviewed for those states participating in the CZARA process as a cross-check on the primary research.

In order to identify the principal state authorities, and to keep the study within manageable scope, the research was conducted upon state statutes. State regulations were consulted only where needed to clarify the jurisdiction conferred by state laws. Thus, for example, where a forest practices statute clearly created enforceable obligations, state regulations under that statute were not reviewed. Conversely, where a state statute was ambiguous on the enforceability of a program, the regulations were consulted, but only to the extent needed to understand the reach of the statute. Once a statute was identified as enforceable or potentially enforceable, no attempt was made to list all of its substantive requirements. Thus, for example, the study indicates the existence in various states of enforceable land use standards for erosion and sediment control, but it does not identify the specific buffer zone requirements, erosion rates, or control structures required by such programs.

For similar reasons, and because this was a study of *state* enforceable mechanisms, the study does not identify and discuss *local* ordinances and rules. Instead, the study identifies those state laws that create the enforceable authority in local governments, or that authorize delegation of the relevant enforceable statewide control programs to local governments.

Finally, because this study is intended to identify relevant legal authorities, it looks at the maximum possible uses of existing law for nonpoint source pollution control, rather than at state implementation practices. The study is aimed at answering the question: What kinds of existing tools do the states have available to them in the event that they need to control nonpoint source water pollution by enforceable means? Thus if a state has an applicable law that has remained unenforced - for policy reasons, lack of staff, absence of controlling judicial construction, failure to adopt regulations, or other reasons - the law is nevertheless included in this study.

GOALS OF THIS REPORT

This report provides an overview of the current legal landscape. It identifies the kinds of state laws that exist, the opportunities they present, and their limitations. The report is primarily intended to provide objective baseline information for policy makers and others wrestling with the need to control nonpoint sources of water pollution that have not, thus far, been amenable to other forms of control.

The report serves three major functions. First, it is intended to help guide *federal* legislation, regulation, and policymaking that may hereafter affect nonpoint source discharges. Such federal decisions may come in the context of Clean Water Act reauthorization, federal budgeting priorities, and components of other federal legislation including transportation, flood control, water projects, and agriculture. Administrative decisions informed by this report may include those regarding stormwater, state water quality standards, TMDL development, and other implementation issues. The report is intended to enable federal policymakers to draw upon state trends and experiments in selecting federal approaches, to identify general weaknesses or gaps in existing state approaches, and to identify useful state laws and programs that should not be inadvertently undermined by federal decisions to adopt new federal policies, requirements, and guidelines.

Second, the report is intended to identify potentially useful state approaches that can be *borrowed by other states* and used in drafting legislation. This function is intended to make the most of the states' functions as "laboratories" for innovation and experiment, enabling states to borrow from similar states with less risk and greater likelihood of legislative acceptance. Thus, the report is intended to assist states in improving their programs. At the same time, by establishing a baseline or "snapshot" of current state practice, the report can serve as the basis for future work analyzing trends and assessing effectiveness of various approaches. With baseline information, state mechanisms can be tracked for effectiveness in the future by others, and compared, leading to a better understanding of what works and why.

Third, the report identifies - indeed, in some cases, exhumes - state laws on the books that could be *used creatively* by individual state agencies and law enforcers (such as public health officers, district or states' attorneys, agency staff, and state attorneys general) to deal with specific nonpoint source problems. Some of the older fish and game authorities, public health and nuisance provisions, and other laws may provide ways to address - albeit imperfectly - some nonpoint problems without requiring agencies to go back to the legislature for new authority. While these laws cannot substitute for integrated nonpoint programs including enforceable mechanisms where necessary, they can be components of such programs and can bridge gaps in existing authorities.

The report finds that there are numerous legal authorities on the books that can be used to establish and enforce nonpoint source control requirements. It also finds that these authorities appear in different kinds of state laws, with many exemptions and limitations, and that - as a consequence - the availability of an enforceable authority to address any particular nonpoint source discharge may depend upon complex issues of interpretation, evidence, and process.

Chapter Two:

Discharge Prohibitions

Virtually all of the states have some enforceable statutory authority to deal generally with the subject of water pollution and activities on the land that may lead to such pollution. These authorities come in several forms. Many are parts of states' broad water pollution control laws. Provisions in public health and penal codes, typically enforced as petty criminal offenses, may prohibit specific kinds of discharges and substances that detrimentally affect public waters. Statutory nuisance and public health laws provide additional authorities where certain adverse effects can be proven. So does the common law of nuisance. And state fish and game protection laws frequently contain general provisions prohibiting pollution harmful to fish; or imposing liability for fish kills due to pollution events, not limited to point source pollution.

Although these were collected separately by source of law, these broad authorities discussed together below. The key issues in each statute are determining exactly what needs to be proven to demonstrate a "violation" of the law resulting in imposition of a sanction. Careful scrutiny of these laws is essential in assessing their utility in controlling nonpoint source pollution. For example, while various state water pollution control act provisions superficially resemble the federal Clean Water Act's prohibition of the discharge of a pollutant without a permit, 33 U.S.C. 1311(a), unlike the federal act many of these can be applied to nonpoint source pollution because they lack the limitation in 33 U.S.C. 1362(12) which defines "discharge of a pollutant" as "from any point source."

ELEMENTS OF THE GENERAL DISCHARGE PROHIBITION

Materials Discharged

The first issue in assessing the potential applicability of any discharge prohibition to any nonpoint discharge is to determine what materials are included in the prohibition. A law which prohibits the discharge of "wastes" without a permit may, for example, have some utility in regulating discharges of manure from stock raising operations or motor oil from suburban driveways, but be useless in addressing sediment discharges and be uncertain in addressing farm runoff containing pesticides. On the other hand, a similar state law prohibiting unpermitted discharges of "pollutants" may be limited by the need to show that the substance discharged either is on a list of pollutants or actually results in pollution of the receiving waters.

Complicating these definitional inquiries is the fact that states frequently do not define the same words in the same ways. For example, Fla. Stat. 403.031(12) defines "wastes" as "sewage, industrial wastes, and all other liquid, gaseous, solid, radioactive, or other *substances which may pollute* or tend to pollute any waters of the state." This definition, which is similar to definitions of "wastes" in a number of other states, clearly avoids the problem of a waste definition that excludes sediment and other non-discarded substances. But at the same time it raises problems of proof similar to those in state statutes prohibiting discharges of "pollutants" -- that an impact on the receiving waters may need to be shown in order for enforcement to occur. The broadest provisions found among the states prohibit the unpermitted discharges of "any substance" or any "organic or inorganic matter." (e.g., S.C. Code 48-1-90)

Another kind of common state statute, frequently found in public health laws, criminal laws, fish and game laws, or state environmental laws, actually lists materials that cannot be lawfully discharged - either at all, or without a permit - into the waters of the state or onto land adjacent to such waters. These lists typically include such specifics as offal, ashes, rubbish, paper, wood, sawdust, sludge, and other specific materials, only some of which are typical of nonpoint source pollution. Obviously, these provisions have only limited utility in the nonpoint source enforcement context. However, some state laws end these lists with a catch-all provision -- such as "anything else of an unsightly or unsanitary nature" (Ohio Rev. Stat. 1531.29) or "or substance in any form resulting from domestic, industrial, commercial, mining, agricultural, or governmental operations" (Fla. Stat. 403.413), or "any other article which might pollute the water" (Vern. Tex. Code Ann. Water 11.090).

Although such provisions may expand the reach of some narrow "list"-type statutes, the expansion may be limited by two common legal doctrines of statutory construction. The first is *noscitur a sociis*, which simply means that a word is interpreted in accordance with the words around it. Thus, for example, if the list contains only materials associated with industrial processes, but no agricultural materials, the catch-all provision will be interpreted to reach only industrial-type materials. Similarly, if all the listed materials are wastes or products of human action, the doctrine may constrain the use of the law in reaching sediment discharges. The second doctrine, which is similar but not identical, is *ejusdem generis*, which indicates that the last word or phrase in a series should be read as a subset or subcategory of the preceding terms rather than as a term with greater breadth. Of course, the doctrine of plain meaning can be invoked in opposition to these others. The upshot is that reliance on a broad catch-all phrase at the end of a list has some risks in an enforcement context depending on the substance at issue.

Prohibited Conduct

The second major issue in interpreting the general discharge prohibitions is to determine what conduct is covered by the law. Such provisions usually come in two forms: (1) prohibition of mere discharge (or discharge without permit) without requiring the state to demonstrate any effect on the receiving waters, and (2) prohibitions of discharges that have, or can be projected to have, adverse effects on receiving waters.

Connecticut law illustrates both types. For example, Conn. Gen. Stat. 22a-430(a), 22a-423, prohibits any person from discharging or maintaining any discharge of "any water, substance or material into the waters of the state without a permit for such discharge...whether or not such substance causes pollution." At the same time, Conn. Gen. Stat. 22a-427 prohibits any person from causing "pollution" of any of the waters of the state.

The typical type (1) prohibition states that the discharge of a material, substance, or waste into the waters of the state or onto the land where it may enter the waters of the state without a permit is unlawful. These provisions are typically the cornerstone of state NPDES programs for point source discharges, but they may also have some application to nonpoint discharges where state definitional limitations do not constrain such use. Approximately half the states have such provisions in their water pollution control laws without statutory provisions limiting them only to point source discharges.

The difficulties in applying type (1) prohibitions to nonpoint sources largely arise in two ways. First, a significant number of the states with such provisions have explicit statutory or regulatory exceptions for agriculture and/or forestry (e.g. Fla. Stat. 403.927, 314 Code Mass. R. 3.05; Alabama Admin. Code 335-6-6-.03). While these exceptions remove significant nonpoint sources from the scope of these provisions, the exceptions themselves demonstrate the reach of the provisions over nonpoint source activities that are not specifically excepted. The second difficulty is more complex. Where there is a prohibition on discharge without a permit, but no permit scheme has ever been established, is the prohibition enforceable? A number of states have resolved this issue - either by establishing explicit permit authorities, or alternative authorities, or by case law - but others have not. In general, use of type (1) prohibitions where no permit program exists for nonpoint source discharges is possible, and many states assert the right to use such prohibitions in after-the-fact enforcement actions against polluters. But after-the-fact enforcement in a limited number of cases may not provide the same kinds of environmental benefits as a clear regulatory program that operates in advance of pollution events.

The vast majority of states have a type (2) prohibition that is potentially applicable to nonpoint source pollution. The typical type (2) prohibition does not address the issuance of a permit or the lack thereof. It simply prohibits discharges causing an identifiable harmful effect on the receiving waters. Such provisions typically make it "unlawful for any person to cause pollution of any of the waters of the state" (e.g. Okla. Stat. tit. 27A 2-6-105; Neb. Rev. Stat. 81-1506). Some of these provisions may spell out what is meant by "pollution," or may require that the state prove that the discharge caused a violation of a water quality standard in order to enforce the provision (e.g., Miss. Code 49-27-29(2)(a)(ii)). Some state laws explicitly prohibit not only discharges that "cause" water quality standards to be violated, but also discharges that "contribute" to such conditions (e.g., N.Y. Env. Cons. L. 17-0501; Indiana Code 13-18-4-5).

Type (1) and (2) prohibitions found in state water pollution control laws are usually enforceable by the entire panoply of regulatory tools, including administrative orders, injunctions, civil penalties, criminal fines and sentences, and, in some cases, summary abatement and cost recovery.

In addition to these two types of general prohibitions found in water pollution control laws, there are other common prohibitions. Typically found in other parts of the state codes, these are usually directed at specific environmental harms beyond the mere exceedance of water quality standards or causing pollution. These include provisions limited to conduct that causes or threatens to cause pollution of a drinking water supply, that endangers public health, that causes a nuisance, or that results in the death of fish or other aquatic life. Using these provisions for enforcement requires proof of a particular kind of adverse effect. These provisions are typically enforceable as misdemeanor offenses with modest fines, some provision for jail time or imprisonment, and are often subject to abatement by injunction. To the extent to which these are petty criminal offenses, proof of wrongful intent (or at least reckless disregard) may be required.

Location of the Discharge

The last issue that arises with general prohibition statutes is whether the material actually must enter the water in order for a violation to exist. While type (1) provisions often have such a requirement, a significant number of states, although not a majority, contain provisions that prohibit the placement of materials where they are "likely to cause pollution" (e.g., Ark. Code Ann. 8-4-217(a)(1); N.D. Cent. Code 61-28-06) or "likely to enter the waters" (e.g., R.I. Gen. Laws 46-12-5(a)). Some states approach this problem a different way. For example, Connecticut authorizes issuance of an order where any person has created or is maintaining a condition "which reasonably can be expected to create a source of pollution to the waters of the state." Conn. Gen. Stat. 22a-432.

REVIEW OF STATE GENERAL DISCHARGE PROHIBITIONS IN WATER POLLUTION LAWS

This section summarizes the general prohibition authorities in the respective states and notes explicit limitations. It does not include state authorities that are explicitly limited to point sources - e.g. prohibitions of "discharge" where the state definition is limited to point sources. This summary is intended to illustrate the potential scope of these provisions. Obviously, issues of statutory construction, regulatory interpretations, typical practice, and state institutions will influence the actual application of the provisions. In effect, this section identifies the outer bounds of such authorities as they appear on the books.

It is important to recognize in this brief summary that states have other authorities available to them -- many discussed later in this report. Indeed, where states are employing explicit strategies under other authorities aimed directly at nonpoint sources, they may make little or no use of the authorities summarized in this section. The following summary is organized by EPA region.

As noted above, Connecticut prohibits both the discharge of any substance without a permit, and causing water pollution. Both provisions are potentially applicable to nonpoint sources. Conn. Gen. Stat. 22a-427, -430. Maine prohibits the discharge of any pollutant without a permit, but explicitly provides that this provision is not violated by any discharge that is in compliance with an approved agricultural erosion and sediment control plan, 38 Maine Rev. Stat. 413; Maine also prohibits any violations of water quality notwithstanding any permits or exemptions, but requires establishment of a mixing zone before enforcement of this provision against any source may occur. 38 Maine Rev. Stat. 451. Massachusetts prohibits discharge of a pollutant without a permit, 21 Mass. Gen. L. 42, but agricultural and silvicultural nonpoint source discharges are exempted by regulation. 314 Code Mass. R. 3.05. New Hampshire prohibits discharge of a waste without a permit, but also has a provision making it unlawful for any person to dispose of wastes in such manner that water quality standards will be violated. N.H. Rev. Stat. Ann. 485-A:12. Rhode Island prohibits the placement of any pollutant in a location where it is likely to enter the waters, and the placement of any solid waste or debris in the waters; but it only prohibits the "discharge [of] any pollutant" from a "point source" R.I. Gen. Laws 46-12-5. Vermont prohibits discharge of any substance without a permit, but expressly exempts the "proper application of fertilizer to fields and crops." 10 Vt. Stat. Ann. 1259.

New Jersey law prohibits discharge of pollutants without a permit or as otherwise authorized, N.J. Stat. Ann. 58:10-6; and also prohibits the placement of "deleterious" substances into the waters or where they can find their way into such waters, but exempts from the latter provision chemicals used in agriculture, forestry, horticulture, and livestock if done in an approved manner. N.J. Stat. Ann. 23:5-28. New York prohibits the direct or indirect discharge of any substance that "shall cause or contribute to" a condition in violation of water quality standards. N.Y. Env. Cons. L. 17-0501. Puerto Rico authorizes its state agency to forbid any discharges that do not have the appropriate permit. 12 P.R. Laws Ann. 1131(13)(A)(a), and also expressly prohibits direct or indirect discharge of any substance capable of polluting or leading to pollution in violation of water quality standards. 24 P.R. Laws Ann. 595.

Delaware requires a permit for any activity "which may cause or contribute to a discharge of a pollutant into any surface or ground water" 7 Del. Code 6003. The adopted implementing regulations appear limited to point source discharges to water and land, but the statute is not so limited and Delaware maintains that this authority also applies to nonpoint sources; indeed, Delaware's nonpoint programs rely in part upon this authority. District of Columbia law expressly authorizes the mayor to regulate and require permits for nonpoint source pollution. D.C. Code 6-926. Maryland law prohibits the discharge of a pollutant without a permit or other authorization and allows the imposition of permit requirements for activities that could cause or increase the discharge of pollutants. Md. Code Ann., Envir. 9-322, 9-323(b). Pennsylvania prohibits the discharge of any substance resulting in pollution, 3 Purdon's Stat. 691.401; Pennsylvania also has a provision prohibiting discharge without a permit, which it has used for nonpoint sources, but the provision applies only to industrial wastes, 3 Purdon's Stat. 691.301. Virginia law prohibits the discharge of wastes or any "noxious or deleterious substances" or the pollution of waters without a permit, Va. Code 62.1-44.5, as well as the placement of any substance which may contaminate or impair the lawful use or enjoyment of waters of the state except as permitted by law. Va. Code 62.1-194.1. West Virginia's general water pollution control law appears not to provide for the regulation or prohibition of nonpoint source discharges. W. Va. Code 22-11-8.

Alabama requires a permit for discharges of "pollution", Ala. Code 22-22-9(I)(3), but although the requirement is not limited to point sources, the regulations provide that a permit is not required for discharges "from non-point source agricultural and silvicultural activities." Ala. Admin. Code 335-6-6-.03(a). Florida law provides that causing pollution except as provided by law is prohibited, Fla. Stat. 403.161, and requires permits for discharges of waste that contribute to violation of water quality standards, Fla. Stat. 403.088, but further provides that agricultural activities (including all "normal and customary" farming and forestry operations), and agricultural water management systems, are authorized and do not require permits. Fla. Stat. 403.927.

Georgia expressly requires anyone seeking to "erect or modify facilities or commence or alter an operation of any type which will result in the discharge of *pollutants from a nonpoint source* into the water of the state, which will render or is likely to render such waters harmful to the public health, safety, or welfare, or harmful or substantially less useful for domestic, municipal, industrial, agricultural, recreational or other lawful uses, or for animals, birds or aquatic life" to obtain a permit. Georgia Rev. Stat. 12-5-30(b). Kentucky prohibits the discharge of any pollutant or substance that shall cause or contribute to water pollution "in contravention of any rule, regulation, permit, or order or...the statute" Ky. Rev. Stat. 224.70-110; the law further provides that if a violation is traceable to an agricultural operation, it shall be handled under the state's enforceable agricultural water quality act rather than under the stricter water pollution control act. Ky. Rev. Stat. 224.120(10).

Mississippi prohibits pollution of the waters of the state or placement of wastes where they are likely to cause pollution, defining "pollution" as contamination not "in compliance with a valid permit," Miss. Code Ann. 49-27-29(2)(a)(I), 49-17-5(1), but the regulations provide that no permit shall be required for agriculture and silviculture nonpoint source pollution. Miss. Wastewater Reg. - Gen. Req. B.5. Mississippi has another provision, not linked to permitting definitions, prohibiting the discharge of any "wastes" which reduce water quality below adopted water quality standards. Miss. Code Ann. 49-27-29(2)(a)(ii). North Carolina prohibits the discharge of wastes and certain other discharges without a permit, N.C. Gen. Stat. 143-215.1(a); of perhaps greater immediate utility in the nonpoint context is its authority to issue "special orders" to "any person...responsible for causing or contributing to any pollution of the waters of the state within the area for which standards have been established." N.C. Gen. Stat. 143-215.2. South Carolina prohibits the direct or indirect discharge, seepage, or drainage of any substance into the waters of the state except in compliance with a permit. S.C. Code 48-1-90. Tennessee has a general prohibition against any discharge causing "pollution" except as properly authorized, Tenn. Code Ann. 69-3-114, but the law does not apply to any nonpoint source discharges from "any agricultural or forestry activity." Tenn. Code 69-3-120(g).

Illinois prohibits any person from causing, threatening, or allowing the discharge of any "contaminants" that would cause or tend to cause water pollution, or that would violate regulations or standards adopted by the Pollution Control Board. 415 Ill. Cons. Stat. 5/12(a). While this provision is not expressly limited to point sources, a second provision, 415 Ill. Cons. Stat. 5/12(f), which prohibits the unpermitted discharge of contaminants (without requiring evidence of water pollution) is expressly limited to point source discharges. Indiana law provides that a person may not "cause, permit or suffer to be...drained, allowed to seep, or otherwise disposed into any waters...any organic or inorganic matter that causes or contributes to a polluted condition of any waters" in violation of adopted water quality standards. Indiana Code 13-18-4-5. Michigan prohibits the direct or indirect discharge of any substance that may be injurious to health, safety or welfare, uses of waters, riparian lands, and fish and wildlife. Mich. Cons. L. 324.3109(1). Although this section is codified in a chapter of the code entitled "point source pollution control", Michigan law provides that chapter headings are not part of the act and are not to be used to construe the scope of the act. Mich. Cons. L. 324.103.

Minnesota has a general requirement of notice to the state of water pollution events and requires reasonable attempts by the discharger to minimize or abate pollution caused thereby. Minn. Stat. 115.061. Furthermore, by regulation, Minnesota has provided that "no sewage, industrial waste or other wastes shall be discharged from either a point or nonpoint source into the waters of the state in such quantity or in such a manner alone or in combination with other substances as to cause pollution." Minn. Rules 7050.0210(13). Ohio's water pollution law prohibits causing pollution or placing any wastes where they cause pollution except in accordance with a permit, but exempts agricultural and silvicultural runoff and earthmoving activities subject to regulation under Ohio's nonpoint source control programs administered by soil and water conservation districts and local governments. Ohio Rev. Stat. 6111.04. These programs are discussed later in this report. The Ohio law also exempts runoff of excrement from domestic and farm animals, only some of which is subject to regulation under the referenced programs. Wisconsin law authorizes the state agency to issue orders for the abatement of nonpoint source pollution if the source is "significant" and impairs water quality. Wis. Stat. 281.20. The provision has limitations on its use to control pollution caused by animal waste and pollution from an agricultural source in a priority watershed, where other planning and implementation tools are to be used first.

Arkansas makes it unlawful for any person to cause pollution or place waste in a location where it is likely to cause pollution. Ark. Code Ann. 8-4-217(a). Louisiana prohibits any "activity" which results in the discharge of any substance to the waters of the state without the "appropriate permit, variance, or license." 30 La. Rev. Stat. 2075. It also prohibits the discharge of any substance that will tend to cause water pollution in violation of any provision. 30 La. Rev. Stat. 2076(A)(1). However, the law also provides that these and other provisions of the water pollution control law "shall not apply to any unintentional nonpoint-source discharge resulting from or in connection with the production of raw agricultural, horticultural, or aquacultural products." 30 La. Rev. Stat. 2076(A)(2).

New Mexico's water pollution law does not itself contain a prohibition applicable to nonpoint source water pollution, but rather authorizes the water quality control commission to adopt regulations "to prevent or abate water pollution in the state" and to require permits. N.M. Stat. Ann. 74-6-4. Thus, the availability of any enforceable authority depends entirely on the promulgation of specific regulatory requirements. Oklahoma law makes it unlawful for any person to cause water pollution or to place wastes in any location where they are likely to cause pollution. Ok. Stat. Ann. tit. 27A, 2-6-105. This provision is expressly interpreted to apply to nonpoint sources. Ok. Regs. 252:610-7-1. Texas prohibits the discharge of waste, including agricultural waste, into or adjacent to any waters, and prohibits any other act which causes pollution of any waters, except as authorized. Vern. Tex. Code Ann., Water Code 26.121(a). The law exempts agricultural and silvicultural discharges in compliance with a certified water quality management plan under Ag. Code 201.026.

Iowa prohibits "disposal" of a pollutant (defined as "waste") by discharge into the waters of the state except pursuant to a permit. Iowa Code Ann. 455B.186. Kansas prohibits the discharge or placement or flowage of "sewage" (defined as any substance that contains human or animal waste products or excrement or any wastes from domestic, manufacturing, or other forms of industry) into the waters of the state except pursuant to a permit. Kan. Stat. Ann. 65-164. The law also allows the attorney general to take action to secure abatement of "abatable pollution of the surface waters detrimental to the animal or aquatic life in the state." Kan. Stat. Ann. 65-171b. Missouri law prohibits causing pollution or placing any water contaminant where it is reasonably certain to cause pollution; it also prohibits the discharge of water contaminants which reduce the water quality below adopted water quality standards if not otherwise subject to effluent regulations. Mo. Rev. Stat. 644.051. Nebraska law makes it unlawful to cause water pollution or to place any wastes in a location where they are likely to cause water pollution, or to discharge wastes that reduce the water quality in the receiving waters below adopted water quality standards. Neb. Rev. Stat. 81-1506.

Colorado's water pollution control law authorizes the water quality control commission to adopt regulations relating to any "activity" that "does or could reasonably be expected to cause pollution of any state waters in violation of control regulations or...any applicable water quality standard." Colo. Rev. Stat. 25-8-205. With this authority, the state clearly may choose to regulate nonpoint sources of pollution; however, "control regulations related to agricultural practices shall be promulgated only if incentive, grant, and cooperative programs are determined by the commission to be inadequate and such regulations are necessary to meet state law or the federal act."

Colo. Rev. Stat. 25-8-205(5). Montana law makes it unlawful to cause water pollution or place any wastes "where they will cause pollution of any state waters." Mont. Code Ann. 75-5-605(a). However, the law exempts materials placed in connection with activities permitted by any other state or federal agency, 75-5-605(a), and expressly exempts from state nondegradation requirements those nonpoint sources existing on April 29, 1993, all new nonpoint sources that follow "reasonable land, soil, and water conservation practices," land application of manure, and use of agricultural chemicals if done in accordance with an agricultural ground water management plan. Mont. Code. Ann. 75-5-317(2).

North Dakota law makes it unlawful to cause water pollution or place any wastes where they are likely to cause water pollution. N.D. Cent. Code 61-28-06(1)(a). South Dakota has a similar provision. S.Dak. Codified L. Ann. 34A-2-21. In addition, any discharge of wastes (defined as any polluting "substances") that results in degradation of water quality is also prohibited. S.Dak. Codified L. Ann. 34A-2-22. Utah prohibits causing pollution that constitutes a menace to public health and welfare, is harmful to fish or wildlife, or impairs beneficial uses of water, and prohibits placement of waste where there is "probable cause" to believe it will cause pollution. Utah Code Ann. 19-5-107. Wyoming makes it unlawful to "cause, threaten or allow the discharge of any pollution or waste into the waters of the state" except as authorized by permit. Wyo. Stat. Ann. 35-11-301. The prohibition has been held to apply to polluting activities for which no permit was available.

Arizona law requires the Department of Environmental Quality to adopt a permit requirement for point sources, and for certain facilities likely to pollute aquifers, and a "program to control nonpoint source discharges of any pollutant or combination of pollutants into navigable waters." Ariz. Stat. 49-203.A. Its general prohibition law makes it a criminal offense to (with criminal intent) discharge substances to waters without a required permit or other "appropriate authority," or to violate a water quality standard. Ariz. Rev. Stat. 49-263.A. California law requires a "report of waste discharge" from any person proposing to discharge "waste." The regional water quality control board must then issue waste discharge requirements (WDRs) - essentially a permit. Cal. Water Code 13260. However, these requirements may be conditionally waived by the regional board. Cal. Water Code 13269. California uses these requirement by first seeking to abate nonpoint source pollution through nonregulatory means, but reserves the power to either grant a conditional waiver (to secure operational changes in a discharger) or to require the report of waste discharge and issue a WDR.

Hawaii prohibits the discharge of any pollutant to waters of the state except as authorized by law or permit. Hawaii Rev. Stat. 342D-50. Hawaii, moreover, has explicit authority to regulate nonpoint source pollution under a provision that allows the issuance of enforceable nonpoint source rules which may include "water quality standards for specific areas, types of nonpoint source discharge, or management measures." Hawaii Rev. Stat. 342E-3(a). Nevada's general pollution prohibition authority is expressly limited to point sources. Nev. Rev. Stat. 445A.465. However Nev. Rev. Stat. 455A.565 also allows the state to prescribe controls for nonpoint sources ("diffuse sources") to prevent degradation of high quality waters, but not for "normal...farming practices". And 455.570 allows regulation of nonpoint sources existing on Jan 1, 1979 that are "significantly causing or adding to water pollution in violation of a water quality standard" and for new nonpoint sources where they impair high quality waters.

Alaska law provides that "a person may not pollute or add to the pollution of the...water of the state." Alaska Stat. 46.03.710. Idaho has very limited jurisdiction over nonpoint sources. It defines "discharge" in its water pollution control act as not including "surface water runoff from nonpoint sources." Idaho Code 39-3602. Another provision states that nonpoint sources are not required to meet water quality standards other than those necessary to support designated uses, unless a TMDL is required to be developed. Idaho Code 39-3604. In the context of TMDLs for high-priority impaired waters, the law provides that "nothing in this section shall be interpreted as requiring best management practices for agricultural operations which are not adopted on a voluntary basis." Idaho Code 39-3610. Indeed, the only direct authority is a prohibition on new or expanded nonpoint activities which "can reasonably be expected to lower the water quality of an outstanding resource water," Idaho Code 39-3618, and these sources are entirely exempt from permitting or other regulation if they implement BMPs. Idaho Code 39-3620(6).

Oregon law prohibits any person from polluting waters of the state or placing any waste where it is "likely to escape or be carried into the waters of the state, and from discharging wastes into water if such discharge reduces water quality below the adopted standards. Ore. Rev. Stat. 468B.025(1). Washington prohibits the discharge of "any organic or inorganic matter that shall cause or tend to cause" water pollution. Wash. Rev. Code 90.48.080, and permits are required for disposal of material into the waters of the state. Wash. Rev. Code 90.48.160. However, the law does not authorize the adoption of a permit system for nonpoint sources or imposition of penalties for pollution arising from forest practices conducted in compliance with the state's forest practices law. Wash. Rev. Code 90.48.420.

The general prohibition authorities summarized above are typically used by states not to carry out a detailed regulatory approach to nonpoint source water pollution, but rather as "back-up" authority to other programs intended to control such pollution, or to deal with egregious cases in the absence of other programs. In many states, because of the absence of an implementation program, they may represent an unused tool in the toolbox; in others, they are an integral part of the state's approach. In general, these tools have some importance because they potentially link nonpoint source pollution control to the states' point source control authorities. And they typically provide a wider array of order, abatement, and penalty authorities than either focused nonpoint source programs or older nuisance or misdemeanor-type prohibitions.

DISCHARGE PROHIBITIONS OF NARROWER SCOPE

In addition to the general prohibitions found in most states' water pollution control laws, virtually every state has other - usually older - provisions prohibiting certain kinds of discharges deemed detrimental to the public health or welfare, fisheries, drinking water, or other interests identified by the legislature. Typically misdemeanor provisions, these may nevertheless serve in some instances the important role of providing an enforceable response to a nonpoint source pollution event, or in some cases, threatened pollution event.

Discharge of Listed Substances

Various statutes specifically list detrimental substances whose discharge into the waters of the state is prohibited. These provisions are found most often in public health laws, criminal laws, and fish and game laws. Sometimes they take aim primarily at "litter" that may enter the waters of the state. Other laws seem more concerned with disease-bearing wastes or substances. "Offal, filth, rubbish..." heads a typical list. West Virginia has a typical provision, making it an offense "to place, deposit, dump, or throw, or cause to be placed, deposited, dumped or thrown, any litter...garbage, refuse, trash, can, bottle, paper, ashes, carcass of any dead animal or part thereof, offal, or any other offensive or unsightly matter into any river, stream, creek, branch, brook, lake or pond, or upon the surface of any land within one hundred yards thereof, or in such location that high water or normal drainage conditions will cause any such materials to be washed into any [such waters]." The offense is defined as a misdemeanor punishable by fine of not less than $50 nor more than $500. W.V. Code 20-7-8. This study identified similar provisions in Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Florida, Illinois, Indiana, Michigan, Minnesota, Ohio, Arkansas, Oklahoma, Texas, Iowa, and California, although undoubtedly other states have such provisions.

Discharge of Substances Harmful to Fish

Approximately half the states' fish and game codes contain provisions that prohibit the discharge of various substances that are, or that may be, harmful to fish. These provisions do not require proof of injury to fish, but focus on the nature of the substances discharged. This is usually clear from the nature of the prohibition, but it is spelled out explicitly in some laws - for example, "it is not necessary to prove that the violation has actually caused the death of, or damage to, any particular fish" 30 Pa.C.S.A. 2504. Some of these provisions are written quite broadly, while others are narrow.

For example, Kentucky's law provides: "No person shall place or cause to be placed in any public waters any substance that might injure, interfere with, or cause the waters to be unfit for the support of wildlife [including fish]" Ky. Rev. Stat. 150.460(1) (penalty of up to $500 and/or 6 months). Arkansas law provides that "it shall be unlawful for any person to deposit, throw, drop, or discharge in any manner in any of the waters of this state any substance, liquid, or gas or anything else that will or does intoxicate or stupefy or in any manner injure any fish therein, whether done for the purpose of catching or taking fish or not." Ark. Code Ann. 15-43-317. Rhode Island law provides: "No person shall place, deposit, or explode any substance injurious to the health or life of a fish in any stream or fresh water pond" R.I. Gen. L. 20-11-10. Far more narrowly, Vermont prohibits the deposit of "lime, creosote, coculus inducus or other drug or poison destructive to fish" 10 Vt. Stat. Ann. 4606(b). Given the principles of statutory construction discussed earlier in this chapter, it may be harder to apply this provision to many forms of nonpoint source pollution.

Although many states have provisions of this type, others have drafted them in such a way as to be useless for reaching nonpoint source discharges. For example, contrast Maine's prohibition on the use of any "explosive, poisonous or stupefying substance...for the purpose of taking or destroying any kind of fish." 12 Maine Rev. Stat. Ann. 7617.

State fish and game laws can also provide regulatory authority over pollution discharges in some cases. For example, Massachusetts has an unusual provision that allows the state fisheries agency to determine that a "prohibition or regulation of the discharge of waste or material from any source" is needed for particular inland waters because of the value of the fishery therein, leading to action by the pollution control agency. 131 Mass. Gen. L. 41.

Some states, such as New York and California, use fisheries protection provisions to control nonpoint source pollution of shellfish production areas. For example Cal.

Water Code 14950(d) provides that regional water quality boards "shall have primary responsibility for the protection of commercial shellfish harvesting from the effects of point and nonpoint pollution sources." Regulatory authority under the law arises once the area has been downgraded or restricted by the state's Department of Health Services, closed for more than 30 days per year for 3 previous years, or formally determined to be threatened. Cal. Water Code 14954. "Once the nature, sources, scope, and degree of the pollution affecting a commercial shellfish growing area have been determined, the regional board, with the advice of the local technical advisory committee, shall *order* appropriate remedial action, including the adoption of best management practices to abate the pollution affecting that area." Cal. Water Code 14956(a). However, Cal. Water Code 14956(b) provides that "if *agricultural* sources of pollution have been identified as contributing to the degradation of shellfish growing areas, the regional board shall *invite* members of the local agricultural community representing the type of agricultural discharge affecting the local shellfish growing area, the local resource conserve district, the local soil conservation service.....and affected shellfish growers to develop and implement appropriate short- and long-term remediation strategies that will lead to a reduction in the pollution affecting the commercial shellfish growing area."

Fish Kill Caused by Pollution

Many states also have provisions that prohibit fish kills or that allow enforcement responses to fish kills. Although some of these are simply broadly written prohibitions on killing fish without a valid fishing license, many others clearly proscribe nonpoint source and other discharges that result in harm to aquatic life.

Some of these provisions are similar to those described in the preceding section, but possibly may require proof of injury to fish, not simply discharge of an injurious substance. For example, Puerto Rico's law might be interpreted as falling within either category: "It is prohibited to throw or cause to be thrown or deposited into any...body of water...oils, acids, poisons, or any other substance which kills or destroys fish, crustacea, or mollusca." 12 P. R. Laws Ann. 61. Indiana's law prohibits drainage or placement of material into state waters that causes or contributes to a polluted condition such that "any fish life or any beneficial animal or vegetable life in any waters may be destroyed or propagation thereof prevented or injuriously affected." Indiana Code 13-1-3-8.

Other laws prohibit killing fish by depositing in any "public stream or body of water..any poison, poisonous substance...or other deleterious or poisonous matter" Ala. Code 9-11-93; or they provide that "No fish, other than migratory food fish of the sea in the marine and coastal district, shall be taken except by angling." N.Y. Env. Cons. L. 11-

1301(1)("taking" includes killing). States with potentially applicable fish kill laws include at least Massachusetts, New York, Puerto Rico, Maryland (where the harm is from sediment), Alabama, Indiana, Minnesota, New Mexico, Wyoming, and Arizona.

In addition to state laws prohibiting fish kills, including those caused by polluting substances that may be discharged from nonpoint sources, it is also worth noting other state provisions that create explicit liability to the state where an "unlawful" pollution discharge damages fish. These include New Hampshire, Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Kansas, South Dakota, California, Alaska, Oregon, Washington. Pennsylvania law provides: "The Commonwealth has sufficient interest in fish living in a free state to give it standing, through its authorized agencies, to recover damages in a civil action against any person who kills any fish or who injures any streams or stream beds by pollution or littering." 30 Pa.C.S.A. 2506(a). See N.C. Gen. Stat. 143-215.3 (similar)

Pollution of Drinking Water or Public Water Supply

About a fourth of the states have older provisions specifically aimed at preventing or criminalizing the pollution of a drinking water supply. Typical is Ok. Stat. tit. 11, 37-115: "No person...shall pollute or permit the pollution of the water supply of a municipality, or any stream, pond, spring, lake, or other water reservoir or groundwater aquifer, which is used or which is being held for use as a water supply by a municipality." Compare Minn. Stat. 144.35 "No sewage or other matter that will impair the healthfulness of water shall be deposited where it will fall or drain into any pond or stream used as a source of water supply for domestic use."

Nuisance and Public Health Provisions

All, or virtually all states have statutory provisions that provide for the abatement of nuisances, and many have additional public health provisions that may have some application to particular instances of nonpoint source pollution. The common law of nuisance also applies in every state. Nuisances are of basically two types: public nuisance and private nuisance. Public nuisance is the creation of a condition that causes injury to the public welfare, while private nuisance impairs the use and enjoyment of property. Nuisance is not a fault-based doctrine, but requires only proof of the adverse condition. Thus, even a condition that does not violate any law or regulation may still be abatable as a nuisance. Remedies for public nuisances are typically injunctions for abatement, or authority for a public entity to conduct summary abatement of the nuisance and recover its abatement costs, and/or the imposition of fines - reflecting the historic origins of public nuisance as a quasi-criminal action. Public nuisance actions may be brought by the state or, often, by any affected entity or person, while private nuisance actions are brought by adversely affected land owners.

Nonpoint source water pollution that impairs the usefulness of waters, adversely affects human health, or impairs the rights of others may be abatable under state nuisance laws. Two types of nuisances are generally addressed by state statutes - first, and more important for most nonpoint sources, are state provisions declaring water pollution to be a nuisance. Such legislative declarations limit the need to prove particular deleterious effects in order to secure relief. Second, are state provisions that provide for the abatement of conditions dangerous to public health or otherwise noxious or offensive to the senses.

Alabama law combines both approaches in one provision: "Any and all pollution is hereby declared to be a public nuisance and, if it creates, or is about to create, a health hazard, shall be subject to immediate control of the commission by order or injunction." Ala. Code 22-22-9(I)(4). This provision both declares water pollution a nuisance making it subject to injunctive relief by the state or any person, and declares that particular kinds of water pollution (health hazards) are subject to certain kinds of administrative relief and summary abatement action. Pennsylvania law provides a typical, but especially complete, version of the "water pollution as nuisance" provision: "The discharge of...any substance into the waters of this Commonwealth, which causes or contributes to pollution...or creates a danger of such pollution is hereby declared not to be a reasonable or natural use of such waters, to be against public policy and to be a public nuisance" and "shall be abatable in the manner provided by law or equity for the abatement of public nuisances." 3 Purdon's Stat. 691.3, 691.601. Minnesota's provision is given additional detail in state regulations, making its applicability to nonpoint discharges explicit: "No sewage, industrial waste or other wastes shall be discharged from either point or nonpoint sources into any waters of the state so as to cause any nuisance conditions, such as the presence of significant amounts of floating solids, scum...excessive suspended solids, material discoloration...undesirable slimes or fungus growths, aquatic habitat degradation, excessive growth of aquatic plants, or other harmful effects" Minn. Rules 7050.021.

Some laws more directly reflect the historic petty criminal nature of water pollution as a nuisance. Cal. Penal Code 374.4(a) provides: "Every person who...dumps or causes to be dumped, any waste matter into any bay, lagoon, channel, river, creek, slough, canal, lake, or reservoir, or other stream or body of water, or upon a bank, beach, or shore within 150 feet of the high water mark of any stream or body of water, is guilty of a misdemeanor" and imposes a fine of $100-1000. A few states have even older provisions, like Kentucky Rev. Stat. 438.060, which makes it a violation for any person to place or cause to be placed "in any stream, dam, pool or pond" any substance that renders the water "unfit for use or produces a stench," punishable by fine of not less than $10 nor more than $100 and/or imprisonment for 30 days to 6 months. Ohio Rev. Stat. 3767.13(C): "No person shall...corrupt or render unwholesome or impure, a watercourse, stream, or water." This is a misdemeanor punishable by up to 60 days and/or $500.

General nuisance law is typified by Minn. Stat. 561.01: "Anything which is injurious to health, or indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, is a nuisance." Some states have made the connection to public health abatement explicit. For example, Kansas's Secretary of Health and Environment and county boards of health can examine all "nuisances, sources of filth and causes of sickness"..."When such source is found to exist on any private property or upon any watercourse in the state" they have the power to order the owner to remove the nuisance within 24 hours. Failure to obey an order is punishable by a fine of $10 to $100. Kan. Stat. Ann. 65-159.

Nuisance laws are generally not preempted by state regulatory laws; however, a number of states have expressly enacted savings clauses to preserve public and private nuisance actions for abatement of water pollution (e.g., Ala. Code 22-22-9(o)).

Virtually every state has enacted "right to farm" legislation exempting agricultural activities (and in a few states, silvicultural activities) from abatement as a nuisance. These laws vary in the extent of the exemption. All of them are clearly aimed at preventing private nuisance actions occasioned by recent suburban dwellers encountering the odors and noise of normal farming operations, but some are broader and apply to public as well as private nuisance actions and to a wider array of conduct. Most also provide that the exemption from nuisance liability does not apply where the agricultural activity is conducted in violation of law, or negligently, or (in some cases) where the nuisance alleged is water pollution. The following selected state laws give an idea of the scope of these ubiquitous laws.

Delaware has a typical right to farm provision: "No agricultural or forestal operation...which has been in operation for a period of more than 1 year shall be considered a nuisance, either public or private, as the result of a changed condition in or about the locality where such...operation is located. This section shall not apply when the nuisance is determined to exist as the result of the negligent or improper operation...or when such operation is being operated in violation of state or federal law or any local or county ordinance." 3 Del. Code 1401.

New Hampshire agricultural operations cannot be found a nuisance if they were in operation for one year or more and were not a nuisance when operations commenced; however this exception does not apply if operations are "injurious to public health or safety" N.H. Rev. Stat. Ann. 432.33, nor if the nuisance results from "negligent or improper operation". N.H. Rev. Stat. Ann. 432.34. But operations "shall not" be found negligent or improper" if they are obeying all laws. Thus, New Hampshire agricultural operations are exempt from nuisance actions unless they create a public health hazard, or they are violating an explicit legal requirement. Michigan law provides that a farm operation is not a nuisance if it "conforms to generally accepted agricultural and management practices according to policy determined by the Michigan commission of agriculture" Mich. Cons. L. 286.473.

Idaho law goes farther by exempting not only agriculture but also agricultural processing operations and forestry activities from nuisance actions; the law also preempts local regulation of such activities, declares the right to conduct forest practices a "natural right" and has an exception only for "improper or negligent operation" - defined as operations not in compliance with law and adversely affecting public health and safety. Idaho Code 22-4501 and 38-1401.

New York exempts agricultural activities only from *private* nuisance actions, and subjects the exemption to various exceptions for increased activities and activities causing conditions dangerous to life or health. N.Y. Pub. Health L. 1300-c. California's right to farm nuisance exemption specifically provides that it "shall not invalidate " provisions of the state's Health and Safety Code, Fish & Game Code, Food & Ag. Code, or Porter-Cologne Water Quality Act that declare such an activity a nuisance "specifically defined or described in any of those provisions."

Some states' right to farm provisions specifically do not protect agricultural operations from nuisance claims based on water pollution. e.g., Hawaii Rev. Stat. 165-2, Ark. Code Ann. 2-4-106, Iowa Code Ann. 176B.11, N.D. Cent. Code 42-04-03.

ENFORCEMENT AND SANCTIONS

Most general discharge prohibitions under state water pollution control laws are enforceable by administrative orders, civil injunctions, civil penalties in the $10,000 to $25,000 range, criminal sanctions and other sanctions. This is why determining whether these authorities can be applied (particularly in the absence of an adopted permitting program for nonpoint sources) can be extremely important to a state effort.

Most of the discharge prohibitions based on other statutes are enforceable as petty criminal offenses and through abatement orders or injunctions.

These distinctions are important, not only because of their potential effectiveness in changing behavior, but also because they affect issues of process and issues of proof. For example, while proving that a discharge was of a "waste" or that it caused "pollution" presents one set of difficulties in a civil or administrative context, proving an offense in a criminal case (even in a magistrate's court) can present additional hurdles. Can the state show that the discharge was of a "deleterious substance" harmful to fish "beyond a reasonable doubt" and that the act occurred with the requisite intent? And is this even worthwhile if the sanction is $500? On the other hand, if an offense is criminal, even if petty, does this provide sufficient practical effect to bring about compliance and the deterrence of others? State discharge prohibitions come in many types, often presenting complex issues for prosecution or enforcement in the nonpoint source context.

PERFORMANCE OF URBAN STORMWATER

BEST MANAGEMENT PRACTICES

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Introduction

Surface water quality degradation in urban and urbanizing areas is largely attributed to stormwater runoff (EPA 1993, Duda 1993, Bannerman et al. 1993). The hydroecological impacts on receiving waters from urban runoff pose a health risk from the rate at which they enter the system and the numerous types of pollutants associated with stormwater runoff (Klein 1979, Schueler 1987, Hall and Anderson, 1988). Table 1 highlights conventional, inorganic, and organic contaminants in urban stormwater and the ir risk to human and aquatic health (Makepeace et al. 1995). To control the quantity, and improve the quality of urban runoff in a cost-effective manner, best management practices (BMPs) have been widely implemented for over 20 years. Table 2 lists BMPs commonly practiced and the relative size of drainage basin for which they are designed.

Performance data on best management practices is needed to derive design criteria to ensure that they will effectively treat stormwater to desired target levels. Numerous studies on BMP performance document a wide range of pollutant removal capabilitie s for suspended solids, nutrients, bacteria, oxygen-demand, and a few heavy metals. Only recently has research begun to focus on the fate of organic contaminants in urban stormwater facilities (Helfield and Diamond 1997, Wren et al. 1997, Pitt et al. 1993). Despite the diversity of data sources on BMP performance, the predictive utility is surprisingly low as there is considerable variability amongst study site characteristics, pollutants studied, climatic factors and data quality (Tanner et al. 1998).

Given the variable nature of BMP monitoring studies, it is difficult to conclude specific criteria that could be applied to all situations to maximize their performance. Rather, research suggests design characteristics and environmental conditions that may affect BMP performance and should be considered when evaluating its pollutant removal capabilities. Further, it has been shown that desired pollutant reductions are not consistently achieved based on design expectations. The performance of BMPs is qu ite variable with detention facilities acting as a sink for some pollutants, while at times also as a net source for other constituents. Conclusions regarding the processes and mechanisms responsible for improving ambient water quality are inferred based on design elements of the BMP and an understanding of chemical cycling and fate. Most studies, however, are limited to monitoring input and output concentrations or mass loadings to determine BMP effectiveness.

Table 1. A selection of contaminants in urban stormwater and their risk to human and aquatic health.

(from Makepeace et al. 1995)[a].

Chemical	*Range (mg/L)*	*Risk*		*Chemical*	*Range (mg/L)*	*Risk*	
		Human[b]	*Aquatic*			*Human*	*Aquatic*
Total solids	76-36,200	No	Major	**Zinc**	0.0007 -22.0	Minor	Major
TSS	1 - 36,200	Major	Major	**DO**	0 - 14.0	No	Major

Aluminum	0 7 - 16.0	Major	Major	**Polychlorinated biphenyl**	2.7E-5 - 1.1E-3	Minor	Major
Barylium	0.001 - 0.049	Minor	Major	**Total PAH**	2.4E-4 - 1.3E-2	Major	No
Cadmium	0.00005 - 13.73	Minor	Major	**Benzo(a)anthracene**	3E-7 - 1E2	Unknown	Unknown
Chloride	0.30 - 25,000	Major	Major	**Tetrachlorethylene**	0.0045-0.043	Major	No
Chromium	0.001 -2.30	Major	Major	***Bis*(2-ethylhexl) phthalate**	0.007-0.039	Minor	Major
Copper	0.00006 - 1.41	No	Major	**gamma-BHC**	5.2E-5 - 1.1E-2	Minor	Major
Iron	0.08 - 440.0	Major	Major	**Chlordane**	0.001 - 0.010	Minor	Major
Lead	0.00057 - 26.0	Major	Major	**Heptochlor +H. epoxide**	<0.0002	No	Major
.Maganese	0.007-3.80	Major	Unknown	***Expressed as per 100mL***			
Mercury	0.00005 - 0.067	Major	Major	**Fecal coliform**	0.2 -1.9E6	Major	- - -
Nitrogen (all forms)	0.07 - 16.0	Minor	Major	**Fecal streptococci**	3 - 1.4E6	Major	- - -
Silver	0.0002 - 0.014	No	Major	**Enterocci**	1.2E2 - 3.4E5	Major	- - -

[a] **Many of the results presented are based on preliminary findings of the NURP by Cole et. al. (1984).**

[b] **A problem is considered "major" if the upper contaminant concentration limit is ten times the regulation maximum allowable concentration (MAC) for drinking water quality or aquatic life guidelines. Minor problems are associated w ith upper concentrations between the MAC and ten times the MAC.**

Table 2. Types of Best Management Practices (BMPs) for urban stormwater (from Brix 1994, EPA 1993, Yu and Nawang 1993, Schueler et al. 1992).

Type	*Relative Size of Drainage Area*	*Description*
Constructed Wetland	Moderate to large	Intentionally created from non-wetland sites for sole purpose of wastewater or stormwater treatment. Types include: 1) free-floating macrophyte, 2) emergent macrophyte 3) submerged macrophyte.
Extended (Dry) Pond	Moderate to large	Outlet structure of dry pond is modified as a "retention outlet" that provides slow release of runoff from a 1-yr design storm, moderate to higher removal rates for particulates (40-70%), very low for dissolved pollutants.
Grassed Swales	Small	Shallow, vegetated ditch above watertable. It is used as an infiltration/filtration method to provide pretreatment before runoff is discharged to other treatment systems. Vegetative cover should never be shorter than 3-4 inches.
Infiltration Basin	Moderate	Impoundments that store runoff temporarily until it gradually infiltrates into the soil surrounding the basin. Infiltration basins should drain within 72 hours to maintain aerobic conditions. Runoff is pretreated to remove coarse sediment and prevent c logging.
Infiltration Trench	Moderate	Shallow excavated ditches with coarse substrate (sand, gravel) to allow infiltration to subsoil and groundwater. Some facilities are lined with fine fabric to prevent infiltration to groundwater.
Porous Pavement	Small	Thin layer of open-graded asphalt mixture on top of a deep-based filled with large-size crushed stone aggregate to serve as reservoir to detain stormwater. Stored runoff exfiltrates from the reservoir into the soil. A fine filter fabric may be used to prevent infiltration to groundwater. Limited data available on performance.
Vegetated Filter Strips	Small	Areas of vegetated cover designed to strictly treat low to moderate overland sheet flow. Used as pretreatment for other structural practices such as infiltration basins and trenches.
Water Quality Inlets	Small	Underground retention systems designed to remove solids. A basin is constructed 2-4 feet deep below an outlet pipe to collect sediment. Multiple-chamber systems may include an additional basin to filter fine sediment. Oil/grit separators can provide ad ditional treatment.
Wet Pond	Moderate to large	Permanent pool of water that temporarily stores runoff and allows particulate pollutants to settle out and dissolved pollutants to be removed by biological uptake or other decay processes. Stormwater is released at a controlled rate.

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Performance of Urban BMPs

A review of the research provides a range of removal efficiencies for a select suite of urban stormwater constituents, design characteristics, and processes attributed to promoting water quality improvement (Table 3). Design elements such as the r atio of stormwater pond to catchment area, pond geometry, and detention time are primary design considerations to ensure the BMP provides the desired level of pollutant removal. Such design features are typically designed to treat the volume of runoff g enerated from 1-yr and 2-yr storm events, rather than more frequent events (Allan et al. 1997). The physical-chemical environment of the BMP is also suggested to significantly affect effluent from wet detention basins. As an example, Borden et al. (1997) found that large seasonal differences in pollutant removal of both total and dissolved nitrogen and phosphorus species was attributed to thermal stratification. Turnover in the fall releases phosphorous that has accumulated in the anaerobic sediment in t he hypolimnion. Processes such as thermal dynamics of the pond, plant growth and senescence, and other physical, chemical and biological interactions, however, are not incorporated in modelling the design of BMPs. Such internal pond dynamics and the sen sitivity of chemical species to pH, redox potential, organic matter content, and available exchange sites dictate the dominant form and phase of the chemical, and thus pollutant removal.

Table 3. Factors affecting the performance of BMPs.

Design Characteristics	Detention time Storage volume Shape of BMP (length:width ratio of detention pond, slope, flow path obstructions, buffer width) Pond surface area relative to contributing catchment area Type of substrate/sediment; Auxiliary devices (e.g. baffles, sediment forebay) Presence of vegetation
Processes	Adsorption Sedimentation/resuspension Precipitation Complexation Degradation (photolysis, hydrolysis, volatization, biological) Biotic uptake

Environmental Conditions	Storm intensity, loading rate
	Drainage basin land cover
	Physical-chemical properties of BMP surface water
	Particle-size distribution and settling velocity
	Pre-storm water quality in BMP
	Thermal stratification

EPA (1993) and Brown and Schueler (1997) provide summaries of stormwater BMP effectiveness which include: extended wet detention ponds, wet ponds, stormwater wetlands, multiple pond systems, infiltration trenches, infiltration basins, porous pavement, sand filters, grassed swales, filter strips, and water quality inlets/oil grit separators. Dry detention ponds are another BMP but are designed for controlling peak flows rather than quality control. Appendix A provides a summary of BMP e ffectiveness based on work by Schueler et al. (1992) and additional research. An examination of factors contributing to the treatment of suspended solids, nutrient and heavy metals is provided. As the most common type of BMP studied is the wet detention p ond for a variety land use characteristics (e.g., suburban resident, commercial, rural), the data presented is biased towards this particular BMP facility.

Suspended Solids

BMPs are primarily designed to remove total suspended solids (TSS) and pollutants sorbed to particles. As such, gravitational settling is relied upon as the predominant process for pollutant removal. The effectiveness is illustrated by sediment accumul ation in wet detention ponds (e.g. 0.8cm/yr to 2 cm/yr) (Marsalek et al. 1997, Guo 1997, Allan et al. 1997). Studies report TSS load reductions for wet detention basins to be generally greater than 50%, but range from 20-98% (Borden et al. 1997, Schueler et al. 1992).

BMPs are primarily designed to remove total suspended solids (TSS) and pollutants sorbed to particles by sedimentation. Studies report TSS mass load reductions for wet detention basins to be generally greater than 50%, but range from 20-98% (Borden et al. 1997, Schueler et al. 1992). Another indicator of effectiveness is provided by the rate of sediment accumulation in BMPs that range from 0.8cm/yr to 2 cm/yr (Marsalek et al. 1997, Guo 1997, Allan et al 1997). The ability to treat TSS, however, is a function of particle-size distribution, storm intensity, loading rate, and geometry and age of BMP facility.

Particle-size distribution of the influent is shown to influence the treatment capabilities of a BMP (Ferrara and Witkowski 1983, Yu and Nawang 1993, Wu et al 1998b). Ferrara and Witkowski (1983)

generalize that as storm intensity increases the concen tration of TSS increases due to larger size fractions of TSS resulting in a greater removal efficiency. Based on research by Randall (1983), Allan et al. (1997) concludes BMP removal to be a function of influent concentration. Removal rates were poor whe n TSS concentration was less than 10mg/L and increased to a consistent percentage removal up to100 mg/L. However, research by Tanner et al. (1997) on sub-surface flow wetlands observed the greatest annual percent mass removal and lowest outflow concentrat ion to be generally associated with the lowest hydraulic loading rate. This conclusion did not apply to ammonium-nitrogen, total phosphorus and one sample of suspended solids. There was a lag-effect in the effluent concentration for nutrient species.

The sedimentation rate is also affected by pond geometry. If there is insufficient length-to-width ratio, the finer particles will not settle-out. Marsalek et al. (1997) observed sediment sorting in detention ponds draining a commercial complex, with c oarsest particles settling nearest the inlet (Marsalek et al. 1997). The available storage volume and hydraulic loading rate of runoff to the BMP further limit the effectiveness of sedimentation. Storms that produce a runoff volume greater than the stora ge volume of the BMP, or if sediment is allowed to accumulate and consequently reduce storage volume, short-circuiting within the pond will adversely affect BMP performance (Marsalek et al. 1997, EPA 1993, Martin 1988a). It is suggested that a minimum de tention time of 24-hours is necessary to ensure high removal rates for stormwater pollutants to allow for settling and biological uptake (Pitt et al. 1993, Yu and Nawang 1993, Schueler 1987). The age of the BMP facility is another factor contributing to BMP performance. Tanner et al. (1997) reported a decline in removal efficiencies with an increase in age of the BMP. TSS percent mass removal declined from 75-80% in the first year of operation to 55-70% by the 5th year.

Nutrients

Wet detention ponds and constructed wetlands can act as a sink, source or transformer of nutrients (Mitsch and Gosselink 1993). To improve stormwater quality polluted with excessive nutrient levels, BMP facilities are designed to provide sedimentation for particle-phase constituents and biological uptake for soluble nutrients (Martin 1988b). It has been found that the performance of BMPs for nutrient-enriched stormwater is unpredictable. This may be attributed to the complex nature of nutrient speciat ion, which is affected by seasonality, detention time, organic matter content, oxygen availability, and plant biomass. The most effective phosphorus removal mechanisms have been found to be adsorption, complexation, precipitation reactions with aluminium, iron, calcium and clay particles and by peat accretion (Brix 1994, Mann and Bavor 1993). Pond conditions amenable to nitrification-denitrification processes are most effective for nitrogen removal (i.e. aerobic vs anaerobic conditions/oxygen availability) (Brix 1994, Mitsch and Gosselink 1993). Further, similar to TSS, particle size distribution affects removal efficiencies of nutrients. The quality of the substrate and age of facility are also determinants of BMP performance.

Many studies report greater variability in BMP performance for nutrients than other constituents (Tanner et al. 1997, Yu et al. 1993, Martin 1988b, Mann and Bavor 1993). There is a range in removal efficiencies for particle and dissolved phases, as wel l as different species of nutrients. For example, Ferrara and Witkowski (1983) report a net export of TKN of 25.4% for the most intense storm (17.5mm) and a net gain by a wet detention facility of 23.9% for a less intense storm (10mm). A different pattern is found for TP in which there was a net reduction for the same storms of 48.6%

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and 30.9%, respectively. In another study using three methods to calculate BMP performance, Martin (1988b) reported a range in percent pollutant reduction for all species and phases of nutrients, from a net export of dissolved ammonia (i.e. 8-33%) to a reduction of 15-57% in dissolved phosphorus. Similarly, variable performance of nutrient species is observed for a pond/wetland system in Colorado in which there was a net expo rt (76%) of nitrate and an overall reduction of 19% for total nitrogen, and net reduction of 51% and 40% for total and dissolved phosphorus, respectively (Anon 1994).

It is indeterminate what factors contribute to the reduction of nutrients in stormwater runoff from the data collected in the studies. The variability of reduction for all particle size classes for TKN and TP does not appear to have a clear relationshi p between particle-size distribution and storm intensity (Ferrara and Witkowski 1983). The net export of pollutants may be attributed to the large proportion of pollutants associated with the soluble size fraction of solids (i.e. < 1µm). This was also observed for the effluent concentrations, which may suggest the soluble phase of nutrients are not being effectively treated in this wet detention basin. Mann and Bovar (1993) suggest that the type of substrate and age of facility affect pollutant remova l. The net export and gain of phosphorus was attributed to the 50% difference in sorption capacity of two types of gravel substrate in similar constructed wetland systems (i.e. 25.8 and 47.5 µg P/g substrate) (Mann and Bavor 1993). The decline in performa nce observed in the subsequent year was attributed to the saturation of phosphorus in the substrate. Similar reasons are provided for a 50% reduction in performance for total phosphorus for gravel-bed constructed wetlands (e.g. 35-75% to 15-38%) over a 5- yr period (Tanner et al. 1993). However, the standard error was large for these samples. The clogging of gravel substrate also contributes to reduced performance. Currently, long-term studies on a variety of BMPs are not available, nor are internal pond m easurements, to assess the longevity or treatment capacity.

Heavy Metals

BMPs generally have a positive impact on reducing total heavy metal pollutants from urban stormwater. Overall, studies report a moderate to high removal efficiency for wet detention basins, constructed wetland systems and combined pond-wetland systems (Schueler et al. 1992). Sedimentation is considered to be the predominant removal mechanism for heavy metals as it is assumed that pollutants in urban stormwater are largely sorbed to suspended sediments (Allan et al. 1997, Scholze et al. 1993). The co ncentration of heavy metals in sediments indicates the improvement BMPs have on stormwater quality (Marsalek et al. 1997).

Overall, characterization of BMP sediments (i.e. detention basins) indicates an accumulation of heavy metals associated with sedimentation rates ranging from 0.8cm/yr to 2 cm/yr (Marsalek et al. 1997, Guo 1997). Despite the strong ability of particula tes and organic matter to sequester heavy metals, Allan et al. (1997) found that TSS is not a good surrogate for other pollutants (Borden et al. 1997). This counters a design principle for BMPs that assumes an 80% removal of TSS will control other polluta nts, including heavy metals (EPA 1993). Further, the reliance on sedimentation to remove pollutants from the water column is not sufficient as data illustrates the presence of heavy metals in urban runoff in the dissolved-phase .

The results of performance studies reflect total metal concentration for a select number of pollutants. Pollutant removal efficiencies for wet detention ponds range from a net mass export of 17% to a reduction of 96% for Zn, an approximate reduction of 18-95% for Pb, generally >50% for Cu, and less the 0% to 51% for Cr. In a combined level spreader/vegetative buffer strip, a greater mass reduction in total Pb and Zn from runoff increased with filter length. An average mass loading reduction for thre e storm events of 25% and 51% was achieved for Pb and Zn respectively (Yu et al. 1993). For the largest storm (32.5mm) there was a net export of 55% and 16% of Pb at 6m and 21 m, respectively.

The benefits derived from improved water quality may be countered by adverse affects induced by sediment contamination. Further, cation-exchange capacity, and sensitivity to pH and Eh can affect the solubility of heavy metals, thus affecting the abili ty of sediments to sequester heavy metals from the water column. In a wet detention basin in Kingston, Ontario, Marsalek et al. (1997) found a suite of heavy metals to exceed the Ontario Lowest Effect Level (LEL) guidelines for the protection and manageme nt of aquatic sediment quality for 8 of the 10 metals sampled (i.e. Cd, Cr, Cu, Fe. Pb, Mn, Ni, and Zn). Arsenic and mercury were below the sediment LEL. These results reflect an average concentration of the top 18cm of sediment that has accumulated over a 9yr period (i.e. based on calculated sedimentation rate of 2cm/yr). Guo (1997) found that the concentration of heavy metal in the sediment generally decreased with depth and was correlated to percent organic content of the sediment (Guo 1997). The co ncentration of Pb, Zn and Cu decreased with depth and organic matter. The relationship was more consistent with organic matter than depth. The higher concentration of heavy metals in surficial sediments indicates a high risk to biota given the susceptibi lity of chemical speciation to changes in water quality. The mobilization of heavy metals from the sediment can be enhanced due to intermittent flooding which produces alternating periods of aerobic and anaerobic conditions. The change in the oxidized-sta te of an environment can alter the speciation of chemicals, and thus their bioavailability. For example, Marsalek et al. (1997) indicates the probability of a lower toxic form of Cr (Cr III) to be oxidized into a more toxic form of chromium, Cr (VI). In the same study, the proportion of heavy metals in a potentially mobile fraction was significant. Cadmium mobility also is increased during oxidized conditions under a range in pH values and has limited mobility during reducing conditions (Fergusson 1990).

Conclusions

The use of BMPs to control and treat urban stormwater runoff has become common practice in developing watersheds. Ordinances have been developed by local governments to dictate the use of BMPs for new development to protect surface water quality. To da te, studies on BMP effectiveness demonstrate a wide range of pollutant removal capabilities that range from a net export to more than a 90% reduction for a select suite of chemicals. Research indicates that performance is affected by specific design char acteristics, processes affecting chemical phase and speciation, and environmental conditions. However, it is difficult to interpret the pollutant removal efficiency of BMPs beyond generalities. Studies report only influent and effluent concentration and /or pollutant loading reductions, thus making it difficult to determine what specific factors are affecting BMP performance. Currently there is a lack of within-BMP monitoring of water quality and other media (e.g. sediment, vegetation) to provide a stro ng understanding of factors and processes that affect pollutant fate within a BMP. There is a particular lack of long-term monitoring of the processes responsible for export or detention of urban stormwater pollutants. There is a need to study the fate o f contaminants within the BMP and the interactions amongst media. For example, processes such as diffusion, turbulence, resuspension and bioturbation will affect the movement of chemicals across the sediment-water interface. Such processes are affected by physical-chemical properties such as temperature, pH, Eh, organic matter, etc.. Monitoring should also be expanded to include organic contaminants which are present in urban stormwater and pose health risks to humans and aquatic biota due to their persi stence in the environment and ability to transform into more harmful compounds (Makepeace et al. 1993, Helfield and Diamond 1997). Further, the variability in results is not only due to factors affecting BMP performance, but also the methods used to calcu late effectiveness and estimate flow for non-gaged BMPs.

Recommendations

- The long term performance of BMPs needs to be evaluated. The pollutant removal capabilities of BMPs are likely limited by a finite capacity of sediment/substrate to sorb and retain pollutants. The majority of studies reflect seasonal, short-term monit oring activities, and as such long-term performance of BMPs is uncertain (i.e. ≥ 5 yrs.). To date, research findings infer that the longevity of BMPs is linked to the ability of the substrate to assimilate pollutants (Mann and Bovar 1993, Tanner et al. 1997) and maintenance practices (Schueler et al. 1992).
- To more effectively manage BMPs, it is important to understand the specific process and interactions that cause the transformation, immobilization, and export of pollutants. The interactions amongst physical, biological and chemical processes need to be better understood. As an example, research on internal processes that affect chemical transformation and mobilization of particle-sorbed constituents in urban stormwater detention facilities is limited. The export of pollutants from BMPs indicates the release and/or transformation of pollutants within the BMP, yet the data presently available relies upon influent and effluent measurements to determine the effectiveness of the BMP facility. Such information on internal pond dynamics is necessary to imp rove upon effective BMP design and maintenance practices.
- The effect of an urban BMP needs to extend beyond water quality and include other media such as sediment, benthic invertebrates and vegetation. The reliance on sedimentation as the predominant design feature to remove pollutants from the water column, in addition to a lack of maintenance, results in contaminated sediments. The use of vegetation in wet detention ponds and constructed wetlands also introduces uncertain risk from the introduction of pollutants at low, but harmful concentrations. The cap acity of vegetation, bacteria and benthic invertebrates to accumulate and breakdown pollutants is not fully understood.
- The types of pollutants studied should be extended to include a more extensive array of priority pollutants such as hydrocarbons (e.g PAHs, pesticides) and inorganic pollutants. Helfield and Diamond (1997) and Makepeace et al. (1995) illustrate the r isk that may be induced by the presence of such chemicals in urban stormwater.
- The aggregation of data needs to be reported on a monthly and seasonal basis, rather than annual averages of pollutant removal. At this temporal scale, seasonal factors affecting BMP performance, such as thermal stratification of pond water and plant growth and senesce can be assessed.

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Appendix A. Summary of pollutant removal efficiencies (%) for stormwater management ponds and constructed wetlands.

Study	Nutrients		Heavy Metals						Other
	Nitrogen (N)	Phosphorus (P)	Zinc (Zn)	Lead (Pb)	Nickel (Ni)	Copper (Cu)	Cadmium (Cd)	TSS	
DRY EXTENDED									
1. Lakeridge	**$TN/NO_3/TKN$** 10/9	**TP/Solub** 20/(6)[a]	(10)					14	**COD** (1)
2. London Commons	**TN** A[b]: 25 B: 60	40/ -- 46/ --	24 40	39 25				29 74	**COD** 17 41
3. Stedwick	**$TN/NO_3/TKN$** 24/--/30	13/ --	57	62				70	**COD** 27
4. Maple Run III	**$TN/NO_3/NH_3$** 35/52/55	18/ --	(38)	29		31		30	**COD**: 2 **TOC**: 3 **BOD**: 3 **Fcoli**: 7
5. Oakhampton	**NO_3/NH_4** (10)/53.5	26/(12)						87	

6. No lcoation given	NO_3 20	19.0	65	66				3	COD 16

WET PONDS

7. total > 105 µm <105 + >1µm < 1µm	**TKN** (37.4) - 23.9 (81.1) -37.6 (152) - (55.5) (17) - 39.5	**TP** (10.7) -48.6 (92.9) - 9.26 42.2 - 66.7 (35.2) - 60.8						29.1 - 51.6 30.9 - 83.7 46.8 - 62.4 21.6 - 30.1	**COD** **5.4 – 16.1 · 48.8 (138) -52.6 13.7-**
8. Burke		**TP/solub** 48/53%							
9. Westleigh		**TP/solub** 54/ 71							
10. Seattle		78.4/ --	65.2	65.1		66.5		86.7	
11. Boynton Beach	**TN/NO_3/TKN** --/87/58	--/76						91	
12. Grace Street	6/(1)/7	12/ --		26				32	**BOD** 3
13. Pit - AA	--/7/14	18/ --	13	62				32	**BOD** 2
Study	**Nutrients**		**Heavy Metals**						**Other**

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	Nitrogen (N)	Phosphorus (P)	Zinc (Zn)	Lead (Pb)	Nickel (Ni)	Copper (Cu)	Cadmium (Cd)	TSS	
15. Waverly Hill	62 66 60	**TP/Solub** 79/ --	91	95		57		91	**BOD:** 6
16. Lake Ellyn		34/ --	71	78		71		84	
17. Lake Ridge	A[c]:41/10/50 B:24/17/28	61/11 37/8		73 52				90 85	
18. West Pond	-- 61/23	25/ --	66	8-79			12-91	65	**TOC**:1 **Cr**: 48-
19. McCarrons	**TN** 85	78/ --		90				91	
20. McKnight Basin	**TN/NO_3/TKN** A[c]:30/24/31 B:14/11/15	48/13 34/12		67 63		75		85 85	**Fcoli**:7 **Pest**: 2
21. Monroe Street		65/70	65	70				90	
22. Runaway Bay	**TKN**: 24	24/ --	42			38	<0	54	**TOC**:3
23. Buckland		45/ --	51	18-59				61	
24. Hwy Site	**TN** 21	17/ --	37	41				65	**COD**: 7
25. Woodhollow	**TN/NO_3** **39/45/** **TKN/ NH_3** **26/26**	46/ --	69	76				54	**COD**: 4 **BOD**:3 **Fcoli**: 4

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26. SR 204		91/--	87	88.2		90		90	COD [illegible]
27. Farm Pond	TN/ NH_3 34/107	86/73						85	COD 2
28. Burke	TN/NO_3/TKN 32/--/27	39/77	38	84				(33.3)	COD 3
29. Westleigh	TN 37	54/71	26	82				81	COD: 7
30. Mercer		67	38	23		51		75	
31. I-4	TN/NO_3/TKN --/97/68	69	69	41-94		66-81	43-51	54	TOC: 4
32. Timber Creek	15/80/--	60/80						64	
Study	**Nutrients**		**Heavy Metals**						**Other**
	Nitrogen (N)	**Phosphorus (P)**	**Zinc (Zn)**	**Lead (Pb)**	**Nickel (Ni)**	**Copper (Cu)**	**Cadmium (Cd)**	**TSS**	
33. Maitland	NO_3/ NH_3 87/82	TP/Solub --/90	96	95		77			
34. Lakeside	TKN 6	23/--	82					91	

WET EXTENDED

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35. Uplands		69 --						82	Fcoli: 9
36. East Barrhaven		47 --						52	Fcoli:5(
37. Kennedy-Burnett	TN 54	79 --	39	39				98	BOD: 3 Fcoli:9(

SW WETLANDS

38.	TN	TP							CBOD
L1	65.3 ± 14.5	38 ± 32.1						61 ±17.4	91 ± 5.5
L2	64 ± 8.6	35 ± 30.4						78 ± 4.7	87 ± 3.4
L3	59 ± 9.3	39 ±27.3						72 ± 2.7	86 ± 4.1
L4	51 ± 3.0	15 ± 16.9						67 ± 8.7	76 ± 4.(
L5	48 ± 4.1	19 ± 17.5						58 ± 15.3	73 ± 2.7
Cont'd	NH_4-N								Fcoli.
L1	60 ± 23.6								99.6 ± (
L2	57 ± 21.3								99.0 ± (
L3	48 ± 23.6								99.2 ± (
L4	37 ± 9.7								95.0 ± (
L5	34 ± 17.6								92.5 ± (
39	TN								BOD
Subsurface	41.6	33.7						82.8	85.1
Free-water surface	62.2	53.7						65.3	73.2
	NO_3								
40. EWA3	**70**	59						72	Fe:48
41. EWA4	42	55						76	Fe: 43

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42. EWA5	70	69						89	Fe 5?
43. EWA6	95	97						98	Fe 92
44. B31	4	(2)						14	
Study	**Nutrients**		**Heavy Metals**						**Other**
	Nitrogen (N)	**Phosphorus (P)**	**Zinc (Zn)**	**Lead (Pb)**	**Nickel (Ni)**	**Copper (Cu)**	**Cadmium (Cd)**	**TSS**	
45. PC12	20	**TP/Solub** (2)/ --						56	
46. McCarrons	**TN** 24	36/ --		68				87	**COD** 7?
47. Queen Anne's	**TN/NO_3** **23/55** **NH_4/Org N** **55/ (5)**	39/44						65	**Part. P**
48. Swift Run	**NO_c** **80**	3/29		82				85	**COD** 2 **BOD** 4

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49. Tampa Office Pond	**Org N**: (3.7)	55/65	34					64	
50. Highway Site	**TN** 30	19/ --	50	75				66	
51. Plan Beach PGA	**NO_3/TKN/NH_3** **33/16/17**	62/ --						50	**BOD**: 3 **TOC**: 1(
52. Benjamin Franklin	**NO_3/TKN/NH_3** **60/4.4/0**	14.9/23.6	(73.5)				(79.8)	62	
53. Tanner's Lake	**TN/TKN** A[c]: 36/4 B: 5/7	24/10 7/(14)		63 59		40	70	62 63	
54. Mays Chapel	**NH_3**:43	16/24				80	67	24	
55. Clear Lake	**TKN/NH_3** 25/55	5440						76	

POND/ WETLAND

56. Colorado	**TN/NO_3**	**TP/sol.P**	**Total/Solub**						
Pond	(12)/(85)	**49/32**	51/34			57		78	
Wetland	1/(1)	**3/12**	31/(5)			2		(29)	
Pond-Wetland	(19)/76	**51/40**	66/30			5		72	
57) Wet-Detention Pond	**TN/ organ/NH_4**	**TP/ortho-P**							**TOC**
EMC[d]	10/ 5/57	28/34	-17	31					2
SOL	13/ 9/54	33/37	10	32					3
ROL	18/ 18/55	38/37	39	40					3

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Study	Nutrients		Heavy Metals						Other
	Nitrogen (N)	Phosphorus (P)	Zinc (Zn)	Lead (Pb)	Nickel (Ni)	Copper (Cu)	Cadmium (Cd)	TSS	
b) Wetland									
EMC	5/16/(73)	3/(21)	51	69					1
SOL	20/25/(19)	15/0	55	73					17
ROL	21/23/(54)	17/2	56	73					18
c) Pond-Wetland									
EMC	15/23/4	22/(2)	50	77					9
SOL	30/34/32	37/21	62	81					23
ROL	36/39/61	43/28	70	83					22
58. Lake Munson	**$TN/NO_3/TKN$** **11/15/11** **NH_4:(39)**	64/ --	59	55				92	**COD**: 2 **BOD**:4:
59. Carver Ravine	**$TN/NO_3/TKN$** **A[c]:5/18/14** **B:(6)/9/10**	24/21 1/1		42 6				46 20	
60. McCarrons	(83)	78/ --		90				94	**COD**: 9
61. Lake Jackson	**TN/NH_4** 75/37	90/ --						96	
62. Long Lake		92/ --						95	

VEGETATED BUFFER STRIPS

63. Storm	$NO_3 + NO_2$ (soluble)	TP			
17.3mm	29	45	10	33	43
32.5mm	(27)[a]	25	55	(16)	54
11.7mm	40	25	50	39	84
13.5 mm	20	40	53	50	73

[a] ( ) denotes negative retention;

[b] A: pre-adjustment, <10hr of ED; B: post-adjustment, <20hrs of ED.

[c] A = rainfall only; B = rainfall + snowmelt

[d] EMC = event mean concentration, SOL = summation of loads, ROL = regression of loads

1. MWCOG, 1983. Minor extended detention provided (1-2hrs). Frequent resuspension by clogging of low-flow orifice

2. OWML, 1987. Exfiltration of runoff accounted for some removal

3. Schueler and Helfrich, 1988. Achieved extended detention of 6-8 hrs., prone to resuspension

4. City of Austin, 1991. Originally dry pond, due to poor maintenance, 3-6hrs of extended detention was achieved

5. Baltimore Department of Public Works

6. Pope and Hess, 1988. Resuspension, extended detention volume was very high

7. Ferrara and Witkowski (1983). Impounded tributary in Hillsborough Township, NJ, mixed rural-suburban land use, 42% residential, 21.7 under construction, 9.7% pasture/grassland, 7.4% cropland, 49% forested, range reported.

8 Hartington 1989, site located in Burke Washington, D.C. Single family resid, 34% impervious, residence time = 4.9wks

9. Hartington 1989, site located in Westleigh, Washington, D.C, Single family resid, 24% impervious, residence time = 6.7wks

10. Horner et al. 1990
11. Holler. 1987.
12. Driscoll, 1983. NURP pond
13. Driscoll, 1983. NURP pond
14. Driscoll, 1983. NURP pond
15. Driscoll, 1983. NURP pond
16. Driscoll, 1983. NURP pond
17. Oberts et al. 1989.
18. Dorman et al. 1989. Highway runoff
19. Wotzka and Oberts 1989. Some ED provided
20. Oberts et al. 1989.
21. Bannerman, forthcoming March 1992
22. Wu et al. 1988.
23. Dorman et al. 1989. 8000ft of grassed swale treatment prior to pond, very shallow permanent pool
24. Martin 1988
25. City of Austin, 1990. Negative removal for TDS off-line facility

26. Horner et al. 1990
27. OWML. 1983(b). Farm pond. no urban development
28. OWML. 1983(b). TSS removal estimate appears to be a serious underestimate due to use of medium storm EMC calculations
29. Driscoll, 1986. High algal uptake
30. Horner et al. 1990
31. Dorman et al. 1990. Highway runoff
32. Cullum, 1985. Commerical area
33. Yousef et al. 1986. Multiple cell wet pond
34. Wu et al. 1988 goose excrement cited for poor nutrient removal
35. OMOE, 1991. No winter data, manual extended detention
36. OMOE, 1991. No winter data, manual extended detention
37. OMOE. 1991. No winter data, manual extended detention
38. Tanner et al. (1998), 5 pilot scale gravel bed wetlands (19 m^2, 9.5 x 2x0.6m deep) in Hamilton, NZ. Purpose to study 5 different loading rates on constructed wetland performance over 5 yr period, all resutls are mean value ± 1 s.d for 5^{th} yr of operation
39. Brix (1994), values are based on composite mean of several studies.
40. Hey and Barrett, 1991. Cited in Strecker et al. 1990, Resuspension
41. Hey and Barrett, 1991. Cited in Strecker et al. 1990
42. Hey and Barrett, 1991. Cited in Strecker et al. 1990
43. Hey and Barrett, 1991. Cited in Strecker et al. 1990. No surface discharge during 6 months of the year
44. Reinelt et al. 1990. Cited in Strecker et al. 1990. Channelization reduced effectiveness
45. Reinelt et al. 1990. Cited in Strecker et al. 1990. Channelization reduced effectiveness
46. Wotzka and Oberts, 1988. Runoff pretreated by pond.
47. Athanas and Stevenson, 1991
48. Driscoll 1983. Shallow pond with wetlands
49. Rushton and Dye, 1990. Cited in Strecker et al. 1990
50. Wotzka and Oberts 1988. Runoff pretreated by pond
51. Blackburn et al. 1986. Cited in Strecker et al. 1990. Residential golf course, polish runoff to natural wetland
52. OWML and GMU, 1990. Poor removal for large storm in excess of treatment capacity
53. Oberts et al. 1989.
54. OWML and GMU, 1990.
55. Barten, 1983. Cited in Strecker et al. 1990.
56. Anon. 1994.
57. Martin (1988b), built in 1980, total chemical species presented in table. mixed land use within 16.9ha drainage area (33% urban r oads. 28% forest 40%, resid), used 3 methods to determine efficiency (EMC, SOL, ROL), analytical variance (RMS) ~15%-20%
58. Maristany and Bartell 1989. 30-yr old lake wetland systems
59. Oberts et al. 1989.
60. Wotzka and Oberts, 1988. Wetpond to wetland
61. Esry and Cairns, 1988. Cited in Strecker et al. 1990. Pond to filter to wetland
62. Jolly, 1990. Study period did not cover periods of high phosphorus loading or spring thaw (snowmelt) and was primarily in an agricultural watershed.
63. Yu et al. 1993. Site located in Charlottesville, VA, level spreader/ vegetative buffer strip, 4-ha comm ~ 100% impervious; design storm 10-yr rtn, 10min (60cfs);

    values in table are for percent mass removed for max distance of 21m for all storm events with the exception of 17.3mm that is 16m from LS.

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - LOS ANGELES REGION

STANDARDS AND ENFORCEMENT UNIT FINAL

Storm Water Industrial General Permit Group DRAFT

Analysis of the Sampling Results

1996-1997 Annual Report for Storm Water Industrial Activities General Permit

August 1998

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This report, which is a first, statewide, to the author's knowledge, has not been possible without the support and involvement from:

- State Water Resources Control Board, Storm Water Unit for providing funding to perform the duties required to manipulate such a large volume of data. Special thanks to the State Board staff for making this project possible;
- Regional Board management, that was very supportive of this effort, and Dr. Xavier Swamikannu's constant assistance and advice;
- Santa Monica Bay Restoration Project for providing funding to accomplish this task. Special thanks to the SMBRP staff for making this project possible;
- And special thanks to the student assistants working on this project. Without their hard work and perseverance, this task could not be concluded:
  - Binh Phan,
  - Robert Tom, and
  - Jessica Huynh.

Again, many thanks to those contributing to the success of this project that can provide useful information in an area crucial to the progress of the Storm Water Program in improving water quality in our region.

Its substance reaches everywhere; it touches the past and prepares the future; it moves under the poles and wanders thinly in the heights of the air...

If there is magic on the planet, it is contained in water.

Loren Eiseley, Naturalist

EXECUTIVE SUMMARY

INTRODUCTION

In 1987 the **Clean Water Act** was amended by Congress to require the regulation of point source discharges of storm water from industry and from municipal separate storm sewer systems serving over 100,000 people. In 1990 the **U.S. Environmental Protection Agency (EPA)** promulgated regulations requiring, in part, **National Pollution Discharge Elimination System (NPDES)** permits for all storm water discharges associated with industrial activity. The regulations allow authorized states to issue general permits or individual permits to regulate storm water discharges. California is one of the authorized states to issue NPDES permits.

Consistent with Tier I, Baseline Permitting, of the U.S. EPA permitting strategy, the **California State Water Resources Control Board** issued a statewide **General Industrial Activities Storm Water Permit (General Permit)** on November 19, 1991, that applied to all storm water discharges requiring a permit except construction activity. The General Permit was reissued on April 17, 1997.

The nine California **Regional Water Quality Control Boards (Regional Boards)** have the responsibility of implementing and enforcing the statewide General Permit.

Some of the General Permit key requirements are:

- to prepare and implement a **Storm Water Pollution Prevention Plan (SWPPP)** by each regulated facility;

- the develop and implement a **Monitoring Program (MP)**;
- submit an **Annual Self-Monitoring Report (AR)** by July 1, each year the facility continues coverage under the permit.

BACKGROUND

Since the implementation of the storm water regulations, Los Angeles Regional Board embarked, with limited staff resources, in a sustained effort to administer and enforce the General Permit requirements. The Board staff also provided outreach, compliance support and guidance to the permittees and other interested stakeholders.

The Los Angeles metropolitan area is one of the most industrialized areas of the State and the nation. It is home to thousands of industrial and commercial facilities, ranging from petroleum refineries to aerospace corporations, from wastewater treatment plants to recycling facilities. In the region are also located some of the major harbors and airports in the country, military bases, transportation facilities and many other types of businesses. A recent report: *Effectiveness of Industrial Storm Water General Permitting Program* - October 1996, prepared by the **Water Environment Federation** for the US EPA, determined that California had over 10% of the total number of **Notices of Intent (NOIs)** filed nationwide. Under L.A. Regional Board's jurisdiction (covering most of L.A. and Ventura Counties), there were 2,457 industrial facilities covered by the General Permit, as of July 1, 1997. That represents 30% of the total number of NOIs filed in California (See Attachment 1). As a consequence, the number of NOIs filed in L.A. Region (excluding construction NOIs) is almost the same as that in the states of New Jersey and Wyoming combined, or more than the number of NOIs in Louisiana or Arizona (Source: US EPA NOIs database, June 1998, See Attachment 2).

One of the objectives of this staff report is to give an overview of the facilities' compliance performance. The second objective is to perform a brief analysis of the sampling results as reported by the permittees in their ARs. The analyzed data are presented in tables and graphs.

METHODS AND PROCEDURES

The main objectives of the monitoring program required by the General Permit are:

- to demonstrate compliance with the permit;
- aid in implementing the SWPPP; and,
- measure the effectiveness of the **Best Management Practices (BMPs)** in reducing or preventing pollutants in storm water discharges and authorized non-storm water discharges.

All facility operators (except for inactive mining operations) are required to:

1. Perform visual observations of storm water discharges and authorized non-storm water discharges.

2. Collect and analyze samples of storm water discharges. Analysis must include:

   - pH;
   - total suspended solids (TSS);
   - total organic carbon (TOC) or Oil and Grease;
   - specific conductance;
   - toxic chemicals, and other pollutants which are likely to be present in storm water discharges in significant quantities; and,
   - those parameters listed in **Table D** of the General Permit. The Table D parameters are those listed in the U.S. EPA Multi-Sector General Permit (See **Federal Register**/ Vol. 60, No. 189/ September 1995, page 50804-51319).

- Facility operators subject to Federal storm water effluent limitation guidelines in **40 CFR Subchapter N** must also sample and analyze for any pollutant specified in the appropriate category of 40 CFR Subchapter N.

The examination focused on:

- a cursory review of the ARs, to determine the overall level of compliance with the requirements of the General Permit, as self reported by the permittees,
- a limited statistical analysis of the **sampling analytical results (SAR)**, as reported by the facilities.

The following procedure was used to process the documents and enter the data:

- **First step** was to process the documents immediately upon receipt at the L.A. Regional Board and date stamp the ARs as received. In the process, thousands of documents were handled, summing up to over 15 cubic feet of records.

- **The second step** was to enter the date when the ARs were received into a database file containing the identification number of the facility.

- **The third step** was to sort the documents in the order of their **Waste Discharge Identification (WDID)** number, verify that each had a date stamp as a proof of the date when they were received and also, to confirm that the certification signature was existent. In case the certification signature was missing, the AR form was returned to the facility operator with a note to be signed by the proper facility representative. The ARs with missing certification signature were not processed until received with the proper signature present. The date when AR was received with the proper signature was logged in as the receiving date.

- **The fourth step** was to perform a cursory review of the ARs, verifying a limited range of compliance items:
    - any change of information (phone number, contact person, address, etc.);
    - AR was submitted by the deadline;
    - the facility has prepared a SWPPP and MP;
    - the required visual observations were performed;
    - required storm water runoff samples were taken and analyzed;
    - the mandatory annual site inspection/comprehensive evaluation was performed.

The reviewed items are also marked on a checklist form attached to the individual AR document. A sample checklist is attached to this report.

Next, a spreadsheet table of overall compliance was developed. The results of the review are entered in the table: ***Compliance Evaluation for 1996-97 Annual Reports, page 2-1***. The compliance data were not entered as separate records for each individual facility, instead a general tally for all facilities was developed.

Concomitant, the SAR data, as submitted with the ARs, were entered on a database file as separate records for each facility, for each storm event sampled. Depending on the number of existing outfalls, a facility may have more than one set of sampling data records for each storm event.

The SAR for the following parameters were entered in the database file:

- pH;
- Oil and Grease;
- Total Organic Carbon;
- Total Suspended Solids;
- Specific Conductance;

- Chemical Oxygen Demand;
- Biological Oxygen Demand;
- Total Chromium;
- Copper;
- Nickel;
- Zinc;
- Toluene;
- Xylene;
- Total Dissolved Solids.

More than 10,000 data values were entered in the file.

RESULTS

Compliance Evaluation for 1996-97 Annual Reports, page 2-1, presents a tabulated synthesis of the compliance items reviewed by February 28, 1998. The data shows a large percentage of the facilities, 55%, failed to submit the AR by the deadline. As a consequence, in concordance with the State and Regional Board progressive enforcement strategy, **442** Notices of Non-Compliance were issued, followed by **131** Notices of Violation. There was also a significant number of facilities, 105, which declared they did not prepare a SWPPP, mostly due to the claim that they recently applied for coverage under the General Permit.

The assessment shows that a significant percentage of facilities:

- 55% failed to take and analyze samples from the required two storm events,
- 32% did not take samples at all, and,
- 21% reported they have some type of non-storm water discharges present.

There was no attempt to determine if the samples were taken from a qualified storm event or when a discharge was present.

The **Group Monitoring Plan (GMP)** evaluation shows that the percentage of designated sampling facilities, taking samples in our Region, 18%, approaches the yearly percentage mandated by the General Permit: 20%.

Overall Sampling Results Analysis for 1996-97 Annual Reports, page 2-2, presents a synthesis of the SAR from the facilities submitting data as of January 1, 1998. There was no attempt to determine the quality control and quality assurance or the manner in which the samples were taken, handled and analyzed. For a limited number of reported values that seemed grossly out of range, or obviously wrong (as in the case of pH, values reported above 14), the facility operator was contacted for confirmation, to correct eventual typo errors. However, some of the results were confirmed as high as reported.

The values of the SAR were than compared with existing storm water **benchmark levels (BLs)**, (See Federal Register/ Vol. 60, No. 189/ September 1995, page 50826). The values of mean and median are computed for each parameter analyzed.

The data shows that a significant percentage of **SAR values** are outside or above BLs:

- for pH: 13%,
- for TSS: 27%,
- for SC: 29%.

The percentage of **facilities** reporting values outside or above BLs are also notable:

- for pH: 23%,
- for TSS: 27%,
- for SC: 29%.

For some parameters, there are a number of very low SAR values reported, uncharacteristic for typical values for common storm water runoff composition.

An attempt was made to present together the data from 1992-1993 and 1996-1997 seasons in: ***Combination of 1992-93 & 1996-97 Annual Reports Overall Analysis, page 3-1 and 3-2***. A brief analysis of the 1992-1993 SAR data was presented in the first ***Storm Report*** Newsletter issued by the Regional Board. It is important to note that the missing data from 1993 to 1996 can be made accessible in electronic format subject to availability of additional resources to perform the data entry task. Attached to the report there are a number of graphs organized by parameter and year, from page 4-1 to 5-5. There is another set of graphs organized by parameter, year and watershed, found at page 6-1 to 11-5. A third set of graphs, at page 12-1 to 12-6, are organized by **Standard Industrial Classification (SIC) Codes**, parameters and year, for 1996-1997 season only.

A brief review of the comparison do not show any dramatic improvement, percentage wise, in the number of samples reported outside or above the BLs, between 1992-1993 and 1996-1997 season. While the median values are within the BLs, the mean for TSS, SC and O&G are consistently above the BLs. As previously shown, there is a significant number of facilities reporting values above BLs and in addition a significant number of facilities still failed to take the required samples and analyze them, excluding GMP participants scheduled not to sample in a particular year or those previously obtaining an exemption from sampling from the Regional Board. The data available can not detect an overall trend or for any given parameter, due to the three year gap in recording.

The 1992-1993 season was the first year in which the permittees had to submit an AR with sampling results. There is a significant difference in the number of samples analyzed and number of facilities taking samples between 1992-1993 and 1996-1997:

an overall four to five fold increase can be noticed. This may be due to increased awareness about the requirements of the General Permit and constant compliance assistance and enforcement activities performed by the State and Regional Board staff.

Data for 1996-1997 season may be skewed upwards for some parameters due to a number of very high values. For a number of limited records, staff contacted the facility for confirmation, as stated before.

FINAL REMARKS

The brief analysis presented in this report was used to better prepare and plan the 1997-1998 season ARs review effort. The attempt to input all sampling results values in an electronic database will be continued in the future, subject to adequate, continued funding support. This data can make a significant contribution to various efforts under way in our region, to determine background levels of storm water runoff contribution to water quality impairments, trends and loads into the various regional watersheds. This gives RB staff an additional tool in the effort to determine the existence of any geographical or sector-wise "hot spots". The data can help in the process of determining **Total Maximum Daily Loads (TMDLs)** for various parameters, it can assist the municipalities' efforts to improve monitoring and control of diffuse pollution contributed from industrial sites into the municipal storm drain system. Also, a number of research projects under way, at prestigious universities in our area, can benefit from the accessibility to this database.

The availability of this data, with all inevitable constraints and unknowns, represents an important step forward in the endeavor to better understand and address complex diffuse pollution phenomena and their impact on aquatic systems. The research and interpretation of the data can be also expanded beyond the limited attempt of this report.

The greatest benefit is for the permittees themselves, since they can better quantify and evaluate their performance and they can direct their resources to address the real on-site issues in an economic, effective and efficient way.

Aranalys.doc

List of Tables

Analysis of Sampling Results

From Storm Water Annual Reports 1996-1997

2457 Facilities Active on July 1, 1997

2178 Facilities (100%) Annual Reports Reviewed as of February 28, 1998 out of 2178 Received

	Annual Report Late	Change of Information	SWPPP Not Prepared	Non-Stormwater Discharges Present	No Dry Weather Observations (one or more)	No Wet Weather Observations (one or more)	No Sample Taken	Samples From Only One Storm Event	No Sample for Toxic Chemicals & Other Pollutants	Number of Facilities Submitting Sample Results (including GMP)	GMP Participants
Number Facilities out of the Total Reviewed	1205	685	107	458	211	1287	688	509	573	1042	542
% of the Total Reviewed	55%	31%	5%	21%	10%	59%	32%	23%	26%	48%	25%

GROUP MONITORING PLAN (GMP) ASSESSMENT

GMP Participants	No Sample Taken	Number of GMP Facilities Submitting Sample Results
542	442	100
	82%	18%

R0010376

Analysis of Sampling Results

From Storm Water Annual Reports 1996-1997

2457 Facilities Active on July 1, 1997

942 Facilities (38%) Reported Sampling Results as of January 1,1998

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)	COD (mg/l)	BOD (mg/l)	TOTAL Cr (mg/l)	Cu (mg/l)	Pb (mg/l)	Ni (mg/l)	Zn (mg/l)	Toluene (mg/l)	Xylene (mg/l)	TDS (mg/l)
Maximum Value	12.5	300000.0	339000.0	24000.0	2700.0	46300.0	12000.0	31.0	127.0	392.0	26.0	679.0	490.0	2.9	34000.0
Minimum Value	1.56	0.002	0.015	0.020	0.010	7.0	0.100	0.006	0.010	0.010	0.170	0.010	0.250	2.4	0.180
Mean	6.97	441.18	853.24	39.91	45.11	615.00	208.85	1.89	2.02	5.52	6.38	6.16	117.96	2.65	852.87
Median	6.90	42.00	90.00	5.00	13.00	77.00	17.50	0.12	0.15	0.19	1.96	0.55	4.86	2.65	52.00
Benchmark Levels (BL) *	6.0-9.0	100.0	200.0	15.0	110.0	120.0	30.0		0.06	0.08	1.42	0.12	10.0		
Number of Facilities Sampled	928	895	879	702	416	49	37	8	82	68	5	154	4	2	40
Number of Facilities above (outside) BL	212	359	326	159	44	24	16		78	65	3	150	2		
% of Facilities above (outside) BL	23%	40%	37%	23%	11%	49%	43%		95%	96%	60%	97%	50%		
Number of Samples	2452	2282	2313	1740	1106	119	90	18	167	130	5	364	6	2	94
Number of Samples with results above (outside) BL	309	607	660	231	69	43	31		156	121	3	354	2		
% of Samples above (outside) BL	13%	27%	29%	13%	6%	36%	34%		93%	93%	60%	97%	33%		
Estimated Spending	$24,520	$41,076	$34,695	$60,900	$55,300	$2,975	$2,250	$540	$5,010	$3,900	$150	######	$360	$120	[illegible]

Total Estimated Spending $244,126

* Source: NPDES Storm Water Multi-Sector General Permit for Industrial Activities - September 29, 1995, FR/ Vol 60, No. 189/ p 50804-51319.

R0010377

Analysis of Sampling Results

From Storm Water Annual Reports 1992-1993

633 Facilities Reported Sampling Results

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Maximum Value	11.2	42000.0	10000.0	556.0	164.0
Minimum Value	1.20	0.60	0.10	0.10	0.01
Mean	6.99	438.47	387.05	18.04	39.14
Median	6.90	51.00	97.00	5.00	11.00
Benchmark Levels (BL) *	**6.0-9.0**	**100.0**	**200.0**	**15.0**	**110.0**
Number of Facilities Sampled	620	557	554	367	229
Number of Facilities above (outside) BL	82	186	170	91	16
% of Facilities above (outside) BL	13%	33%	31%	25%	7%
Number of Samples	620	557	554	367	229
Number of Samples with results above (outside) BL	82	186	170	91	16
% of Samples above (outside) BL	13%	33%	31%	25%	7%
Estimated Spending	$6,200	$10,026	$8,310	$12,845	$11,450

Total Estimated Spending $48,831

R0010378

Overall Sampling Results Analysis for 1992-93 Annual Reports

Analysis of Sampling Results

From Storm Water Annual Reports 1992-1993 and 1996-1997

1992-1993

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Number of Facilities Sampled	620	557	554	367	229
Number of Facilities above (outside) BL	82	186	170	91	16
% of Facilities above (outside) BL	13%	33%	31%	25%	7%

1996-1997

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Number of Facilities Sampled	928	895	879	702	416
Number of Facilities above (outside) BL	212	359	326	159	44
% of Facilities above (outside) BL	23%	40%	37%	23%	11%

1992-1993

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Number of Samples	620	557	554	367	229
Number of Samples with results above (outside) BL	82	186	170	91	16
% of Samples above (outside) BL	13%	33%	31%	25%	7%

1996-1997

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Number of Samples	2452	2282	2313	1740	1106
Number of Samples with results above (outside) BL	309	607	660	231	69
% of Samples above (outside) BL	13%	27%	29%	13%	6%

1992-1993

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Estimated Spending	$6,200	$10,026	$8,310	$12,845	$11,450

Total Estimated Spending $48,831

1996-1997

	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Estimated Spending	$24,520	$41,076	$34,695	$60,900	$55,300

Total Estimated Spending $216.491

R0010379

Combination of 1992-93 and 1996-97 Annual Reports Overall Analysis

Analysis of Sampling Results

From Storm Water Annual Reports 1992-1993 and 1996-1997

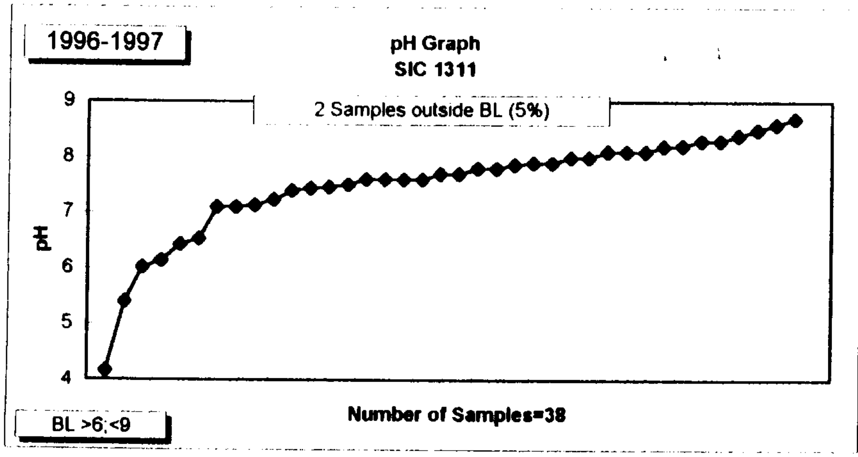
1992-1993	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Maximum Value	11.2	42000.0	10000.0	556.0	164.0
Minimum Value	1.20	0.60	0.10	0.10	0.01
Mean	6.99	438.47	387.05	18.04	39.14
Median	6.90	51.00	97.00	5.00	11.00
Number of Samples	620	557	554	367	229
Number of Samples with results above (outside) BL	82	186	170	91	16
% of Samples above (outside) BL	13%	33%	31%	25%	7%

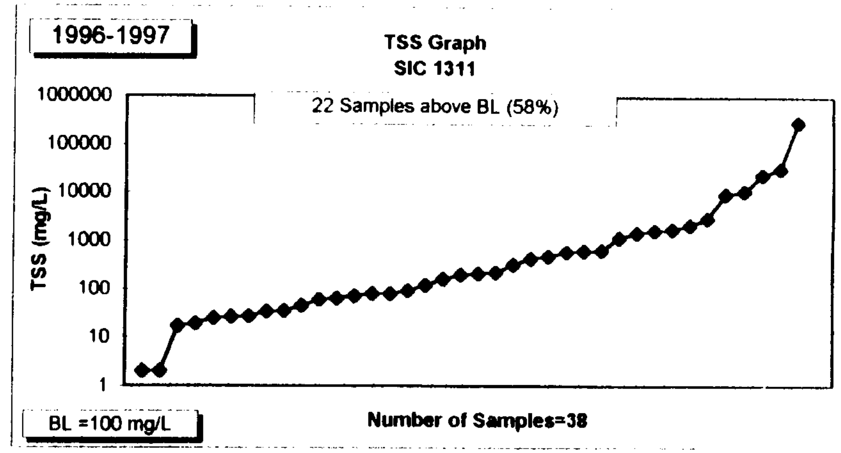
1996-1997	pH (units)	TSS (mg/l)	SC (umhos/cm)	O&G (mg/l)	TOC (mg/l)
Maximum Value	12.5	300000.0	339000.0	24000.0	2700.0
Minimum Value	1.56	0.002	0.015	0.020	0.010
Mean	6.97	441.18	853.24	39.81	45.11
Median	6.90	42.00	90.00	6.00	13.00
Number of Samples	2452	2282	2313	1740	1106
Number of Samples with results above (outside) BL	309	607	660	231	69
% of Samples above (outside) BL	13%	27%	29%	13%	6%

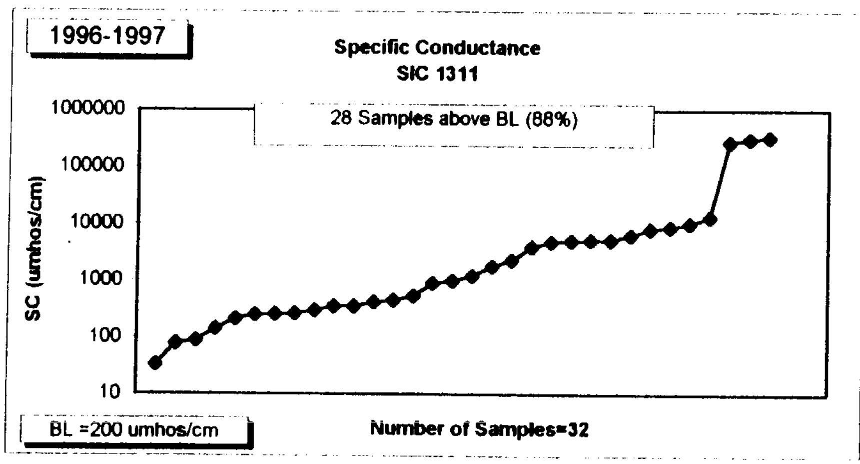
Benchmark Levels (BL) *	6.0-9.0	100.0	200.0	15.0	110.0

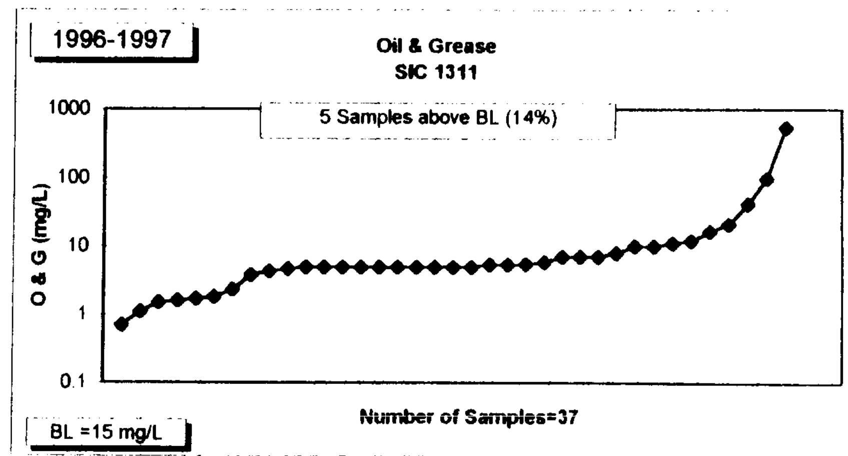
R0010380

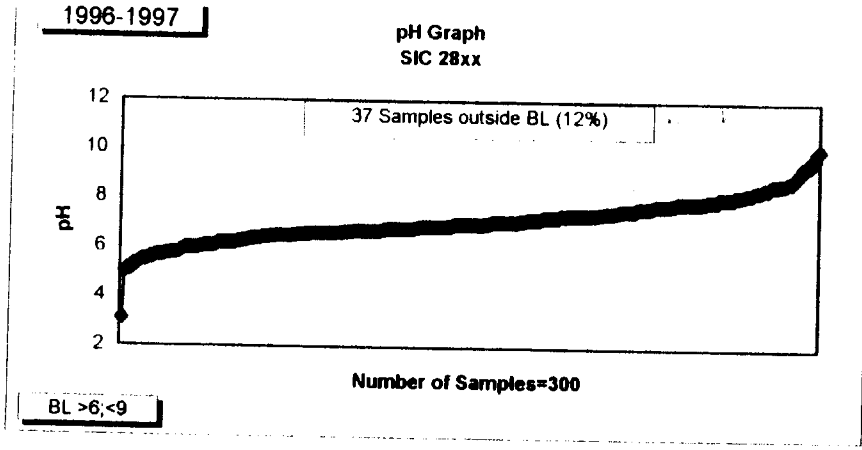
SIC Codes Graphs
(1996-1997)

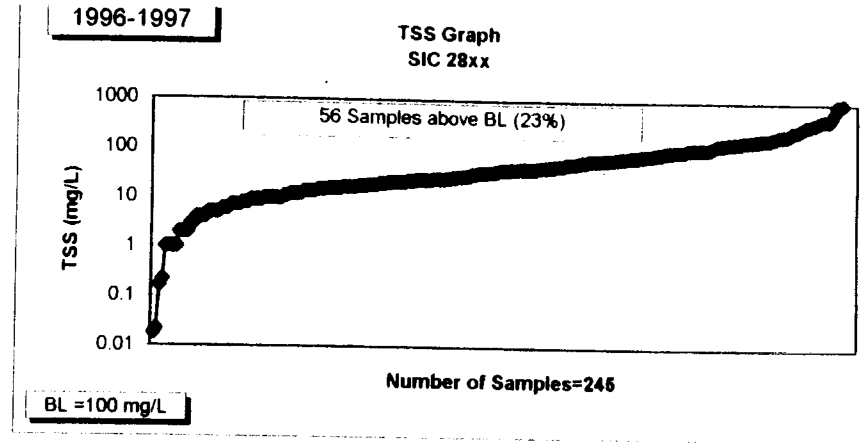

1996-1997
pH Graph
SIC 1311
2 Samples outside BL (5%)
pH
9
8
7
6
5
4
BL >6;<9
Number of Samples=38

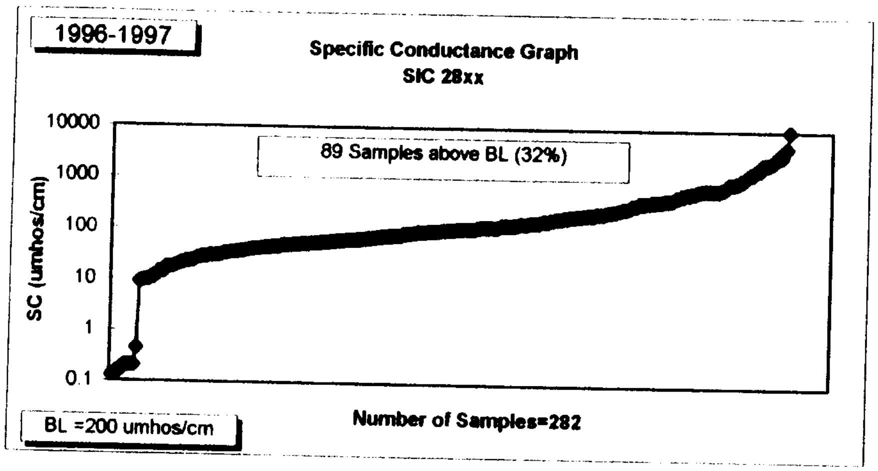

1996-1997
TSS Graph
SIC 1311
22 Samples above BL (58%)
TSS (mg/L)
1000000
100000
10000
1000
100
10
1
BL =100 mg/L
Number of Samples=38

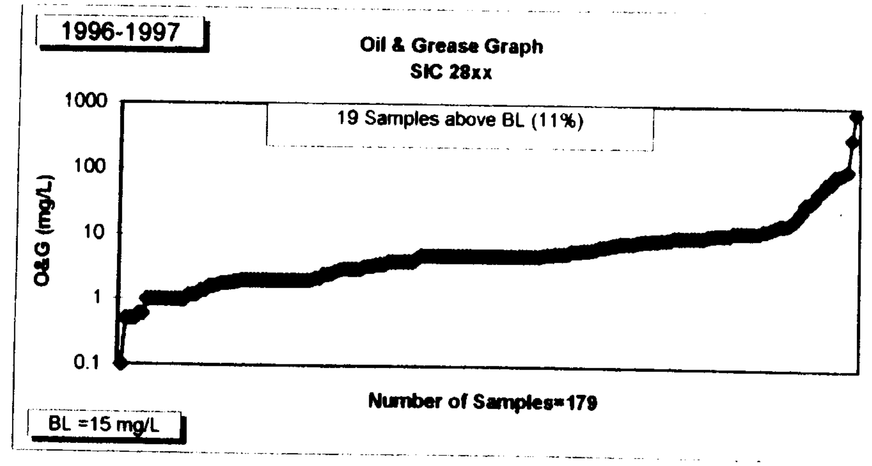

1996-1997
Specific Conductance
SIC 1311
28 Samples above BL (88%)
SC (umhos/cm)
1000000
100000
10000
1000
100
10
BL =200 umhos/cm
Number of Samples=32


1996-1997
Oil & Grease
SIC 1311
5 Samples above BL (14%)
O & G (mg/L)
1000
100
10
1
0.1
BL =15 mg/L
Number of Samples=37


1996-1997
pH Graph
SIC 28xx
37 Samples outside BL (12%)
pH
12
10
8
6
4
2
Number of Samples=300
BL >6;<9

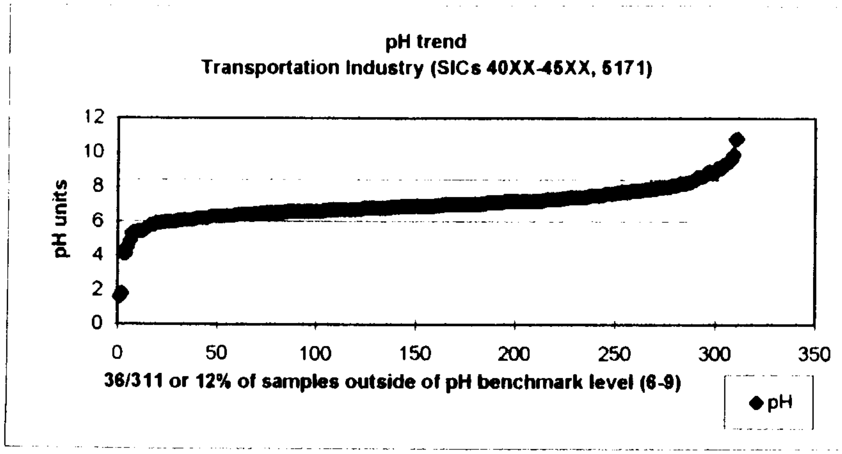

1996-1997
TSS Graph
SIC 28xx
56 Samples above BL (23%)
TSS (mg/L)
1000
100
10
1
0.1
0.01
Number of Samples=245
BL =100 mg/L

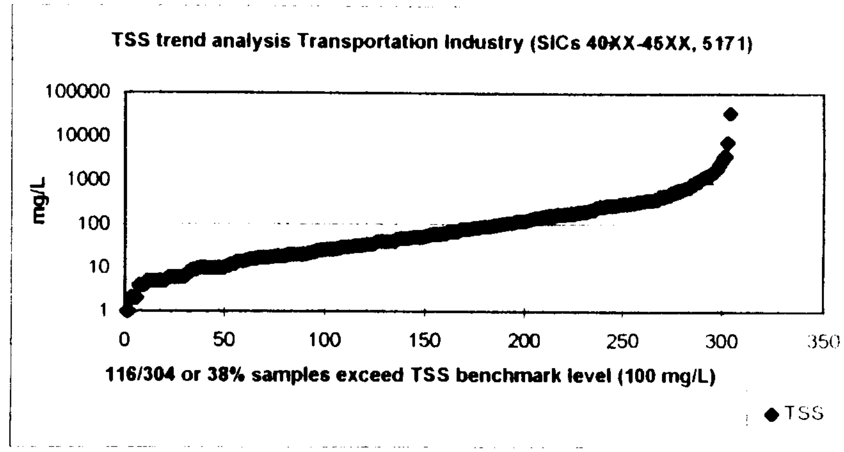

1996-1997
Specific Conductance Graph
SIC 28xx
89 Samples above BL (32%)
SC (umhos/cm)
10000
1000
100
10
1
0.1
Number of Samples=282
BL =200 umhos/cm

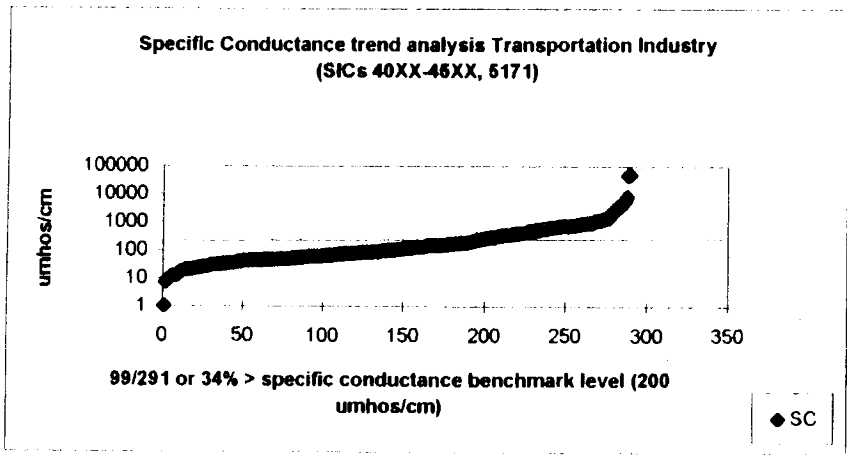

1996-1997
Oil & Grease Graph
SIC 28xx
19 Samples above BL (11%)
O&G (mg/L)
1000
100
10
1
0.1
Number of Samples=179
BL =15 mg/L

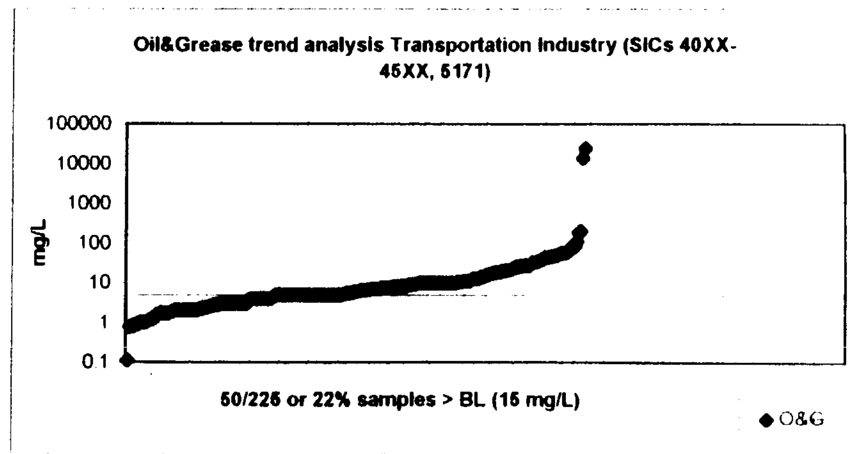
R0010383

SIC 40XX-45XX, 5171 - Transportation

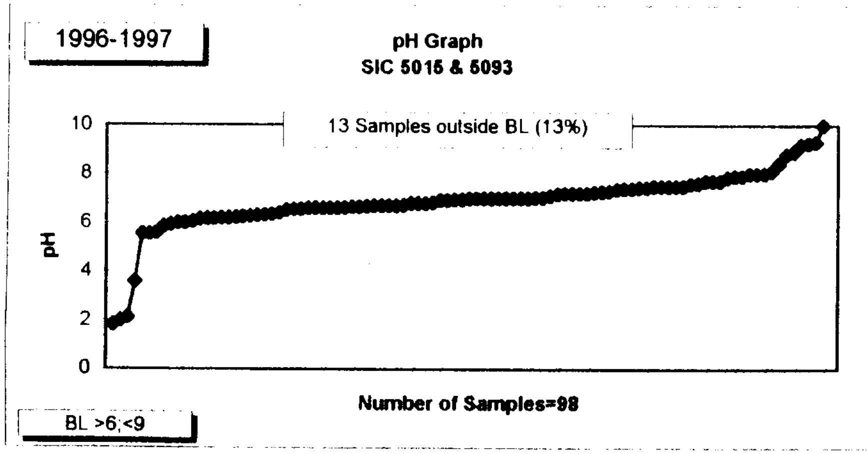


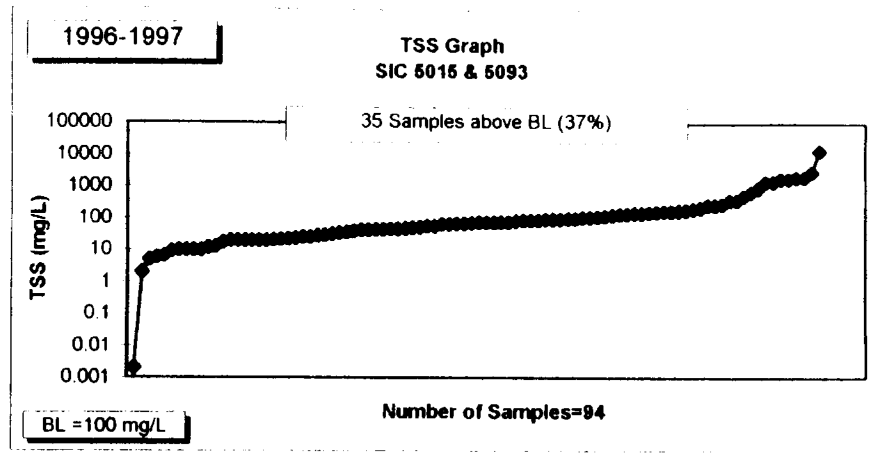


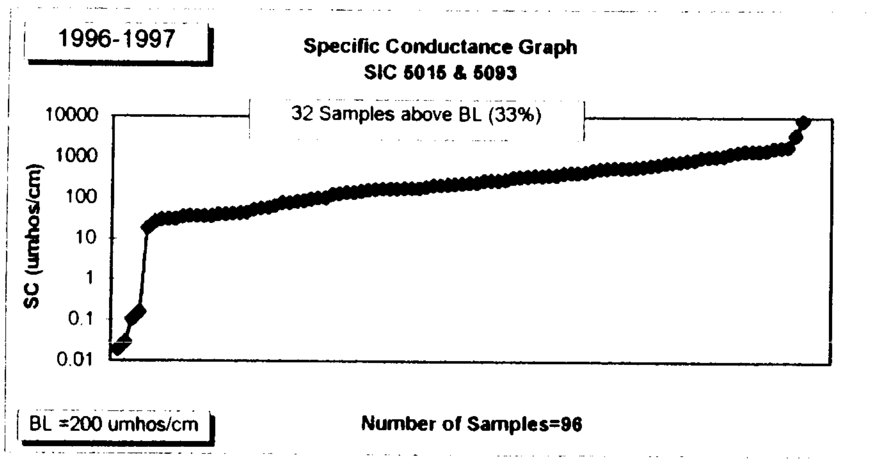


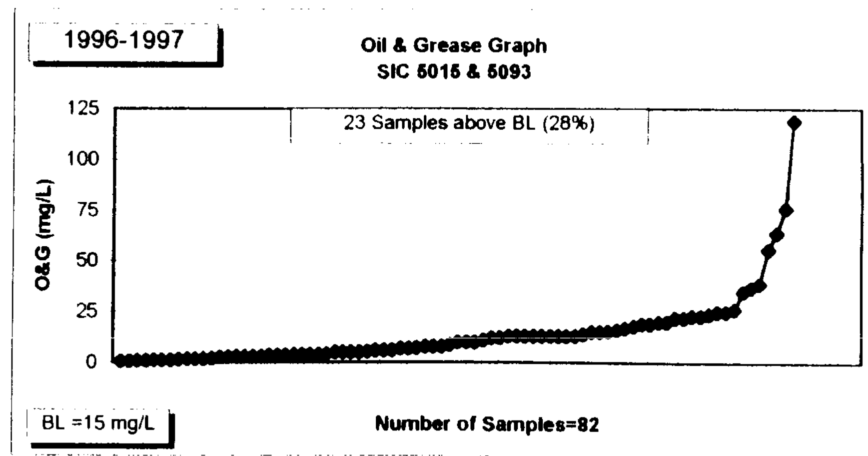


SIC 5015, 5093 - Automobile Salvage/Scrap Recycling





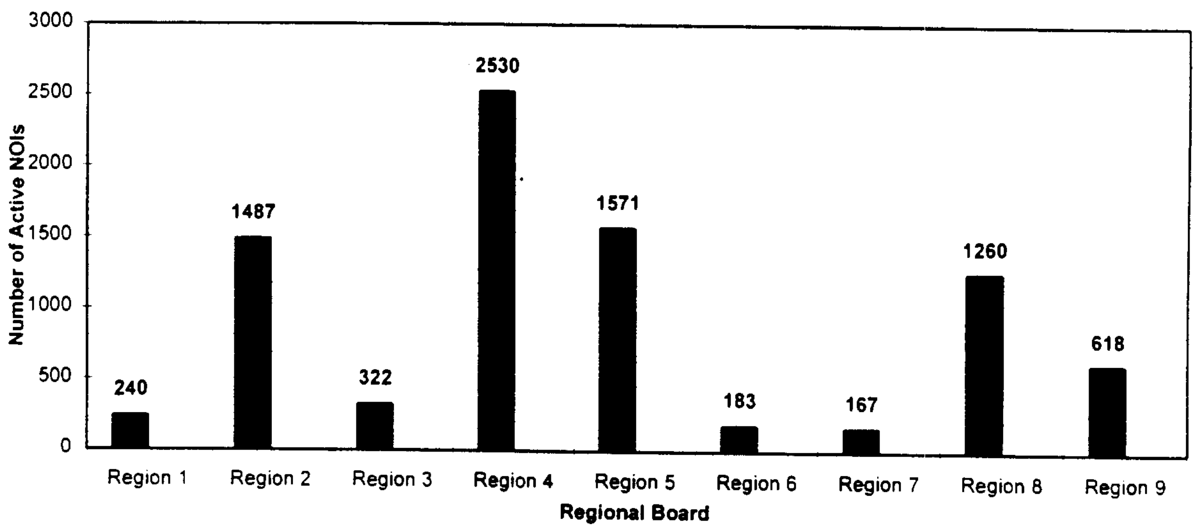




R0010385

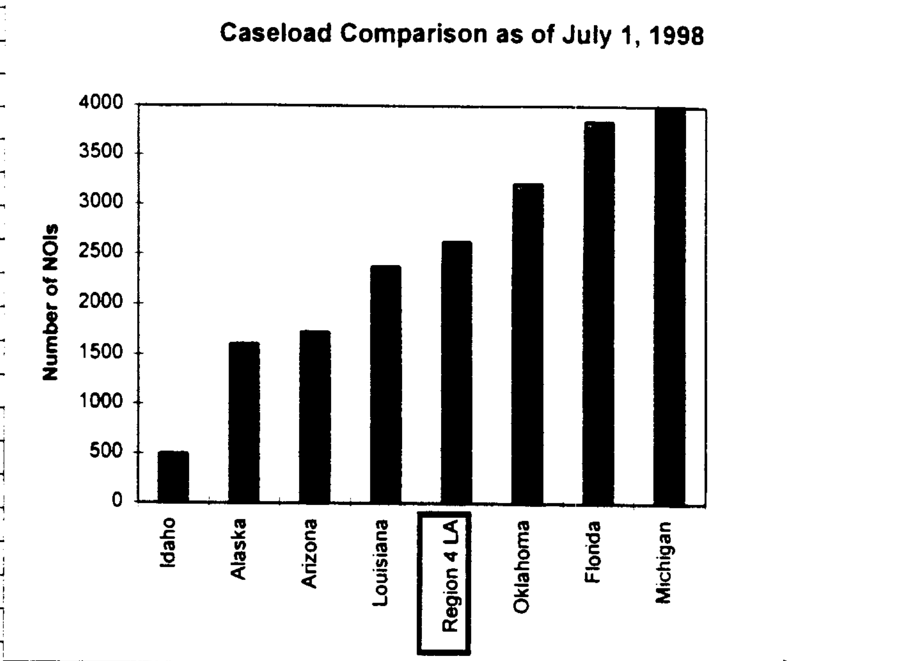
Status of Statewide Storm Water Industrial NOIs as of October 1997		
Region	*Number Of NOIs*	*% of total*
Region 1	240	3%
Region 2	1487	18%
Region 3	322	4%
Region 4	**2530**	**30%**
Region 5	1571	19%
Region 6	183	2%
Region 7	167	2%
Region 8	1260	15%
Region 9	618	7%
Total	**8378**	

Distribution of Active Industrial NOIs per Regional Board



Attachment 1

Entity	Number of NOIs
Idaho	500
Alaska	1600
Arizona	1720
Louisiana	2381
Region 4 LA	**2628**
Oklahoma	3214
Florida	3841
Michigan	4000



Attachment 2

STORM WATER ANNUAL REPORT 1996/1997

WDID#:	
REVIEW DATE:	
BY:	
COMMENTS/DEFICIENCIES:	
☐	AR late Date received
☐	Change of information
☐	A SWPPP was not prepared for the site
☐	Non-storm water discharges present, BMPs yes ☐ no ☐
☐	Unauthorized non-storm water discharges, eliminate yes ☐ no ☐
☐	Did not perform an annual inspection, explained yes ☐ no ☐
☐	Dry weather observations not performed, explained yes ☐ no ☐
☐	Wet weather observations not performed, explained yes ☐ no ☐
☐	GMP Participant/ Group name: sampled yes ☐ no ☐
☐	Self certification pending, approved yes ☐ no ☐
☐	No samples taken, explained yes ☐ no ☐
☐	Took samples from only one storm event, explained yes ☐ no ☐
☐	Did not sample for toxic chemicals and other pollutants likely to be present in storm water discharge, explained yes ☐ no ☐
☐	Certification was not signed
☐	The benchmark value for pH was exceeded
☐	The benchmark value for TSS was exceeded
☐	The benchmark value for Specific Conductance was exceeded
☐	The benchmark value for Oil & Grease was exceeded
☐	The benchmark value for TOC was exceeded
	Proposed action:

IF NEEDED CONTINUE ON BACK

R0010388

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Glossary of Terms

Best management practice (BMP): A practice or combination of practices that are determined to be the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point and non-point source pollutants at levels compatible with environmental quality goals.

Constructed wetland: An artificial wetland system designed to mitigate the impacts of urban runoff.

Forebay: An extra storage space provided near an inlet of a wet pond or constructed wetland to trap incoming sediments before they accumulate in the pond.

Gabion: A rectangular basket or mattress made of steel wire in a hexagonal mesh. Gabions are generally subdivided into equal-sized cells that are wired together and filled with stones, forming a large, heavy mass used for shore protection.

Impervious area: A hard surface area (e.g., parking lot) that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Nonpoint source pollution: Water pollution caused by rainfall or snowmelt moving over and through the ground which carries pollutants. A nonpoint source is any source of water pollution that does not meet the legal definition of point source in section 502(14) of the Clean Water Act.

Nonstructural control: A practice that does not require construction of a facility to control urban runoff.

Premium: An additional charge for real estate property with an amenity such as a water view or a view of wooded land.

Receiving waters: Lakes, rivers, wetlands, coastal waters, and groundwaters that receive runoff.

Riprap: A protective layer or facing of quarrystone placed to prevent erosion, scour, or sloughing of an embankment or cliff.

Sediment: The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice.

Structural control: A practice that involves design and construction of a facility to mitigate the adverse impact of urban runoff, and often requires maintenance.

Urban runoff: The portion of precipitation, snowmelt, or irrigation water that does not naturally percolate into the ground or evaporate, but runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters.

Wet pond: Pond for urban runoff management that is designed to detain urban runoff and always contains water.

FROM THEORY TO IMPLEMENTATION - FINDING ILLICIT CONNECTIONS

Barry Johnson, M.S., P.E., Camp Dresser & McKee
Dean Tuomari, Wayne County Department of Environment

The Rouge River National Wet Weather Demonstration Project (Rouge Project) began in 1992 by the Department of the Environment, Wayne County, Michigan. The Project is a United States Environmental Protection Agency (USEPA) grant funded comprehensive program to manage wet weather pollution to restore the water quality of the Rouge River, an urbanized tributary of the Detroit River in Southeast Michigan. The Rouge River has been designated as a significant source of pollution to the Great Lakes system.

The Rouge Project is designed to identify the most efficient and cost effective controls of wet weather pollution, while assuring maximum use of the resource. Combined sewer overflow (CSO) controls are being implemented in phases. Under Phase 1, six communities are separating their sewers and eight communities are constructing 10 retention treatment basins. A two-year evaluation study of the CSO control basins began on June 1, 1997. These results coupled with efforts to control storm water and other pollution sources in the watershed will provide the basis for the Phase 2 CSO control program on the remaining CSO sources in the watershed. The information gained from the evaluation of design storms and control technologies will be useful nationwide in determining cost effective CSO controls to meet water quality standards.

Innovative storm water control technologies are also being evaluated under the Rouge Project. A total of 60 pilot storm water management projects are being implemented throughout the watershed by 25 different communities and agencies. Categories of pilot storm water management projects currently underway include wetlands creation and restoration, structural practices such as grassed swales and detention ponds, illicit discharge elimination, erosion controls, stream bank stabilization and habitat restoration to name a few.

Innovative, readily transferable tools have been developed, employed by the Project, and are being shared with other cities and state agencies. These include a suite of computer models to simulate the water quality and quantity response of the Rouge River in response to wet weather events for existing and future conditions under various CSO and storm water runoff management alternatives; a comprehensive geographic information system (GIS); relational databases were designed and implemented to manage the wealth of data collected under the Project (DataView and Rouge Information Manager); and the use of a holistic watershed approach.

The Rouge Project in southeastern Michigan is a working demonstration of a watershed-wide approach to restoring and protecting an urban river system by using a cooperative locally based approach to pollution control. Innovative, readily transferable tools have been developed and employed by the Project. The environmental results of the Project are already very evident.

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ABSTRACT

The Rouge River Watershed located in southeastern Michigan encompasses approximately 438 square miles. A primary objective of the Rouge Project is to demonstrate how to address and correct urban wet weather pollution problems. However, water quality objectives in the Rouge River Watershed will not be achieved unless illicit discharges are eliminated. The Rouge Project illicit connection program has utilized several methods to identify sources of illicit discharges, but first, a method to prioritize areas for detailed evaluations had to be developed. A GIS database was established to assist in this area.

Several methods were explored to identify illicit connections, however, this paper discusses five of those methods used to provide information to prioritize areas of the watershed for detailed investigation. Those include: *dye testing of plumbing* and *on-site sewage disposal systems*; *visual observations of manholes*, *outfalls* and *on-site sewage disposal systems*; *aerial photography*; *televising of storm sewers*; and *testing for ammonia, surfactants, E. coli* and *isotopes of hydrogen* and *oxygen*. Data collected suggested that there are 5,260 illicit discharges and at least 3,600 failing on-site sewage systems in the watershed. This data has been helpful in convincing municipalities to include an illicit discharge investigation and an on-site sewage maintenance program in their application for a storm water discharge permit.

KEYWORDS

Illicit discharges, on-site sewage, dye test, illicit connections

INTRODUCTION

Sampling and modeling of CSOs to the Rouge River in southeast Michigan indicates that when the CSOs are treated or eliminated, the river will not meet water quality standards. Investigations by municipalities have identified illicit connection problems. These sources of non-storm water pollutants into storm drainage systems are required to be investigated and eliminated as part of the voluntary National Pollutant Discharge Elimination System (NPDES) storm water permits for communities and as part of NPDES permits for storm water associated with industrial activities.

Considerable effort has been made since 1994 in the Rouge Watershed to locate and eliminate illicit connections. Published material suggested many possible ways to trace the sources of illicit connections. As part of the Rouge Project, methods to locate illicit connections have been evaluated. This paper presents the approaches used to locate areas with illicit discharges, and methods to locate illicit connections and results.

DISCUSSION

The Rouge River Watershed has a population of over 1.5 million people and has 43,520 businesses. Because of the size of the area, it was necessary to develop criteria to prioritize areas for investigation. One screening was done to eliminate businesses that were on combined sewer systems. This reduced the number of businesses to 22,467. Once developed, the criteria used was to identify areas of known water quality problems, to review complaints related to water quality, and to review water quality data and land use. Land use was of particular interest because the data were used to identify areas in communities that were used for business operations. Businesses were a priority based on findings in Washtenaw County (Schmidt, 1986). These findings indicated that 38 percent of the businesses tested were improperly connected to the storm sewer system. The highest percentage of illicit storm drain connections were detected at automobile-related facilities.

Water sample results were given more weight in residential areas in selecting areas for investigation because it is more convincing to the public and municipal employees that there is a problem. *E. coli* bacteria was found to be the most significant water quality problem in the residential areas. This could have resulted from on-site sewage disposal systems (OSDS), sanitary sewers, pet waste, wildlife, and illegal dumping. Census data from 1990 reported that there were over 18,000 OSDS in the Rouge Watershed. It was suspected that failing OSDS could be contributing to the bacterial problem in the watershed. This encouraged the development of a program to investigate non-residential operations, and OSDS in areas with high *E. coli* results and storm sewers. The data collected has been used to project illicit connections and their impact on water quality in each subwatershed in the Rouge River Watershed.

METHODOLOGY

First, dye testing was used to locate illicit connections in businesses. A method to prioritize the investigation was developed based on the Standard Industrial Classification (SIC) of businesses. Businesses were surveyed in the target areas and dye was placed into the plumbing fixtures to observe discharge locations. Storm and sanitary sewers in the business target areas were observed after dye was placed in the fixture.

Dye testing was also used to evaluate OSDS. Dye was placed in the septic tank and the surface water downstream from the property was checked for visual observation of the dye. If no dye was seen, a charcoal packet was placed in the stream to collect dye that was not visible. The charcoal packets were collected and taken to the laboratory for analysis.

In residential areas, a second and third method was used to help isolate sources of bacteria; water testing and visual observations. Visual observations were conducted on manholes, outfalls, and on-site disposal systems. Manholes and outfalls in areas that had reported high *E. coli* bacteria were also tested for ammonia, surfactants and *E. coli*. The manhole or outfall was photographed and the following were recorded: water color, staining on the structure, debris and odor.

A fourth method, consisted of television cameras in storm sewers which were used to show staining on the pipe, debris in the sewer, and the sewer lead location of a suspicious discharge. The fifth method was the use of aerial photography. It was believed that infrared photography could identify warm water discharges in the winter. These warm discharges would then be investigated for the source of the water. An analysis of the same area in the warm months might also allow concentrations of chlorophyl to be identified. The source of the nutrients that stimulated the chlorophyl might identify an illicit discharge.

RESULTS

Dye Testing

From 1987 through December of 1997, Wayne County dye tested approximately 3,340 businesses and industries for illicit connections to the storm sewer system. Approximately 8 percent of the 3,340 facilities inspected were found to have illicit connections and the elimination of these improper discharges has diverted raw sewage and other pollutants from the river to the wastewater treatment plant. If one illicit connection was found at a business, it usually resulted in finding others. An average of 2.5 improper connections were found at businesses that had an illicit connection.

The majority of illicit connections found in non-residential facilities were drains connected to storm sewers. Drains include floor drains, trench drains, interior catch basins, oil separators, machine process water and sump pumps. The categories of illicit connections found were: floor drains (46 percent), sinks (20 percent), horse washing-washing machines (15 percent), toilets (11 percent), and a variety of others (8 percent). **Figure 1** is a chart of these findings.

Another study, funded in the Oakland County portion of the Rouge Watershed included stream sampling for fecal coliform, *E. coli* bacteria, and benthic macroinvertebrates, along with dye testing of septic tanks.

a. Of the 49 surface water sampling sites, 43 percent had a daily geometric mean for *E. coli* bacteria of 1000 or more per 100 mL. of sample.
b. The macroinvertebrate study was done to indicate water quality of the streams in the survey area. A scale has been developed to rate macroinvertebrate and water quality. The results in the study area ranged from 7 which indicates poor water quality, to 20 which is considered good water quality.
c. Dye testing in 1994 found 52.3 percent of the homes tested had discharges to the river.
d. An optical brightener test was done at the river sites where dye was collected. These were all negative. The brightener test has been used to detect laundry waste in coastal areas.
f. Dye testing in 1995 found a 39.3 percent failure rate for OSDS in the communities surveyed.

Water Testing and Visual Observations

Hundreds of manholes and outfalls were tested for ammonia and photographic documentation and field data sheets were recorded at each manhole and outfall. Over 150 manhole locations and outfalls were identified to have over 1 ppm ammonia or visual evidence of suspicious discharges. Follow up sampling was done to relate *E. coli* levels with ammonia and surfactants at each manhole and outfall. Over 200 manholes and outfalls have been checked for ammonia, anionic surfactants and *E. coli*. Nineteen of the these had *E. coli* counts over 5000 per 100 mL.

A grant was funded by the Rouge Program Office to Wayne County to survey OSDS serving homes in one of the tributaries that drain to an area that was planned to be used for canoeing. Canoeing has been discouraged in most of the Rouge River due to the high *E. coli* bacteria counts. Through December 31, 1997, 427 homes have been visited and a visual survey of the property has been done to identify signs of OSDS problems. Ninety-three of the systems have been described as failing or potentially failing for a failure rate of 21 percent. Typical descriptions from the field notes are:

- Sewage backup in the home
- Gray water discharging to the ground surface
- Standing water on top of gravel seepage field
- Mushy area, associated with back end of apparent seepage field
- Illicit connection and undersized septic tank (100 gallons) drained by a trench type (long single perforated pipe) seepage field.
- Black sludge residue and toilet paper debris around surface of the septic tank covering
- Growth of cattails, wet marsh on the face of the downward sloping hill.

Visual observations from field crews and the public have identified significant improper discharges to the river. Two examples that field crews found and reported were:

- a team doing a habitat study found a combined sewer discharging during dry weather. The sewer maintenance personnel investigated this, corrected the problem and reported that the discharge gate had stuck in the open position.
- a team sampling outfalls noticed signs of sewage in the outfall. Tracing the flow upstream they found that a sewer contractor was by-passing the sanitary waste to the storm sewer so he could work on the sanitary.

Stable isotopes of oxygen and hydrogen have been used to determine the existence of illicit connections in a discharge. The study funded under this project found that the isotope signatures of groundwater, sanitary sewer water and tap water were significantly different. This signature allowed the discharges to be identified as having come from groundwater, precipitation or sanitary sewage. For further details of methods and findings refer to the paper "Identification of Illicit Connections in Storm Sewers: An Innovative Approach Using Stable Isotopes," by Suresh Sangal et. al.

Aerial, Infrared and Thermal Photography

The use of aerial, infrared and thermal photography to find illicit discharges is in the experimental phase. An examination of the aerial photo of a site with a known illicit discharge revealed thermal conditions that were too similar to other warm conditions to make it distinguishable.

Televising of Sewers

Several television tapes of storm sewers were reviewed. The tapes did not show the characteristic staining or debris that is seen when an illicit discharge has been occurring for some time. The storm sewer televised was newly constructed a year ago. The failure to observe sewage debris or detect an odor during the field work also helped support that there was no illicit discharge occurring when the sewer was being televised.

Results of One Detailed Investigation

A storm sewer relief drain was investigated to locate a pollution source. This 11 foot diameter storm sewer had been under suspicion for several years. In 1997, samples from manholes were taken upstream from the discharge point of the sewer. These samples were taken from the main pipe of the sewer and in laterals that connected to the sewer. One of the laterals that connects to the sewer had *E. coli* results of 8160 per 100 mL of sample. A confirmation sample a few days later showed 9600 *E. coli*. When the results were found at that level, additional samples were taken 5 days after the confirmed sample (9600) had been taken. The sample results going upstream in the storm sewer where the 8160 and the 9600 *E.coli* were found were: 12,560, 24,000, 160,000 and 9600 per 100 mL. These results indicate an increase and then a decrease as you move upstream. The manhole where the 160,000 result was the "hot spot." **Figure 2** shows a representation of the sewer and the test results.

The results were shared with the city which had the sewer televised. The television tapes did not show any suspicious connections. Plans were made to begin dye testing the homes next to the storm sewer. Before beginning the process of dye testing, a sample was taken to show current information. The results of that sample indicated less than 8 *E. coli* per 100 mL. in the sample. After discussion with the city, it was agreed to postpone the dye testing and instead inform the residents of the results of the sampling on their street. At this point it was felt that the high *E. coli* may have been due to dumping of waste into the sewer. A letter was prepared to ask residents to inform the city or county personnel of anything they may have knowledge about which would have resulted in the high *E. coli* counts. As a result of this investigation, dry weather sampling continues on a monthly basis at this location.

Other findings have included:

- The prioritization method for businesses was successful in locating illicit connections; it was not helpful in locating illicit discharges of *E.coli*.
- There was no definite correlation to date between field tests for ammonia, anionic surfactants (a test to detect detergents) and *E.coli*.
- Projections have been made of illicit connections for the Rouge Watershed based on these findings. The estimated number of potential illicit connections in the entire watershed is 5260. It is estimated that 51 million gallons of liquid would be discharged from these illicit connections. (Boerma, 1997)
- Eighteen percent (77) of the residences contacted indicated that they did not have an OSDS. They indicated that they were connected to the sewer. In most cases, the municipality had no record of the sewer connection and were not charging them.

CONCLUSION

Future areas to be checked will be developed based on complaints, a review of manhole and outfall sampling to determine contributing conveyances, and instream/in-sewer sampling to localize the sources. Results of the manhole sampling have found several that have *E. coli* results over 10,000 per 100 mL. Utilizing the Rouge Project GIS, maps have been prepared for tracking sampling of manholes and outfalls, and other data to illustrate results, and to help prioritize further investigations. These will be helpful in showing municipalities the areas that need to be investigated.

The future direction of illicit connection/discharges is to have each community in the Rouge Watershed commit to actively exploring illicit connections/discharges within their community. Grants and assistance from county agencies are available for communities. As part of an application for a general storm water permit from the State of Michigan under the NPDES program, a community is required to develop an Illicit Discharge Elimination Plan. The Rouge Project is assisting communities in the preparation of these applications. Elements of the Illicit Discharge Elimination Plan that are recommended to be included are: a legal basis for the program, how problem areas will be identified, how the sources will be pinpointed, and how to achieve correction and evaluation and reporting. **Figure 3** was developed to describe these elements to communities and suggest options for them to consider. Education is very important when developing an illicit discharge elimination plan. Reference is made to education development in the boxes below each element.

On-site sewage disposal systems contribute to surface water pollution. With over 18,000 of these in the watershed and average failure rates between 17 and 39 percent, there are a substantial number impacting surface water. Using a 20 percent failure rate, there would be 3600 OSDS failing in the watershed. Two hundred gallons (200) per day per OSDS would result in 720,000 gallons per day of sewage being discharged to the ground surface or directly to surface water each day. The discharge of this waste can be prevented if there is regular inspection and maintenance of OSDS.

The liquid waste discharged from illicit discharges is estimated to be 51 million gallons per year. This is a significant amount. This waste includes human waste, oil, grease, detergents, chemical and solids.

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Figure 1
Types of Violations - Rouge River
October 1987 - March 1998

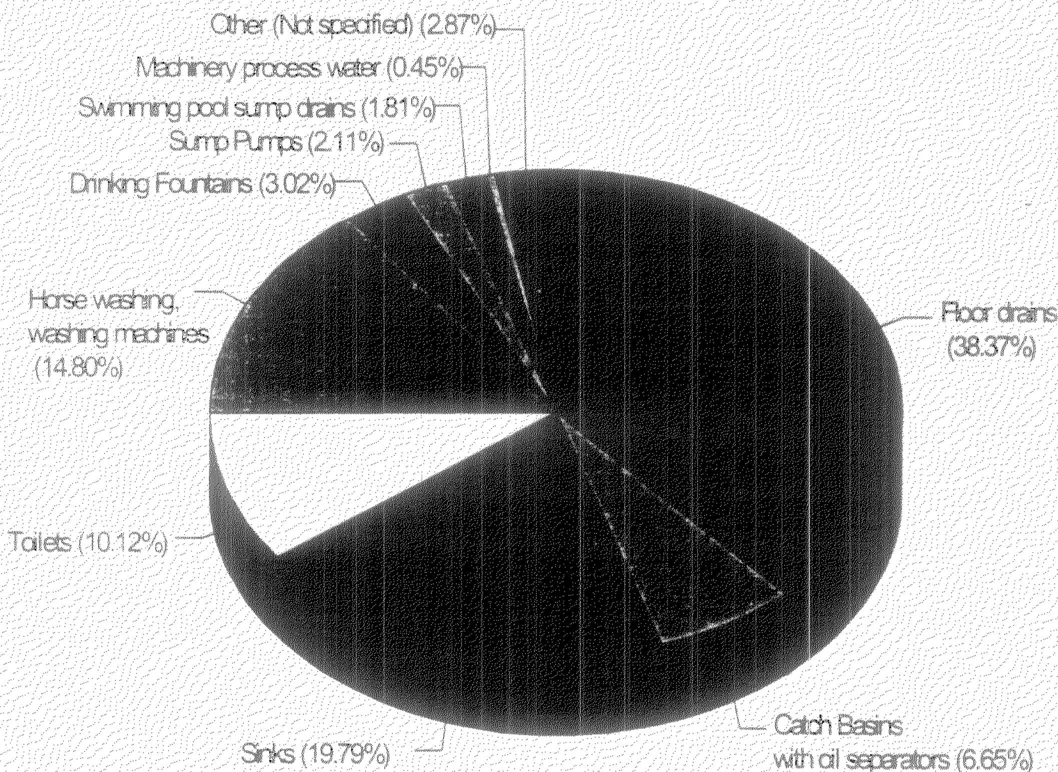

Figure 2
E. coli Results June 11-18, 1997
Farmington Relief Sewer

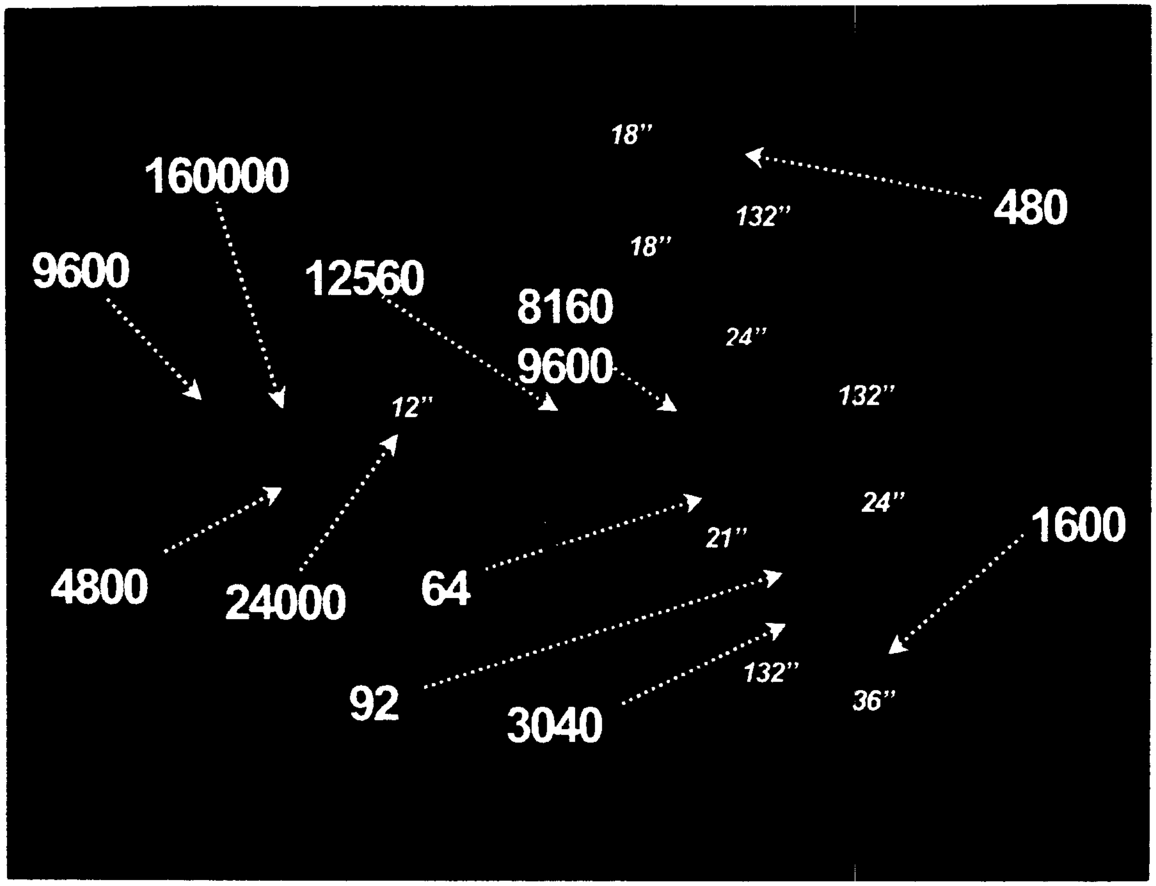

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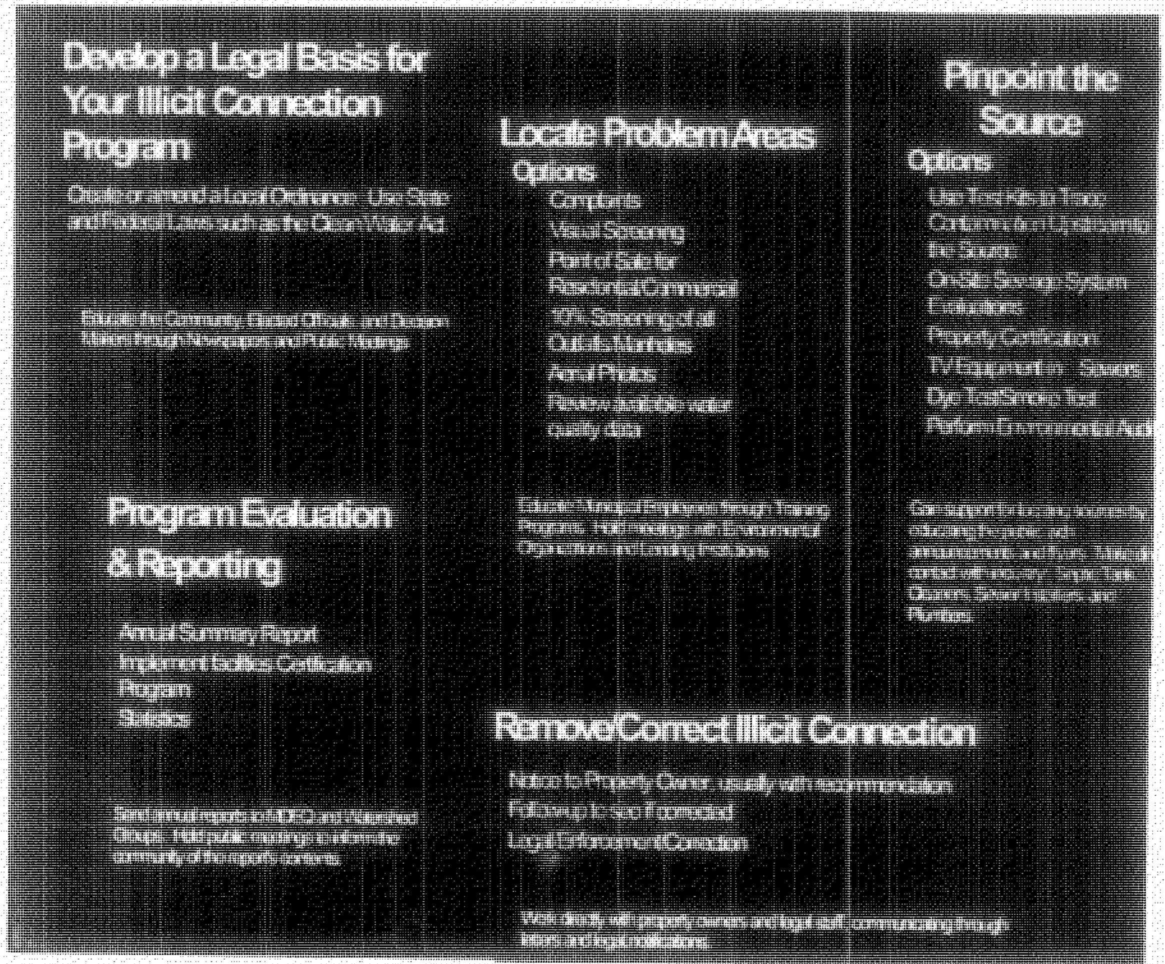
Figure 3
Eliminating Illicit Discharges



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Clean Water & Oceans: Water Pollution: In Depth: Report
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Chapter 2

THE CAUSES OF URBAN STORMWATER POLLUTION

Runoff pollution occurs every time rain or snowmelt flows across the ground and picks up contaminants. It occurs on farms or other agricultural sites, where the water carries away fertilizers, pesticides, and sediment from cropland or pastureland. It occurs during forestry operations (particularly along timber roads), where the water carries away sediment, and the nutrients and other materials associated with that sediment, from land which no longer has enough living vegetation to hold soil in place.

This report, however, focuses on runoff pollution from developed areas, which occurs when stormwater carries away a wide variety of contaminants as it runs across rooftops, roads, parking lots, baseball diamonds, construction sites, golf courses, lawns, and other surfaces in our cities and suburbs. The oily sheen on rainwater in roadside gutters is but one common example of urban runoff pollution.

This chapter discusses some of the causes of stormwater runoff and pollution, which are important to understand before adopting management strategies.

The United States Environmental Protection Agency (EPA) now considers pollution from all diffuse sources, including urban stormwater pollution, to be the most important source of contamination in our nation's waters. [1] While polluted runoff from agricultural sources may be an even more important source of water pollution than urban runoff, urban runoff is still a critical source of contamination, particularly for waters near cities -- and thus near most people. EPA ranks urban runoff and storm-sewer discharges as the second most prevalent source of water quality impairment in our nation's estuaries, and the fourth most prevalent source of impairment of our lakes. [2] Most of the U.S. population lives in urban and coastal areas where the water resources are highly vulnerable to and are often severely degraded by urban runoff.

Urban stormwater continues to impair the nation's waterways, 27 years after passage in 1972 of the law now known as the Clean Water Act. The main reason why urban stormwater remains such an important contributor to water pollution is the fact that in most areas, stormwater receives no treatment before entering waterbodies. The storm-sewer system merely collects the urban runoff and discharges it directly to the nearest river, lake, or bay.

Over the past 27 years, water pollution control efforts have focused primarily on certain process water discharges from facilities such as factories and sewage treatment plants,

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with less emphasis on diffuse sources. While these efforts have led to many water quality improvements, new efforts are now needed to address the remaining sources of water pollution, including urban runoff pollution.

Comprehensive stormwater regulation has been slow to develop (see box: "History of Stormwater Regulation in the United States"). Since 1992, cities with a population over 100,000, certain industries, and construction sites over 5 acres have had to develop and implement stormwater plans under Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater regulations. To date, states and the EPA have issued more than 260 permits affecting some 850 operators, including larger cities operating separate storm sewer systems, which requires them to develop stormwater management plans. A number of stormwater discharges from industrial activities are also subject to NPDES stormwater permit requirements.

In October 1999, EPA is expected to promulgate a rule requiring smaller municipalities, those with populations of fewer than 100,000 people located in urbanized areas (where population density is greater than 1,000 persons per square mile) to develop stormwater plans. Municipalities not in urbanized areas that have more than 10,000 residents and a population density greater than 1,000 persons per square mile will also have to develop stormwater plans if the state so designates. Under this so-called "Phase II" rule, the EPA and states will develop "tool boxes" from which the smaller local governments can choose particular stormwater strategies, including the strategies presented in this report, to develop their stormwater plans.

Stormwater must be distinguished from other urban sources of pollution largely caused by wet weather since each separate source is regulated differently. In addition to stormwater runoff, which is the focus of this study, there are two other significant sources of urban wet weather pollution: sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). SSOs occur when sanitary sewers, often because of leaks and cracks, become surcharged in wet weather and overflow, often through manholes or into basements. CSOs occur when flows into combined sewer system (systems that receive stormwater, sanitary sewer discharges from residences and businesses, and wastewater discharges from industrial facilities and transport it all through a single pipe) exceed the treatment and storage capacity of the sewer system and waste treatment facility. At that point, this combined waste stream overflows into creeks, rivers, lakes or estuaries through designated outfalls usually without treatment. CSOs and SSOs are more of a problem with older systems while stormwater is an issue for all metropolitan areas, especially growing areas. Moreover, while prevention programs can be very important to efforts to reduce CSOs and SSOs, structural changes are usually necessary. By contrast, much stormwater pollution can be *prevented* with proper planning in growing or redevelopment areas.

Remarkably, studies have shown that stormwater alone can be almost as contaminated as these sewage/stormwater mixtures.[3] Yet stormwater runoff remains to be regulated in most of the nation's populated areas. While many CSO and SSO control measures may overlap with stormwater pollution control measures, strategies that deal with stormwater specifically must be implemented if the quality of America's waterbodies is to improve. These strategies are the focus of this report.

HISTORY OF STORMWATER REGULATION IN THE UNITED STATES
The history of stormwater regulation began over 25 years ago. It has been in and out of the courts, Congress, EPA and is now in the hands of states and local governments.

1972: EPA issues exemptions from the federal Clean Water Act NPDES permit program for most sources of stormwater. NRDC sues EPA to require permits for all point sources, including urban storm sewers (applications by 1973 and permits by 1974).

1975–1977: The U.S. District Court finds that EPA exemptions are contrary to the

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Clean Water Act (NRDC v. Train).[a] This decision is upheld by U.S. Court of Appeals in 1977 (NRDC v. Costle).[b]

1980: EPA issues rules responding to the court's decision that exempt cities outside "urbanized areas from needing NPDES permits for their storm sewers." NRDC and industry sue EPA over the rules (NRDC v. EPA).[c]

1980–1990: During this period, EPA struggled with developing stormwater rules, and extends the stormwater permit deadlines for large cities until 1987 and 1989. EPA also issues "nonenforcement letters" informing cities that EPA would not take enforcement actions against cities with permit applications and proposes narrowing the definition of stormwater discharges. In 1983, EPA issues a final report on the Nationwide Urban Runoff Program. In 1984, NRDC and the states negotiated with EPA to reject narrowing coverage and revoke letters.

1987: In Clean Water Act amendments, Congress requires EPA to issue by 1989 "Phase I" rules addressing stormwater from cities with a population over 100,000 and from industrial sites, and to issue by 1992 "Phase II" rules for other significant sources of stormwater pollution.

1990: EPA promulgates "Phase I" NPDES stormwater regulations and extends compliance beyond those dates in the 1987 law. NRDC sues EPA for illegally extending deadlines and excluding certain sources from regulations (NRDC v. EPA).[d]

1992: A U.S. Court of Appeals ruling prohibits further stormwater dead-line extensions (NRDC v. EPA)[e] and invalidates certain provisions of the Phase I rule. EPA and the states issued initial general permits for storm-water discharges.

1992: Congress provides an additional extension to small cities for storm-water permit applications.

1995: EPA is sued for its failure to conduct study, file report, and issue regulations concerning Phase II stormwater pollutant sources (NRDC v. Browner).[f] EPA issues Report to Congress on "Storm Water Discharges Poten-tially Addressed by Phase II of the NPDES Storm Water Program." NRDC and EPA enter into consent decree requiring EPA to issue a final rule by March 1999 (later extended to October 1999) addressing both Phase II stormwater and Phase I issues remanded by the court. In 1996, EPA convenes a federal advisory committee.

1997: EPA issues draft Phase II stormwater rules.

a 396 F.Supp. 1393 (D.D.C. 1975), aff'd by NRDC v. Costle, 568 F.2d 1369 (D.C. Cir. 1972).

b 568 F.2d 1369 (D.C. Cir. 1972).

c 673 F.2d 392 (D.C. Cir. 1980) (per curiam).

d 915 F.2d 1314 (9th Cir. 1990).

e 966 F.2d 1292 (9th Cir. 1992).

f No. 95-634 PLF (D.D.C.) (consent order signed April 6, 1995).

The Water Cycle

To fully understand the stormwater pollution problem, it is helpful to step back and review the water cycle, also known as the hydrologic cycle. The water cycle is simply the constant movement of water from the sky to the ground and back again. The main components of the water cycle are precipitation, infiltration, evapotranspiration (evaporation and transpiration, the process by which plants release water they have absorbed into the atmosphere), surface and channel storage, and groundwater storage. As part of that cycle, when rainwater falls to the ground, or when snow or hail on the ground melt, that water may take several paths, as illustrated in Figure 2-1 (print report only).

While the magnitude of these effects varies across the country depending on the precipitation patterns, soil types and other factors, the underlying principles remain the same. [4] In a typical Midwestern undeveloped area, for example, with natural ground cover such as forests or meadows, a large fraction -- perhaps 50 percent -- of the water infiltrates the soil. Much of this water may remain near the surface from which it often resurfaces into lakes or streams. Other infiltrated water descends to a deeper level, perhaps recharging an underground aquifer used for drinking water. A significant share -- 40 percent in this example -- of the water returns to the atmosphere through evapotranspiration. Only a small amount of the water -- the remaining 10 percent, in this example -- typically remains on the surface of undeveloped land to run off into streams and other waterbodies.

Urbanization can dramatically alter this water cycle, increasing runoff and reducing, at times to almost zero, infiltration. This can completely alter the physical and chemical character of the receiving waterbody.

The Causes of Stormwater Pollution

The stormwater pollution problem has two main components: the increased volume and velocity of surface runoff and the concentration of pollutants in the runoff. Both components are directly related to development in urban and urbanizing areas. Together, these components cause changes in hydrology and water quality that result in a variety of problems including habitat loss, increased flooding, decreased aquatic biological diversity, and increased sedimentation and erosion, as well as affects on our health, economy, and social well-being. These consequences will be discussed in Chapter 3; the following is a discussion of the sources of these problems.

Table 2-1
Impacts from Increases in Impervious Surfaces

	Resulting Impacts				
Increased Imperviousness Leads to:	**Flooding**	**Habitat Loss (e.g., inadequate substrate, loss of riparian areas, etc.)**	**Erosion**	**Channel Widening**	**Streambed Alteration**
Increased Volume	•	•	•	•	•
Increased Peak Flow	•	•	•	•	•
Increased Peak Flow Duration	•	•	•	•	•
Increased Stream Temperature		•			
Decreased Base Flow		•			
Changes in Sediment Loadings	•	•	•	•	•

Source: *Urbanization of Streams: Studies of Hydrologic Impacts*, EPA 841-R-97-009, 1997

INCREASED VOLUME AND VELOCITY: THE IMPERVIOUS COVER FACTOR

Types of Impervious Cover

Some impervious cover, such as exposed rock or hardpan soil, is natural. Land development, however, greatly increases it. Human-made impervious cover comes in three varieties: rooftop imperviousness from buildings and other structures; transport imperviousness from roadways, parking lots, and other transportation-related facilities; and impaired pervious surfaces, also known as urban soils, which are natural surfaces that become compacted or otherwise altered and less pervious through human action. Examples of the hard soils include the base paths on a baseball diamond or a typical suburban lawn.

Transport imperviousness generally exceeds rooftop imperviousness in urban areas of the United States.[5] "Cumulative figures show that, worldwide, at least one third of all developed urban land is devoted to roads, parking lots, and other motor vehicle infrastructure. In the urban United States, the automobile consumes close to half the land area of cities; in Los Angeles the figure approaches two thirds."[6] The city of Olympia, Washington, also found that transport imperviousness constituted approximately

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two-thirds of total imperviousness in several residential and commercial areas.[7] This distinction is important because rainfall on transportation surfaces drains directly to a stream or stormwater collection system that discharges to a waterbody usually without treatment, whereas some roofs drain into seepage pits or other infiltration devices. Research has also found a strong relationship between curb density and overall imperviousness in residential areas suggesting that roads lead to the creation of other impervious surfaces.[8]

The creation of additional impervious cover also reduces vegetation, which magnifies the effect of the reduced infiltration. Trees, shrubs, meadows, and wetlands, like most soil, intercept and store significant amounts of precipitation. Vegetation is also important in reducing the erosional forces of rain and runoff. In one study, conversion of forest to impervious cover resulted in an estimated 29 percent increase in runoff during a peak storm event.[9]

Imperviousness Thresholds

Research has shown that when impervious cover reaches between 10 and 20 percent of the area of a watershed, ecological stress becomes clearly apparent.[10] After this point, stream stability is reduced, habitat is lost, water quality becomes degraded, and biological diversity decreases. Figure 2-3 (print report only) shows that as the amount of impervious surface in a watershed increases infiltration and evapotranspiration both drop substantially. As a result, more water, having nowhere else to go, runs off the surface picking up pollutants from activities occurring on the impervious surfaces.

To put these numbers into perspective, typical total imperviousness in medium-density, single-family home residential areas ranges from 25 percent to nearly 60 percent.[11] Total imperviousness at strip malls or other commercial sites can approach 100 percent.

Increased Volume of Runoff

The effect of impervious surfaces on the volume of stormwater runoff can be dramatic. For example, a 1-inch rainstorm on a 1-acre natural meadow would typically produce 218 cubic feet of runoff, enough to fill a standard size office to a depth of about 2 feet. The same storm over a 1-acre paved parking lot would produce 3,450 cubic feet of runoff, nearly 16 times more than the natural meadow, and enough to fill three standard size offices completely.[12]

On a larger scale, the effect is even greater. In a 620-square-mile portion of the watershed of the Des Plaines River in Illinois, in 1886, when agricultural or urban development covered 10 percent of the land area, the river's median annual discharge was 4 cubic feet per second. Today, when development covers approximately 70 to 80 percent of that same area, the median annual discharge has been 700 to 800 cubic feet per second, 175 to 200 times the earlier discharge level.[13]

Greater Stream and Runoff Velocity During Storm Events

Impervious surfaces increase the speed of runoff as it drains off the land. Unlike grassy meadows or forests, hard, impervious cover, such as parking lots and rooftops, offers little resistance to water flowing downhill, allowing it to travel faster across these surfaces.[14] In addition, the faster rate of runoff delivers more water in a shorter time to receiving waters than would occur under natural conditions. The increased velocity and delivery rate greatly magnifies the erosive power of water as it flows across the land surface and once it enters a stream.

Increased Peak Discharges

Increased imperviousness not only changes the volume of stormwater flows, but also the distribution of flows over time. When land is undeveloped, the initial stormwater flow following a rain event is relatively small, since the land absorbs and infiltrates much of the water. However, impervious cover forces rainwater or snowmelt to run off the land immediately, causing a sharp peak in runoff immediately following the rain event, as illustrated in Figure 1-5 (print report only). Impervious cover can double, triple, quadruple or even quintuple peak discharge.[15] Streams receiving these increased urban peak flows are described as "flashy," meaning that they are prone to sporadic and unstable discharges including flash floods or sudden high pulses of storm flows. An increase in peak flow can have significant impacts on the human and natural environment. Greater peak flows lead to increased flooding, channel erosion and widening, sediment deposition, bank cutting, and general habitat loss as discussed in Chapter 3.

Reduced Stream Base Flow

Because impervious cover reduces infiltration and forces stormwater to run off the land immediately, it also typically reduces the amount of groundwater available to recharge streams when there is no rain.[16] Hydrologists often refer to groundwater zones under urban areas as "starved" since they are not replenished. This groundwater-charged stream flow, known as base flow, can fall to 10 percent of the regional average when the level of imperviousness in the stream watershed reaches 65 percent.[17] Prolonged low flow can have a significant impact on aquatic life and, in some cases, a greater impact than extreme peak flows.[18] Reduced infiltration can also lead to shortages of drinking water supplies.

Decreased Natural Stormwater Purification Functions

Government flood control agencies often replace the beds of creeks, streams, and other drainage ways with concrete open channels, or completely replace those drainage ways with subsurface concrete storm drain lines. These changes degrade or eliminate habitat and dramatically alter hydrology. Channelizing, diking, and levying disconnects a river from its floodplain and reduces its ability to modify floods naturally. Similarly, this and other development fills, converts, or otherwise eliminates swamps, marshes and other wetlands. Eliminating these natural drainage ways reduces flow storage and detention and soil moisture maintenance and can increase overall flooding and erosion. In addition, natural streambeds and floodplains provide a hydrologic link between groundwater and surface water and can naturally clean waters. By capturing and slowing stormwater, these areas trap sediment, trace metals, and soluble forms of nutrients.[19] Studies have shown that wetlands can retain up to 100 percent of the metals present in water.[20] Wetlands reduce nitrogen discharges, both through the process of bacterial denitrification and through plant uptake, but less effectively reduce phosphorous when soils are saturated.

Similarly, other natural areas can reduce pollutant loads. One riparian forest in the Chesapeake Bay region removed 89 percent of the nitrogen and 80 percent of the phosphorus from runoff.[21] Forests also typically absorb 70 to 80 percent of atmospherically deposited nitrogen.[22] Trees and other plants stabilize the soil, giving it structure that prevents erosion, and reduce runoff by intercepting and storing precipitation. When rapid stormwater flows have already created erosion on bare soils, plants on downhill slopes slow those flows and allow sediment, as well as other pollutants, to settle onto the land rather than in a waterbody.

However, use of wetlands, streams, and other natural systems is not desirable unless stormwater is delivered at a rate at which pollutants can be assimilated. Natural wetlands, while playing an important role in managing the quality and quantity of runoff, should not be viewed as a sink for polluted runoff. While wetlands help remove pollutants from runoff, some pollutants can accumulate in wetlands or be converted to more potent forms, thereby degrading the natural ecosystem functions and values of these systems and impact the organisms living there.[23] Furthermore, the US EPA recommends protection for any wetland or riparian area which removes pollutants from runoff to coastal waters.[24] Therefore, use of these systems for stormwater management should be carefully considered, realizing that these systems need quality water delivered at an appropriate rate to function properly.

INCREASED DEPOSITION OF POLLUTANTS

The second aspect of urbanization that contributes to urban stormwater pollution is the increased discharge of pollutants. As human activity increases in a given area, the amount of waste material deposited on the land and in drainage systems increases. The principal contaminants of concern for stormwater fall into seven categories. The following table lists these categories and provides examples.

While all activities can be a source of some contaminants, certain activities are particularly large contributors. Industrial sites can be major sources of metals and organic chemicals. Feedlots are a large source of pathogens, nutrients, and BOD. Agricultural and timber operations discharge high quantities of sediment. This report focuses on those activities in urbanized and urbanizing areas, practices of homeowners, businesses, and government agencies that also contribute many of these contaminants.

TABLE 2-2
Categories of Principal Contaminants in Stormwater

Category	Examples
Metals	zinc, cadmium, copper, chromium, arsenic, lead
Organic chemicals	pesticides, oil, gasoline, grease
Pathogens	viruses, bacteria, protozoa
Nutrients	nitrogen, phosphorus
Biochemical oxygen demand (BOD)	grass clippings, fallen leaves, hydrocarbons, human, and animal waste
Sediment	sand, soil, and silt
Salts	sodium chloride, calcium chloride

Vehicle Use

Driving a car or truck contributes a number of different types of pollutants to urban runoff. Pollutants are derived from automotive fluids, deterioration of parts, and vehicle exhaust. Once these pollutants are deposited onto road and parking surfaces, they are available for transport in runoff to receiving waters during storm events. One landmark study estimated that cars and other vehicles contributed 75 percent of the total copper load to the lower San Francisco Bay through runoff.[25] Brake pad wear contributed 50 percent of the total load, and 25 percent came from atmospheric deposition -- the eventual settling of metals from tailpipe emissions onto the ground. Other car- and truck-related sources of metals include tire wear, used motor oil and grease, diesel oil, and vehicle rust.[26] Tire ware is a substantial source of cadmium and zinc; concentrations at outfalls often exceed acute toxicity levels. Engine coolants and antifreeze containing ethylene glycol and propylene glycol can be toxic and contribute high BOD to receiving waters.

Vehicle exhaust contributes the nutrient nitrogen to our nation's waters. Studies estimate that deposition of nitrogen from power plant and vehicle exhaust contributes 17 pounds per year of nitrogen and 0.7 pounds per year of phosphorus to a typical acre of land in the metropolitan Washington, DC, area.[27] In general, fossil fuel combustion is the largest contributor of nitrogen to the waters of the northeastern United States, and is a very large contributor elsewhere.[28]

Oil, grease, and other hydrocarbons related to vehicle use and maintenance also contaminate our waters. These come from disposal of used oil and other fluids on the ground or into storm drains, spills of gasoline or oil, and leaks from transmissions or other parts of automobiles and trucks. The stormwater discharge from one square mile of roads and parking lots can yield approximately 20,000 gallons of residual oil per year.[29] Runoff from residential car washing also contributes oil, grease, grit, and detergents to the stormwater system. Even gas vapor emitted when filling tanks can subsequently mix with rain, contributing significantly to polluted runoff.[30]

Roads and Parking Lots

In many communities, most impervious cover is related to the transportation system.[31] Material accumulates on these surfaces during dry weather conditions, only to form a highly concentrated first flush during storm events. One study found streets to be the impervious surface with the highest pollutant loads in most land use categories.[32] Another found that transportation related land uses have the second highest level of pollutant concentrations; only piped industrial sources were higher.[33]

Table 2-3
Sources of Heavy Metals from Transportation

Source	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Gasoline	•			•				•	•
Exhaust							•	•	
Motor Oil & Grease		•			•		•	•	•
Antifreeze					•				•
Undercoating								•	•
Brake Linings				•	•		•	•	•
Rubber	•			•				•	•
Asphalt				•			•		•
Concrete				•			•		•
Diesel Oil	•								
Engine Wear					•	•	•	•	•

Source: Local Ordinances: A Users Guide, Terrene Institute and EPA, Region 5, 1995.

Home Landscaping and Public Grounds Maintenance

Landscaping practices are another potential source of pollutants in urban runoff. Turf management chemicals including fertilizers used at home and on golf courses, cemeteries, and public parks can add nutrients to runoff.[34] Monitoring has shown a direct link between the chemicals found in lawn care products and urban water quality.[35] While there remain questions on some details of the contribution of turf management to receiving water quality, it is clear that the type, quantity, and timing of materials used make a significant difference.

One important variable is the quantity of chemicals being applied. Over or improper application at homes and other places is far too common.[36] Experts estimate that residential fertilizer use accounts for one-third of the excess nitrogen entering the Sarasota Bay watershed in southwest Florida.[37] Of particular concern is the application of fertilizers and pesticides just before an intense storm event, since they may not have had time to become fixed in the soil and thatch.

Similarly, harmful pesticides found in stormwater, such as chloropyrifos, 2,4-D, and diazinon come from golf courses, municipal parks, highway medians and roadsides, and residential lawns and gardens.[38] The percentage of pesticide lost in runoff can be large; one study found up to 90 percent of the herbicide 2,4-D was lost in runoff after being applied a few hours before a storm event.[39]

Since organic matter contains nutrients, raking autumn leaves or grass clippings into gutters or streets for municipal collection or otherwise facilitating the entry of these materials into the storm-sewer system also adds nutrient loads and oxygen-demanding substances to stormwater. Poorly maintained garden beds or lawns can be a source of sediment as well.

Table 2-4
Six Pesticides Found Frequently in Stormwater Samples

Pesticide Name	Human Health and/or Environmental Effects
2,4-D	Associated with lymphoma in humans; testicular toxicant in animals.
Chlorpyrifos	Moderately toxic to humans; neurotoxicant; can be highly toxic to birds, aquatic organisms, and wildlife.
Diazinon	Moderately toxic to humans; neurotoxicant; can be highly toxic to birds, aquatic organisms, and wildlife.
Dicamba	Neurotoxicant; reproductive toxicity in animals; association with lymphoma in some human studies.
MCPA (Methoxane)	Low toxicity to non-toxic in test animals, birds, and fish; suspected gastrointestinal, liver, and kidney toxicant.
MCPP (Mecoprop)	Slightly to moderately toxic; some reproductive effects in dogs; suspected cardiovascular, blood, gastrointestinal, liver, kidney, and neurotoxicant.

Sources: T.R. Schueler, quot;Urban Pesticides: From the Lawn to the Stream,quot; Watershed Protection Techniques, vol. 2, no. 1, Fall 1995, pp. 247, 250 and Extoxnet: Extension Toxicology Network Pesticide Information Profiles, http://ace/orst.edu/info/extoxnet, and Environmental Defense Fund, Scorecard Chemical Profiles, http://www.scorecard.org/chemical-profiles.

Construction Sites

Construction activity is the largest direct source of human-made sediment loads.[40] quot;Results from both field studies and erosion models indicate that erosion rates from construction sites are typically an order of magnitude larger than row crops and several orders of magnitude greater than rates from well-vegetated areas, such as forest or pastures.quot;[41] Since erosion rates are much higher for construction sites relative to other land uses, the total yield of sediment and nutrients is higher.[42] Studies indicate that poorly managed construction sites can release 7 to 1,000 tons of sediment per acre during a year, compared to 1 ton or less from undeveloped forest or prairie land.[43] Construction activity can also result in soil compaction and increased runoff.

Like nutrients, soil and sediment are, to a certain degree, a naturally occurring and functional component of all waterbodies. Yet human activities usually increase the amount of sediment entering our waterbodies to such an extent as to turn sediment into a water quality problem.

Illicit Sanitary Connections to Storm Sewers From Homes and Businesses

Illicit connections from toilets to storm sewer pipes can add pathogens to stormwater.[44] [45]

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Pathogens are viruses, bacteria, and protozoa harmful to human health. Coliform bacteria, which come from human waste, is commonly used as an indicator that harmful pathogens may be present in the water.[46] Studies have found high levels of coliform bacterial in stormwater.[47]

Illicit sanitary connections can also add nutrients such as nitrogen and phosphorus to stormwater. Human waste also contributes to bod. Leaking sanitary sewer lines located near storm sewer lines can pose the same problems as illicit connections.[48]

Septic Systems

Effluent from poorly maintained or failing septic systems can rise to the surface and contaminate stormwater.[49] Septic systems can be important sources of pathogens and nutrients, especially nitrogen, that are not effectively removed from the waste stream. Bathing beach and shellfish bed closures are frequently the result of septic system effluent. One study found that 74 percent of the nitrogen entering the Buttermilk Bay estuary in Massachusetts originated from septic systems.[50] Fecal coliform and BOD can be present in stormwater if the system is improperly sited, designed, installed, or maintained.

Illicit Industrial Connections to Storm Sewers

Businesses that illicitly connect pipes containing wastewater from industrial processes to the storm sewer system rather than to the sanitary sewers can add metals, solvents or other contaminants to stormwater. In Seattle, one industrial facility's discharge of lead to the storm sewer system resulted in sediment so contaminated that it could be sent to a smelter to be refined.[51] Floor drains, dry wells, and cesspools are also frequent sources of illicit industrial discharges and connections.

Uncovered Materials Stored Outside

Rain or melting snow can erode piles of bulk material, such as sand, loose topsoil, or road salt if left uncovered, adding sediment, salts or other pollutants to nearby waterbodies. Likewise, precipitation can wash contaminants off leaking or dirty objects left outdoors. For example, water quality monitoring showed that untreated runoff collected from auto recycling facilities near Los Angeles frequently exceeded EPA benchmark figures, for biochemical oxygen demand, nitrogen, oil and grease, phosphorus, and sediment.[52]

Street, Sidewalk, and Airport De-icing

In colder parts of the country, salts used to keep roads, parking lots and sidewalks free of ice often drain into our waterbodies as snow and ice melt and spring rain falls. While some salt and ice treatment is necessary to keep roads safe in winter, measures can be taken to reduce or prevent the impacts from de-icing. The principal salts used are sodium chloride and calcium chloride, although materials such as calcium magnesium acetate and other commercial products are also used.[53] Some municipalities spread sand to maintain road traction on snow and ice, and this sand eventually may increase sediment loads. Airports de-ice runways and planes, usually with glycol mixtures that can be both toxic to fish, wildlife, and humans and exert high BOD on receiving streams.

Landfills

Because the soil cover on landfills is not stabilized with vegetation or other retaining cover while the landfill is operational, soil can erode from landfills as it does from construction sites. Additionally, improperly maintained hazardous-waste landfills can allow toxic contaminants to reach or stay on the surface of the landfill, allowing stormwater to carry these pollutants to nearby waterbodies.

Pets and Wild Animals

Waste from domestic and wild animals is a source of pathogens, nutrients and BOD in stormwater.[54] The Northern Virginia Soil and Water Conservation District estimates that each day, dogs leave 180,000 pounds of waste on the ground in Fairfax County, Virginia, alone.[55] Waste from birds such as pigeons, geese, and gulls that are attracted to human activity can also be a problem. Wild geese that congregate in large numbers on cultivated turf adjacent to bodies of water also contribute to pathogen, nutrient and BOD loadings.[56]

Littering

Not only does stormwater frequently receive no treatment, it also often does not even have the benefit of simple filtering or screening for visible objects. As a result, paper cups, cigarette butts, virtually anything made of styrofoam, newspaper, and other materials that people toss on the ground are carried into storm sewer systems -- and eventually into lakes, streams, and oceans.

This list, exhaustive as it is, is incomplete. Galvanized roofs, unpaved roads, the dust that collects on paved streets, and countless other aspects of daily life in urban areas contribute to polluted runoff. The first step in stormwater management is not to memorize any particular list, but rather to recognize the breadth of opportunities for pollution prevention and the need to think holistically about the entire chain of human activities that affect runoff quantity and quality. The case studies presented in this report demonstrate a wide variety of effective and efficient strategies for addressing stormwater runoff at the source.

Notes

1. U.S. Environmental Protection Agency, *Nonpoint Source Pollution: The Nation's Largest Water Quality Problem*, www.epa.gov/OWOW/NPS/facts/point1, January 21, 1997.

2. U.S. Environmental Protection Agency, *National Water Quality Inventory: 1996 Report to Congress*, EPA841-R-97-008, April 1998, p. ES-13.

3. Haile, R. W. et al, *An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay*, Santa Monica Bay Restoration Project, 1996. 70 pp.; Novotny V. H. and H. Olem, *Water Quality: Prevention, Identification, and Management of Diffuse Pollution*, Van Nostrand Reinhold, New York, 1994, p. 36; Pitt, R., *Stormwater Quality Management*, CRC Press, forthcoming 1999; Moffa and Associates, R. Pitt, and SAVIN Engineers, Assessment of Decision Criteria used to Determine Benefits of CSO/SSO/SW Investments, WERF-sponsored report, forthcoming 1999.

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Report To Congress On The Phase II Storm Water Regulations

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on the
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Table of Contents

I. INTRODUCTION

A. PURPOSE OF REPORT TO CONGRESS

EPA provides this Report to Congress in compliance with Section 431(a) of the Departments of Veterans Affairs and Housing and Urban Development and Independent Agencies Appropriations Act of 2000, Pub. L. No. 106-74 (1999) ("Appropriations Act"). The Appropriations Act directs the Administrator of the Environmental Protection Agency ("EPA") to submit two reports to the Committee on Environment and Public Works in the Senate and the Committee on Transportation and Infrastructure in the House of Representatives. The first of the reports is to address several issues related to EPA rulemaking to implement Section 402(p)(6) of the Clean Water Act ("CWA"). This rulemaking is also referred to as the Storm Water Phase II rule. Section 431(a) of the Appropriations Act directs the Administrator to submit a report containing:

> (1) an in-depth impact analysis on the effect the final regulations will have on urban, suburban, and rural local governments subject to the regulations, including an estimate of --
>
> > (A) the costs of complying with the 6 minimum control measures described in the regulations; and
> >
> > (B) the costs resulting from the lowering of the construction threshold from 5 acres to 1 acre;
>
> (2) an explanation of the rationale of the Administrator for lowering the construction site threshold from 5 acres to 1 acre, including --
>
> > (A) an explanation, in light of recent court decisions, of why a 1-acre measure is any less arbitrarily determined than a 5-acre measure; and
> >
> > (B) all qualitative information used in determining an acre threshold for a construction site;
>
> (3) documentation demonstrating that storm water runoff is generally a problem in communities with populations of 50,000 to 100,000 (including an explanation of why the coverage of the regulation is based on a census-determined population instead of a water quality threshold); and
>
> (4) information that supports the position of the Administrator that the Phase II storm water program should be administered as part of the National Pollutant Discharge Elimination System under section 402 of the Federal Water Pollution Control Act (33 U.S.C. 1342).

Section 431(c) of the Appropriations Act directs EPA to publish the reports in the Federal Register for public comment. The Appropriations Act does not specify whether EPA should seek and respond to public comment on the reports prior to submitting them to the Committees. Section 431(a) does provide, however, that the Administrator shall not promulgate the Phase II rule until submitting the Section 431(a) report to the Committees. EPA is subject to a judicial consent decree in NRDC v. Browner, (D.D.C., Civ. No. 95-634 PLF) to take final action by October 29, 1999 on the Phase II rule proposed earlier. The Appropriations Act does not relieve EPA from the timing of this rulemaking obligation. Therefore, EPA will invite public comment on the Section 431(a) report after submitting it to the Committees. EPA will carefully review and evaluate comments received and determine whether the comments warrant further action regarding the October 29, 1999, final rule.

As noted above, on October 29, 1999, the Administrator of EPA will take final action on a notice of proposed rulemaking under CWA section 402(p)(6), 33 U.S.C. § 1342(p)(6). On January 9, 1998, at 63 Fed. Reg. 1536, EPA proposed to expand the National Pollutant Discharge Elimination System (NPDES) permitting program for storm water to apply to discharges from certain small municipal separate storm sewer systems (MS4s) and from construction activity generally disturbing between one and five acres of land surface. Although EPA designated for regulation discharges from these two categories, the rulemaking would also allow for waivers (for subsequent exclusion from regulation of certain sources in these categories) and designation (for subsequent inclusion of certain sources that fall outside of the categories). Waivers would be available based on criteria by which the NPDES permitting authority would determine a low potential for adverse water quality impact, and the permitting authority would designate additional sources on a localized basis when necessary to protect or remedy localized adverse water quality impacts.

Rulemaking under CWA section 402(p)(6) is to be based on a study that EPA was directed to provide to Congress under CWA section 402(p)(5). Section 402(p)(5) provides that:

> The Administrator, in consultation with the States, shall conduct a study for the purposes of -
>
> (A) identifying those stormwater discharges or classes of stormwater discharges for which permits are not required pursuant to [CWA sections 402(p)(1) and (p)(2)];
>
> (B) determining, to the maximum extent practicable, the nature and extent of pollutants in such discharges; and
>
> (C) establishing procedures and methods to control stormwater discharges to the extent necessary to mitigate impacts on water quality.

CWA section 402(p)(5) directed EPA to provide reports to Congress on the different components of this study. In proposing the regulations under CWA section 402(p)(6), EPA identified the reports to Congress comprising the study described in CWA section 402(p)(5), specifically, *Storm Water Discharges Potentially Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program: Report to Congress* (U.S. EPA, 1995, EPA 833-K-

94-002). Today's report under section 431(a) of the Appropriations Act is a supplement to the study described in CWA section 402(p)(5).

B. PURPOSE OF THE PHASE II RULE

The Phase II rule would establish a cost effective, flexible approach for reducing environmental harm by storm water discharges from many point sources of storm water that are currently unregulated. Some of the costs of implementing the Phase II rule are discussed in Chapter II of this report. A summary of the rule's benefits are described below. EPA's Economic Analysis of the Final Phase II Storm Water Rule fully analyzes the costs and benefits expected from implementation of the rule.

The environmental harm currently caused by discharges from municipal separate storm sewer systems (MS4s) and construction activity is well documented:

- Urbanization alters the natural infiltration capability of the land and generates a host of pollutants that are associated with the activities of dense populations, thus causing an increase in storm water runoff volumes and pollutant loadings in storm water discharged to receiving water bodies.

- The National Urban Runoff Program (NURP) Study (U.S. EPA 1983) indicated that discharges from MS4s draining runoff from residential, commercial, and light industrial areas carried more than ten times the annual loadings of total suspended solids as did discharges from municipal sewage treatment plants that provide secondary treatment, and somewhat higher annual loadings of chemical oxygen demand (COD), total lead, and total copper.

- The National Water Quality Inventory (305(b)), 1996 report to Congress shows that urban runoff/storm sewer discharges affect 13% of impaired rivers, 21% of impaired lakes and 45% of impaired estuaries.

- Urban storm water runoff, sanitary sewer overflows, and combined sewer overflows have become the largest causes of beach closings in the United States in the past three years. A survey of coastal and Great Lakes communities found that more than 1,500 beach closings and advisories were attributable to storm water runoff in 1998 based on EPA data supplemented with additional data (Natural Resources Defense Council. 1998. "Testing the Waters Volume VIII-Has Your Vacation Beach Cleaned Up Its Act?" New York, NY). Recreational bathers are at the highest risk for contracting illnesses such as gastroenteritis, typhoid, dysentery, hepatitis, skin rashes, and respiratory infections.

- The MS4 program will address illicit discharges, which can contribute high levels of pollutants, including heavy metals, toxic substances, oil and grease, solvents, nutrients, viruses and bacteria into receiving water bodies.

- The NURP study found that pollutant levels from illicit discharges were high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health.

- Discharges from construction activity impact the biological, chemical, and physical integrity of receiving waters. A number of pollutants are preferentially absorbed onto particles found in fine sediment. Estimates indicate that 80 percent of the phosphorus and 73 percent of the Kjeldahl nitrogen in streams is associated with eroded sediment from construction and other activities.

- Sediment yields from smaller construction sites are as high as or higher than the 20 to 150 tons/acre/year measured from larger sites.

- Siltation is the largest cause of impaired water quality in rivers and the third largest cause of impaired water quality in lakes, according to the 305(b) Report to Congress.

The implementation of the six minimum measures identified for small MS4s should significantly reduce pollutants in urban storm water compared to existing levels and do so in a cost effective manner. Similarly, the implementation of best management practice ("BMP") controls at small construction sites should also result in a significant reduction in pollutant discharges and an improvement in surface water quality. EPA's Economic Analysis of the Final Phase II Storm Water Rule details the expected benefits from implementation of the rule. These benefits include:

- Enhanced Commercial Fishing: Commercial fisheries are a significant part of the nation's economy. In 1997, the commercial shellfish catch was worth $1.04 Billion and the finfish catch was worth $581 Million. 18% of surveyed estuary miles identified storm water as a significant source of impairment.

- Enhanced Recreational and Subsistence Fishing: The potential value of marine recreational fishing is $1.1 Billion to $11.3 Billion annually. Pollutants in storm water may result in eliminating or decreasing the numbers or size of sport fish or shellfish in receiving waters. In September 1996, there were 2,196 fish consumption advisories and about 25% of waters designated for fishing did not support that use.

- Enhanced Opportunities for Boating: Storm water controls offer benefits to boaters by reducing sediment and other pollutants in waters, increasing water clarity and enhancing the experience for boating users. EPA estimates that pollution reduction due to Phase II controls may result in 3,000 currently non-boatable miles of river becoming boatable.

- Enhanced Opportunities for Swimming: EPA estimates that Americans participated in 1.3 billion non-pool swimming days. EPA estimates that at least 28% of these trips are to either marine or fresh water that is impacted by runoff from Phase II sources. For example, in 1998, storm water runoff caused beach closures that resulted in the loss of an estimated 86,000 individual trips to beaches impacted by Phase II sources.

- Enhanced Opportunities for Noncontact Recreation: Activities like picnicking, jogging, biking, camping and hunting do not necessitate direct contact with water, but water quality affects the ability to enjoy these activities when in close proximity to water. Storm water controls reduce turbidity, odors, floating trash and other pollutants and allow waters to be used as focal points for recreation, enhancing the experience of current and future users.

- Enhanced Nonconsumptive Wildlife Uses: An estimated 76.1 million people participated in observing wildlife and waterfowl in 1991. Storm water controls that result in greater numbers or diversity of viewable wildlife species will produce benefits.

- Reduced Flood Damage: Storm water runoff controls may mitigate flood damage by addressing problems due to the diversion of runoff, insufficient storage capacity, and reduced channel capacity from sedimentation.

- Drinking Water Benefits: Storm water was identified as a major source of impairment in rivers, streams, lakes, reservoirs and ponds. Pollutants from storm water runoff, such as solids, toxic pollutants (including pesticides) and bacteria, may impose additional costs for treatment or even render the water unusable for drinking.

- Water Storage Benefits: Storm Water is a major source of impairment for reservoirs. The heavy load of solids deposited by storm water runoff can lead to rapid sedimentation of reservoirs and the loss of needed water storage capacity.

- Navigational Benefits: Storm water also delivers high sediment loads to rivers and harbors critical to navigation and commerce. Where waters are used for navigation, solids must be dredged and disposed of to maintain the utility of the waterway. An estimated 5% of these sediments (12.6 million cubic yards of material) is attributed to storm water runoff from roads and constructions sites. Storm water controls will reduce the rate and amount of sediment loadings.

- Reduced Illness from Consuming Contaminated Seafood: Storm water controls may reduce the presence of pathogens in seafood caught by commercial or recreational anglers. Researchers have estimated 2,700 cases of illness annually from raw or partially cooked contaminated seafood.

- Reduced Illness from Swimming in Contaminated Water: Epidemiological studies have indicated that swimmers in water contaminated by storm water runoff are more likely to experience illness than those that swim farther from a storm water outfall. By reducing illicit connections and other sources of pathogens in storm water, EPA estimates that up to 500,000 cases of illness will be avoided annually.

- Enhanced Aesthetic Value: When storm water affects the appearance or quality of a water body, the desirability of working, living, traveling or owning property near that water body is similarly affected. Improvements in water quality due to reductions in storm water pollution will result in benefits as these waters recover and become more desirable locations near which people want to live, work, travel or own property.

Thus, the rule will result in significant monetized financial, recreational and health benefits, as well as benefits that EPA has been unable to monetize.

II. IMPACT OF PHASE II RULE ON LOCAL GOVERNMENTS

This section responds to the Appropriations Act's direction to provide a report containing:

"(1) an in-depth impact analysis on the effect the final regulations will have on urban, suburban, and rural local governments subject to the regulations, including an estimate of-
(A) the costs of complying with the 6 minimum control measures described in the regulations; and
(B) the costs resulting from the lowering of the construction threshold from 5 acres to 1 acre;"

A. SUMMARY OF PHASE II RULE REQUIREMENTS

EPA conducted an in-depth impact analysis of the effect of the final Storm Water Phase II Rule on local governments. Two provisions of the Phase II rule are expected to result in compliance costs for local governments. These are the provision requiring certain municipalities to regulate discharges from their municipal separate storm sewer systems (MS4s) and the provision which extends the storm water construction program to cover sites between one and five acres in size. The analysis considers potential cost impacts to all local governments, including urban, suburban and rural governments, and provides insight into the differing situations of small or very small local governments. Based on this analysis, EPA determined that the Phase II rule is not expected to have a significant impact on a substantial number of local governments.

Municipal Storm Water Program:

The Phase II Rule would automatically designate for regulation discharges from small MS4s located in urbanized areas, and require that NPDES permitting authorities examine for potential designation, at a minimum, a particular subset of discharges from small MS4s located outside of urbanized areas. The MS4 provision would result in costs primarily for local governments in urbanized areas. An urbanized area is defined by the U.S. Census Bureau as an area with a population of at least 50,000 and a minimum average population density of more than 1,000 people per square mile. Thus, this rule would primarily affect suburban and urban local governments, because these MS4s are more likely to be located in urbanized areas. Rural local governments may be designated on a case-by-case basis if the permitting authority determines that they have a significant impact on water quality. The Phase I storm water program addressed runoff from "medium" and "large" MS4s, generally those discharges from governmental jurisdictions serving populations of 100,000 or more people. The Phase II Storm Water regulations will address discharges from smaller MS4s. The rule also would allow MS4s that are automatically designated because they are within an urbanized area to obtain a waiver from the otherwise applicable requirements if the discharges from small MS4s are not causing impairment of a receiving water body. Qualifications for the waivers vary depending on whether the MS4 serves a population under 1,000 or a population under 10,000.

Under the Phase II rule, a storm water discharge control program that meets the requirements of six minimum control measures would be administered within the jurisdiction of all regulated small MS4s. Small MS4 operators would design and administer the program, or would arrange with other government entities (including operators of nearby larger MS4s) to do so. These minimum control measures would consist of: public education and outreach on storm water impacts, public involvement/ participation, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. The Agency provides an analysis of the costs to local governments of implementing the six municipal minimum control measures in Section B below.

Municipal Construction:

The 1990 Phase I rule required all operators of construction activity disturbing five or more acres of land surface to apply for an NPDES permit for any resulting point source discharges of storm water.[1] The construction provisions of the Phase II rule would extend similar requirements to construction projects that disturb between one and five acres of land. This provision would impose additional requirements on small construction projects of local governments, regardless of whether the local government is urban, suburban or rural. The rule excludes routine road maintenance from the definition of construction, thereby excluding many municipal public works projects. EPA expects that most new one to five acre road construction projects are likely to be built in conjunction with either larger development projects or State and Federal transportation programs and at least partially funded by these other sources. The Phase II rule would also provide waivers from coverage based on the potential to discharge storm water and cause a significant impact to water quality. EPA's analysis of construction starts concluded that the additional requirement for municipally constructed projects should not have a significant impact on a substantial number of the local governments subject to the regulation. EPA reports on its analysis of the costs to local governments of implementing the soil erosion control provisions for their construction sites between one and five acres in Section C below.

Regulatory Flexibility:

In promulgating Storm Water Phase II, EPA examined regulatory flexibility issues and potential cost impacts on small entities, including small local governments. In order to solicit input from potentially regulated small entities, EPA convened a Small Business Regulatory

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[1] On December 18, 1991, Congress enacted the Intermodal Surface Transportation Efficiency Act (ISTEA), which postponed NPDES permit application deadlines for most storm water discharges associated with industrial activity at facilities that are owned or operated by small municipalities, including construction activity over five acres.

Enforcement Flexibility Act (SBREFA) Panel which included small local government representatives as well as other stakeholders. EPA conducted an analysis and determined that the rule was expected not to have a significant impact on a substantial number of small local governments or other small entities. However, in order to provide additional flexibility for small local governments, EPA included several programmatic options and potential waivers for small governments.

The rule would allow for a great deal of flexibility by providing various options for obtaining permit coverage and satisfying the required minimum control measures. For example, the NPDES permitting authority would be able to incorporate by reference qualifying State, Tribal, or local programs in a NPDES general permit and recognize existing responsibilities among different governmental entities for the implementation of minimum control measures. In addition, a regulated small MS4 could participate in the storm water management program of an adjoining regulated MS4 and could arrange to have another governmental entity implement a minimum control measure for them. The rule also provides potential waivers for MS4s serving a population less than 10,000 and also for construction projects not expected to significantly impair water quality. Therefore, Storm Water Phase II is not expected to have a significant impact on a substantial number of small local governments, and offers significant flexibility to those local governments in implementing provisions of the rule which may result in compliance cost impacts.

B. Impacts of the Municipal Minimum Control Measures on Local Governments

EPA estimated that the overall annual cost to local governments of implementing a storm water program based on the six minimum measures would be $297 million. EPA developed this estimate using actual program cost information from Phase II communities with existing storm water programs. The estimate assumes that all of the 5,040 Phase II designated municipalities would incur program costs and that costs are related to the size of the community served. Therefore, the Agency probably overestimates national costs because permitting authorities can waive permitting requirements for MS4s serving up to 10,000 people.

EPA conducted an in-depth analysis of the potential cost of complying with the six minimum measures on local governments in urbanized areas. These local governments are primarily urban and suburban, although a few rural governments may be designated by States to be included in the program based on potential water quality impacts. While the total regulatory costs associated with Phase II include all sizes of local government, EPA specifically considered the impacts to small local governments as required under the Regulatory Flexibility Act, as amended by the Small Business Regulatory and Enforcement Fairness Act. In preparing the analysis, EPA compared estimated annual compliance costs with annual municipal revenues for 4,455 small local governments (municipalities with fewer than 50,000 people) and evaluated cost-to-revenue ratios for indication of significant economic impacts. The results, which are reported in the economic analyses prepared for the proposed and final rules, led EPA to conclude that there would not be a substantial economic impact on a significant number of small governments; EPA expects even less of an impact on larger governments. Below is a summary of EPA's analysis.

Cost Analysis:

EPA estimated annual costs for the municipal programs based on a fixed cost component and a variable cost component. The fixed cost component included costs for the municipal application, record keeping, and reporting activities. On average, EPA estimated annual costs of $1,525 per municipality. Variable costs include the costs associated with annual operations for the six minimum measures. EPA reviewed cost data from existing Phase I storm water programs and cost data gathered from Phase II communities by the National Association of Flood and Storm Water Management Agencies (NAFSMA). These costs reflect the actual operating costs of program elements that are comparable to the six minimum measures for municipalities representing a wide range of population sizes. EPA estimated costs on a per household basis from both data sets. Annual mean costs per household are comparable across the data sets: $8.93 (NASFMA) and $8.85 (Phase I).

Total annual cost for each of the 4,455 municipalities was calculated as the sum of the $1,525 fixed cost and the urbanized area household estimate multiplied by the per household cost based on the NAFSMA data.[2] For example, a municipality with 5,000 households would have a total program cost of:

$$\$46,175 = \$1,525 + (5,000 * \$8.93).$$

Small Local Governments:

EPA estimated municipality revenues based on state-level revenue data collected by the U.S. Bureau of the Census 1992 Census of Governments. The Bureau of the Census reports municipal government revenues by population size for eight size categories including three used by EPA: less than 10,000, 10,000 to 24,999, and 25,000 to 49,999. For every state, EPA gathered the aggregate municipal revenue data and aggregate municipal population data reported by the Bureau of the Census for these three size categories.[3] EPA then divided revenue by population to obtain revenue per capita for each size category within each state. EPA merged this data set with the Phase II municipality population data set and multiplied the appropriate per capita revenue estimates by the Phase II urbanized area populations to obtain 4,455 estimates of annual municipal revenues.

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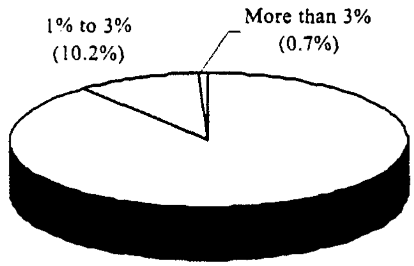
[2] Based on Census data, EPA used a conversion factor of 2.62 people per household to obtain household estimates for the Phase II communities.

[3] EPA did not adjust municipal revenue from their 1991 values to 1998 values, which is the unit of measure EPA used for costs. There is no standard adjustment factor for municipal revenues. Thus, the cost-to-revenue ratio probably overstates the cost impact.

Finally, EPA divided the 4,455 cost estimates by the 4,455 revenue estimates to obtain cost-to-revenue ratios. EPA categorized these ratios according to whether they were less than 1% (i.e., cost is less than 1% of revenue), between 1% and 3%, and greater than 3%. Figure A summarizes the results, showing that the cost-to-revenue ratios were less than 1% for 89% of the Phase II municipalities and greater than 3% for less than 1% of municipalities.

Under, the Phase II rule, the permitting authority could waive permitting requirements for systems serving less than 1,000 people. All of the municipalities with cost-to-revenue ratios that are greater than 3% have populations less than 1,000 people, and may qualify for a waiver. Consequently, the flexibility of the rule addresses any potentially significant adverse cost impacts. Because no Phase II municipality with a population of more than 6,000 had a cost-to-revenue ratio of more than 1%, EPA does not expect this provision will have significant economic impacts on the 585 municipalities with populations larger than 50,000.

Figure A. Summary of Cost-to-Revenue Ratios for 4,455 Phase II Municipalities with Populations Less than 50,000



C. COSTS OF THE SOIL EROSION CONTROL PROVISION ON LOCAL GOVERNMENTS

EPA's cost analysis for the soil erosion control provision multiplies cost estimates per construction site for soil erosion control measures and administrative costs by the number of construction sites potentially affected by the rule. EPA estimates that the rule would apply to approximately 110,223 currently unregulated construction starts per year (using 1998 estimates) out of a total of 528,499 construction starts. Annual costs associated with installing the soil erosion controls and completing permitting activities is estimated as $505 million. Less than 0.5% (< $500,000) is expected to accrue from local governments.

<u>Cost Analysis:</u>

Most soil erosion control costs would accrue to the private sector, primarily to dischargers in the construction industry. However, local governments may also incur soil erosion control costs for discharges from public works projects that disturb between one and five acres (costs borne either directly by the local government or indirectly through a contractor). Since routine road maintenance is excluded from coverage under Storm Water Phase II, those public works starts are excluded from analysis. EPA used the site-based estimates of soil erosion control costs that it developed for the economic analysis of the final rule and Bureau of Census construction start data to estimate the expected annual impact on local governments. Table A summarizes the two types of costs by site size that a construction company or public works department may incur.

Table A. Summary of Site-Based Soil Erosion Control Costs

Cost	1 Acre Site	3 Acre Site	5 Acre Site
Administrative [a]	$937	$937	$937
Soil Erosion Control BMPs [b]	$1,206	$4,598	$8,709
Total Cost	$2,143	$5,535	$9,646
Annualized Cost (7%)[c]	$202	$522	$910

Notes:
a. These activities would include costs to submit a notice of intent to be covered by a general permit, to notify the municipality, to develop a storm water pollution prevention plan, to retain records, and to file a notice of termination from a general permit.
b. BMPs (best management practices) costs are based on combinations of the following that differ across sites with different sizes, slopes, and soil types: silt fence, mulch, seed/mulch, stabilized entrance, stone check dam, earth dike, and sediment traps.
c. Annualized cost assumes a 20-year period and a 7% cost of capital. The capitalization factor is 0.09439.

<u>Small Local Governments:</u>

There are four categories of local governments which may experience costs of compliance associated with the Phase II rule. These are:

1) Phase I jurisdictions (subject to Phase II requirements for construction between one and five acres; already required to have a municipal storm water program),
2) Phase II jurisdiction above 50,000 population (subject to Phase II municipal and construction requirements),
3) Phase II jurisdictions below 50,000 population (subject to Phase II municipal and construction requirements; subject to SBREFA review), and
4) Jurisdictions that are not required to have a municipal storm water program under

Phase I or Phase II (subject to Phase II requirements for construction).

The greatest potential economic impact of the soil erosion control provision is expected to be on the third category, because they would incur soil and erosion control costs in addition to annual program costs for the six minimum measures, and because of their smaller size. Therefore, the analysis below focuses on the impacts on these small local governments.

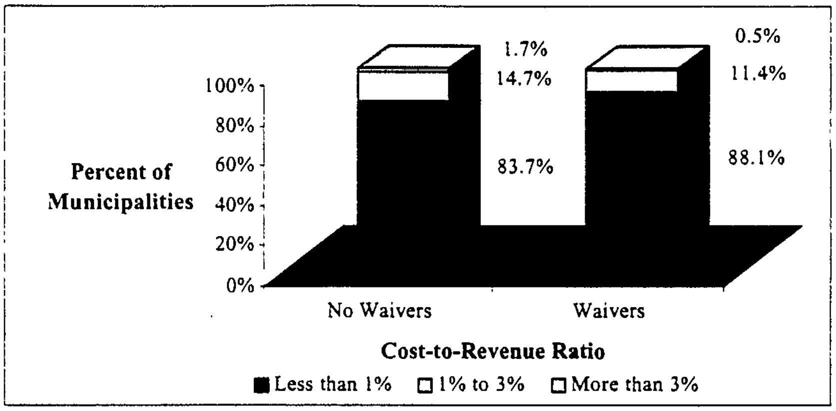
To evaluate the severity of potential impact, EPA used the Bureau of the Census construction start database to estimate the annual number of construction starts in Phase II municipalities that are classified by the Bureau of the Census as a "public works" start, excluding routine road maintenance. The data showed that 2% of municipalities are expected to have a 1-acre start, 2% are expected to have a 3-acre start and 1% are expected to have a 5-acre start. These results indicate that local governments would not incur soil and erosion control costs on an annual basis, because they would not necessarily have Phase II construction starts in any given year. As a conservative assumption (i.e., tending to overstate costs), EPA annualized the costs over a 20-year period, assuming a 7% cost of capital (see Table A). The 20-year assumption is conservative because it implies higher construction rates than the data suggest [i.e., 1-acre site (5%), 3-acre site (5%), and 5-acre site (5%)]. EPA then added the annualized values to obtain an annual cost of $1,634 per municipality for the soil erosion control provision.

Because the soil erosion control provision of the Phase II rule would apply to discharges from construction sites between one and five acres regardless of location, local governments other than Phase II designated municipalities could incur costs. EPA compared the annualized value across all site sizes of $1,634 to the national mean estimate of local government revenues. For the smallest municipality size category, the mean annual revenue was $1.4 million (1991 dollars; 1992 Census of Governments). The cost-to-revenue ratio for the smallest size category is well below 1%.

Finally, EPA then added the cost of complying with the Phase II soil erosion program for small construction to the cost-to-revenue ratios for the MS4 program discussed above to evaluate the combined impact on Phase II municipalities of the municipal minimum measures and soil erosion control costs that may be borne directly or indirectly (passed through from construction companies). Based on this revised cost-to-revenue analysis, the combined costs are not expected to have a significant economic impact on a substantial number of designated Phase II municipalities.

Figure B summarizes the cost-to-revenue impacts for all 4,455 Phase II municipalities with populations less than 50,000 (bar on left). Figure B also summarizes impacts for these Phase II municipalities assuming that the municipalities with populations below 1,000 are granted waivers so they incur soil erosion control costs as regulated small construction site dischargers but no program costs as small MS4 dischargers (bar on right). In either case, a vast majority of municipalities would not incur annual costs that are greater than 1% of revenues and fewer than 2% of municipalities would incur costs that are greater than 3% of revenues. Therefore, EPA concluded that the Phase II rule would not have a significant impact on potentially regulated small local governments.

Figure B. Summary of Cost-to-Revenue Ratios Revised to Include Soil Erosion Control Costs for 4,455 Phase II Municipalities with Populations under 50,000



* "No Waivers" estimates costs assuming (for the purpose of this analysis) that no small local governments with populations below 1,000 receive a waiver and, therefore, are subject to both the municipal and the soil erosion provisions of Phase II. Even if this were to occur, the potential impacts are not significant.

R0010433

III. RATIONALE FOR THE ONE ACRE CONSTRUCTION THRESHOLD

This section responds to the Appropriations Act's direction to provide a report containing:

"(2) an explanation of the rationale of the Administrator for lowering the construction site threshold from 5 acres to 1 acre, including --
(A) an explanation, in light of recent court decisions, of why a 1-acre measure is any less arbitrarily determined than a 5-acre measure; and
(B) all qualitative information used in determining an acre threshold for a construction site;"

BACKGROUND

In 1990, EPA promulgated the first phase of the NPDES permit application rules for storm water. (*National Pollutant Discharge Elimination System Permit Application Requirements for Storm Water Discharges*, 55 Fed. Reg. 47990 (Nov. 16, 1990), referred to as the "Phase I" rule). As directed under CWA section 402(p)(4)(A), the Phase I rule set forth the permit application requirements for storm water discharges "associated with industrial activity," including, applicability provisions defining the term "storm water discharge associated with industrial activity." Under CWA section 402(p)(2)(B), storm water discharges associated with industrial activity were excluded from the moratorium against permitting discharges composed entirely of storm water.

Among other things, the Phase I rule defined storm water discharge associated with industrial activity to include discharges from "construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale." 40 C.F.R. 122.26(b)(14)(x). In 1992, a court ruled that the five acre threshold used for defining construction activity as "industrial activity" was improper because EPA had failed to identify information to support its position that construction activities on less than five acres are non-industrial in nature.

The Phase II rule would regulate storm water discharges from additional smaller construction activities. The rule would regulate these construction-related storm water sources under CWA section 402(p)(6) to protect water quality rather than under CWA section 402(p)(2). Designation under 402(p)(6) gives States and EPA the flexibility to waive the permit requirement for construction activity that is not likely to impair water quality, and to designate additional sources below one acre that are likely to cause water quality impairment. Thus, the one acre threshold under the Phase II rule would not be an absolute threshold like the five acre threshold that applies under the Phase I rule. The one acre threshold is reasonable for accomplishing the water quality goals of CWA section 402(p)(6) because it results in 97.5% of the total acreage disturbed by construction being designated for coverage by the NPDES storm water program, while excluding from automatic coverage the numerous smaller sites that represent 24.7% of the total number of construction sites.

Rationale for Five Acre Threshold in the Phase I Rule

In the preamble to the Phase I rule, which regulates storm water discharges from construction activity disturbing five acres or more as "storm water discharges associated with industrial activity," EPA had explained that the construction industry should be subject to storm water permitting because at a high level of intensity, construction is equivalent to other regulated industrial activities. 55 Fed. Reg. 48033. The Phase I rule regulates storm water "associated with industrial activity." EPA had proposed that the Phase I regulations apply to construction site discharges from sites disturbing down to one acre. EPA increased the size threshold to five acres for the final rule.

After a judicial challenge to the Phase I regulations, the Ninth Circuit remanded the regulation to EPA for further proceedings. NRDC v. EPA, 966 F.2d 1292, 1306 (9th Cir. 1992). To support the increased threshold (from one to five acres), the Agency had explained that larger sites typically involve heavier equipment for removing vegetation and bedrock than smaller sites. 55 Fed. Reg. 48036. The court found that EPA's rationale for increasing the limit was inadequate because the Agency cited no information to support its perception that construction activities on less than five acres are non-industrial in nature. 966 F.2d at 1306. Thus, the Court focused on the relationship between the size threshold and the statutory reference to "industrial."

Rationale for One Acre Threshold in the Phase II Rule

In lowering the threshold to one acre in the Phase II rule, the Phase II rule would not regulate discharges from small construction site as "industrial activity." Instead, EPA interprets the text of CWA section 402(p)(6) as a basis to designate small construction site discharges as sources "to be regulated to protect water quality." EPA interprets this language as less restrictive than the terms "associated with industrial activity" for the purpose of establishing an applicability threshold that is based on size alone but which may be modified by permitting authorities to account for higher and lower threat sources. In addition to water quality considerations, the text of CWA section 402(p)(6) allows for designations based on considerations of administrative feasibility by specifying that the Agency has discretion to identify sources "to be regulated."

Though the Phase II rule would not regulate a discharge from a construction site below the five acre threshold as a "discharge associated with industrial activity," the Phase II rule nonetheless responds to the Ninth Circuit's direction to conduct further rulemaking on the matter of discharges from sites disturbing more than one acre (from the Phase I proposed rule) and from sites disturbing less than five acres (from the Phase I final rule). For discharges from sources in this category, which the Agency still believes present water quality concerns based on the potential for water quality impairment due to gross sediment runoff (among other pollutants), CWA section 402(p)(6) rather than CWA section 402(p)(2)(B) and (3) provides a more sensible basis to address the sources that threaten water quality. In light of the Agency's decision to regulate these sources down to one acre to protect water quality with controls similar to those applied to Phase I sources, EPA believes it is unnecessary to examine further whether sites below five acres are "associated with industrial activity."

EPA is regulating storm water discharges from construction activity disturbing between 1 and 5 acres because the cumulative impact of many sources, and not just a single identified source, is typically the cause for water quality impairments, particularly in relation to sedimentation-related water quality standards.

The one acre threshold provides an administrative tool for more easily identifying those sites that are identified for coverage by the rule (but may receive a waiver) and those that are not automatically covered (but may be designated for inclusion). Although all construction sites less than five acres could have a significant water quality impact cumulatively, EPA is automatically designating for permit coverage only those storm water discharges from construction sites that disturb land equal to or greater than one acre. Categorical regulation of discharges from construction below this one acre threshold would overwhelm the resources of permitting authorities and might not yield corresponding water quality benefits. Construction activities that disturb less than one acre make up, in total, a very small percentage of the total land disturbance from construction nationwide (about 2.5%).

In addition to the diminishing water quality benefits of regulating all sites below one acre, the Agency relies on practical considerations in establishing a one acre threshold and not setting a lower threshold. Regardless of the threshold established by EPA, a NPDES permit can only be required if a construction site has a point source discharge. A point source discharge means that pollutants are added to waters of the United States through a discernible, confined, discrete conveyance. "Sheet flow" runoff from a small construction site would not result in a point source discharge unless and until it channelized. As the amount of disturbed land surface decreases, precipitation is less likely to channelize and create a "point source" discharge (assuming the absence of steep slopes or other factors that lead to increased channelization). Categorical designation of very small sites may create confusion about applicability of the NPDES permitting program to those sites. EPA's one acre threshold reflects, in part, the need to recognize that smaller sites are less likely to result in point source discharges. Of course, the NPDES permitting authority could designate smaller sites (below one acre, assuming point source discharges occur from the smaller designated sites) for regulation if a watershed or other local assessment indicated the need to do so. The Phase II rule would include this designation authority at 40 CFR 122.26(a)(9)(i)(D) and (b)(15)(ii).

Though location-specific water quality studies would provide the ideal information base from which to make regulatory decisions, the Phase II rule establishes one acre as a default standard for regulation in the absence of location-specific studies. The rule does account for location-specific water quality information, however, for any deviation from the default standard through additional designations and waivers. The rule codifies the ability of permitting authorities to provide waivers for sites greater than or equal to one acre and designate additional discharges from small sites below one acre when location-specific information suggests that the default one acre standard is either unnecessary (waivers) or too limited (designations) to protect water quality.

OTHER QUALITATIVE AND QUANTITATIVE INFORMATION ON SIZE THRESHOLDS

EPA had difficulty evaluating the water quality consequences of designating specific size thresholds because, while generally proportional to the size of the disturbed site, the water quality threat posed by discharges from construction sites of differing sizes varies nationwide, depending on the local climatological, geological, geographical, and hydrological influences. In order to ensure improvements in water quality nationwide, however, the Phase II rule does not allow various permitting authorities to establish different size thresholds except based on the waiver and designation provisions of the rule. EPA believes that a national one acre threshold for automatic designation, coupled with procedures for waiving sites above one acre and for designating sites below one acre based on local water quality considerations, ensures protection against adverse water quality impacts from storm water discharges from small construction sites while not overburdening the resources of permitting authorities and the construction industry.

EPA believes that the water quality impact from small construction sites is as high as or higher than the impact from larger sites on a per acre basis. The concentration of pollutants in the runoff from smaller sites is similar to the concentrations in the runoff from larger sites. The proportion of sediment that makes it from the construction site to surface waters is likely the same for larger and smaller construction sites in urban areas because the runoff from either site is usually delivered directly to the storm drain network where there is no opportunity for the sediment to be filtered out.

The expected contribution of total sediment yields from small sites depends, in part, on the extent to which erosion and sedimentation controls are being applied. Because current storm water regulations are more likely to require erosion and sedimentation controls on larger sites in urban areas, smaller construction sites that lack such programs are likely to contribute a disproportionate amount of the total sediment from construction activities (MacDonald, L.H. 1997. Technical Justification for Regulating Construction Sites 1-5 Acres in Size. Unpublished report submitted to the U.S. Environmental Protection Agency, Washington). Smaller construction sites are less likely to have an effective plan to control erosion and sedimentation, are less likely to properly implement and maintain their plans, and are less likely to be inspected (Brown, W. and D. Caraco. 1997. Controlling Storm Water Runoff Discharges from Small Construction Sites: A National Review. Submitted to the U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, DC. by the Center for Watershed Protection, Silver Spring, MD).

To confirm its belief that sediment yields from small sites are as high as or higher than the 20 to 150 tons/acre/year measured from larger sites, EPA gave a grant to the Dane County, Wisconsin Land Conservation Department, in cooperation with the USGS, to evaluate sediment runoff from two small construction sites. The first was a 0.34 acre residential lot and the second was a 1.72 acre commercial office development. Runoff from the sites was channeled to a single discharge point for monitoring. Each site was monitored before, during, and after construction.

The Dane County study found that total solids concentrations from these small sites are similar to total solids concentrations from larger construction sites. Results show that for both of the study sites, total solids and suspended solids concentrations were significantly higher during construction than either before or after construction. For example, preconstruction total solids concentrations averaged 642 mg/L during the period when ryegrass was established, active construction total solids concentrations averaged 2,788 mg/L, and post-construction total solids concentrations averaged 132 mg/L (on a pollutant load basis, this equaled 7.4 lbs preconstruction, 35 lbs during construction, and 0.6 lbs post-construction for total solids). While this site was not properly stabilized before construction, after construction was complete and the site was stabilized, post-construction concentrations were more than 20 times less than during construction. The results were even more dramatic for the commercial site. The commercial site had one preconstruction event, which resulted in total solids concentrations of 138 mg/L, while active construction averaged more than 15,000 mg/L and post-construction averaged only 200 mg/L (on a pollutant load basis, this equaled 0.3 lbs preconstruction, 490 lbs during construction, and 13.4 lbs post-construction for total solids). The active construction period resulted in more than 75 times more sediment than either before or after construction (Owens, D.W., P. Jopke, D.W. Hall, J. Balousek and A. Roa. 1997. "Soil Erosion from Small Construction Sites in Dane County, Wisconsin." Draft Report. USGS and Dane County Land Conservation Department, WI).

Construction start data indicates that excluding construction sites below one acre from coverage under the Phase II rule would exclude a significant percentage of sites from automatic coverage while only excluding a small percentage of the total acreage. As is indicated in Table B, by choosing a nationwide threshold of one acre, the Phase I and Phase II rules will together address 97.5% of the national disturbed acreage yet will only regulate 75.3% of the construction starts. The remaining construction starts (24.7% or 130,435 starts) each occur on less than one acre of disturbed land and together constitute only 2.5% of total acreage disturbed by construction.

Table B. Percentage of national disturbed acreage and construction starts addressed by regulating all construction above different thresholds

	percentage of national disturbed area controlled by regulating all sites:	number of construction starts addressed (percent of national total)
all sites	100 %	527,774 (100 %)
greater than 1.0 acres	97.5 %	397,309 (75.3 %)
greater than 2.0 acres	92.3 %	301,941 (57.2 %)
greater than 3.0 acres	87.8 %	253,224 (48.0%)
greater than 4.0 acres	83.7 %	221,471 (42.0 %)
greater than 5.0 acres	78.1 %	188,425 (35.7 %)

* Table includes all construction starts. It does not exclude starts already regulated by Phase I, equivalent State programs, or potential Phase II waivers.

A two acre threshold would have tripled the total number acres that would not be designated for permit coverage. A threshold below one acre would have significantly increased the number of sites regulated without significantly increasing the number of acres for which storm water controls would be required. Thus, the additional increment in water quality protection that would be achieved by a lower size threshold would have resulted in a disproportionately higher burden on the regulated community.

CONCLUSION ON ONE ACRE THRESHOLD

The Ninth Circuit concluded that EPA arbitrarily defined discharges "associated with industrial activity" when the Agency established the five acre size threshold, particularly in light of the Agency's proposal to establish the threshold at one acre. The Phase II one acre threshold is not arbitrary because (1) sediment loads from disturbed land surface cause adverse impacts on water quality, (2) as site size decreases, the likelihood that precipitation will create "discernible, confined, discrete conveyances" through channelization decreases, (3) the one acre threshold is not an absolute threshold because NPDES authorities can waive the threshold for sites (and during seasons) when there is a lower potential for a discharge that would impair water quality and can designate sources below the threshold where necessary to protect water quality on a localized basis, and (4) the number of additional sites that would be regulated by a threshold below one acre is disproportionately high relative to the total number of acres disturbed by those sites.

EPA recognizes that the size criterion alone may not be a perfect predictor of the need for regulation, but effective protection of water quality depends as much on simplicity in implementation as it does on the scientific information underlying the regulatory criteria. The default size criterion of one acre will ensure protection against adverse water quality impacts from storm water discharges from small construction sites while not overburdening the resources of permitting authorities and the construction industry to implement the program to protect water quality in the first place. Further, as noted above, NPDES permit authorities can designate sources below one acre where necessary to protect water quality in a particular area, or waive sites above one acre where NPDES permit coverage under the Phase II rule is not necessary to protect water quality.

IV. Storm Water Problems in Census Designated Urbanized Areas

This section responds to the Appropriations Act's direction to provide a report containing:

"(3) documentation demonstrating that storm water runoff is generally a problem in communities with populations of 50,000 to 100,000 (including an explanation of why the coverage of the regulation is based on a census-determined population instead of a water quality threshold);

Background

In 1990, EPA promulgated the first phase of the NPDES permit application rules for storm water ("Phase I"). Phase I required NPDES permits for storm water discharges from large and medium municipal separate storm sewer systems generally serving populations of 100,000 or more. Areas with a combined sewer were not included in the total population served for Phase I.

This definition of large and medium MS4s for Phase I created so-called "donut holes." Donut holes are unregulated MS4s located within those urbanized areas that include systems covered by the Phase I storm water program, but are not currently addressed by the storm water program because the Phase I regulations specify applicability based on political jurisdiction. In other words, donut holes are geographic gaps in the existing NPDES storm water program's regulatory scheme. Storm water discharges from donut hole areas present a problem due to their adverse impacts on local waters, as well as by frustrating the attainment of water quality goals of neighboring regulated communities.

The storm water Phase II rule designates discharges from small MS4s located in urbanized areas for NPDES permit coverage. EPA adopted the Bureau of the Census definition of an urbanized area as comprising a place and the adjacent densely settled surrounding territory that together have a minimum population of 50,000 people. A permitting authority may designate additional small MS4s after the authority develops designation criteria and applies those criteria to small MS4s located outside of an urbanized area, in particular those with a population of 10,000 or more and a population density of at least 1,000 per square mile. The permitting authority may waive the requirement for a permit for any small MS4 serving a jurisdiction with a population of less than 1,000 unless storm water controls are needed because the MS4 is contributing to a water quality impairment. The permitting authority may also waive permit coverage for MS4s serving a jurisdiction with a population of less than 10,000 if all waters that receive a discharge from the MS4 have been evaluated and discharges from the MS4 do not significantly contribute to a water quality impairment or have the potential to cause an impairment. The Phase II rule also allows States with a watershed permitting approach to phase in coverage for MS4s in jurisdictions with populations under 10,000.

EPA's Rationale for Basing Regulation on Census-Determined Population Rather Than a Water Quality Threshold

EPA adopted the Bureau of the Census definition of "urbanized area" for the purposes of the Phase II rule. The existing storm water Phase I rule already covers discharges from MS4s with more than 100,000 population. Phase II would address the remaining MS4s in urbanized areas.

The Bureau of the Census defines an urbanized area as comprising a place and the adjacent densely settled surrounding territory that together have a minimum population of 50,000 people. The densely settled surrounding territory generally has at least 1,000 people per square mile. The Bureau of the Census definition of "urbanized area," adopted by EPA for the purposes of the Phase II rule, was published in the Federal Register (55 FR 42592, October 22, 1990).

EPA is using urbanized areas to automatically designate regulated small MS4s on a nationwide basis for several reasons:

(1) Water Quality Impacts from Urban Runoff

Studies and data show a high correlation between degree of development/ urbanization and adverse impacts on receiving waters due to storm water. See section A below for a full discussion of storm water impacts due to urban development.

(2) Addresses gaps in coverage

The blanket coverage within the urbanized area encourages the watershed approach and addresses the problem of "donut-holes," where unregulated areas are surrounded by areas regulated under Phase I.

(3) Pollution Prevention

This approach targets present and future growth areas as a preventative measure to help ensure water quality protection. Urbanized areas have experienced significant growth over the past 50 years. According to EPA calculations based on Census data from 1980 to 1990, the national average rate of growth in the United States during that 10-year period was more than 4 percent. For the same period, the average rate of growth within urbanized areas was 15.7 percent and the average for outside of urbanized areas was just more than 1 percent. Table C below illustrates the growth of urbanized areas for the past five Census (EPA, 1995). The new development occurring in these growing areas can provide some of the best opportunities for implementing cost-effective storm water management controls.

Table C. Growth of Urbanized Areas in the United States Between 1950 and 1990

Year	Number of Urbanized Areas	Population in Urbanized Areas (millions)			Land Area (sq. mi.)
		Total	Central Cities	Urban Fringe	
1950	157	69.2	48.4	20.9	19,728
1960	213	95.8	57.9	37.8	25,544
1970	273	120.7	65.1	55.6	35,081
1980	366	139.2	67.0	72.1	52,017
1990	405	160.4	79.7	80.7	61,520

(4) Simplified Designation and Coverage

The determination of urbanized areas by the Bureau of the Census allows operators of small MS4s to quickly determine whether they are included in the NPDES storm water program as a regulated small MS4.

Using urbanized areas as a basis for designation effectively targets resources to the most densely developed territory. The 405 urbanized areas in the United States cover only 2 percent of the total U.S. land areas yet contain approximately 63 percent of the nation's population.

Documentation of Water Quality Problems Due to Storm Water Runoff from Urbanized Areas

EPA has compiled a number of studies demonstrating that storm water runoff is generally a problem in urbanized areas. This information is divided into storm water impacts due to urban development (section A below) and other discharges to municipal storm sewers (section B below). The Appropriations Act specifically requested that this report provide "documentation demonstrating that storm water runoff is generally a problem in communities with populations of 50,000 to 100,000." While 50,000 is the population threshold used by the Bureau of the Census for defining urbanized areas and EPA adopted the Census definition for the purpose of automatic designation in the Phase II rule, the studies below indicate that water quality impacts will occur in these areas and potentially in areas with lower population densities as well. The Phase II rule would allow the lower population density areas to be designated on a case by case basis.

A. Storm Water Impacts Due to Urban Development

EPA's 1995 Storm Water Phase II Report to Congress (EPA, 1995) and the Coastal Zone Management Measures Guidance (EPA, 1992) describe the impacts from urbanization. Urbanization impacts water quality principally through changes in hydrology and increases in pollutant loadings. Increases in population density and imperviousness due to urbanization can result in significant changes to stream hydrology including:

- increased peak discharges compared to predevelopment levels;
- increased volume of urban runoff produced by each storm in comparison to predevelopment conditions;
- decreased time needed for runoff to reach the stream, particularly if extensive drainage improvements are made;
- increased frequency and severity of flooding;
- reduced streamflow during prolonged periods of dry weather due to reduced level of infiltration in the watershed;
- greater runoff velocity during storms due to the combined effects of higher peak discharges, rapid time of concentration, and the smoother hydraulic surfaces that occur as a result of development.

An increase in imperviousness can also significantly decrease the amount of water infiltration, reducing groundwater recharge.

The types of pollutants found in urban runoff include sediment, nutrients, oxygen-demanding substances, pathogens, road salts, hydrocarbons, heavy metals, and toxics. In addition, thermal impacts from increased temperature of urban runoff and loss of riparian habitat can severely impair aquatic organisms that have finely tuned temperature limits.

1. Urbanization and Imperviousness

Urbanization alters the natural infiltration capability of the land and generates a host of pollutants that are associated with the activities of dense populations, thus causing an increase in storm water runoff volumes and pollutant loadings in storm water discharged to receiving waterbodies (U.S. EPA, 1992). Urban development increases the amount of impervious surface in a watershed as farmland, forests, and meadowlands with natural infiltration characteristics are converted into buildings with rooftops, driveways, sidewalks, roads, and parking lots with virtually no ability to absorb storm water. Storm water and snow-melt runoff wash over these impervious areas, picking up pollutants along the way while gaining speed and volume because of their inability to disperse and filter into the ground. What results are storm water flows that are higher in volume, pollutants, and temperature than the flows in less impervious areas, which have more natural vegetation and soil to filter the runoff (U.S. EPA, 1997. Urbanization and Streams: Studies of Hydrologic Impacts. EPA 841-R-97-009. Office of Water. Washington, DC).

Studies reveal that the level of imperviousness in an area strongly correlates with the quality of the nearby receiving waters. For example, a study in the Puget Sound lowland ecoregion found that when the level of basin development exceeded 5 percent of the total impervious area, the biological integrity and physical habitat conditions that are necessary to support natural biological diversity and complexity declined precipitously (May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. May. 1997. Quality Indices for Urbanization Effects in Puget Sound Lowland Streams, Technical Report No. 154. University of Washington Water Resources Series). Research conducted in numerous geographical areas, concentrating on various variables and employing widely different methods, has revealed a similar conclusion: stream degradation occurs at relatively low levels of imperviousness, such as 10 to 20 percent (even as low as 5 to 10 percent according to the findings of the Washington study referenced above) (Schueler, T.R. 1994. "The Importance of Imperviousness." Watershed Protection Techniques 1(3); May, C., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 1997. "Effects Of Urbanization On Small Streams In The Puget Sound Lowland Ecoregion." Watershed Protection Techniques 2(4); Yoder, C.O., R.J. Miltner, and D. White. 1999. "Assessing the Status of Aquatic Life Designated Uses in Urban and Suburban Watersheds." In Proceedings: National Conference on Retrofits Opportunities in Urban Environments. EPA 625-R-99-002, Washington, DC; Yoder, C.O and R.J. Miltner. 1999. "Assessing Biological Quality and Limitations to Biological Potential in Urban and Suburban Watersheds in Ohio." In Comprehensive Stormwater & Aquatic Ecosystem Management Conference Papers, Auckland, New Zealand). Furthermore, research has indicated that few, if any, urban streams can support diverse benthic communities at imperviousness levels of 25 percent or more. An area of medium density single family homes can be anywhere from 25 percent to nearly 60 percent impervious, depending on the design of the streets and parking (Schueler, 1994).

In addition to impervious areas, urban development creates new pollution sources as population density increases and brings with it proportionately higher levels of car emissions, car maintenance wastes, pet waste, litter, pesticides, and household hazardous wastes, which may be washed into receiving waters by storm water or dumped directly into storm drains designed to discharge to receiving waters. More people in less space results in a greater concentration of pollutants that can be mobilized by, or disposed into, storm water discharges from municipal separate storm sewer systems. A modeling system developed for the Chesapeake Bay indicated that contamination of the Bay and its tributaries from runoff is comparable to, if not greater than, contamination from industrial and sewage sources (Cohn-Lee, R. and D. Cameron. 1992. "Urban Stormwater Runoff Contamination of the Chesapeake Bay: Sources and Mitigation." The Environmental Professional, Vol. 14).

2. Large-Scale Studies and Assessments

In support of Phase II's regulatory designation of MS4s in urbanized areas, the Agency relied on broad-based assessments of urban storm water runoff and related water quality impacts, as well as more site-specific studies. The first national assessment of urban runoff characteristics was completed for the Nationwide Urban Runoff Program (NURP) study (U.S. EPA. 1983.

Results of the Nationwide Urban Runoff Program. Volume 1 - Final Report. Office of Water. Washington, D.C.). The NURP study is the largest nationwide evaluation of storm water discharges, which includes adverse impacts and sources, undertaken to date.

EPA conducted the NURP study to facilitate understanding of the nature of urban runoff from residential, commercial, and industrial areas. One objective of the study was to characterize the water quality of discharges from separate storm sewer systems that drain residential, commercial, and light industrial (industrial parks) sites. Storm water samples from 81 residential and commercial properties in 22 urban/suburban areas nationwide were collected and analyzed during the 5-year period between 1978 and 1983. The majority of samples collected in the study were analyzed for eight conventional pollutants and three heavy metals.

Data collected under the NURP study indicated that discharges from separate storm sewer systems draining runoff from residential, commercial, and light industrial areas carried more than 10 times the annual loadings of total suspended solids (TSS) than discharges from municipal sewage treatment plants that provide secondary treatment. The NURP study also indicated that runoff from residential and commercial areas carried somewhat higher annual loadings of chemical oxygen demand (COD), total lead, and total copper than effluent from secondary treatment plants. Study findings showed that fecal coliform counts in urban runoff typically range from tens to hundreds of thousands per hundred milliliters of runoff during warm weather conditions, with the median for all sites being around 21,000/100 ml. This is generally consistent with studies that found that fecal coliform mean values range from 1,600 coliform fecal units (CFU)/100 ml to 250,000 cfu/100 ml (Makepeace, D.K., D.W. Smith, and S.J. Stanley. 1995. "Urban Storm Water Quality: Summary of Contaminant Data." Critical Reviews in Environmental Science and Technology 25(2):93-139). Makepeace, et al., summarized ranges of contaminants from storm water, including physical contaminants such as total solids (76 - 36,200 mg/L) and copper (up to 1.41 mg/L); organic chemicals; organic compounds, such as oil and grease (up to 110 mg/L); and microorganisms.

Monitoring data summarized in the NURP study provided important information about urban runoff from residential, commercial, and light industrial areas. The study concluded that the quality of urban runoff can be affected adversely by several sources of pollution that were not directly evaluated in the study, including illicit discharges, construction site runoff, and illegal dumping. Data from the NURP study were analyzed further in the U.S. Geological Survey (USGS) Urban Storm Water Data Base for 22 Metropolitan Areas Throughout the United States study (Driver, N.E., M.H. Mustard, R.B. Rhinesmith, and R.F. Middleburg. 1985. U.S. Geological Survey Urban Storm Water Data Base for 22 Metropolitan Areas Throughout the United States. Report No. 85-337 USGS. Lakewood, CO). The USGS report summarized additional monitoring data compiled during the mid-1980s, covering 717 storm events at 99 sites in 22 metropolitan areas and documented problems associated with metals and sediment concentrations in urban storm water runoff. More recent reports have confirmed the pollutant concentration data collected in the NURP study (Marsalek, J. 1990. "Evaluation of Pollutant Loads from Urban Nonpoint Sources." Wat. Sci. Tech. 22(10/11):23-30; Makepeace, et al., 1995).[4]

America's Clean Water - the States' Nonpoint Source Assessment (Association of State and Interstate Water Pollution Control Administrators (ASIWPCA). 1985. America's Clean Water - The States' Nonpoint Source Assessment. Prepared in cooperation with the U.S. EPA, Office of Water, Washington, DC), a comprehensive study of diffuse pollution sources conducted under the sponsorship of the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) and EPA revealed that 38 States reported urban runoff as a major cause of designated beneficial use impairment and 21 States reported storm water runoff from construction sites as a major cause of beneficial use impairment. In addition, the 1996 305(b) Report (U.S. EPA. 1998. The National Water Quality Inventory, 1996 Report to Congress. EPA 841-R-97-008. Office of Water. Washington, DC), provides a national assessment of water quality based on biennial reports submitted by the States as required under CWA section 305(b) of the CWA. In the CWA 305(b) reports, States, Tribes, and Territories assess their individual water quality control programs by examining the attainment or nonattainment of the designated uses assigned to their rivers, lakes, estuaries, wetlands, and ocean shores. A designated use is the legally applicable use specified in a water quality standard for a watershed, waterbody, or segment of a waterbody. The designated use is the desirable use that the water quality should support. Examples of designated uses include drinking water supply, primary contact recreation (swimming), and aquatic life support. Each CWA 305(b) report indicates the assessed fraction of a State's waters that are fully supporting, partially supporting, or not supporting designated beneficial uses.

In their reports, States, Tribes, and Territories first identified and then assigned the sources of water quality impairment for each impaired waterbody using the following categories: industrial, municipal sewage, combined sewer overflows, urban runoff/storm sewers, agricultural, silvicultural, construction, resource extraction, land disposal, hydrologic modification, and habitat modification. The 1996 Inventory, based on a compilation of 60 individual 305(b) reports submitted by States, Tribes, and Territories, assessed the following percentages of total waters nationwide: 19 percent of river and stream miles; 40 percent of lake, pond, and reservoir acres; 72 percent of estuary square miles; and 6 percent of ocean shoreline waters. The 1996 Inventory indicated that approximately 40 percent of the Nation's assessed rivers, lakes, and estuaries are impaired. Waterbodies deemed as "impaired" are either partially supporting designated uses or not supporting designated uses.

The 1996 Inventory also found urban runoff/discharges from storm sewers to be a major source of water quality impairment nationwide. Urban runoff/storm sewers were found to be a source of pollution in 13 percent of impaired rivers; 21 percent of impaired lakes, ponds, and

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[4] EPA notes that it is not relying solely on the NURP study to describe current water quality impairment. Rather, EPA is citing NURP as a source of data on typical pollutant concentrations in urban runoff. Recent studies have not found significantly different pollutant concentrations in urban runoff compared to the original NURP data (see Makepeace, et al., 1995; Marsalek, 1990; and Pitt, et al., 1995).

reservoirs; and 45 percent of impaired estuaries (second only to industrial discharges). In addition, urban runoff was found to be the leading cause of ocean impairment for those ocean miles surveyed.

In addition, a recent USGS study of urban watersheds across the United States has revealed a link between urban development and contamination of local waterbodies. The study found the highest levels of organic contaminants, known as polycyclic aromatic hydrocarbons (PAHs) (products of combustion of wood, grass, and fossil fuels), in the reservoirs of urbanized watersheds (U.S. Geological Survey (USGS). 1998. Research Reveals Link Between Development and Contamination in Urban Watersheds. USGS news release. USGS National Water-Quality Assessment Program).

Urban storm water also can contribute significant amounts of toxicants to receiving waters. Pitt, et. al. (1993), found heavy metal concentrations in the majority of samples analyzed. Industrial or commercial areas were likely to be the most significant pollutant source areas (Pitt, R., R. Field, M. Lalor, M. Brown 1993. "Urban stormwater toxic pollutants: assessment, sources, and treatability" Water Environment Research, 67(3):260-75).

3. Local and Watershed-Based Studies

In addition to the large-scale nationwide studies and assessments, a number of local and watershed-based studies from across the country have documented the detrimental effects of urban storm water runoff on water quality. A study of urban streams in Milwaukee County, Wisconsin, found local streams to be highly degraded due primarily to urban runoff, while three studies in the Atlanta, Georgia, region were characterized as being "the first documentation in the Southeast of the strong negative relationship between urbanization and stream quality that has been observed in other ecoregions" (Masterson, J. and R. Bannerman. 1994. "Impacts of Storm Water Runoff on Urban Streams in Milwaukee County, Wisconsin." Paper presented at National Symposium on Water Quality: American Water Resources Association; Schueler, T.R. 1997. "Fish Dynamics in Urban Streams Near Atlanta, Georgia." Technical Note 94. Watershed Protection Techniques 2(4)). Several other studies, including those performed in Arizona (Maricopa County), California (San Jose's Coyote Creek), Massachusetts (Green River), Virginia (Tuckahoe Creek), and Washington (Puget Sound lowland ecoregion), all had the same finding: runoff from urban areas greatly impair stream ecology and the health of aquatic life; the more heavily developed the area, the more detrimental the effects (Lopes, T. and K. Fossum. 1995. "Selected Chemical Characteristics and Acute Toxicity of Urban Stormwater, Streamflow, and Bed Material, Maricopa County, Arizona." Water Resources Investigations Report 95-4074. USGS; Pitt, R. 1995. "Effects of Urban Runoff on Aquatic Biota." In Handbook of Ecotoxicology; Pratt, J. and R. Coler. 1979. "Ecological Effects of Urban Stormwater Runoff on Benthic Macroinvertebrates Inhabiting the Green River, Massachusetts." Completion Report Project No. A-094. Water Resources Research Center. University of Massachusetts at Amherst.; Schueler, T.R. 1997. "Historical Change in a Warmwater Fish Community in an Urbanizing Watershed." Technical Note 93. Watershed Protection Techniques 2(4); May, C., R. Horner, J.

Karr, B. Mar, and E. Welch. 1997. "Effects Of Urbanization On Small Streams In The Puget Sound Lowland Ecoregion." Watershed Protection Techniques 2(4)).

Pitt and others also described the receiving water effects on aquatic organisms associated with urban runoff (Pitt, R.E. 1995. "Biological Effects of Urban Runoff Discharges" In Stormwater Runoff and Receiving Systems: Impact, Monitoring, and Assessment, ed. E.E Herricks, Lewis Publishers; Crunkilton, R., J. Kleist, D. Bierman, J. Ramcheck, and W. DeVita. 1999. "Importance of Toxicity as a Factor Controlling the Distribution of Aquatic Organisms in an Urban Stream." In Comprehensive Stormwater & Aquatic Ecosystem Management Conference Papers. Auckland, New Zealand).

In Wisconsin, runoff samples were collected from streets, parking lots, roofs, driveways, and lawns. Source areas were broken up into residential, commercial, and industrial. Geometric mean concentration data for residential areas included total solids of about 500-800 mg/L from streets and 600 mg/L from lawns. Fecal coliform data from residential areas ranged from 34,000 to 92,000 cfu/100 mL for streets and driveways. Contaminant concentration data from commercial and industrial source areas were lower for total solids and fecal coliform, but higher for total zinc (Bannerman, R.T., D.W. Owens, R.B. Dods, and N.J. Hornewer. 1993. "Sources of Pollutants in Wisconsin Stormwater." Wat. Sci. Tech. 28(3-5):241-59).

Bannerman, et al. also found that streets contribute higher loads of pollutants to urban storm water than any other residential development source. Two small urban residential watersheds were evaluated to determine that lawns and streets are the largest sources of total and dissolved phosphorus in the basins (Waschbusch, R.J., W.R. Selbig, and R.T. Bannerman. 1999. "Sources of Phosphorus in Stormwater and Street Dirt from Two Urban Residential Basins In Madison, Wisconsin, 1994-95." Water Resources Investigations Report 99-4021. U.S. Geological Survey). A number of other studies have indicated that urban roadways often contain significant quantities of metal elements and solids (Sansalone, J.J. and S.G. Buchberger. 1997. "Partitioning and First Flush of Metals in Urban Roadway Storm Water." ASCE Journal of Environmental Engineering 123(2); Sansalone, J.J., J.M. Koran, J.A. Smithson, and S.G. Buchberger. 1998. "Physical Characteristics of Urban Roadway Solids Transported During Rain Events" ASCE Journal of Environmental Engineering 124(5); Klein, L.A., M. Lang, N. Nash, and S.L. Kirschner. 1974. "Sources of Metals in New York City Wastewater" J. Water Pollution Control Federation 46(12):2653-62; Barrett, M.E, R.D. Zuber, E.R. Collins, J.F. Malina, R.J. Charbeneau, and G.H Ward., 1993. "A Review and Evaluation of Literature Pertaining to the Quantity and Control of Pollution from Highway Runoff and Construction." Research Report 1943-1. Center for Transportation Research, University of Texas, Austin).

4. Beach Closings/Advisories

Urban wet weather flows have been recognized as the primary sources of estuarine pollution in coastal communities. Urban storm water runoff, sanitary sewer overflows, and combined sewer overflows have become the largest causes of beach closings in the United States in the past three years. Storm water discharges from urban areas not only pose a threat to the ecological environment, they also can substantially affect human health. A survey of coastal and Great Lakes communities found that more than 1,500 beach closings and advisories where attributable to storm water runoff in 1998 (Natural Resources Defense Council. 1998. "Testing the Waters Volume VIII-Has Your Vacation Beach Cleaned Up Its Act?" New York, NY). Other reports also document public health, shellfish bed, and habitat impacts from storm water runoff, including more than 823 beach closings/advisories issued in 1995 and more than 407 beach closing/advisories issued in 1996 due to urban runoff (Natural Resources Defense Council. 1996. Testing the Waters Volume VI: Who Knows What You're Getting Into. New York, NY; NRDC. 1997. Testing the Waters Volume VII: How Does Your Vacation Beach Rate. New York, NY; Morton, T. 1997. Draining to the Ocean: The Effects of Stormwater Pollution on Coastal Waters. American Oceans Campaign, Santa Monica, CA). The Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay (Haile, R.W., et. al. 1996. "An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay." Final Report prepared for the Santa Monica Bay Restoration Project) concluded that there is a 57 percent higher rate of illness in swimmers who swim adjacent to storm drains than in swimmers who swim more than 400 yards away from storm drains. This and other studies document a relationship between gastrointestinal illness in swimmers and water quality, the latter of which can be heavily compromised by polluted storm water discharges.

B. Other Discharges to Municipal Storm Sewers

In addition to runoff from storm events, municipal separate storm sewer systems may receive and ultimately discharge other materials introduced into the system. Non-storm water discharges to storm sewers come from a variety of sources, including:

- illicit connections and cross connections from industrial, commercial, and sanitary sewage sources
- leaking sanitary sewage systems
- malfunctioning on-site disposal systems (septic systems)
- improper disposal of wastes such as used oil, wastewater and litter
- spills
- infiltration of ground water contaminated by a variety of sources, including leaking underground storage tanks
- wash waters, lawn irrigation, and other drainage sources.

Studies have shown that discharges from MS4s often include wastes and wastewater from non-storm water sources. Federal regulations (§ 122.26(b)(2)) define an illicit discharge as "...any discharge to an MS4 that is not composed entirely of storm water...," with some exceptions. These discharges are "illicit" because municipal storm sewer systems are not designed to accept, process, or discharge such wastes. Sources of illicit discharges include, but are not limited to,: sanitary wastewater; effluent from septic tanks; car wash, laundry, and other industrial wastewaters; improper disposal of auto and household toxics, such as used motor oil and pesticides; and spills from roadway and other accidents.

Illicit discharges enter the system through either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the MS4 from cracked sanitary systems, spills collected by drain outlets, and paint or used oil dumped directly into a drain). The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses and bacteria into receiving waterbodies. The NURP study, discussed earlier, found that pollutant levels from illicit discharges were high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health. The study noted particular problems with illicit discharges of sanitary wastes, which can be directly linked to high bacterial counts in receiving waters and can be dangerous to public health.

Because illicit discharges to MS4s can create severe widespread contamination and water quality problems, several municipalities and urban counties performed studies to identify and eliminate such discharges. In Michigan, the Ann Arbor and Ypsilanti water quality projects inspected 660 businesses, homes, and other buildings and identified 14 percent of the buildings as having improper storm sewer drain connections. The program assessment revealed that, on average, 60 percent of automobile-related businesses, including service stations, automobile dealerships, car washes, body shops, and light industrial facilities, had illicit connections to storm sewer drains. The program assessment also showed that a majority of the illicit discharges to the storm sewer system resulted from improper plumbing and connections, which had been approved by the municipality when installed (Washtenaw County Statutory Drainage Board. 1987. Huron River Pollution Abatement Program).

In addition, an inspection of urban storm water outfalls draining into Inner Grays, Washington, indicated that 32 percent of these outfalls had dry weather flows. Of these flows, 21 percent were determined to have pollutant levels higher than the pollutant levels expected in typical urban storm water runoff characterized in the NURP study (U.S. EPA. 1993. Investigation of Inappropriate Pollutant Entries Into Storm Drainage Systems -- A User's Guide. EPA 600/R-92/238. Office of Research and Development. Washington, DC). That same document reports a study in Toronto, Canada, that found that 59 percent of outfalls from the MS4 had dry-weather flows. Chemical tests revealed that 14 percent of these dry-weather flows were determined to be grossly polluted.

Inflows from aging sanitary sewer collection systems are one of the most serious illicit discharge-related problems. Sanitary sewer systems frequently develop leaks and cracks, resulting in discharges of pollutants to receiving waters through separate storm sewers. These pollutants include sanitary waste and materials from sewer main construction (e.g., asbestos cement, brick, cast iron, vitrified clay). Municipalities have long recognized the reverse problem of storm water infiltration into sanitary sewer collection systems; this type of infiltration often disrupts the operation of the municipal sewage treatment plant.

The improper disposal of materials is another illicit discharge-related problem that can result in contaminated discharges from separate storm sewer systems in two ways. First, materials may be disposed of directly in a catch basin or other storm water conveyance. Second, materials disposed of on the ground may either drain directly to a storm sewer or be washed into a storm sewer during a storm event. Improper disposal of materials to street catch basins and other storm sewer inlets often occurs when people mistakenly believe that disposal to such areas is an environmentally sound practice. Part of the confusion may occur because some areas are served by combined sewer systems, which are part of the sanitary sewer collection system, and people assume that materials discharged to a catch basin will reach a municipal sewage treatment plant. Materials that are commonly disposed of improperly include used motor oil; household toxic materials; radiator fluids; and litter, such as disposable cups, cans, and fast-food packages. EPA believes that there has been increasing success in addressing these problems through initiatives such as storm drain stenciling and recycling programs, including household hazardous waste special collection days.

Programs that reduce illicit discharges to separate storm sewers have improved water quality in several municipalities. For example, Michigan's Huron River Pollution Abatement Program found the elimination of illicit connections caused a measurable improvement in the water quality of the Washtenaw County storm sewers and the Huron River (Washtenaw County Statutory Drainage Board, 1987). In addition, an illicit detection and remediation program in Houston, Texas, has significantly improved the water quality of Buffalo Bayou. Houston estimated that illicit flows from 132 sources had a flow rate as high as 500 gal/min. Sources of the illicit discharges included broken and plugged sanitary sewer lines, illicit connections from sanitary lines to storm sewer lines, and floor drain connections (Glanton, T., M.T. Garrett, and B. Goloby. 1992. The Illicit Connection: Is It the Problem? Wat. Env. Tech. 4(9):63-8).

V. RATIONALE FOR USING A NPDES APPROACH

This section responds to the Appropriations Act's direction to provide a report containing:

"(4) information that supports the position of the Administrator that the Phase II stormwater program should be administered as part of the National Pollutant Discharge Elimination System under section 402 of the Federal Water Pollution Control Act (33 U.S.C. 1342)"

EPA interprets Clean Water Act section 402(p)(6) as authorizing the Agency to develop a storm water program for Phase II sources either as part of the existing NPDES permit program or as a stand alone non-NPDES program such as a self-implementing rule. Although EPA believes that it has the discretion to not require sources regulated under CWA section 402(p)(6) to be covered by NPDES permits, the Agency has determined, for the reasons discussed below, that it is most appropriate to use NPDES permits in implementing the program to address the sources designated for regulation in Phase II. EPA believes that the NPDES program best achieves the goals of the Phase II rule for the following reasons:

- Applying an NPDES permit approach to Phase II sources allows for consistent regulation between larger MS4s and construction sites regulated under Phase I and smaller sources regulated under Phase II.
- Use of NPDES permits to regulate Phase II municipalities will allow co-permitting of small regulated MS4s with larger MS4s regulated under the existing Phase I storm water program.
- The use of NPDES permits is a familiar regulatory implementation vehicle that is well understood by State regulators and potential permittees.
- NPDES permits provide the flexibility to allow the use of general permits on a watershed basis, while also allowing site-specific controls to be developed on a case-by-case basis.
- NPDES permits allow incorporation by reference of existing State, Tribal and local programs.
- NPDES permit applications and NOIs provide important information to regulatory authorities and the public.
- NPDES permit procedures include beneficial processes for citizen participation and enforcement.
- NPDES permits are federally enforceable under the CWA.

- NPDES permit coverage provides "permit as a shield" legal protection to the permittee.

- NPDES permit coverage provides an established and predictable regulatory regime to avoid duplicative regulation under the Resource Conservation and Recovery Act and the Comprehensive Emergency Response, Compensation, and Liability Act, due to exclusions from regulation for facilities subject to NPDES permits.

In developing an approach for the Phase II rule, individual members of both the FACA Committee and the Storm Water Phase II FACA Subcommittee encouraged EPA to seek opportunities to integrate, where possible, the proposed Phase II requirements with existing Phase I requirements, thus facilitating a unified and "seamless" storm water discharge control program. EPA believes that using the NPDES framework is the best means of integrating the regulation of Phase II sources with the existing storm water program. The NPDES framework is already applied to regulated storm water sources and can be extended to the sources to be regulated in Phase II. This approach facilitates program consistency, public access to information, and program oversight.

Requiring Phase II sources to be covered by NPDES permits would help address the consistency problems currently caused by municipal "donut holes." Donut holes are gaps in program coverage where a small unregulated MS4 is located next to or within a regulated larger MS4 that is subject to an NPDES permit under the existing NPDES storm water program. The existence of such "donut holes" creates an equity problem because similar discharges may remain unregulated even though they cause or contribute to the same adverse water quality impacts. Using NPDES permits to regulate the unregulated discharges in these areas is intended to facilitate the development of a seamless regulatory program for the mitigation and control of contaminated storm water discharges in an urbanized area. For example, the Phase II rule would allow a newly regulated MS4 to join as a "limited" co-permittee with a regulated MS4 by referencing a common storm water management program. Such cooperation should be further encouraged by the fact that the minimum control measures to be required in the Phase II rule for regulated small MS4s are very similar to a number of the permit requirements for medium and large MS4s under the existing storm water program. The minimum control measures applicable to discharges from smaller MS4s under Phase II are described with slightly more generality than under the Phase I permit application regulations for larger MS4s, thus enabling maximum flexibility for operators of smaller MS4s to optimize efforts to protect water quality.

The Phase II rule would also apply NPDES permit requirements to construction sites below 5 acres that are similar to the existing requirements for those 5 acres and above. In addition, the rule would allow compliance with qualifying local, Tribal, or State erosion and sediment controls to meet the erosion and sediment control requirements of the general permits for storm water discharges associated with construction, both above and below 5 acres.

Incorporating the CWA section 402(p)(6) program into the NPDES program capitalizes upon the existing governmental infrastructure for administration of the NPDES program.

Moreover, much of the regulated community already understands the NPDES program and the way it works.

Another goal of the NPDES program approach is to provide flexibility in order to facilitate and promote watershed planning and sensitivity to local conditions. The following are some of the more significant examples of the flexibility provided by the NPDES approach:

- NPDES general permits may be used to cover a category of regulated sources on a watershed basis or within political boundaries.
- The NPDES permitting process provides a mechanism for storm water controls tailored on a case-by-case basis, where necessary.
- The NPDES permit requirements of a permittee may be satisfied by another cooperating entity.
- NPDES permits may incorporate the requirements of existing State, Tribal and local programs, thereby accommodating State and Tribes seeking to coordinate the storm water program with other programs, including those that focus on watershed-based nonpoint source regulation.

NPDES permits generally require an application or a notice of intent to trigger coverage. This information exchange assures communication between the permitting authority and the regulated community. This communication is critical in ensuring that the regulated community is aware of the requirements and the permitting authority is aware of the potential for adverse impacts to water quality from identifiable locations. The NPDES permitting process includes the public as a valuable stakeholder and ensures that the public is included and information is made publicly available.

Another concern for EPA and several of the individual FACA Subcommittee members was that the program ensure citizen participation. The NPDES approach ensures opportunities for citizen participation throughout the permit issuance process, as well as in enforcement actions. NPDES permits are also federally enforceable under the CWA.

EPA believes that the use of NPDES permits makes a significant difference in the degree of compliance with regulations in the storm water program. The Agency does not anticipate that a self-implementing rule would ensure the degree of public participation needed for the development, enforcement and revision of the storm water management program. Citizen suit enforcement has assisted in focusing attention on adverse water quality impacts on a localized, public priority basis. Citizens frequently rely on the NPDES permitting process and the availability of NOIs to track program implementation and help them enforce regulatory requirements.

NPDES permits are also advantageous to the permittee. The NPDES permit informs the permittee about the scope of what it is expected do to be in compliance with the Clean Water Act. As explained more fully in EPA's April 1995 guidance, Policy Statement on Scope of Discharge Authorization and Shield Associated with NPDES Permits, compliance with an NPDES permit constitutes compliance with the Clean Water Act (see CWA section 402(k)). In addition, NPDES permittees are excluded from duplicative regulatory regimes under the Resource Conservation and Recovery Act and the Comprehensive Emergency Response, Compensation and Liability Act under RCRA's exclusions to the definition of "solid waste" and CERCLA's exemption for "federally permitted releases."

Throughout development of the rule, State representatives sought alternatives to the NPDES approach for State implementation of the storm water program for Phase II sources. Discussions focused on an approach whereby States could develop an alternative program that EPA would approve or disapprove based on identified criteria, including that the alternative non-NPDES program would result in "equivalent or better protection of water quality." The State representatives, however, were unable to propose or recommend criteria for gauging whether a program would provide equivalent protection. EPA also did not receive any suggestions for objective, workable criteria in response to the Agency's explicit request for specific criteria (by which EPA could objectively judge such programs) in the preamble to the proposed rule.

EPA also considered suggestions that the Agency authorize Phase II to be implemented as a self-implementing rule, which would be a regulation promulgated at the Federal, State, or Tribal level to control some or all of the storm water dischargers regulated under the Phase II rule. Under this approach, a rule would spell out the specific requirements for dischargers and impose the restrictions and conditions that would otherwise be contained in an NPDES permit. It would be effective until modified by EPA, a State, or a Tribe, unlike an NPDES permit which cannot exceed a duration of five years. Some stakeholders believed that this approach would reduce the burden on the regulated community (e.g., by not requiring permit applications), and considerably reduce the amount of additional paperwork, staff time and accounting required to administer the proposed permit requirements.

EPA is sensitive to the interest of some stakeholders in having a streamlined program that minimizes the burden associated with permit administration and maximizes opportunities for field time spent by regulatory authorities. Key provisions in the Phase II rule would address some of these concerns by promoting a streamlined approach to permit issuance by, for example, using general permits for coverage of Phase II permittees and allowing the incorporation of existing programs. By adopting the NPDES approach rather than a self-implementing rule, the Phase II rule also allows for consistent regulation between larger MS4s and construction sites regulated under the Phase I rule and smaller sources regulated under Phase II.

EPA believes that it is most appropriate to use NPDES permits to implement a program to address Phase II sources. In addition to the reasons discussed above, NPDES permits provide a better mechanism than would a self-implementing rule for tailoring storm water controls on a case-by-case basis, where necessary. A self-implementing rule would not ensure the degree of public participation that the NPDES permit process provides for the development, enforcement and revision of the storm water management program. A self-implementing rule also might not have provided the regulated community the "permit shield" under CWA section 402(k) that is provided by an NPDES permit. Based on all these considerations, EPA declined to adopt a self-implementing rule approach and adopted the NPDES approach for Phase II sources.

United States
Environmental Protection
Agency

Office of Water
Washington, DC 20460
www.epa.gov/water

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EPA REDUCING POLLUTED RUNOFF: THE STORM WATER PHASE II RULE

As part of the Administration's ongoing efforts to curb polluted runoff, the Environmental Protection Agency (EPA) is finalizing a new rule to control storm water runoff from smaller storm sewer systems in urbanized areas and smaller construction sites. The second half of EPA's effort to control storm water, the storm water Phase II rule will make approximately 3,000 more miles of rivers safe for boating and protect up to 500,000 people a year from illness due to swimming in contaminated waters. Improving controls on storm water runoff will also prevent thousands of annual beach closures, make fish and seafood safer to eat, and reduce the costs of drinking water treatment.

Storm water runoff is polluting our waterways. When it rains or snows, the water that runs off of city streets, parking lots, and construction sites can wash sediment, oil, grease, toxics, pathogens, and other pollutants into nearby storm drains. Once this pollution has entered the sewer system, it is discharged–untreated–into local streams and waterways. Known as storm water runoff, this pollution is a leading threat to public health and the environment today.

Improving controls on storm water runoff. New regulations being finalized by EPA, known as storm water Phase II, will reduce the impacts of storm water runoff through a strengthened, yet flexible and cost-effective, storm water program. Phase I of the storm water program, which was promulgated in November 1990, covered municipal storm sewer systems serving populations over 100,000, construction sites above five acres, and industrial activities.

Expanding permit requirements for municipal storm sewer systems. Building upon the existing storm water program, storm water Phase II requires municipal storm sewer systems serving populations under 100,000 that are located in urbanized areas to obtain a National Pollutant Discharge Elimination System (NPDES) permit under the Clean Water Act. This will result in storm water controls for approximately 5,040 additional municipalities across the country. Types of controls could include public education programs, storm sewer inspections for illegal connections, and ordinances to control construction site runoff.

Providing flexibility for municipalities. The Phase II rule takes a "best management practice" approach, providing municipalities with the flexibility to decide what these practices should be. Municipal Phase II storm water programs are to be composed of six minimum control measures, including:

- public education and outreach;
- public involvement and participation;
- illicit discharge detection and elimination;

- construction site storm water runoff control;
- post-construction storm water management; and
- pollution prevention, or "good housekeeping," for municipal operations.

Municipalities may be able to use existing programs to satisfy these control measures, thereby avoiding program duplication. The use of general, rather than individual, permits is encouraged. There is permitting flexibility for municipal storm sewer systems serving under 10,000 people, including waivers and permit phase-in options. In addition, to control environmental and public health impacts, unregulated facilities and activities that are causing water quality impairments may be brought into the program and required to obtain a storm water permit on a case-by-case basis.

Controlling impacts of development. Storm water Phase II requires operators of construction sites disturbing one to five acres to obtain an NPDES permit. Sediment, which runs off of construction sites at a rate of anywhere between 20 and 150 tons/acre/year, has been identified as the single largest cause of impaired water quality in rivers and the third largest cause of impaired water quality in lakes. The additional coverage provided under the storm water Phase II rule will ensure that sediment discharges from more than 97 percent of the land disturbed by construction activity will be controlled under a storm water permit. Types of controls could include filter fences, storm drain inlet protections, and temporary mulching and seeding of exposed land areas.

Providing incentives for industrial facilities. For those industrial facilities currently covered under Phase I of the storm water program, the new rule provides incentives to protect operations from storm water exposure. At least 70,000 industrial facilities may be able to take advantage of this new provision by adopting practices to protect their operations from exposure to storm water impacts, such as covering operations under a storm resistant shelter.

Targeting polluted runoff–an Administration priority. The new storm water Phase II rule is a key action under the Administration's Clean Water Action Plan. A primary goal of the Clean Water Action Plan is to strengthen controls for polluted runoff, the leading remaining cause of water pollution today.

*****

The storm water Phase II rule was proposed by EPA in January 1998 and received more than 500 comments during a 90 day comment period. EPA will provide a 'tool box' to facilitate implementation, including fact sheets, federal financing programs, guidance, training, research and additional support. Municipalities and construction sites will have up to three years and 90 days from the date the new rule takes affect to obtain a storm water permit. For more information on storm water Phase II, please call (202) 260-5816, e-mail your questions to sw2@epa.gov or visit EPA's website at http://www.epa.gov/owm/sw/phase2 on the Internet.

City of Greensboro
Storm Water Services

Stormwater Management Manual

First Edition

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SECTION 1: INTRODUCTION

1.1 Purpose

The purpose of the Stormwater Management Manual is to provide engineers, developers, property owners and managers, and interested citizens with information on stormwater management requirements, technical guidance on the methodology that can be used to meet the requirements, and guidelines for designing, implementing, and maintaining Best Management Practices (BMPs) that may be used in the City of Greensboro to improve the quality of surface waters, and minimize the stormwater runoff volume and discharge rates from developed areas. This manual will explain the need for stormwater management in Greensboro and describe the minimum design requirements and accepted methodology for meeting City ordinance requirements. The manual also includes a comprehensive review of the most effective BMPs currently used for stormwater management: which BMPs work best for different development scenarios, which BMPs may be implemented to meet different regulatory requirements, and those BMPs that can be used to receive credit on the stormwater utility fee. The manual provides design, installation, and maintenance guidelines for various BMPs to increase the options for stormwater BMPs and to improve BMP's water quality functionality, ease of maintenance, and longevity.

This manual is not intended to stifle creativity of the designer; rather the City encourages and is open to reviewing new procedures, techniques, and stormwater best management practices where they can be shown to be appropriate by the design professional. While the City intends to develop stormwater quantity and quality management master plans for all watersheds within the city limits to serve as guidance for drainage system and best management practice design, the responsibility for adequate and appropriate stormwater management control measures for a given site remains with the qualified design professional.

Because urban stormwater quantity and quality management is a relatively new practice, design guidelines will likely be changing in the future as the needs for each watershed and sub-watershed are determined in the master planning process, new technologies are developed based information obtained from long-term monitoring data, and changes occur in regulatory requirements. The City will strive to keep this manual updated to allow for increased flexibility and efficiency in stormwater management.

1.2 Need for Stormwater Management

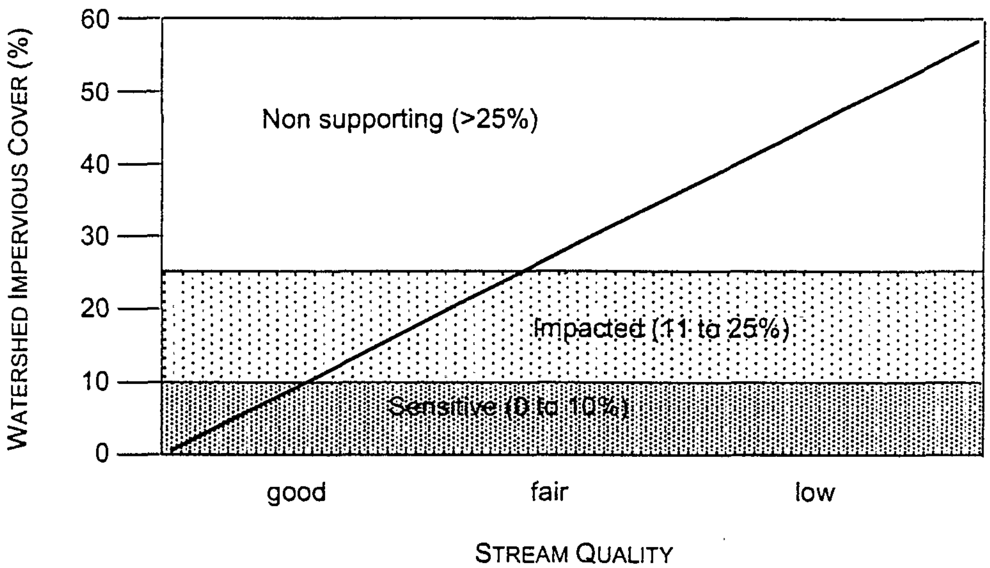
1.2.1 Effects of Urbanization on Watershed Hydrology and Pollutant Loading

Changes in the land use in Greensboro resulting from urbanization have affected the regional hydrology and pollutant loading in stormwater runoff. This has resulted in increased stormwater quantity and quality problems including:

⇨ degradation of overall water quality
⇨ floodplain expansion
⇨ increased flooding frequency
⇨ stream channel enlargement and erosion
⇨ changes in stream flow patterns (high storm flows, low dry weather flow)
⇨ loss of stream habitat
⇨ decline in stream biological function
⇨ property damage and safety concerns
⇨ unsightly stream channel conditions

Research has generally shown that impacts to surface waters are directly related to watershed imperviousness and that impacts can begin to be significant when the watershed reaches the threshold value of 10% imperviousness (Figure 1.1).

Figure 1.1: Relationship Between Impervious Cover and Stream Quality



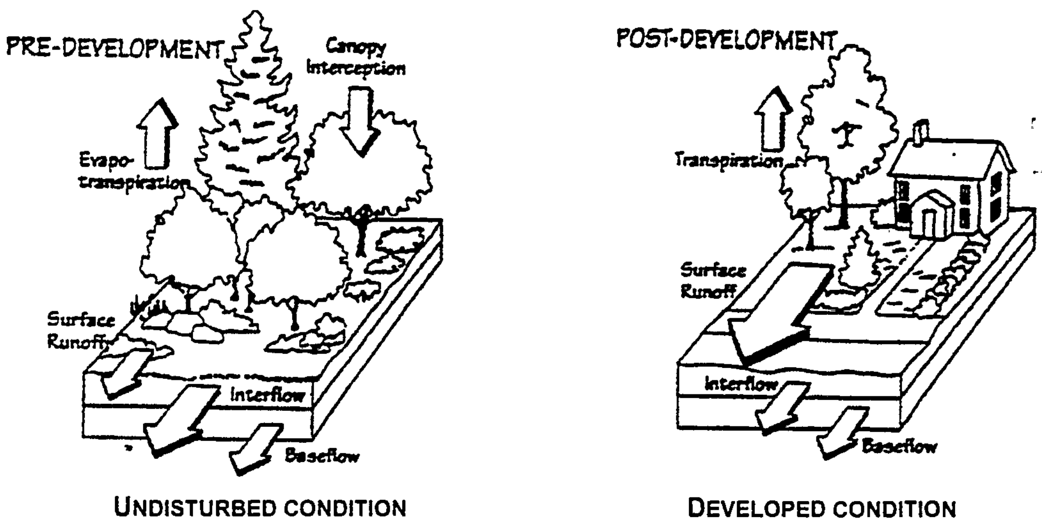
SOURCE: SCHUELER

Watershed Hydrology

Undisturbed areas have vegetation and organic topsoil that intercept precipitation and a natural topography that consists of small depressions that store precipitation and allow a significant fraction of precipitation to infiltrate into the ground. As these areas are developed, the vegetation and organic topsoil are stripped away, the complex natural topography is graded to uniform slopes, the soil is tightly compacted by heavy construction equipment, and impervious areas such as streets, sidewalks, parking lots, and buildings cover the landscape. As a result, much less water has a chance to infiltrate into the soil and therefore, the quantity of stormwater runoff drastically increases after the site is developed (Figure 1.2).

To manage the higher rates and larger volumes of runoff, drainage systems have historically been designed to remove the stormwater from developed areas as quickly as possible. This practice adequately served its purposes during the early days of Greensboro's development. However, the recent urbanization and corresponding increased runoff has produced drastic changes to stream channel geometry, stream hydrology, and floodplain expansion.

Figure 1.2: Changes in Water Balance due to Urbanization

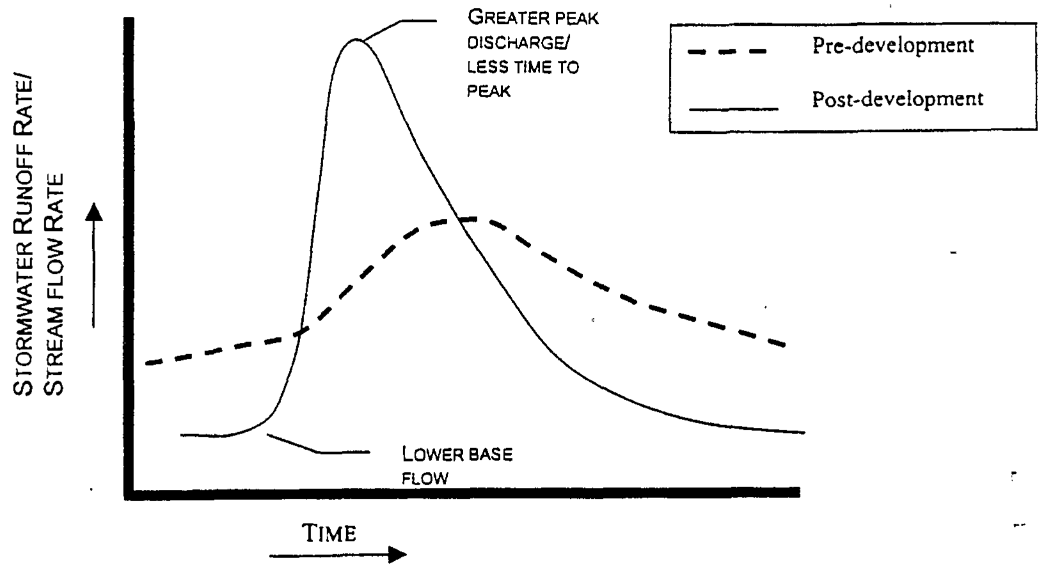


Source: CONTROLLING URBAN RUNOFF, METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

As higher flowrates are experienced in streams (Figure 1.3), streams naturally increase their cross sectional area to accommodate the increased flow. The stream will deepen and widen, often resulting in high vertical banks that are unstable. As the watershed continues to urbanize, the stream will continue to erode away its channel banks and bottom.

Stream erosion contributes to water quality problems by increasing the sediment loading in the stream flow which increases turbidity, degrades aquatic habitat, and fills in slow moving surface waters more rapidly. Also, eroded banks have created unsightly conditions and, in some cases, damage to adjacent public and private property, as well as a potential safety hazard.

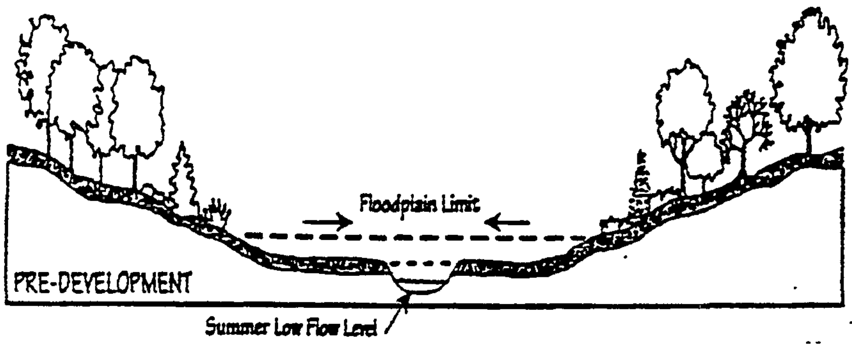
Figure 1.3: Changes in Hydrology due to Urbanization



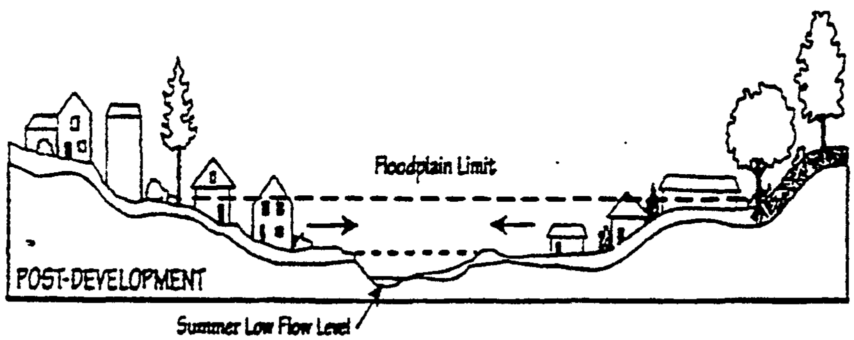
As previously stated, in urban areas the majority of precipitation is converted to surface runoff that quickly discharges to the stream. Thus, the infiltration of precipitation into the soil is significantly reduced which results in lower groundwater (base) flow. The base flow supplies streams with steady flow during dry periods. This reduction in base flow may cause streams that used to be normally wet during the year to "dry up" and only convey runoff during and shortly after a rain storm event. The aquatic habitat in the stream section may not be able to survive. In larger urban streams the quantity and depth of stream flow during dry periods will generally be less, which may impact the diversity of fish habitat and their ability of passage.

In addition, the increased stream flow volumes and rates associated with stormwater from urbanized areas tends to produce more frequent floods and cause expansion of the floodplain. For example, areas that were previously flooded only once during five years may flood every year, or even several times each year. Also, areas that were previously not flooded now may be within the floodplain and those properties in the floodplain will experience higher flood levels, as shown in Figure 1.4.

Figure 1.4: Changes in Floodplain due to Urbanization



PRE-DEVELOPMENT FLOODPLAIN



POST-DEVELOPMENT FLOODPLAIN

SOURCE: CONTROLLING URBAN RUNOFF METROPOLITAN WASHINGTON COUNCIL OF GOVERNEMENTS

Pollutant Loading

In addition to the changes in watershed hydrology, urbanization has adversely impacted surface water quality through pollution transported by stormwater runoff. According to EPA's report to Congress, urban runoff is the number two source of pollution in lakes and estuaries and the number three source of pollution in rivers (Horsely, 1997). Examples of pollution associated with urban stormwater runoff are shown in Table 1.1.

The City has performed monitoring studies to determine the effects that urbanization has on pollutant loading in stormwater runoff. The studies included collecting runoff samples from different land use areas within the City of Greensboro and determining the concentration of various pollutants. Table 1.2 summarizes some of the monitoring data collected between April 1995 and October 1998.

Table 1.1: Examples of Pollution in Urban Runoff	
POLLUTANTS	**EXAMPLES**
Floatables	Litter such as paper cups and plastic bags
Bacteria	Leaking sanitary sewers; septic tanks; animal wastes
Oil and grease	Vehicle drippings; improper disposal
Nutrients	Fertilizers; sanitary sewer leaks
Pesticides	Outdoor applications
Metals	Vehicle parts wear (brakes, tires, engine parts), paint
Thermal impacts	Runoff from impervious surfaces; loss of stream canopy

TABLE 1.2: POLLUTANT EVENT MEAN CONCENTRATIONS (MG/L) FOR DIFFERENT LAND USES IN GREENSBORO			
POLLUTANT	**COMMERCIAL[1]**	**RESIDENTIAL[2]**	**OPEN[3]**
Cadmium	0.0009	0.0003	0.0003
Copper	0.02	0.01	0.003
Lead	0.02	0.024	0.005
Zinc	0.22	0.01	0.02
Ammonia Nitrogen	0.65	0.51	0.50
Biochemical Oxygen Demand 5-Day (BOD)	33.92	20.79	6.25
Chemical Oxygen Demand (COD)	99.79	86.26	33.13
Nitrate	1.48	0.76	0.19
Dissolved Phosphorus	0.38	0.31	0.26
Total Phosphorus	0.66	0.35	0.29
Total Dissolved Solids (TDS)	120	98	90
Total Suspended Solids (TSS)	157	87	45
Total Kjeldahl Nitrogen (TKN)	2.1	1.46	0.53

[1] Heavy Commercial Land Use – 90% imperviousness
[2] Residential/Institutional Land Use – 50% imperviousness
[3] Open Park/Undisturbed Land Use – 2% imperviousness

From Table 1.2 it can be seen that pollutant concentrations generally increase as urbanization intensifies.

Urbanization has major impacts on the hydrology of watersheds in the City and the quality of our limited water resources. For this reason, it is crucial that stormwater BMPs be implemented to help offset the impacts of development through proper management of pollutant sources and stormwater runoff.

1.2.2 Stormwater Management Regulations and Policies

To address the adverse effects of urbanization on water quality, Federal, State and local regulations have been adopted to protect the quality of surface waters. In the past, regulations targeted point source discharges such as effluent from wastewater treatment facilities, but now regulations also require pollution control of stormwater runoff.

NPDES Discharge Permits

With the Clean Water Act, the EPA mandated that it is illegal to discharge any pollutant to "waters of the United States" without a National Pollutant Discharge Elimination System (NPDES) Permit.

Industrial Stormwater Permit
Stormwater runoff from "Industrial Activities" is considered a discharge that is illegal without an NPDES Permit. Generally, the Industrial NPDES Permit requires certain industries to develop and implement a Stormwater Pollution Prevention Plan (SWPPP), which includes various BMPs to minimize pollution to surface waters.

Municipal Stormwater Permit
The City of Greensboro and other municipalities with a population over 100,000 (Phase I cities) are required to obtain a NPDES Municipal Separate Storm Sewer System (MS4) Discharge Permit. The Permit requires the development and implementation of a Storm Water Quality Management Program (SWQMP) to control the discharge of pollutants from the municipal separate storm sewer system to the maximum extent practicable. The City of Greensboro established the Storm Water Services Division to administer and manage this program. Storm Water Services is responsible for monitoring of water quality in streams, stormwater master planning, providing public environmental education, implementation of capital improvement projects, and other activities aimed at improving the quality of our surface waters and management of stormwater runoff.

To fund the Storm Water Services Division, a stormwater utility fee is assessed on all properties within city limits. Residential properties are assessed a flat rate, while non-residential properties are assessed a fee based on the amount of impervious area that exists on the property.

Water Supply Watershed Protection Requirements

The City of Greensboro utilizes and depends on a series of lakes on the Reedy Fork Creek in the northern region of the city for its drinking water supply. Due to rapid development in the watershed of the water-supply lakes, Guilford County and subsequently the City adopted a Water Supply Watershed Protection Ordinance in the mid 1980s to protect the Reedy Fork (Greensboro) watershed (refer to Appendix A for maps showing the Greensboro watershed). There are other protected drinking water supply watersheds besides the Reedy Fork watershed where a portion of the watershed is within the jurisdictional boundaries of the City. A portion of High Point, Randleman Lake, and Burlington watersheds are regulated by the City of Greensboro.

In the early 1990s, the State of North Carolina adopted regulations that set forth minimum watershed management requirements to protect drinking water supplies and required local governments to adopt and enforce these regulations within their water supply protection ordinance. In 1999, the State set forth new regulations for increased protection of the Upper and Lower Randleman watersheds. These regulations were adopted in the City's ordinance in December 1999 (see Appendix A). The State regulations serve to protect water supply reservoirs and their watersheds by imposing restrictions on "new development" in the following ways:

- ⇨ **limits on built-upon area**
- ⇨ **use of stormwater BMPs**
- ⇨ **protection of buffers along streams and lakes**

To enforce these regulations, the City requires that before any new development or re-development activities begin on a site located within a protected water supply watershed, a *Watershed Development Plan* must be submitted to the City for approval. The Watershed Development Plan, when required, should be incorporated into the *Stormwater Management Plan* as described in the following section.

The Watershed Development Plan must show that built-upon surfaces do not exceed the maximum percentage of built-upon area allowed. Built-upon area includes all impervious surfaces but also includes some areas that are partially impervious (e.g. gravel areas, dirt roads, etc.). The amount of built-upon area that is allowed on new development sites in a particular watershed depends on the classification of the watershed.

For "high density" development sites, the Watershed Development Plan must show how structural BMPs will be implemented to improve the quality of runoff from the site. The structural BMPs must be proven facilities and at a minimum meet the design criterion of

85% removal of total suspended solids (TSS) from runoff resulting from the first one inch of rainfall.

For "low density" development sites in the General Watershed Area, the Watershed Development Plan must indicate that the site design will minimize impacts to the environment. A passing score on the "General Watershed Area Performance Scoresheet" is required before a "low density" development can be approved for watershed protection. Low density development in the watershed critical area has different requirements.

The Watershed Development Plan must also show buffers along streams that are required to be protected. The type of streams that are required to be protected and the development activity that is allowed in the buffer may differ in each watershed.

This manual gives guidance on site design techniques to reduce impacts to the water-supply watersheds, and design criteria for structural BMPs to meet the requirements for high-density development. For items required on the Watershed Development Plan refer to Section 2. For more information on specific regulations in the water supply watersheds, refer to Section 2 of this manual and the City's water supply watershed protection ordinance, which can be viewed online at *www.ci.greensboro.nc.us.*

Storm Water Management Ordinance

Chapter 27 of the City Code of Ordinances is the Storm Water Management Ordinance. The main objective of this ordinance is to provide enforcement authority to meet the City's municipal NPDES Permit and associated SWQMP.

Another key objective of this ordinance is to protect properties from potential stormwater quantity and quality problems. Potential problems include increased flooding and drainage problems due to inadequate or lack of conveyance systems and excessive stream bank erosion/channel widening due to increased runoff from developed areas.

On March 16, 1999 and April 4, 2000, the City Council adopted amendments to Chapter 27 of the Greensboro Code of Ordinances (Section 27-22) to control the adverse effects of increased stormwater runoff associated with newly developed or redeveloped sites. The revised ordinance requires all new development within the city limits to submit a *Stormwater Management (SWM) Plan.*

The SWM Plan must show stream buffers along all open (1) perennial streams and (2) drainage channels draining an area greater than 50 acres. The SWM Plan must also include an *offsite stormwater conveyance system analysis* that shows the effects the development will have on the downstream properties including a determination if the development will cause or increase quantity or quality problems. If the analysis shows that negative impacts will result, stormwater management improvements including structural and/or non-structural BMPs are to be implemented to minimize the impact.

Section 2 of this manual provides basic technical guidance including suggested analysis and design procedures to meet the requirements of the City of Greensboro's stormwater management ordinance. The information provided in this manual is not intended to be exhaustive, but rather to represent a concise collection of established, technically sound, and efficient means to produce stormwater management plans that may include non-structural and/or structural facilities to satisfy requirements of the City's stormwater quantity management ordinance. The ordinance provides flexibility for the City to work with developers and engineers to provide stormwater management facilities to minimize the adverse downstream impacts of stormwater runoff, but does not require the proliferation of facilities that may provide minimal benefit to the citizens of Greensboro and/or the public drainage system.

Stormwater Utility Credit Policy

A stormwater utility fee is assessed on all properties within city limits. Since the main goals of the City are to reduce the amount of pollutants that are discharged to surface waters and to minimize stream and property damage associated with increased flowrates, the City offers credit on the stormwater utility fee to those who implement approved stormwater BMPs on-site.

This manual provides guidelines for BMPs to be considered to receive credit. Refer to the City's *Stormwater Utility Credit Policy* for more information regarding credit opportunities, including the actual credit that can be awarded for implementation of BMPs.

SECTION 2: STORMWATER MANAGEMENT REQUIREMENTS

2.1 City of Greensboro Stormwater Master Plans

It is the intent of the City of Greensboro to produce stormwater management master plans that will guide public and private development projects on various quantity and quality aspects of stormwater management for all of the major sub-watersheds in the city. Where such master plans are available and approved by the City Council, site development projects are to conform to the stormwater management guidance and standards available in said master plans.

2.2 Stormwater Management Plan

A Stormwater Management (SWM) Plan is required:

⇨ for all new development and redevelopment projects in the corporate limits and extraterritorial jurisdiction of the City, unless otherwise exempt.
⇨ to be approved by the City Technical Review Committee prior to site plan or preliminary subdivision plat approval. It is preferred that the SWM Plan be submitted with the site plan or preliminary subdivision plat. For projects located in water-supply watershed areas, a Watershed Development Plan should be incorporated into the Stormwater Management Plan.
⇨ to be approved prior to obtaining a grading or building permit
⇨ to contain all items in section 2.2.1 below.

Site designers are encouraged to develop *comprehensive SWM plans* for the proposed development, including stormwater quantity and quality controls, non-structural and/or structural improvements, and pollution prevention programs for the site. Any proposed measures which go beyond the requirements of Ordinance Section 27-22 may qualify for credits under the City's Stormwater Utility Fee Crediting Program. In addition, most quantity control facilities provided under the requirements of Section 27-22 should qualify for the fee crediting program, at reduced incentive rates compared to more comprehensive plans.

2.2.1 Stormwater Management/Watershed Development Plan Components

The following information is required on all Stormwater Management (SWM) Plans:

<u>General Information</u>

1. Watershed Location of Proposed Site Development: Note the <u>watershed</u> (i.e., North Buffalo Creek, South Buffalo Creek, Horsepen Creek) and <u>sub-watershed</u> names (i.e., North Buffalo Creek Sub-Watershed 1, North Buffalo Creek Sub-Watershed 2), as applicable, for the

proposed site development. Note water-supply watershed name (i.e., Greensboro Watershed) and water-supply watershed designation (i.e., WS-III, WS-IV, WCA), as applicable.

2. Council-Approved Watershed Master Plan Available? – "Yes" or "No"

3. Show existing built-upon area, if any, and note the amount.

4. Show the proposed built-upon area and note the amount.

5. Note the maximum amount of built-upon area (per watershed development restrictions, stormwater control design, etc.)

6. Show the proposed disturbed (site development) area and note the amount.

7. Note on-site soil type(s) and the hydrologic group(s).

8. Show existing and proposed stormwater conveyance system (pipes, channels, swales, catch basins,etc.) layout and applicable easements. Label pipe size, material, elevations, slopes and structure types (grate inlet, manhole, etc.)

9. Label the amount of off-site drainage area and runoff quantities that discharge onto site.

10. Engineer's Certification of Stormwater Quantity Control.

10. Engineer's Certification of Stormwater Quality Control (for high-density development in designated water-supply watershed area).

11. If the site was previously approved or part of a subdivision that was previously approved by the City or County for stormwater management or watershed development, provide the name of the plan and the date that the plan was approved.

Stormwater Management Study – Analysis of Off-site System

12. Map showing the limits of the off-site study. Within the limits the map should show:
    - topography
    - stormwater conveyance system
    - properties and structures adjacent to the conveyance system
    - the total drainage area at the downstream limit of the study (at least 10 times greater than the site development area).

13. Attributes of the off-site stormwater conveyance system including: structure types, materials, slopes, significant elevations, etc.

14. Provide supporting hydrologic and hydraulic calculations.

Stream Buffer and Related Information

15. Show the location of all streams and drainageways that require buffers.

16. Show the buffers and where measured from (that is, top of bank, top of steep slopes adjacent to stream, or edge of wetlands).

17. Label the dimensions and restrictions within the buffer (that is, To Remain Undisturbed, 50% impervious, vegetated, etc.)

18. Show the location of jurisdictional waters and wetlands.*

*The U.S. Army Corps of Engineers and the N.C. Division of Water Quality regulate wetlands and waters of the United States through the 404 Corps Permit and 401 State Water Quality Certification process. The City encourages the protection and enhancement of wetlands and surface waters to promote improved water quality and water quantity management, as well as fish and wildlife biota and habitat preservation, and other benefits to local comprehensive watershed management. *Site designers/developers are responsible for obtaining all applicable Local, State, and Federal permits/certifications/approvals as necessary for proposed site development activities.*

19. Indicate proposed location of proposed stream crossing(s) showing the proposed grading and overall stream impact (includes culvert and outlet protection length). (Alternative analysis may be required by the City to reduce and /or mitigate impacts).

FEMA Regulated Floodway/Floodplain Information

20. Show designated FEMA-regulated floodway and floodplain boundaries on property and note the 100-year Base Flood Elevation (BFE), as applicable.

21. If the site is located within a FEMA Special Flood Hazard Area (SFHA):
    -note the finished floor/floodproofing elevations of all structures.
    -note that no encroachment/development into FEMA-regulated floodway will be made*.
    -If a FEMA-designated Floodway/plain does not exist on the property/parcel, note the nearest distance to a FEMA-designated floodway, if within 2000 feet.

* In general, encroachment into a FEMA-regulated floodway is not permitted unless the developer performs a FEMA No-Rise Certification and/or Conditional/Letter of Map Revision Application and receives approval from the City of Greensboro (Local Floodplain Administrator) and FEMA officials. Questions regarding development procedures within FEMA designated floodplains may be directed to the City's Storm Water Services Division, Technical Support Section.

Low Density General Watershed Development Information

22. Provide completed watershed scoresheet.

23. For each factor where points are claimed, the requirements of that factor must be clearly depicted on the plans (for example, if 20 points for factor 7, "stream buffer along drainageways" are claimed, the plans need to show a 50' buffer on each side of the creek,the areas to remain wooded, and note the total buffer area amount and the wooded area amount).

Watershed Development in WCA (Watershed Critical Area)

24. Show location of natural slopes greater than 15% which are adjacent to streams and drainageways. These areas and jurisdictional wetlands must remain undisturbed and either dedicated as drainageway and open space or platted as a water quality conservation easement (WQCE).

26. Note that drainage will be provided by means of open vegetated channels.

27. Note the intended land use and SIC Industry Code.

28. Show location of proposed storage tank(s) and indicate material to be stored. A secondary containment system must be constructed for the tank(s) and approved by the City.

Stormwater Control BMP Information

29. Indicate the type(s) of non-structural and/or structural stormwater control best management practices (BMPs) that are proposed.*

    *If proposing to use *existing* on-site or off-site controls, provide information to demonstrate that the controls have been approved by the City and can continue to meet quantity/quality control requirements.

30. If proposing to use off-site stormwater controls, indicate the location and owner(s) of the controls and provide information to demonstrate that the property owner will assist in maintaining the controls.

31. If proposing to use a public owned regional stormwater management facility, provide information to demonstrate that the municipality accepts participation from the property owner.

32. Show the location of the proposed stormwater controls and the location of the inlets and outlets to the control.

33. Show and label the access easement to stormwater control from the street R-O-W and the

D.M.U.E. around the facility.

34. Show the approximate size, configuration, and hydraulic structures for the stormwater control/improvement (with calculations).*

*This may be done in lieu of submitting full construction design, details, and calculations for *preliminary subdivision plans only.* No grading permit will be issued *or* recordation of any lot can occur until the construction plans have been approved for the stormwater control(s) that handle runoff from that lot. *Site plans must include construction drawings for review and approval.*

35. Provide applicable maintenance agreements for proposed stormwater controls.

36. Note: The engineer's certification of completion will be required prior to the final plat or certificate of occupancy. The stormwater control is to be inspected to ensure it is functioning as designed and has full design volume prior to issuance of the final certificate of occupancy.

37. Note: The property owner (or homeowner's association) is responsible for maintaining the stormwater control(s) according to the approved maintenance plan and direction of the City of Greensboro.

38. Note: The City of Greensboro and their assigns have right to access the stormwater control(s) for inspections or maintenance, as necessary.

Stormwater Control/Improvement Construction Plans

39. Layout of stormwater control, grading, and significant components (for example, primary outlet structure(s), dam, filter bed depth, bottom drain, etc.).

40. Cross section of proposed SWM improvements showing the elevations of significant components and storage allocations (e.g. sediment storage, peak reduction storage, etc.).

41. Details and material specifications of all significant components of the stormwater control.

42. Provide Engineer's Statement of Pond and Dam Safety (if dam construction is proposed).

43. Provide hydrologic and hydraulic analysis/calculations, water quality and other pertinent calculations for design of the stormwater control.

44. Provide an inspection/maintenance plan for reference by the owner for long-term maintenance needs.

45. Provide the construction sequence for completing the stormwater control.

2.3 Stream Protection Requirements

City Ordinance Sections 27-22 and 30-7 have provisions to help protect and preserve stream channels and floodplains from excessive disturbance and encroachment. The watershed master plans, currently under development, will identify sensitive floodplain areas and may require additional conditions for development and/or buffers within floodplain/ floodprone areas in order to provide protection for citizens from identified existing/future flood risks and/or to meet other objectives within the stakeholder-driven watershed master plans.

2.3.1 Stream Channelization/Piping Restrictions

Generally, no perennial or intermittent stream is to be piped without first obtaining approval from the Technical Review Committee and other applicable city, state and federal permits and certifications. **Perennial streams within a designated water supply watershed and intermittent streams within the Upper and Lower Randleman Lake Watersheds may not be channelized or piped** except where street, driveway and utility crossings and other activities are permitted by the ordinance and are shown to be necessary and impacts are minimized.

2.3.2 Stream Buffers

Stream buffer requirements are summarized in the following tables. Stream buffers are most effective when the buffer remains in an undisturbed state. Therefore, it is encouraged that disturbance be minimized in the entire stream buffer, not just the portion that is required to remain undisturbed. Where the buffer is disturbed, it should be promptly stabilized, re-planting a dense cover of strong rooted grass, plants and trees.

<u>Citywide (excluding Randleman Lake Watershed)</u>

There are four cases within the City, not including the portion of the city inside the Randleman Lake Watershed, where stream buffers are required:

CASE 1: Drainageways draining an area equal to or larger than 50 acres (non-perennial)
CASE 2: Perennial streams (as defined by this manual)*
CASE 3: Perennial streams (on "Watershed Map", "low density" development)
CASE 4: Perennial streams (on "Watershed Map", "high density" development)

*The buffer requirements for Case 2 do not apply to perennial streams that are shown on the "Watershed Map".

Table 2.1: Stream Buffer Requirements (Cases 1-4)				
CASE	MINIMUM WIDTH (each side)	UNDISTURBED	NO BUILT-UPON SURFACE (vegetated)	BUILT-UPON LIMIT OF 50% (no occupied structures allowed)
1	50'	First 15'	N/A	Next 35'
2	50'	First 15'	N/A	Next 35'
3	30'	N/A	Entire 30'	N/A
4	100'	N/A	Entire 100'	N/A

For cases 1 and 2, stream buffers are to be measured from one of the following: (1) the top of the stream bank, or (2) the top of steep slopes adjacent to the stream, or (3) the edge of contiguous wetlands. For cases 3, 4 the stream buffers are to be measured from the top of the stream bank.

Randleman Lake Watershed

The Randleman Lake regulations, including stream buffer requirements, were adopted by the NC Environmental Management Commission in the Spring of 1999 and incorporated into the City's Development Ordinance effective January 1, 2000. The regulations require *riparian* buffers to be maintained on all perennial and intermittent streams in the upper and lower Randleman Lake watersheds. For more information on this buffer requirement including the different zones of the riparian buffer, refer to Ordinance Section 30-7.

Table 2.2: Randleman Lake Watershed Stream Buffer Requirements					
STREAM	Density	MINIMUM WIDTH (each side)	ZONE 1	ZONE 2	ZONE 3
Intermittent	Low	50'	First 30'	Next 20'	N/A
	High	50'	First 30'	Next 20'	N/A
Perennial	Low	50'	First 30'	Next 20'	N/A
	High	100'	First 30'	Next 20'	Last 50'

2.4 Stormwater Quality and Quantity Control

Stormwater quality and quantity control are required by Ordinance Sections 30-7 and 27-22. They are required as follows:

1. **Stormwater Quality Control (Sec 30-7):**
   Applicable to high density development in designated water-supply watershed areas. *Required to* provide structural control that removes 85% Total Suspended Solids (TSS) from the runoff from the first one (1) inch of rainfall.

2. **Stormwater Quantity Control (Sec 27-22):**
   Applicable to all new development sites within the City that increase the net built-upon area of the site by more than 400 square feet.
   Required to minimize off-site flooding, drainage and erosion problems.

The stormwater management (SWM) plan must indicate that these minimum control requirements are met, where applicable. An "ideal site SWM Plan" in most cases is one in which the complete pre-developed stormwater runoff characteristics of the site are maintained in the post-developed conditions, including emulation of the pre-developed runoff hydrographs and pollutant runoff characteristics, and is consistent with an approved watershed master plan. Low-impact developments which incorporate non-structural and/or structural stormwater management practices promote improved urban stormwater management programs and minimize adverse downstream impacts. This concept is increasingly referred to as "sustainable development" from a stormwater and watershed management viewpoint.

2.4.1 Quality Control for High Density Development in Water Supply Watershed Areas (Ordinance Section 30-7)

Section 30-7 requires an "engineered" stormwater quality control to improve the quality of stormwater runoff from new high density development sites. The stormwater quality control must be an acceptable structural BMP as shown in Table 3.2, of this Manual. The requirements and guidelines for designing these BMPs are presented in Section 3.4.

The engineer's certification of stormwater quality control, which is provided in Table 30-7-1-5 of the City's Ordinance, is required for proposed high density developments.

2.4.2 Quantity Control (Ordinance Section 27-22)

Section 27-22 requires a hydrologic and hydraulic engineering analysis to evaluate off-site impacts due to increased stormwater runoff from new development and/or redevelopment sites within city limits. Where problems are determined, it is the developer's responsibility to provide stormwater improvements to minimize the problems.

Site Analysis

1. Evaluate the peak runoff from the property for the pre-development (existing) conditions (Q_1) during a 24-hour rainfall sequence with a recurrence interval of both 2 years and 10 years (where runoff discharges from the property at more than one location, evaluate each location). The 24-hour rainfall sequences for the 2 and 10 year recurrence storms, depth-duration-frequency table, and intensity-duration-frequency table, for the Greensboro area are provided in Appendix C. The rainfall values in the 24-hour rainfall sequence are based on "Type II distribution" (applicable to the Greensboro area, as excerpted from NWS TP-40 and HYDRO-35) of the 24 hour rainfall of 3.5 inches and 5.1 inches for 2- and 10-year recurrence rain storms, respectively.

2. Evaluate the peak runoff from the property for the post-development conditions (Q_2) during a 24-hour rainfall sequence with a recurrence interval of both 2 years and 10 years (where runoff discharges from the property at more than one location, evaluate each location).

3. Evaluate the peak runoff value(s) for post-development conditions (Q_2) and compare that to the pre-development conditions (Q_1) for both the 2-year and 10-year recurrence storms, 24-hour rainfall sequence. If either of the post-development peak flows are greater than the pre-development peak flows, the designer must perform a preliminary and/or detailed hydrologic and hydraulic analysis of the off-site stormwater conveyance system to indicate downstream impacts of any increased stormwater flows to determine if stormwater management improvements are necessary, or provide on-site stormwater control improvements that reduce post-development flows of the 2-year and 10-year recurrence storms, 24- hour rainfall sequence to the pre-development condition, or participate in an approved downstream regional SWM facility, if available.

Off-site Analysis

For new development sites where on-site controls are not provided to reduce post-development flows to pre-development flows, an off-site analysis will be required, unless otherwise exempt. Where on-site quantity controls are provided to reduce post-development flows to pre-development flows, an off-site analysis may generally not be required, provided that conditions in an approved watershed master plan are satisfied. In some cases, however, it is possible that on-site stormwater controls may exacerbate system-wide drainage problems, and thus the designer should verify that the SWM Plan does not create new problems downstream. Therefore, it is recommended that an off-site analysis be performed prior to sizing a quantity control improvement to reduce post-development rates to pre-development rates as the analysis may indicate that different on-site stormwater controls are needed for the given development (other than those developed based on a site-specific analysis only) or that minimal stormwater control measures are required for the site.

Downstream Limits of Analysis: In determining downstream effects from the proposed site development or redevelopment activity, hydrologic and hydraulic engineering studies shall extend downstream to a point where the proposed site development or redevelopment represents less than ten (10) percent of the total drainage area or watershed. This point is referred to as the "10% point."

For example, a 5-acre site located near the headwaters of a drainage basin is proposed for sustainable development of which 4 acres are proposed to be disturbed (that is, the runoff will increase on 4 acres of the site after it is developed). The 4 acres drain to one location before discharging from the site. The downstream limit of analysis would be where the contributory watershed equals 40 acres. In general, the area of interest for analysis is the property / site itself, the drainage exit point of the property, and each component (channel, pipe, culvert, overland flow etc.) of the downstream system to the 10% point in the watershed, at a minimum.

Design Storm Events for Analysis: The studies shall be based on an analysis of both 2- and 10-year design storm events.

Analysis Criteria: The analysis should examine whether the design storm events of interest cause or increase flooding, drainage, or erosion problems on off-site property. In determining downstream effects from the proposed development, studies shall extend downstream to the 10% point and should include:

a) routing of peak flows to the 10% point within the watershed using accepted hydraulic/hydrologic methods described in Section 2.4.3, and

b) if peak flow calculations indicate that adjacent development(s) might be adversely impacted by the proposed development, then hydraulic step-backwater calculations (Corps of Engineers' computer models HEC-2 or HEC-RAS are recommended where detailed hydraulic analysis is required) shall be performed and flood elevations determined for the areas impacted. *Detailed hydrologic and hydraulic engineering studies can be costly, thus the Guidance Manual recommends detailed studies only where peak flow hydrograph routing analysis indicates that drainage / flooding problems might be present.*

Land Use Conditions: Hydrologic / hydraulic studies should utilize the following land use conditions for analysis:

- use existing conditions for downstream areas of interest
- for development of watershed hydrographs (off-site drainage areas), existing conditions land use is the minimum requirement, but future land use conditions are recommended for a conservative analysis
- the effects of upstream stormwater detention facilities can be considered in the analysis only if such structures (i.e., regional facilities) have been accepted for maintenance by the City or otherwise approved by the City.

Implementation of Stormwater Control Improvements

Where it is determined that the development of the said site does contribute to flooding, drainage or soil erosion problems at any location between the proposed development site and the 10 percent downstream point then stormwater quantity control improvements must be implemented. Improvements may consist of:

1. On-site peak reduction – The developer may choose to use nonstructural approaches such as natural or engineered swales, depressions in the land and other natural approaches, or structural approaches such as detention structures, extended detention facilities, and alternative Best Management Practices (BMPs) with provisions for stormwater quantity control. *A combination of nonstructural and structural approaches is encouraged.*

2. Off-site peak reduction – The developer may use an off-site publicly or privately owned facility where: the facility is functional (within 2 years for proposed public facilties); the owner/entity has accepted stormwater runoff from the site; it can be demonstrated that the facility is sized to handle the increased flow; the owner has participated and/or implemented a maintenance agreement for use of the facility; it is demonstrated that there are no quantity problems between the site and the off-site facility.

3. Improvements to the downstream stormwater conveyance system – Where it is determined that the best solution is to upgrade the downstream system, this may be done provided that the downstream property owner where the improvements will be made grants a temporary construction easement and the improvement will not cause other problems downstream. The site developer is to coordinate with the City on all proposed downstream improvements.

Design Storm Events: The improvements shall be evaluated based on both 2- and 10-year 24-hour design storm events.

Method for Design: The designer should demonstrate that the proposed improvements are sufficient to minimize downstream problems. Hydraulic/hydrologic methods presented in Section 2.4.3 should be used to evaluate the proposed improvement. An example of an evaluation of a detention facility is provided in Appendix D.

Land Use Conditions: For site specific design of SWM control structures / facilities, use fully developed land use conditions for the site and existing land use conditions for any upstream areas draining to or through the facility (future land use conditions are recommended, however, for a conservative analysis).

Additional Stormwater Management for Public Benefits

Where the Enforcement Officer determines that additional storage capacity in a stormwater management facility beyond that required for on-site stormwater management is necessary in order to enhance or provide for the public health, safety, and general welfare, to correct undesirable existing drainage or flooding conditions or to provide greater protection for future development, the Enforcement Officer may:

1. require that the applicant grant necessary easements over, through or under the applicant's property to provide access to or drainage for such a facility;

2. require that the applicant attempt to obtain from the owners of property where the proposed stormwater management facility is to be located, any easements necessary for the construction and maintenance of same (and failing the acquisition of such easement(s) the City may, at its option, assist in such matter by purchase, condemnation, dedication or otherwise, and subject to item 3 below, with any cost incurred thereby to be paid by the City); and/or

3. participate financially in the construction of such facility or improvement to the extent that such facility or improvement exceeds the required on-site stormwater management determined by the Enforcement Officer.

To implement this provision, both the City and owner/developer must be in agreement with the proposed stormwater management facility that includes additional storage capacity and jointly develop a cost sharing plan which is agreeable to all parties involved.

2.4.3 Hydraulic/Hydrologic Methods

The following hydraulic/hydrologic methods are accepted by the City for use to address quantity and quality requirements.

Hydrologic Methods (hydrograph formulation and peak flow estimation)

- NRCS (Natural Resources Conservation Service, U.S. Department of Agriculture) hydrologic methods (formerly known as the SCS, Soil Conservation Service) are preferred and acceptable for all applications. NRCS methods include those contained in the TR-55 publication and corresponding computer program.

    - The hydrograph formulation methodology presented in Chapter 5 – Tabular Hydrograph method is the preferred method. A summary of this method is given in Appendix D.

    - Runoff flood peaks for small catchment areas or subwatersheds (approximately 50 acres or less) may be determined using the methodology presented in Chapter 4 of

TR-55. However, as pointed out under Limitations in Chapter 4, if a hydrograph is needed or watershed subdivision is required, the Tabular Hydrograph method given in Chapter 5 should be used.

- The NRCS routines applied within the US Army Corps of Engineers computer models HEC-1 and HEC-HMS are preferred and acceptable for most applications. (The Corps of Engineers HEC-1 / HEC-HMS models are preferred over the NRCS TR-20 model, however, since Corps models will be used by the City in watershed modeling and master planning.)

- The Rational Method, Qp = C I A, is acceptable for determining peak runoff from drainage areas of 200 acres or less.

- The "Small Watershed Method" developed by Dr. H.R. Malcom, PE, NC State University, Raleigh, NC, is acceptable for most hydrologic analyses on small watersheds, based on Malcom's procedures.

- Other hydrologic analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose.

Detention Storage Estimation Methodologies:

- The Storage-Indication (Puls method) is an acceptable method for routing hydrographs through a reservoir of any size. This method is incorporated into the US Army Corps of Engineers HEC-HMS and NRCS TR-20 computer models.

- The "Chainsaw Routing" method developed by Dr. H.R. Malcom, PE, NC State University, Raleigh, NC, is acceptable for most reservoir routing analyses on small reservoirs, as deemed appropriate by the designer based on Malcom's procedures. The procedure and an example of an application of this method are given in Appendix D.

- TR-55 (Chapter 6) and Dr. H.R. Malcom's "Preliminary Design" (given in Appendix E) present methods to give the designer an approximate estimate of the storage required to provide the desired detention. These methods are good for preliminary design, but are to be followed up with an acceptable reservoir routing method for final design.

- Other reservoir routing analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose.

Hydraulic Methodologies (Open and closed conveyance analysis):

- Where step-backwater hydraulic computations are required for open stream channels including bridges and culvert roadway crossings, the US Army Corps of Engineers HEC-2 or HEC-RAS models are preferred and recommended for most applications. Where significant closed conduits represent the stormwater conveyance system, EPA's SWMM model is recommended, if a detailed hydraulic analysis is required for development of the SWM Plan.

- For simple hydraulic analyses, where applicable, the Manning's Equation and other hydraulic relationships (e.g., Hydraulic and Energy Grade Line calculations) may be applied where appropriate assumptions for use are satisfied and the results will be conservative.

- Other hydraulic analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose.

2.4.4 Engineer's Certification Note of Stormwater Quantity Control

For new development plans within the city limits of Greensboro, one of the following certification notes should be made.

1. The development shown on this plan is consistent with the provisions contained on the preliminary plan/site plan ____(name of plan)______, which was approved prior to July 1, 1999 and which approval has not lapsed, as specified in Section 30-6-12 of the Greensboro Development Ordinance, and therefore is exempt from compliance with Section 27-22 of the Stormwater Management Ordinance.

2. The net increase in built-upon area is less than 400 square feet, therefore, this development is exempt from subsection (g)(2) "Quantity Control Requirements" of Section 27-22 of the Stormwater Management Ordinance.

3. The stormwater management study included with this plan indicates that there will be no downstream flooding, drainage, or erosion problems as a result of the proposed development between the point where the runoff discharges from the property to where the site development area represents less than 10% of the total drainage area. Therefore, no quantity control improvement is proposed.

4. The stormwater management study included with this plan indicates that there will be downstream flooding, drainage, or erosion problems associated with this development. The proposed stormwater management improvement(s) indicated on this plan is (will be) designed to minimize increased flooding, drainage and erosion problems from occurring between the point where the runoff discharges from the property to where the site development area represents less than 10% of the total drainage area.

5. The stormwater control structure(s) shown on this plan is (will be) designed to reduce the post-development 2-year 24 hour storm event and the 10-year 24 hour storm event to pre-development rates.

2.5 Modifications to Stormwater Requirements

2.5.1 Water-Supply Watershed Protection (Chapter 30)

Ordinance Section 30-9-11, Modifications, describes the procedures for obtaining a modification to the water supply watershed standards of Chapter 30-7.

2.5.2 Stormwater Management Control (Chapter 27)

A modification shall only be granted after a written request is submitted by the applicant to the Enforcement Officer containing, site plan descriptions and drawings, detailed hydrologic and hydraulic engineering analysis and an explanation of the reasons a variance is warranted. The request should clearly indicate that the modification is in general harmony with the general purpose and intent of the Ordinance, and by granting the modification the public safety and welfare have been assured. Separate written modification requests shall be required if there are subsequent additions, expansions, or modifications which would alter the approved stormwater runoff characteristics of a proposed site development or redevelopment activity receiving a modification.

<u>Stream Protection Requirements</u>

A modification to the requirements of Section 27-22 (f) may be granted by the Enforcement Officer if it can be demonstrated that all alternatives to avoid and/or minimize impacts to the stream channel or buffer has been evaluated and proven to be infeasible.

<u>Quantity Control Requirements</u>

A modification to the quantity control requirements of Section 27-22 (g) may be granted by the Enforcement Officer if it can be shown by detailed hydrologic and hydraulic engineering studies and analysis which are acceptable to the Enforcement Officer that one of the following applies:

1. the installation of stormwater management facilities would have insignificant effects on downstream flood peaks; or
2. stormwater management facilities are not needed to protect downstream developments and the downstream drainage system has sufficient capacity to receive any increase in runoff; or
3. it is not necessary to install stormwater management facilities to control developed peak discharge rates at the exit to a proposed development or redevelopment and installing such facilities would increase flood peak discharge rates at some downstream locations; or
4. the Enforcement Officer determines that stormwater management facilities are not needed to control developed peak discharge rates and that installing such facilities would not be in the best public interest.

Quantity control requirements may not be waived if the Enforcement Officer determines that not controlling downstream flood peak discharge rates would increase known flooding or drainage problems, or exceed the capacity of the downstream drainage conveyance system at any point between the exit of a proposed site development or redevelopment and the 10 percent downstream point.

3.1 Overview of Stormwater BMPs

BMPs can generally be classified into two categories: (1) Pollution Prevention BMPs and (2) Runoff/Pollution Control BMPs. An overview of these two categories are discussed below.

3.1.1 Pollution Prevention BMPs

Pollution prevention BMPs are **activities** that are implemented to control pollution **at the source** by preventing pollutants from commingling with stormwater runoff. Pollution prevention BMPs are often much less expensive and more effective than BMPs which manage stormwater after pollutants have migrated into the runoff. Implementing pollution prevention BMPs is very important to improving the quality of our surface waters and overall environment.

The pollution prevention BMPs presented in this manual are beneficial for reducing pollutants in stormwater runoff. The City promotes pollution prevention BMPs that are relatively easy to implement and, in many cases, required by other environmental regulations for specific types of properties (for example, NPDES requirements for permitted industrial sites). Some facilities in Greensboro should already be implementing these practices. If a facility is not employing these practices at this time, the pollution prevention BMPs presented generally require only relatively minor efforts to implement and can provide significant stormwater pollution reduction.

Pollution prevention BMPs can be utilized to meet industrial NPDES requirements and to receive credit on the stormwater utility fee. Because most of these practices are easy to implement and effective in promoting a cleaner, healthier environment, the City encourages all businesses and interested citizens to use these practices.

The following pollution prevention BMPs are discussed in Section 3.2 of this manual:

- ⇨ Employee education
- ⇨ On-site refuse management
- ⇨ Stormwater system maintenance
- ⇨ Paved area sweeping
- ⇨ Used oil recycling
- ⇨ Covering
- ⇨ Spill containment
- ⇨ Soil erosion control

This list of BMPs is not intended to be exhaustive, but rather to give some of the most effective BMPs for preventing pollution of stormwater runoff from developed areas.

3.1.2 Stormwater Quality/Quantity Control BMPs

Stormwater quality/quantity control BMPs are site design/planning practices, improvements, facilities, etc., that serve to reduce the total volume of runoff generated, reduce peak runoff discharge rates, and provide surface water quality protection by minimizing impacts to environmentally sensitive areas and removing pollutants from stormwater runoff. These BMPs can be non-structural/site development BMPs or structural BMPs.

Non-Structural BMPs

Non-structural BMPs can be defined as **techniques incorporated in site design/planning** to promote low-impact development. These BMPs may be used to reduce the volume of runoff generated, reduce runoff discharge and provide partial pollutant removal. These practices are relatively inexpensive to implement, with the major cost usually being land area. But, with thoughtful site design, these practices can improve the stormwater management and aesthetic value of the development.

These stormwater BMPs can be implemented to help meet requirements for "low density" development in water-supply watershed areas and to reduce the amount of impervious area that is required to be treated for "high density" development. These BMPs can be incorporated in the site design to reduce stormwater runoff quantity and prevent adverse effects on the downstream property and receiving streams. Non-structural BMPs can be used to receive credit on the stormwater utility fee.

The following non-structural BMPs, which have been observed to be effective, are discussed in Section 3.3 of this manual:

- ⇨ Open vegetated conveyances
- ⇨ Stream buffers
- ⇨ Disconnect rooftop drainage
- ⇨ Clustering/Conservation of natural areas
- ⇨ Grass paving
- ⇨ Natural infiltration

Structural BMPs

Structural BMPs can be defined as **"engineered stormwater management facilities"** that can be designed to improve the quality of stormwater runoff and reduce stormwater runoff rates and/or volumes. These BMPs are designed to capture surface runoff from developed areas and improve the quality of the runoff from the site by removing pollutants through processes such as sedimentation, plant uptake, filtration, microbial activity, etc.

Structural BMPs are generally the costliest of the various BMPs to implement and to maintain. Most potential BMP owners are generally aware of the initial construction costs and land allocation that is required for structural BMPs, but some do not fully understand or appreciate the responsibility and costs associated with the maintenance of stormwater BMPs. This manual presents design, installation, and maintenance guidelines for each structural BMP.

This manual describes each structural BMP and provides design guidelines to make the BMP as efficient as possible in removing pollutants. The manual points out which BMPs are acceptable to use to meet water supply watershed protection regulations for high density development and the associated minimum design requirements. The manual describes each BMP's ability to incorporate peak flow reduction and their credit potential toward the stormwater utility fee. The manual also provides guidelines on selecting the best BMP for certain site conditions.

The following structural BMPs are discussed in Sections 3.4, 3.5, and 3.6 of this manual. Section 3.4 presents BMP selection guidelines, regulatory considerations and design information for each structural BMP. Section 3.5 provides general installation guidelines, while Section 3.6 provides inspection and maintenance guidelines for each structural BMP.

- ⇨ Grass swales
- ⇨ Filter strips
- ⇨ Dry detention basins
- ⇨ Wet detention ponds
- ⇨ Stormwater wetlands
- ⇨ Bioretention areas
- ⇨ Sand filtration facilities
- ⇨ Proprietary stormwater treatment facilities

3.2 Pollution Prevention BMPs

3.2.1 Employee Education

Description

Employee education programs are designed to educate employees on the proper operational practices to minimize the potential for on-site pollutants to contact stormwater runoff. Through education, employees become more aware of potential stormwater pollutants, runoff characteristics, spill control measures, and methods to minimize off-site migration of polluted stormwater runoff from commercial and industrial properties. As a result, it is one of the easiest to implement and most beneficial pollution prevention BMPs available. In addition, a proper employee education program outlines methods by which employees can also reduce potential for stormwater pollution at their individual residences.

Applicability

Every commercial, and industrial or related facility that stores materials outside or is involved with receiving or shipping materials can benefit from employee education programs regarding on-site stormwater management practices.

Employee education programs are required by federal law under *40 CFR Part 112 - Oil Pollution Prevention Regulations* and *40 CFR Part 122, 123, and 124 - National Pollutant Discharge Elimination System Regulations for Storm Water Dischargers.* As a result, all facilities conforming to these regulations should already be performing employee education.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the minimum criteria outlined in Table 3.1. For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Public Education Outreach

The City of Greensboro is committed to educate citizens on environmental awareness issues. The Storm Water Services Division, as part of its municipal NPDES permit, has developed educational programs to inform citizens on ways they can help protect the quality of Greensboro's streams and lakes. The City has produced several television and radio ads.

Table 3.1: Summary of Employee Education Requirements

ACTIVITY	DESCRIPTION	FREQUENCY	DOCUMENTATION
Employee Briefings	Education sessions for all employees regarding proper water quality and environmental protection activities.	30 min./quarter	Submit programs with agenda to SWS for approval prior to briefings.
Employee Surveys	Conduct written surveys of each employee per EPA regulations	Once annually	Submit summary of survey responses in Annual Report.
Post/Distribute Information	Post and/or distribute periodic stormwater information provided by Storm Water Services.	As received	Verify posting of Annual Report.

campaigning surface water quality protection. The City has also produced informational videos, brochures, etc., on various environmental topics for a wide range of audiences, including industries, businesses, schools and interested citizens.

The City also has helped form several volunteer groups to help educate citizens on water quality issues and to encourage citizens to get involved in cleaning up the City's surface waters. These groups include:

Environmental Business Partners
This program is setup to create a partnership with the City government and local businesses in order to provide the community with environmental/stormwater information.

"Green Heroes" (Includes Adopt-A-Stream, Adopt-A-Street, and Adopt-A-Park)
This program consists of volunteer groups that periodically remove litter along the stream section that they have adopted.

"Drain Markers" Program
This program involves placing the drain markers on storm water inlets that read "Don't Dump – Drains to Lakes and Creeks"

The City has also set up an "Environmental Helpline" (373-2812) to take calls on pollution problems from spills to excessive erosion problems from construction sites and to answer questions.

If you have an interest in obtaining any informational material, participating in the volunteer groups or have any other questions regarding environmental issues, please contact the Helpline.

3.2.2 On-Site Refuse Management

Description

On-site refuse management programs include specific operating practices designed to minimize the potential for on-site litter and debris. The goal for these types of programs is to limit the amount of floatables and debris collecting in stormwater runoff and discharging off-site. In addition, on-site refuse management programs entail good housekeeping practices and help maintain a clean facility appearance.

Applicability

Commercial and industrial facilities can benefit from an active on-site refuse management program. Many facilities already employ such a program either formally or informally as part of good housekeeping efforts to maintain a clean, aesthetically pleasing business environment.

Litter reduction and recycling activities are essential to improving solid waste management. Nearly 65% of the City's landfill waste comes from local commercial and industrial businesses. Recycling programs can save landfill space, and because the City of Greensboro services recycling dumpsters free of charge, they can save business owners money.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop and implement an on-site refuse management plan which focuses on litter reduction, recycling, and proper disposal and storage. Organizations wishing to receive credit for on-site refuse management, must prepare and submit an on-site refuse management plan. The plan should include the following items at a minimum:

1. A litter reduction program encouraging staff to properly dispose of waste materials. This program should outline the appropriate disposal options for all waste, including hazardous and non-hazardous and general solid waste material.
2. A comprehensive on-site waste material recycling program. This program should include all materials that could be reused or reclaimed either on-site or through the use of contractors of vendors. This may include paper wastes, waste treatment solids, and other materials.
3. Maintain area of refuse container covers designed to eliminate exposure to the environment (i.e. wind, rain, snow, etc.).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Solid Waste Management

The City's Solid Waste Management Division offers twice-a-week garbage service as well as recycling service up to four times per week to its business customers. Business owners are responsible for providing city-approved trash and recycling dumpsters.

Businesses may recycle the following materials in the Recycle Greensboro program:

Office and computer paper	**Newspapers**	**Tin cans**	**Chipboard**
Plastic soda bottles	**Magazines**	**Empty aerosol cans**	
Plastic milk or water jugs	**Aluminum cans**	**Corrugated cardboard**	

The City does **NOT** allow the following to be disposed at the City landfill:

Aluminum cans	**Yard waste**	**Tires**
Lead batteries	**Large appliances**	
Anti-freeze	**Fluorescent bulbs**	

The Solid Waste Management Division publishes the *Business Waste Line* and *"One Man's Trash"* which includes articles such as profiles on recycling programs of local businesses, easy and effective things businesses can do to reduce waste, and updates on the City's collection services. *Business Waste Line* is published twice a year and *"One Man's Trash"* is published quarterly and sent to local businesses.

If you have any questions concerning the City's refuse and recycling program, or would like help setting up a recycling program for you business please contact the City of Greensboro Solid Waste Management Division at 335-5444.

3.2.3 Stormwater System Maintenance

Description

On-site stormwater system maintenance entails property owners or management regularly maintaining the stormwater system on their property. Often, it is very effective for individual facilities to periodically clean out on-site stormwater structures to assist in the City's effort in maintaining the stormwater system. By regularly maintaining on-site storm sewer systems and open channel conveyances, a facility may reduce the amount of sediment and other pollutants that can potentially migrate into the City's storm sewer system and downstream receiving waters. This helps the City meet the pollutant reduction goals associated with its federal National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. Also, periodic cleanings of the stormwater infrastructure can prevent water back ups in the system and potential damage from flooding due to a clogged system.

Applicability

Sites that have stormwater conveyances (pipe system, open channel, and water bodies) on their property that drain the runoff from the site are responsible for maintaining the conveyances. Storm sewer conveyances that cross through private property but receive public runoff, will be maintained by the City of Greensboro. However, inlet structures that collect runoff from private property are the maintenance responsibility of the property owner, even if the structure is connected to a publicly maintained storm sewer pipe.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must prepare and submit an on-site stormwater system maintenance plan. This plan must meet the following minimum criteria:

1. Catch basins (e.g. curb inlets, grate inlets, etc.) and outfalls must be cleaned a minimum of 2 times per year.
2. Curb and gutter systems must be cleaned a minimum of 4 times per year.
3. Other implemented structural BMPs must be routinely maintained and inspected on an annual basis (minimum).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro "SWIMS" Program

The City Storm Water Services Division is currently in the process of inventorying the storm sewer infrastructure and open channel conveyance systems in the city limits. The inventory includes public and private storm sewer systems (pipe diameter size is 12 inches or greater), open channels, and ponds and lakes.

Attribute information, such as structure depth, structure condition, etc, along with location information is gathered for each structure in the system (e.g. pipe, curb inlet). The City will use this information along with a Geographical Information System (GIS) to develop a proactive program termed the Stormwater Infrastructure Management System ("SWIMS"). This program will optimize maintenance of public storm sewer systems by specifying which structures need immediate repairs or cleaning before further problems occur. The program will also allow the City to predict which structures need to be cleaned more frequently based on data collected in the field and the associated land uses.

3.2.4 Paved Area Sweeping

Description

A paved area sweeping program can significantly reduce sediment and other potential pollutants from migrating into the City's waterways. Paved areas are a source of various pollutants (especially hydrocarbons and heavy metals emitted by vehicles). Small pollutants attach to sediment; and when it rains, the sediment, along with the attached pollutants, flow with the stormwater runoff to the nearest waterway. By employing a regular paved area sweeping program, a facility can dramatically reduce the amount of sediment entering the stormwater runoff. This not only helps the City maintain clean waterways but also improves general housekeeping efforts at individual facilities.

Applicability

Essentially, every commercial and industrial facility that has paved areas can employ a sweeping program. Commercial and industrial facilities with large parking lots often receive the most benefit from paved area sweeping. In addition, it is often more cost effective to sweep large paved areas as compared to small paved areas. Many industries may already be employing routine paved area sweeping to comply with their NPDES Storm Water Permit.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop, submit, and document implementation of a detailed paved area sweeping management plan. The plan should include at a minimum: sweeping frequency, name of sweeping contractor, sediment and debris disposal method, and areas regularly swept. All paved areas must be swept a minimum of once every two weeks. For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Paved Area Cleaning Program

The City of Greensboro Street Cleaning Division is responsible for periodically cleaning major and secondary public roads and public parking lots. The City uses a street sweeper that is equipped with a vacuum to pick up loose debris once it is swept to the curb. This prevents the debris from entering the storm sewer system.

3.2.5 Used Oil Recycling

Description

Petroleum-based products are one of the major pollutants found in many urban surface waters. One of the major contributors is improperly managed used oil. Therefore, a used oil recycling program employed at facilities that utilize oil in their operations can be extremely beneficial with respect to improving stormwater runoff quality. Many facilities that utilize oil should already have a used oil recycling practice in place as it has become relatively convenient and cost effective.

Applicability

Commercial and industrial facilities that use oil in its operations can employ a used oil recycling program. There are many commercial vendors that collect used oil and haul it to a commercial recycling facility. This significantly reduces the amount of effort required by facilities to employ used oil recycling. Furthermore, by using a reputable used oil recycling company, a facility can reduce its potential liability regarding used oil contamination.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the following minimum criteria:

1. Offer and maintain an on-site, used oil recycling collection area.
2. Utilize a registered commercial oil recycling company to collect, haul, and recycle the used oil, as necessary.
3. Provide annually to Storm Water Services copies of all manifests for used oil collection performed each year.
4. Display City of Greensboro Used Motor Oil Recycling informational material in clearly visible and frequented on-site locations.

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Household Hazardous Collection Center

Russell and Meiorin conducted a study (1985) of household practices and found that 11 percent of homeowners who change their motor oil disposed of it directly to street drains and another 14 percent disposed of it on the ground (Horsely and Witten).

The City of Greensboro, Guilford County, and ECOFLO, Inc. provide a service to collect household hazardous waste from all households in Guilford County (no commercial or business waste is accepted). The Household Hazardous Waste Collection Center is located at 2750 Patterson Street, Greensboro.

3.2.6 Covering

Covering includes protecting certain areas of a facility from contact with precipitation. Covering dramatically reduces the contact of precipitation on potential stormwater pollutant sources, thereby reducing the pollutant levels in stormwater runoff from a particular property. Covering can include a building, canopy, or other structure that directs rainfall away from areas of concern. Areas at a facility that are commonly covered in some form are stockpile areas, hazardous material storage areas, maintenance areas (i.e. motor vehicle), and loading/unloading areas.

<u>Applicability</u>

Covering is a common practice employed by many commercial and industrial facilities. The City recognizes that constructing coverings for large outdoor storage areas may not be cost effective for some facilities and other BMPs may be utilized.

<u>Storm Water Utility Credit</u>

To be eligible for stormwater utility credit for implementation of this BMP, covering must be employed at all hazardous and petroleum-based material storage areas and any area that entails maintenance activities. Organizations must meet the following minimum criteria:

1. All hazardous and petroleum-based materials must be covered and protected from stormwater contact.
2. A spill control and response plan must be developed and submitted to Storm Water Services for all hazardous and petroleum-based materials stored on-site.
3. All maintenance activities must be performed under covered areas.
4. A site sketch with the covered areas must be submitted to the Storm Water Services Division with the credit application before final approval of a covered area can be granted.

3.2.7 Spill Containment

<u>Description</u>

Spill containment BMPs are provisions incorporated to prevent spilled materials which are potentially hazardous from migrating outside storage areas. The containment may be a dike or pit (for example, a concrete or steel berm) constructed around individual storage containers or a storage area. The dike or pit will may have drain pipes with valves to allow "clean" stormwater to discharge from the containment area; however, the valve is kept shut under normal conditions in cases of a leak or spill.

If the area to be contained is a large area with a storm drainage network, it may be appropriate to construct a basin at the storm sewer outfall. The basin can be designed to trap floating materials through the use of a skimmer baffle, as shown in Figure 3.1.

It is preferred, if possible, that storage areas of significant materials be covered to prevent rainfall from entering the containment area.

Applicability

If a facility uses hazardous or petroleum-based materials (i.e. chemicals, wastes, oils, etc.) and stores them outside, they should employ spill containment around their storage areas. In many cases, however, if facilities do store hazardous materials outside, federal law *(40 CFR Part 112 - Oil Pollution Prevention Regulations* and *40 CFR Part 264 - Hazardous Waste Regulations)* require such facilities to have spill containment for these areas.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, all hazardous and petroleum-based materials that are stored outside must have spill containment. Organizations wishing to receive credit for spill containment must meet the following minimum criteria:

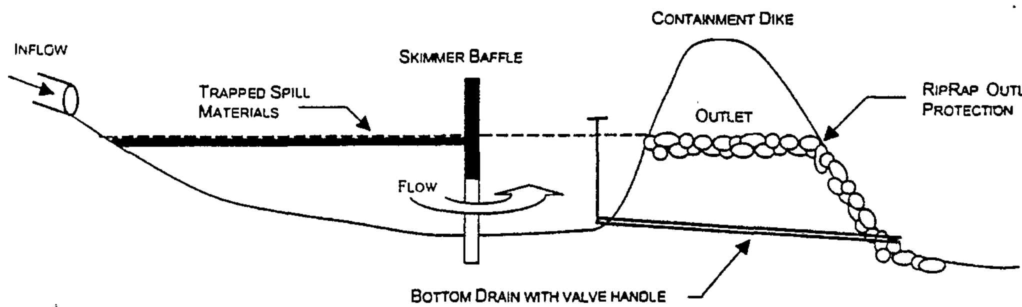
1. All spill containment facilities must be capable of containing 110 percent of the volume of the largest container in the applicable storage area. For example, if the largest container in a storage area is a 55-gallon drum, the spill containment storage area must have at least 61 gallons (55 x 110%) of volume.
2. For storage areas that contain potentially hazardous materials that dissolve in water or otherwise do not float, a spill containment structure must be provided with a valve. The valve must remain closed during normal facility operation. In the event of a rainfall event, the collected stormwater must be visually inspected (sight and smell) for any potential contamination. If no potential contamination is visible, the containment valve may be opened and the collected stormwater discharged. Any contaminated stormwater must be disposed in a proper manner.
3. For storage areas that contain potentially hazardous material that floats on water (e.g. oil), a structure using a skimmer baffle as shown in Figure 3.1 or other trapping provision may be used.
4. A site plan detailing the storage areas and spill containment must be submitted to Storm Water Services.
5. Display easily visible signage indicating a hazardous material storage area.
6. Implement a regular inspection program (once per week minimum) for all spill containment areas.
7. Document all inspection and maintenance activities associated with spill containment facilities (Inspection and maintenance log should be available for City review at any time).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

Spill Containment for City of Greensboro Hugh Medford Service Center

The City of Greensboro has constructed a spill containment structure to protect potential spill areas at its Service Center. The structure is a wet basin with a skimmer baffle that traps floating material at the surface (as shown in Figure 3.1). For more information, contact the Storm Water Services Division.

Figure 3.1: Example Spill Containment Structure for Floatable Material



3.2.8 Erosion and Sedimentation Control

Description

Soil erosion has a major impact on the quality of surface waters. Erosion increases the sediment loading to surface waters causing adverse impacts such as increased turbidity, reduced light penetration, clogging of gills/filters of fish and aquatic invertebrates, and reduced spawning. Other impacts of increased sediment loading occur in low flow receiving waters, such as slow moving meandering streams, ponds and lakes, where the sediment has a chance to settle out. Impacts include smothering of aquatic habitat, more rapid filling of impoundments, increasing the need for costly cleanouts and decreasing the aesthetic value (Schueler, 1987).

The greatest amount of soil erosion occurs during development construction and related land disturbance, where grading activities expose the soil. Soil erosion can also occur on developed sites where pervious areas are not well stabilized (for example, sparse grass cover), and in urban streams where increased flow velocities due to increased runoff has eroded the stream banks, and other places where runoff has been concentrated and the conveyance system is not adequately protected to resist erosion.

Applicability

For all land disturbance activities erosion and sedimentation controls are to be implemented to prevent excessive sediment transport via stormwater runoff. After construction, it is important that property owners periodically inspect the facility grounds to check for any erosion problems or areas where earth is exposed due to poor grass cover or landscape cover.

City of Greensboro Soil Erosion and Sedimentation Control

Through the Soil Erosion and Sedimentation Control Act of 1973 and the City's National Pollution Discharge Elimination System (NPDES) Stormwater Permit, the City of Greensboro enforces sedimentation and erosion controls on all new commercial and residential projects. For sites where land disturbances are greater than one (1) acre, a grading permit is required by City Ordinance. For sites where land disturbances are less than one (1) acre, no grading permit is required; however, the City will still manage and enforce erosion control on the site.

Refer to the City's Soil and Sedimentation Control Section Standards of Practice for more information on the City's regulations, policies, and procedures. Or, contact the Field Services Section of the Storm Water Services Division at 373-2812.

3.3 Non-Structural BMPs

3.3.1 Open Vegetated Conveyance

Description

Open vegetated conveyances may be used instead of curb and gutter (where permitted) and hard piping to convey stormwater runoff where feasible. Open vegetative conveyances may be channels, swales, and, where runoff is in the form of sheet flow, any vegetated area that accepts runoff. Vegetated conveyances help to improve water quality by providing partial pollutant removal as the water is filtered by the vegetation and an opportunity for a portion of the water to infiltrate into the soil. They can also improve stormwater runoff quantity management by reducing the velocity of the flow through the conveyance and providing some infiltration into the soil.

Applicability

Vegetated conveyance systems can best be incorporated into moderate to low density development where land area is available and where the land surface is gently sloping (5% maximum). The site soils must be able to withstand erosion and a dense cover of strong rooted vegetation, such as tall fescue grass, must be established within the conveyance. Vegetated conveyances usually work best when the conveyance is "cut" into existing soils.

A benefit of using open vegetated conveyances is that they can save on construction costs by eliminating the need for stormwater sewer systems.

Open vegetated conveyances may be used for the following:

⇨ *Stormwater conveyance in the watershed critical area.* Section 30-7-3.2 (2) (a) states that drainage shall be provided by means of open channels. Subsection (b) states that the drainage shall have protected channels.

⇨ *Scoring points on the "scoresheet" for low density development in the General water-supply watershed area.* Use of open vegetated conveyances will provide more points than piped conveyances (Factor #10). Also, vegetated conveyances that are used and are designed to resist soil erosion (10-year event), will classify as "protected drainageways" on the scoresheet (Factor #5).

⇨ *To provide stormwater quantity control.* Vegetated conveyance systems can provide temporary retention to reduce stormwater discharge rates. A hydrologic-hydraulic analysis will have to be performed to determine the design that will provide the desired reduction (for more information on design guidelines, see Section 3.4.6, Grass Swales, and section 3.4.7, Filter Strips).

⇨ *Credit towards the stormwater utility fee.* Using vegetated conveyances instead of "hard" conveyances and are designed according to the guidelines given below, will be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

Planning and Design Guidelines

To improve its effectiveness as a stormwater BMP, open vegetated conveyance systems should be used in gently sloping areas to promote shallow, low velocity flow. This will maximize the channel filtering surface, and facilitate sedimentation and infiltration while increasing the travel time to the discharge point.

Channels and swales should be designed to promote shallow flow (i.e. trapezoidal). Conveyances designed with narrow cross sections will have higher velocities and deeper flow depths which allows for less pollutant removal, increased erosion potential, and higher quantity of flow at the discharge point.

The bottom width should be wide enough to maintain a shallow flow but narrow enough to prevent small rills from forming in the bottom during low flows.

Generally the side slopes should not be steeper than 3H:1V. The slopes should be flat enough to maximize the contact surface area (the water with vegetation) and prevent bank erosion while steep enough to reasonably contain the flow.

The permissible velocity for vegetated conveyances should be limited to prevent erosion within the channel. The permissible velocity varies depending on the soil type, the vegetation type, how well the conveyance is maintained, etc. Generally, the velocity should not exceed 4 ft/sec within the channel (10 year storm), for velocities greater than this, check dams may need to be constructed within the channel to slow the velocity.

It is recommended that the lining of open conveyances be a dense cover of erosion resistant grass, such as tall fescue. For channels and swales where relatively steep slopes exist (greater than 3:1), it may be beneficial to plant trees along the top of the slope. Tree roots will provide additional stabilization to the channel banks. It may be necessary to use temporary matting to get the grass established or to use sod.

3.3.2 Stream Buffers

Description

Stream buffers may be implemented along streams, drainageways, and impoundments. The function of the buffers are to:

- ⇨ protect the overall stream quality by providing shading for the stream and provide wildlife habitat;
- ⇨ remove pollutants from stormwater runoff through infiltration and filtering of stormwater runoff from adjacent land areas;
- ⇨ help attenuate flow rates from developed areas;
- ⇨ provide a set back from the stream to prevent damage to structures or improved property due to flooding or changes in the stream channel.

The most effective stream buffers for protecting the overall quality of the stream are those that are left undisturbed including a tree line maintained along the stream bank.

Applicability

All major streams, drainageways, and water bodies should have buffer protection.

Stream buffers must be provided for the following:

Meet water-supply watershed and stormwater management requirements. Refer to Section 2.3 of this Manual for more information.

Stream buffers may be provided for the following:

⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points on the scoresheet can be granted for buffers placed on drainageways and jurisdictional streams (Factor #7).

⇨ *Reduce the stormwater runoff that a site generates.* Stream buffers can serve to reduce the runoff rates that flow into the buffer. The actual reduction depends of the quantity of flow entering the buffer, the flow source (e.g. pipe discharge, sheet flow), the width of the buffer, buffer ground cover, etc.

⇨ *Credit towards the stormwater utility fee.* Properties that implement stream buffers according to City requirements and the guidelines below will be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

Planning Design Guidelines and Requirements

Stream buffers, at a minimum, are required to be implemented on both sides of (1) perennial streams, as defined by this Manual, and (2) drainage channels draining an area equal to or larger than 50 acres. In the Randleman Lake Watershed, buffers on intermittent streams are required as well.

3.3.3 Disconnect Rooftop Drainage

Description

Disconnecting rooftop drainage can reduce the runoff flow rates from developed areas. Disconnecting means that runoff from rooftops will not be directed to storm drainage systems but rather be directed toward pervious surfaces where it can filter through the grass or other landscape material, or infiltrate into the soil.

Applicability

This practice is applicable mostly for low density residential or commercial developments (less than 50% impervious). Disconnection is not applicable where the volume of runoff from rooftops will cause erosion or problems to adjacent downstream properties.

Disconnection practices may be used for the following:

⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points on the scoresheet can be granted for dispersing flow instead of concentrating it (Factor #5). To receive points, the rooftop should disconnected as specified below (along with other impervious areas).

⇨ *Provide stormwater quantity control.* Disconnection of impervious areas can increase the time it takes for runoff to travel to the site outfall (increase time of concentration) and may allow a portion of the runoff to infiltrate into the soil. The effect that disconnection has on stormwater quantity depends on many factors, such as the storm event, the amount of impervious area that is being disconnected, whether the flow is concentrated or not, the soil type, the type of cover on the pervious surface, and the distance from where the runoff is "disconnected" to the nearest downstream area of imperviousness, stormwater conveyance system, or site outfall.

⇨ *Credit towards the stormwater utility fee.* Properties that disconnect rooftop drainage according to the guidelines below, will be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

Planning and Design Guidelines

Downspouts from rooftops should discharge to gently sloping, well vegetated or landscaped areas (mulched areas do a good job in storing and dispersing water as long as the inflow velocity is not great). Erosion control devices, such as splash blocks may be needed at the roof downspout discharge.

Rooftops should provide a downspout for every 5000 square feet of rooftop to reduce the erosion potential at the discharge location. The minimum distance between downspout discharge and the next impervious surface shall be 10 feet.

3.3.4 Clustering/Conservation of Natural Areas

Description

Clustering is a land development practice which can be implemented to concentrate development away from environmentally sensitive areas such as streams, wetlands, mature forests, etc. Because the idea of clustering is to compact development in one location, it will also reduce the amount of roadways, sidewalks and drives required compared to development that sprawls over the entire land area.

Applicability

Clustering and conversation of natural areas should be practiced at least to some extent for all developments, not only to reduce the impacts to our natural resources by minimizing disturbance and percentage impervious, but also to maintain some of the natural beauty of the site.

Clustering and conservation may be used for the following:

⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points for clustering (Factor #1) can be received based on the criteria listed in the water-supply watershed ordinance (Chapter 30). Points can also be earned for conservation of stream buffers (Factor #7) and for conservation or re-creation of wooded areas (Factor #11). Also, by reducing built-upon surfaces, points may be gained for built-upon area (Factor #2).

⇨ *Protection of fragile areas in the watershed critical area.* The City ordinance requires development to conserve fragile areas in the undisturbed state. Fragile areas are steep slopes (>15%) lying adjacent and parallel to streams and drainageways, and wetlands.

⇨ *Reduction of stormwater utility fee.* Clustering and conservation practices are designed to reduce the impervious areas required for the site. Because the stormwater utility is based on impervious surfaces, the fee will be reduced for the site.

⇨ *Other considerations.* Reducing the amount of impervious area reduces the volume of runoff required to be treated by structural BMPs thus reducing the cost and size of the BMPs. Concentrating development away from environmentally sensitive areas will also reduce the amount of time and expense to get federal and state permits for impacts to jurisdictional waters.

Planning and Design Considerations

Concentrate development on the flattest part of the land away from environmentally sensitive areas such as steep slopes, streams, and wetlands. This will not only reduce the impacts to these areas but may reduce the amount of earth moving necessary.

Minimize the width of streets (in accordance with City standards).

Minimize the number of parking spaces and reduce the size of parking stalls and parking aisle widths (in accordance with City standards).

Reduce the amount of overflow parking to the minimum needed.

Take inventory and preserve mature trees and forests.

3.3.5 Grass Paving

Description

Grass paving technology allows for the reduction of paved areas by implementing grass paving in areas that are infrequently used such as fire lanes, overflow parking, golf cart paths, etc. A variety of grass paving units are available on the market. Grass paving units are designed to carry vehicular loading and may be composed of different type materials. The pavers are usually covered with sod to make these areas practically indistinguishable from other grassed areas.

Grass paving provides water quality benefits by allowing stormwater to infiltrate into the underlying soils and by filtering of the stormwater as it flows through the grass.

Applicability

Grass pavers can provide a more aesthetically pleasing site and reduce the "sea of asphalt" look. Grass paving should not be used for frequently traveled or parked in areas, since damage could be done to the grass and the grass needs sunlight to survive.

Grass paving may be used for the following:

⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points can be received for "Other Measures" (Factor #12) for use of grass paving. Sites that incorporate 5% of their total impervious surface as grass paving will receive 10 points for this category.

⇨ *Reduce the runoff generated by a site.* Grass pavers can reduce the runoff volume generated and extend the time of concentration. Some units may provide enough infiltration to be considered a pervious cover; check with the manufacturer for more information on the runoff characteristics of the grass paving.

⇨ *Reduction of stormwater utility fee.* Grass paving is not considered an impervious surface (see note below) as it pertains to the fee, therefore the fee will be less.

⇨ *Credit towards the stormwater utility fee.* Sites that incorporate grass paving into their site, will be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

*Note: Grass paving units are considered by the State and the City to be built-upon area, as it pertains to water-supply watershed regulations.

Design Considerations

Grass paving should not be used in high traffic areas or where vehicles will be permanently parked for long periods of time which may affect the growth of grass.

Refer to the manufacturer's guidelines for proper design considerations, installation, and maintenance of grass paving.

3.3.6 Natural Infiltration

Description

Natural infiltration is a method in which an undisturbed land area covered with natural vegetation accepts runoff from new development and infiltrates the runoff into the soil. Natural infiltration areas should only be used where the soils have a moderate to high infiltration rate (that is, soils in hydrologic group A or B). The area should be in the forested condition with the land surface covered by leaves, needles, and organic matter and should only be used for passive recreation, such as hiking.

Applicability

A natural infiltration area, that meets the design criteria below, may be used a stormwater quality control in the Watershed Critical Area (WCA) where the built-upon area is 6% or less in the Lower Randleman WCA or is 12% or less in any other WCA.

Design Considerations

The following equation is to be used to determine the size of the natural infiltration area (Source: Guilford County Water Quality Protection Manual):

$$A = (KTI)/[(cd - K)$$

Where

A = Natural infiltration area required
K = 0.5 (runoff, inches)
T = Site area
I = Built-upon area ratio (Built-upon area/T)
c = Effective water capacity, in./in. (water/soil)
d = Depth of soil A horizon, in. (determined from table 3.2)

TABLE 3.2: SUITABLE SOIL TYPES FOR NATURAL INFILTRATION

SOIL TYPE	c in/in	d in	HYDROLOGIC GROUP
Appling sandy loam	.25	6	B
Cecil, Madison sandy loam	.25	4	B
Enon, Vance, Helena, fine sandy loam and sandy loam	.17	4	B
Cecil, Enon, Madison, Coronaca and Mecklenburg sandy clay loam and clay loam	.14	4	B or C

SOURCE: GUILFORD COUNTY WATER QUALITY PROTECTION MANUAL

The runoff from areas to be treated should flow into the natural infiltration area as sheet flow and with a non-erosive velocity.

The natural infiltration area is to have the following characteristics:

1. Appropriate soils – high or moderate infiltration rates, low erosion potential, well drained (not in wetland or floodplain)

2. Mature forest cover (the calculated natural infiltration area (A) is to be doubled where a mature forest cover is not present)

3. Slopes not exceeding 10% (where slope exceeds 10% an additional 10% is to be added to the calculated natural infiltration area (A))

4. Remain permanently undisturbed – the natural infiltration area is to be covered by a water quality conservation easement (WQCE)

3.4 Structural BMPs

3.4.1 Introduction

The selection and design guidelines set forth by the City are provided to aid the design engineer in planning and designing the appropriate BMP relative to its function, ease of maintenance, aesthetics, and safety. The design engineer is responsible for designing stormwater BMPs to function properly for each specific site. The City will not be responsible for systems designed according to these guidelines which do not function properly; and will require failed systems to be replaced.

Table 3.3 compares the pollutant removal and peak flow rate reduction efficiency rating of the structural BMPs and notes whether the BMP is acceptable to use to meet the water-supply watershed requirements for high density development. The table also shows the stormwater credit "potential" that each BMP may be able to provide, which is based on its pollutant removal

Table 3.3: Structural BMP Control Efficiency Rating

STRUCTURAL BMP	POLLUTANT REMOVAL CAPABILITY (acceptable method under 30-7-1.12(B)(1)?)	APPROPRIATE FOR PEAK REDUCTION OF 2-YEAR, 10-YEAR STORMS?	STORMWATER UTILITY CREDIT POTENTIAL
Grass swales	2 (No)	2 (maybe feasible for small drainage areas – incorporate check dam(s))	2
Filter strips	2 (No)	2 (maybe feasible for small drainage areas – incorporate check dam at end)	2
Dry detention basins (w/ extended detention)	3 (No)	5	3
Wet detention ponds	4.5 (Yes)	4.5	4.5
Stormwater wetlands	4.5 (Yes)	3	4
Bioretention areas	4.5 (Yes)	1 (usually designed to capture first flush – may be feasible for very small sites	3
Sand filtration facilities	4.5 (Yes)	1	3
Proprietary stormwater treatment facilities	Varies (Depends – monitoring study may be req'd-see Sect. 5.13)	0-1 (most proprietary facilities that will meet watershed requirements are designed to capture the first flush	3

***Note: Scale of 1 through 5**
Where **1** represents limited efficiency/potential and **5** represents excellent efficiency/potential

and peak flow rater reduction capability. The credit potential shown in Table 3.3 is based on general cases. In some cases the BMPs may be able to provide more credit opportunity, for example, incorporating peak flow rate reduction in a bioretetention area that controls a small site.

****NOTE:** The minimum water quality requirements associated with the design of BMPs acceptable to meet water supply watershed requirements are noted by italicized text in the individual BMP sections.*

3.4.2 Structural BMP Selection Guidelines

Once the stormwater control objective has been decided, it is important to select the best BMP for the specific site. This section provides guidance on selecting structural BMPs that best meet certain site characteristics, community acceptance issues, and land uses. Each of the structural BMPs presented in this manual (except for proprietary stormwater treatment facilities) are compared in the following matrices. Again, this section is to provide general guidance; the design engineer should examine the site-specific case thoroughly before deciding on a BMP design.

Site Suitability

Table 3.4 shows some of the main site characteristics that are usually considered when determining which BMPs to be used. The *drainage area* category refers to, generally, the most appropriate BMP to use for certain drainage area sizes. For example, wet detention ponds seem to maintain a permanent pool when it has a larger drainage area

Table 3.4: BMP Site Suitability

Structural BMP	Drainage Area (Acres)	Space Consumption	Site Slope	Soils	Ground Relief B/W Inlet & Outlet
Grass swales	5 max	MED	4% or less	Erosion resistant; permeable	0.5 – 1 feet
Filter strips	Depends[1]	MED			0.5 – 1 ft
Dry detention basins (w/ extended detention)	Full range	MED	15% or less	Erosion resistant; compactable	3 to 6 ft
Wet detention ponds	10 min	HI		Compactable; impermeable	5 to 8 ft
Stormwater wetlands	20 min	HI	5% or less	Impermeable; topsoil for plants	5 to 8 ft
Bioretention areas	5 max	MED	10% or less	"Made" Planting Soil	5 to 7 ft
Underground Sand Filter	1-2 max	NONE – LO		Not restrictive	5 to 7 ft
Perimeter Sand Filter	1-2 max	LO			3 to 5 feet
Surface Sand Filter	5 max	MED			5 feet

[1] The drainage area to the filter strip is limited by the length of surface to be treated –100 feet.

(especially when there is a groundwater source), but most certainly can be used drainage areas smaller than 10 acres. Also, it is usually easier to manage sand filter facilities that have smaller drainage areas, but a larger site may choose to implement several facilities or a combination of different BMPs. The *space consumption* category refers to the relative amount of land space that is taken up by the BMP, including associated dams, benches and embankments. The *ground relief between inlets and outlets* category refers to the elevation difference between the inlet and outlet outfalls. For example, runoff from parking lot that is treated by a bioretention BMP first drops 6 inches from the parking lot to a gravel spreader, then flows down through 3 inches of mulch, 4 feet of "made" planting soil and 6 inches of gravel underdrain, and discharged. In this example, the runoff has to "drop" a little more than 5 feet from the inlet to outlet to be treated.

Community Acceptance

Table 3.5 shows various community and property owner issues that should be considered before selecting a BMP. These issues are important because the property owner will be fully responsible and liable for the BMP that is constructed.

Table 3.5: Community Acceptance

STRUCTURAL BMP	EASY TO MAINTAIN?	SAFE?	RELATIVELY ECONOMICAL[1]?	AESTHETICALLY PLEASING?	PROVIDES HABITAT?
Grass swales	☺	☺	☺	☺	☹
Filter strips	☺	☺	☺	☺	☹
Dry detention basins (w/ extended detention)	☺	😐	☺	😐	😐
Wet detention ponds	☺	😐	😐	😐	☺
Stormwater wetlands	😐	☹	😐	😐	☺
Bioretention areas	☹	☺	😐	☺	😐
Underground Sand Filter	☹	☺	☹	☺	☹
Perimeter Sand Filter	☹	☺	☹	☺	☹
Surface Sand Filter	☹	😐	☹	😐	☹

☺ = Yes 😐 = Maybe ☹ = No

Relatively Economical is based on the construction costs per drainage area treated. It does not take into account land costs.

Land Uses

Table 3.6 shows suggested structural BMPs for various land uses. It is important to note the proximity of residences or to the BMP, the desired aesthetic value, property owner's ability to maintain the BMP, land availability and costs, pollutant sources to the BMP, etc.

Table 3.6: Suggested BMP for Various Land Uses						
STRUCTURAL BMP	SINGLE FAMILY	MULTI-FAMILY	LOW DENSITY COMMERCIAL	HIGH DENSITY COMMERCIAL	LOW DENSITY INDUSTRIAL	HIGH DENSITY INDUSTRIAL
Grass swales	✓	✓	✓		✓	
Filter strips	✓	✓	✓		✓	
Dry detention basins (w/ extended detention)	✓	✓	✓	✓	✓	✓
Wet detention ponds	✓	✓	✓	✓	✓	✓
Stormwater wetlands					✓	✓
Bioretention areas	✓ (for individual home sites)		✓	✓		
Underground				✓		
Perimeter			✓	✓		
Surface			✓			

3.4.3 Control Volumes

Water Quality Volume (WQV)

The Water Quality Volume (WQV) is the storage needed within a structural BMP to control the "first flush" of runoff during a storm event. Studies have generally shown that the highest pollutant concentrations are found in the initial runoff period or "first flush." The State of North Carolina and City of Greensboro designate the "first flush" to be the runoff volume from the first 1.0 inch of rainfall over the drainage area to the structural BMP. The WQV may be calculated (Schueler, 1987) as follows.

$$\mathbf{WQV} = \frac{\mathbf{1.0 * R_v * DA}}{\mathbf{12}}$$

Where;

WQV = Water Quality Volume (in acre-feet)

$\mathbf{R_v}$ = Volumetric Runoff Coefficient (Schueler 1987) = **0.05 + 0.009(I)**

where **I** = percent impervious cover of the drainage area

DA = Drainage Area to BMP (in acres)

Quantity Control Storage Volumes

Refer to Section 2.4.2 of this manual for guidance on determining quantity control storage volumes.

3.4.4 Stormwater Utility Credit

Credit will be granted for sites that construct structural BMPs to treat runoff. The credit will be based on the BMPs pollutant removal and peak flow reduction efficiency. Organizations wishing to receive credit for installation of structural BMPs should follow the guidelines presented in this manual. For more information on credit opportunities refer to the City of Greensboro *Stormwater Utility Credit Policy Manual.*

3.4.5 Regulatory Considerations

The following State and Federal regulations need to be considered when designing structural BMPs.

Dam Safety

Structural BMPs designed to impound water pose a potential hazard to downstream citizens and property. Because structural BMPs are mostly used in urbanized areas or rapidly growing areas, such as in Greensboro, potential hazards related to water impoundments and dams are increased.

The State of North Carolina Dam Safety Law of 1967 [as Amended through 1995] provides for the certification and inspection of dams in the interest of public welfare with respect to reducing the risk of failure to dams. The rules, which are provided in the North Carolina administrative Code Title 15A, Subchapter 2K (see Appendix F), entitled "Dam Safety," state that "no person shall begin the construction of any dam until at least 10 days after filing with the Department a statement concerning its height, impoundment capacity, purpose, location and other information required by the Department." It is important to note that the department requires notification for the construction of *any* dam even if the dam may be "exempt" from the State's regulation.

The Regulations (N.C.G.S 143-215.25A (a) (6)) exempts a dam "that is less than 15 feet in height or that has an impoundment capacity of less than 10 acre-feet, *unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam.*" If the failure of a dam could result in the loss of human life or significant property damage the dam is classified as a High Hazard (Class C) structure. Although many structural BMP dams that are constructed in Greensboro are smaller than the size criteria for State regulation, the fact that they are being constructed in an urban or developing area could potentially have significant impacts to human life and property. Table 3.7 shows the quantitative guidelines used by the State Dam Safety Office for dam hazard classification.

To help ensure that stormwater BMP dams have met the State Dam Safety regulations and that the dams have been designed with public health, safety, and welfare in mind the **Engineer's Statement of Pond and Dam Safety** (Figure 3.2) is required for dams proposed to be constructed for stormwater BMPs that temporarily or permanently store water.

Table 3.7: Dam Hazard Classification

HAZARD CLASSIFICATION	CRITERIA	QUANTITATIVE GUIDELINES
LOW	Interruption of Road Service, Low Volume Roads	Less than 25 Vehicles per Day
	Economic Damage	Less than $30,000
INTERMEDIATE	Damage to Highways, Interruption of Service	25 to Less than 250 Vehicles per Day
	Economic Damage	$30,000 to Less than $200,000
HIGH	Loss of Human Life*	Probable Loss of 1 or More Human Lives
	Economic Damage	More than $200,000
		250 Vehicles per Day at 1000 Feet Visibility
		100 Vehicles per Day at 500 Feet Visibility
		25 Vehicles per Day at 200 Feet Visibility

*Probable Loss of Human Life Due to Breached Roadway or Bridge on or Below the Dam

NOTE: Cost of dam repair and loss of services should be included in economic loss estimate if the dam is a publicly owned utility, such as a municipal water supply dam.

Figure 3.2: Engineer's Statement of Pond and Dam Safety

ENGINEER'S STATEMENT OF POND AND DAM SAFETY

The stormwater pond and dam shown on this plan satisfies requirements of the North Carolina State Dam Safety Law of 1967 [As Amended Through 1995] and the Rules and Regulations as presented in the North Carolina Administrative Code Title 15A, Subchapter 2K - Dam Safety. Even in the case where the dam shown on this plan is determined by the State to be exempt from the above noted Dam Safety requirements, I, as the qualified design engineer, state that the pond and dam are designed to be safe and adequate for the protection of public health, safety, welfare, and downstream property. I understand that this statement as the design engineer shall not relieve the owner or operator of the pond and dam from the legal duties, obligations, and liabilities arising from such ownership or operation.

Jurisdictional Streams and Wetlands

It is the intent in most cases to design stormwater management devices to remove pollutants before they have a chance to enter "waters of the United Sates." Stormwater BMPs should be constructed outside of perennial streams and natural wetland areas unless no practical alternative exists. Also, natural or existing lakes, ponds, and wetlands should not be considered for stormwater BMP retrofits until Federal and State Permits for such purpose have been obtained. The US Army Corps of Engineers (ACE) requires that all impacts to jurisdictional waters and wetlands be reported to their office. Depending on the impact, the US ACE and NC Division of Water Quality (DWQ) may require the applicant to obtain permits, prepare environmental documents, mitigate for the impact, etc. For Greensboro, the contacts are the US ACE Raleigh Regulatory Field Office at 919-876-8441 and NC DWQ Winston-Salem Division Office at 336-771-4608.

Required Stream Buffers

Stream buffers protect the overall quality of the stream, by achieving pollutant removal as runoff flows through the buffer, by providing shade for the stream and habitat for wildlife. Stream buffers are required for certain streams within the City (refer to the City ordinance section 30-7, water-supply watershed districts, ordinance section 27-22, stormwater management control, and Section 2.3 of this manual for more information on buffer requirements). Although stormwater BMPs may be allowed in required stream buffers, other alternative locations should be examined. Whenever there is a practical alternative, structural BMPs should not be placed in stream buffers, but if encroachment into the stream buffer is needed, the amount of stream buffer area that is impacted and the distance between the impact and the stream should be minimized. Also, consideration should be given to the design of the BMP discharge to prevent erosion in the buffer zones and of stream banks.

FEMA Floodway/Floodplain

Placement of structures including stormwater structural BMPs within a designated 100-year floodplain as shown on FEMA's Flood Insurance Rate Map (FIRM), is strongly discouraged. In the event of a large flood, floodwaters could cause significant damage to the BMP. No structural BMP will be allowed in the designated "floodway" without submitting a "Certification of No Rise" to the City for approval, a "Conditional Letter of Map Revision" or a "Letter of Map Revision" is obtained from FEMA and all applicable federal and state permits have been obtained. Structures placed in the floodplain should be appropriately constructed to prevent damage from floodwaters. Refer to Chapter 30-7-5 Flood Damage Prevention, for more information regarding this subject.

3.4.6 Grass Swales

Description

Grass swales are gently sloping waterways or channels that are densely covered with erosion-resistant grasses and designed to slowly convey stormwater runoff. The grass swale is similar to the vegetated conveyance presented in Section 3.3.1 (Non-structural BMPs), but with additional provisions to improve its stormwater management functionality.

In the past, open channels were used for the sole purpose of conveying stormwater runoff, but by incorporating certain design parameters, grass swales can provide modest quality and quantity control. Swales help to improve water quality by providing partial pollutant removal through the filtering action of the grass, particle settling by reduced velocity, and infiltration into the soil. Grass swales can also improve stormwater runoff quantity management by reducing the velocity of the flow through the conveyance and providing some infiltration into the soil.

Applicability

Due to their limited pollutant removal capability, grass swales are not an acceptable BMP for meeting the requirements for "high density" development in the water-supply watershed. However, use of grass swales which are designed according to the guidelines presented in this section can be awarded credit on the stormwater utility fee. Also, grass swales in some cases can attenuate the peak flow rate from developed areas and can be used to meet stormwater management requirements. Typically, swales can be designed to control smaller storms (such as the 1-year or 2-year) and smaller sites (5 acres or less).

Grass swales can best be incorporated into moderate to low density development where land area is available and where the land surface is gently sloping (5% maximum), and the drainage area is relatively small (1 to 2 acres). The in situ soils must be able to withstand erosion and a dense cover of strong rooted grass must be established within the swale. Grass swales resist erosion better when the are "cut" into the natural ground.

Design Guidelines

For grassed swales to meet City regulations, a 15' access easement will be required from the public street right-of-way to the grassed swale. A maintenance easement shall be placed over the swale and shall extend 15' beyond the top of the side slopes.

Cross section geometry: To improve their effectiveness as a stormwater BMP, grass swales should be constructed with a wide cross section (for example, trapezoidal, or parabolic) and in gently sloping areas to promote shallow, low velocity flow. This will maximize the channel filtering surface, and facilitate sedimentation and infiltration while increasing the travel time to the discharge point. Swales that are designed with narrow cross sections tend to have higher velocities and deeper flow depths which allows for less pollutant removal, increased erosion potential, and higher quantity of flow at the discharge point.

WQV storage: The WQV should be discharged within 6 to 24 hours. The water quality volume should be temporarily detained in the grass swale and released over 24 hours (48 hours maximum). The maximum depth of the water quality volume storage within the swale should be 1.5 feet.

Flow Velocity: The velocity for 2-year storm should not exceed 2 feet per second within the swale.

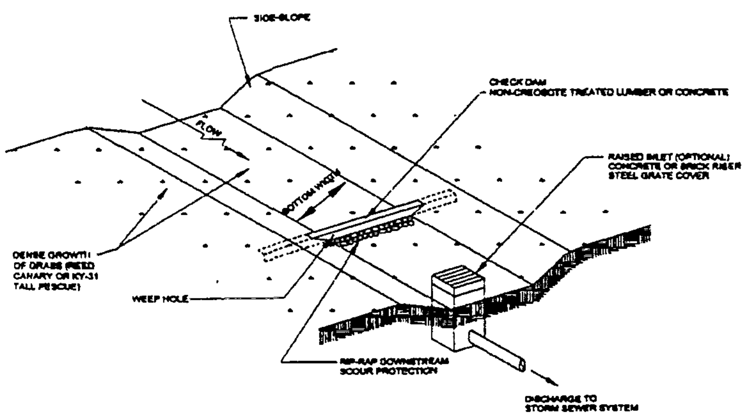
Bottom width: The bottom width should be within the range of two to eight feet. The two feet minimum allows for construction considerations wide enough to maintain a shallow flow but narrow enough to prevent small rills from forming in the bottom during low flows.

Side slopes: The side slopes should be flatter than 4H:1V. The slopes should be flat enough to maximize the contact surface area and prevent bank erosion while steep enough to reasonably contain the flow.

Longitudinal slope: The longitudinal slope should be less than 5%. The slope should allow for sufficient drainage and uniform flow while preventing excessive velocity. For slopes greater than 2%, check dams should be utilized at the specified intervals.

Check dams: A control to increase the stormwater management efficiency of vegetative swales, is to construct check dams spaced at suitable intervals and perpendicular to the flow direction. Check dams may be constructed with treated timber, gabions, or rip rap. For quality credit, check dam spacing is such that the top of a check dam is at the same

Figure 3.3: Example of Grass Swale



elevation as the toe of the check dam immediately upstream. For example, a swale that has a 4% slope and check dams that are two feet high, would have a spacing of every 50 feet. A hydrologic-hydraulic study will have to be performed to determine the spacing and discharge rates of the check dams needed to meet quantity reduction **requirements.**

Capacity: The swale should be designed to adequately convey the 10 year storm event in a non-erosive manner or provide an overflow as shown in Figure 3.3.

3.4.7 Filter Strips

Description

Filter strips are similar to grass swales, with the exception that strips are designed to receive runoff from impervious or pervious areas in the form of sheet flow. The filter strip is usually the same or greater width than the area it is treating and a spreading device (such as a gravel diaphragm) is placed between the runoff area and the filter strip to help distribute the runoff evenly. The filter strip may be a replanted forested area or a densely grassed area (see Figure 3.4). The filter strip may also be a natural undisturbed area where the land characteristics meet the design criteria below.

Filter strips, like swales, provide modest pollutant removal efficiency through the filtering action of the grass and infiltration into the soil.

Filter strips slightly reduce peak flows by reducing velocity and providing some infiltration into the soil. A check dam can be used at the end of the filter strip to provide additional peak reduction and direct the discharge to a conveyance system, if desired.

Applicability

Filter strips are best utilized in low density developments (single and multi-family) where the contributing drainage area is small, relatively flat (less than 5%), and will drain through overland flow. Filter strips can treat runoff from parking lots, roads, or pervious areas that receive chemical treatment such as golf courses. The area to be treated should flat across its width so runoff will be evenly distributed across the filter strip.

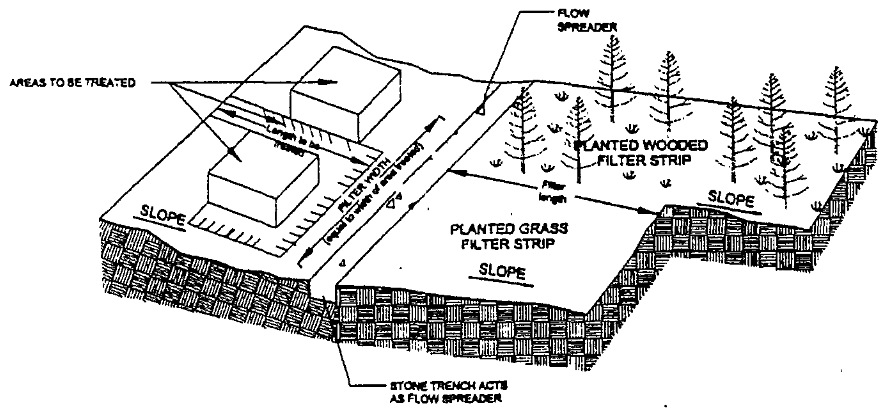
ue to their limited pollutant removal capability, filter strips are not an acceptable BMP for meeting the requirements for "high density" development in the water-supply watershed. However, filter strips can be effective when used as pretreatment for other BMPs such as bioretentDion. Filter strips also do a good job in protecting water resources such as streams, wetlands and lakes.

Design Guidelines

For vegetated filter strips used to meet City regulations (water-supply watershed or stormwater management), a 15' wide access easement will be required from the public street right-of-way to the filter strip. A maintenance easement shall be placed over the filter strip and extend 15' beyond its perimeter.

Length (direction of flow): The length of filter strip should be at least 50 feet. The length of 50 feet will give the runoff time to be filtered or intercepted by the vegetation and allow some infiltration. After 100 feet of run it is probable that the sheet flow will begin to channelize.

Figure 3.4: Example of Filter Strip



Width: The filter strip width should be the same width of the area that it is treating (see diagram). Runoff should enter the filter strip as uniform, low velocity sheet flow. A pea gravel diaphragm or level spreader may be required to uniformly distribute and dissipate the energy of incoming flow.

Longitudinal Slope: The longitudinal slope of the filter strip should be between 1 to 6%. The strip should be sloped enough to provide positive drainage but not too much to exceed the erosion tolerance of the vegetation. The designer should note what type ground cover and soil type that will be used when designing the slope of the filter strip.

Vegetation: The filter strip can be planted with a variety of species but should incorporate a dense cover of strong rooted grass, plants and trees. A mixed, dense, **native** grass species is the most low maintenance, sustainable, effective forms of vegetation cover for reducing runoff volume and pollutant loads (study findings - Texas State Soil and Water Conservation Board Bulletin No 97-1). Where natural areas are used as filter strips, the existing natural vegetation usually provides effective treatment.

Treatment Area: Areas to be treated by the filter strip should be graded uniformly with a longitudinal slope of 5% or less. The maximum length of impervious area that can be treated is 100 feet.

Flow Spreader: A gravel diaphragm (trench) should be used to separate the area to be treated from the filter strip. The trench shall be used to dissipate the energy of incoming runoff and maintain sheet flow. The filter strip should exactly meet the elevation of the level spreader to help prevent the chance of channelization (Schueler, 1987).

Optional Check Dam: For increased quantity control a check dam be placed at the end of the filter strip for temporary storage. The check dam can also provide a means to concentrate discharge at one location (e.g. to a yard inlet) once it passes over the filter strip.

3.4.8 Dry Detention Basins

Description

A dry detention basin is a stormwater temporary storage basin that does not have a permanent pool. Dry basins receive stormwater runoff and temporarily stores (or details) it for a short period of time as the captured water is slowly released. Dry detention basins can be incorporated in underground chambers, athletic fields, open spaces, etc, and therefore, is relatively easy to fit into a site.

Dry detention basins are best used for reducing stormwater runoff peak flow rate to an acceptable rate. Because dry detention basins have a tendency to re-suspend accumulated sediments, they are not the best choice for water quality protection. However, by providing "extended detention" (WQV is discharged over 24 hours), dry detention basins can provide modest pollutant removal, mainly of coarse sediments.

Applicability

The dry detention basin is ideal for reducing flow rates of small and large storm events. Dry detention basins can be sized to support small to large size drainage areas. Therefore, this BMP can be effective to meet the requirements of the quantity control requirements of the stormwater management ordinance.

Dry detention basins do not have the pollutant removal capability of wet detention ponds and are **not** considered an acceptable stormwater BMP to meet the requirements for high-density development in water-supply watershed areas. However, dry detention basins with extended detention do a decent job in settling out coarse particles. Therefore, sites that incorporate extended detention of the WQV and the design guidelines below are eligible for quality credit as specified in the *Storm Water Utility Credit Policy* document .

Also, dry detention basins may be used as part of a "treatment train," for example, as the pretreatment (sedimentation) basin to the surface sand filtration facility.

General Guidelines

Avoid placing these structures in environmentally sensitive areas such as streams and wetlands.

Though dry detention basins impound water temporarily, associated dams should be constructed in accordance with NC Dam Safety Regulations. Careful attention should be paid to dam design and the downstream present and future use.

For dry detention basins used to meet City regulations, a 15' wide access easement will be required from the public street right-of-way to the dry basin. A maintenance easement shall be placed over the basin and extend 15' beyond its embankments (or outer edge for concrete chambers). Underground chambers will need an adequate amount of access doors/manholes for periodic maintenance, such as sediment removal.

The embankment slopes for open basins should be flatter than 3H:1V slope for safety and ease of maintenance. Suitably designed vertical concrete walls may be used instead of earth embankments for open dry detention basins. In this case, it is recommended that a safety fence or other device be constructed around basin perimeter to prevent accidents.

Design Guidelines

For design methodology on meeting stormwater management regulations, quantity control, please refer to section 2.4.2.

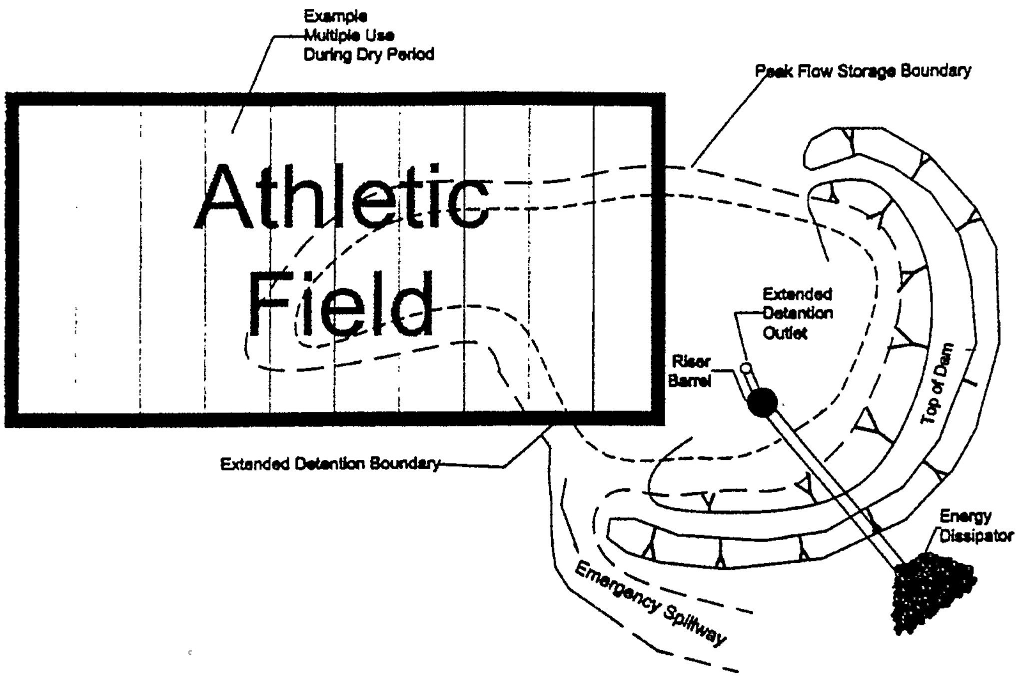
Dry detention basin should temporarily store the WQV for 24 hours or more.

The efficiency of sedimentation basins to settle suspended solids is based mainly on the surface loading rate (outflow divided by basin surface area) and is relatively independent of the depth of the basin. The following equation may be used to size a sedimentation basin with an efficiency of settling particle sizes larger than 20 microns. It was derived by the Washington State Department of Ecology from the Camp Hazen Equation (Schueler, 1996):

$$As = -(Qo/w) * Ln(1-E)$$

Where
- As = Sedimentation basin surface area (sq. ft)
- E = Trap Efficiency - target 90% (equation uses decimal format)
- w = Particle settling velocity (for 20 micron silt particle = 0.0004 ft/sec)
- Qo = rate of outflow (WQV divided by detention time, usually 24 hours)

Figure 3.5: Example of Dry Detention Basin



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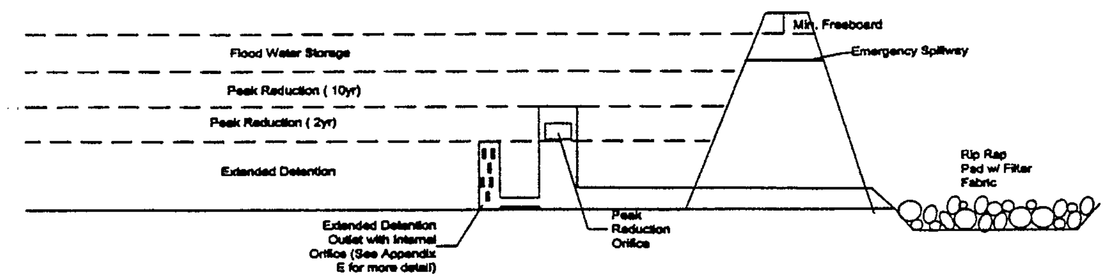

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Low flow Orifice(s)
Low flow orifices are designed to slowly release the volume stored in the basin. The release device may be a perforated riser, pipe with attached orifice plate, or a skimming device. With any of these orifices trash protection must be considered (see Appendix H for examples of trash protection devices).

Spillways
Aboveground dry detention basins should have spillways designed to safely pass up to the 100-year storm event, at a minimum. Riser/barrel assemblies, concrete chutes, or rip rap lined channels may be used to pass larger storm events. Open channel spillways must not be placed in the fill section of earth dams. The spillways must have provisions to prevent erosion of the receiving conveyance.

3.4.9 Wet Detention Ponds

Description

In Greensboro, the wet detention pond is currently the most commonly used BMP for meeting water-supply watershed protection requirements. This stormwater BMP improves stormwater quality primarily by detaining stormwater runoff for an extended period of time (usually 2 to 5 days) to allow pollutants that are suspended in the runoff to settle out. During a storm event, runoff enters the pond and replaces the "treated" water in the permanent pool that has been detained in the permanent pool from the previous storm event(s). As runoff enters the pond, its velocity is significantly reduced allowing suspended pollutants to begin settling. Many pollutant particles found in stormwater runoff are very small in size and, because smaller particles settle slower than larger particles, the pond is designed to provide adequate detention time so smaller particles have a chance to settle out.

The components of the wet detention pond that help increase the pond's pollutant removal efficiency are the permanent pool, temporary pool, and forebay. The permanent pool prevents particles that have settled to the pond bottom from re-suspending when runoff flows into the pond. The temporary pool is storage above the permanent pool that is designed to control the WQV. To increase the detention time of the runoff, the temporary pool is slowly released through low flow orifice(s). A separate smaller pond, called a forebay, is placed upstream of the main pond to trap a majority of the coarser fractions of suspended solids in the runoff before it enters the main pond.

Applicability

The wet detention pond is effective in removing pollutants and can be used to meet water supply watershed regulations. It also can be easily adapted to provide quantity control for storms larger than the water quality storm event, require less periodic maintenance than other structural BMPs, and if desired can provide an amenity to a property such as "lakefront" residential property, wildlife habitat and fountain pools. The wet detention pond BMP is most applicable for large industrial and commercial facilities and residential subdivisions.

Wet detention ponds, based on findings from the City's periodic BMP inspection program, seem to function better when the pond is larger and receives flow from a larger drainage area. This may be attributed to several factors, such as, in larger drainage areas there is usually a better chance for seasonal or permanent surface or groundwater flow into the pond as opposed to smaller drainage areas. This flow may help the permanent pool to be "flushed" more often (as opposed to only during storm events), which may help to prevent undesirable conditions from developing (for example, stagnate water, fluctuating permanent pool elevation, etc.). It is suggested that owners of smaller properties cooperate to construct and maintain one relatively large pond to serve several properties, rather than several individual smaller ponds. Although the City generally recommends a drainage area of 10 acres or more, wet detention ponds may be used for smaller drainage areas.

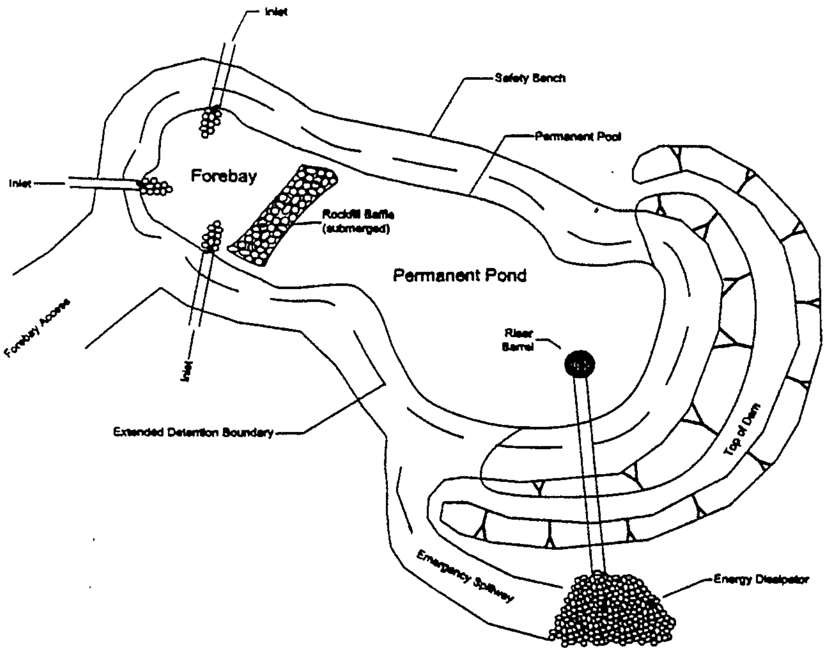
Wet detention ponds have a higher tolerance for runoff with significant sediment concentration than the other BMPs. Therefore, wet detention ponds are the best BMPs to use in large developments where construction will take place in phases or in residential development where site disturbance will occur for a significant period after the BMP is installed. Also, properties where the land may remain fully or partially unstabilized or if there are sources of sediments on the property (e.g. stock yards, gravel/dirt areas, construction equipment storage, etc.) the wet detention pond is a good choice.

General Guidelines

Placement of ponds in jurisdictional waters may require Federal and State Permits. It is suggested that ponds not be placed in perennial streams, whenever possible. Also, wet detention ponds used to meet water-supply watershed regulations will be required to be designed to treat the total drainage area to the pond, on-site and off-site, per the City's water-supply watershed ordinance. That means, if the property owner of a 10 acre site decides to place a wet detention pond in a perennial stream that drains 75 acres, the pond must be sized to control 75 acres of drainage area including the existing development within the drainage area in addition to the 10 acre site. However, the property owner may be able to recoup costs by allowing new development in the off-site drainage area to use the pond to control built-upon area in exchange for financial participation.

When designing the dam and spillways, existing and potential future downstream development should be considered. Avoid placing the dam upstream of highly developed or traffic areas whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or if no conveyance is present, the discharge should be directed away from existing development.

Figure 3.6: Example of Wet Detention Pond



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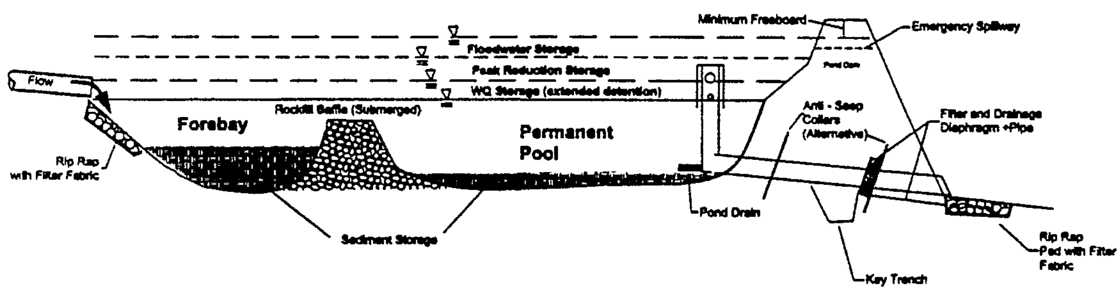

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The pond should be easily accessible for maintenance. A 15' wide access easement shall be provided from the public street right-of-way to the pond. A drainage maintenance and utility easement (DMUE) shall be paced over the pond and extend 15' beyond the embankments. The access easement should be kept easily accessible for maintenance.

For ease of maintenance and safety, the pond embankments should be sloped to a maximum of 3H:1V with flatter slopes preferred. A 10-15' bench (max. slope 10%) placed around the pond near the normal pool surface, is strongly encouraged. This bench will allow machinery gain closer access to the pond during cleanouts. This break in the grade will be a safety amenity and can make the pond more aesthetically pleasing.

The pond surface area shall have a minimum 2:1 length to width ratio, with 3:1 preferred. *The distance between the inlets and outlets should be maximized to increase the pollutant removal capability of the pond.*

It is encouraged to create a pond that fits within the natural contours of the land but care should be taken to prevent "dead storage zones" (areas outside the flow path between the inlet and outlet) within the pond. "Dead storage zones" are areas outside the flow path from the inlets to the outlets. Generally, the pond should be narrower at the inlet forebay area and become wider at the outlet. Whenever possible one forebay should be created and all pond inlet pipes discharge to the forebay area.

The bottom of the pond should be slightly sloped from the upstream end to the downstream end. This will allow the pond and captured sediments to drain better when cleanouts are necessary.

It is encouraged where appropriate to use educational signs at the pond describing the function of the pond and the purpose it serves.

Design Guidelines

Sediment Storage: Storage is to be allocated for sediment accumulation between cleanouts. *Recommended 0.125 inches depth over the drainage area with approximately 75% of this volume be allocated to the forebay.*

Minimum Average Permanent Pool depth: 3 feet.
The average permanent pool depth is the average depth of the permanent pool over the entire pond including the forebay. The permanent pool is measured from the top of the sediment storage to the invert of the low flow orifice that releases the WQV.

Permanent Pool Surface Area: See Table 3.8:

Table 3.8: Wet Detention Pond Permanent Pool Surface Area to Drainage Area Ratio (Percent)							
BUILT-UPON PERCENT	**AVERAGE PERMANENT POOL DEPTH (FT)**						
	3.0	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0+**
10	0.59	0.49	0.43	0.35	0.31	0.29	0.26
20	0.97	0.79	0.70	0.59	0.51	0.46	0.44
30	1.34	1.08	0.97	0.85	0.70	0.64	0.62
40	1.73	1.43	1.25	1.03	0.90	0.82	0.77
50	2.00	1.73	1.50	1.33	1.09	1.00	0.92
60	2.39	2.03	1.66	1.51	1.29	1.17	0.10
70	2.75	2.27	1.96	1.79	1.48	1.35	1.29

Interpolation and extrapolation may be necessary to determine the appropriate surface area to drainage area ratios.

Temporary pool volume: water quality volume (WQV).

Temporary pool draw down time: 2 to 5 days.

Principal Spillway Capacity: 10 year 24 hour storm event.

Emergency Spillway Capacity: Minimum 100 year 24-hour rain storm event (design to be consistent with the NC Dam Safety Requirements).

Dam freeboard: NC Dam Safety requires a one (1) foot minimum freeboard above the maximum flood pool elevation during the spillway design flood. The City encourages the designer to maximize the freeboard to the extent practicable.

Pond Inlets

Inverts for inlet pipes should be at the elevation of the normal pool to allow the pool to dissipate the energy of the inflow to prevent erosion along the embankment slope. Inlets should be designed to discharge to the pond perpendicular to the pool surface to minimize potential erosion problems to the side embankment. Rip rap pads should be underlain with a gravel/sand filter or geotextile fabric which should extend from the pipe invert to the pond bottom.

Forebay

A forebay shall be provided for all inlets to the pond. The forebay area is to be located at the upstream area of the pond. *The forebay is separated from the rest of the pond by a barrier or baffle, which may be constructed of earth, rip rap, or gabions. The forebay serves to trap coarse sediments and minimize their migration into the main pond. Collecting the sediment in this one area makes it easier to clean out, since machinery will not have to go into the entire pond, which can be very expensive.*

The forebay baffle should extend to one foot below the normal pool elevation or above. The baffle material may be earth, rip rap, etc. If earth baffles are used, provisions should be included to allow the forebay to drain out with the rest of the pond to facilitate sediment removal from the forebay. This could include a rip rap check dam in a section of the earth baffle or a perforated riser pipe connecting the forebay to the main pond.

It is recommended that approximately 75% of the required sediment storage be allocated to the forebay. To minimize the resuspension of settled particles, the depth of water in the forebay (between the permanent pool elevation and top of sediment storage) should be at least 2 feet and the average velocity for the 2-year storm peak flow rate (peak flow divided by average cross sectional area of forebay) should be less than 1.0 fps.

An access to the forebay for future sediment cleanouts is to be provided. It is recommended that the access have a maximum slope of 15-20% extending from the top of the embankment to the toe. This access will allow construction equipment to get down in the forebay and will minimize disturbance to the vegetation.

Pond Dam

Notification of the proposed dam construction is to be made to the NC Dam Safety Office.

A concrete retaining wall may be used for the pond dam, but it shall not include more than 50% of the pond perimeter.

For earth dams, the top width of the dam should be 10 feet minimum.

For earth dams, a cutoff trench should be excavated and filled with highly impervious and well compacted material. Incorporating a chimney drain or drainage blanket should be considered to reduce the potential for seepage problems.

For large ponds that have a considerable fetch, wave action during storms should be considered in the freeboard.

Treatment Orifices

Low flow orifice(s) shall be used to slowly release of the water quality volume over a period of 2 to 5 days. Additional low flow orifice(s) or other appropriate provisions may be incorporated above the temporary pool to provide peak flow reduction. Refer to Appendix F for the preferred method for calculating the orifice drawdown time.

The low flow orifices are to be protected from clogging up with floating debris using a trash guard. The trash guard should be durable and secure and should extend at least six inches below the normal pool surface. A common method when using a riser/barrel is to extend the principal spillway trash rack assembly below the normal pool. When the low flow orifice will be placed in a concrete dam or spillway, an inverted or submerged orifice can be used or a half aluminum pipe bolted to the concrete (see Appendix H for example trash protection devices).

Principal Spillway
The principal spillway should be a riser/barrel, concrete free fall weir, or concrete chute with capacity to handle the 10-year 24 hour rain storm event, at a minimum. Of the available options for the riser/barrel material such as reinforced concrete, ductile iron, PVC, or corrugated aluminum piping, reinforced concrete (where the joints are sealed watertight) and ductile iron pipes (being rigid pipes) are preferable for this application. A flexible pipe, such as corrugated aluminum piping may experience distortion of its cross-sectional shape during compaction of the soil around it and result in internal soil erosion problems potentially leading to failure of the embankment around and above the pipe.

Riser/barrel assemblies should be equipped with a trash rack and an anti-vortex device and should be properly anchored to resist buoyancy forces.

A "filter and drainage diaphragm" or anti-seep collars should be used to prevent piping along the barrel within the earth fill, with the diaphragm being the preferred method (see Appendix J for NRCS design guidelines).

Appropriate energy dissipation should be used at the spillway exit to prevent erosive velocities for up to the 10-year peak discharge rate, at a minimum. Every effort should be made to discharge in defined conveyances and parallel to the existing flow to prevent bank erosion. Downstream channels may need to be modified and lined with rip rap to prevent erosion of the channel. Modifications to the downstream channel should be minimized as much as possible to prevent excessive disturbance in the channel.

Emergency Spillway
The emergency spillway should be designed to safely convey discharges resulting from storms up to the 100-year 24 hour storm, at a minimum. The spillway should be located where it will not adversely affect downstream property such as roadways and building structures. The emergency spillway may be incorporated into the principal spillway where accommodating the emergency spillway elsewhere is not feasible for the given site characteristics.

The emergency spillway should be cut into existing soils outside the fill section of the dam. The emergency spillway may be grass lined, when velocities permit, or lined with **rip rap, concrete, or other erosion resistant materials. Grass lined spillways are to be planted with a dense cover of erosion resistant grasses.**

Pond Drain
A pond drain is to be provided to drain the pond for routine maintenance or structural repairs in an emergency situation. It is recommended that the pond drain be designated to have the discharge capability to completely drain the pond in less than 48 hours, in the event of an emergency posed by impending failure of the pond dam. The upstream slope of the pond dam should be designed to be flat enough to prevent slope failure due to "quick drawdown" of the pond (NC Dam Safety Code specifies a factor of safety of 1.25) in an emergency. Care should be taken to minimize transport of settled sediment from the pond during draining.

3.4.10 Stormwater Wetlands

Description

Constructing wetlands to treat stormwater is an attempt to reproduce the excellent pollutant removal capability of natural wetlands. Stormwater wetlands remove pollutants primarily through physical filtration and settling, by biological processes of wetland plants, and bacteria in the substrate. The stormwater wetland BMP is, in some respects, similar in design to the wet detention pond. The major difference is the creation of varying depth zones in the shallow marsh area of the wetland to support emergent wetland vegetation. Because consideration must be paid to creating various depth zones and establishing a plant community that can thrive in the different zones, designing, constructing, and maintaining stormwater wetlands is more complex than wet detention ponds.

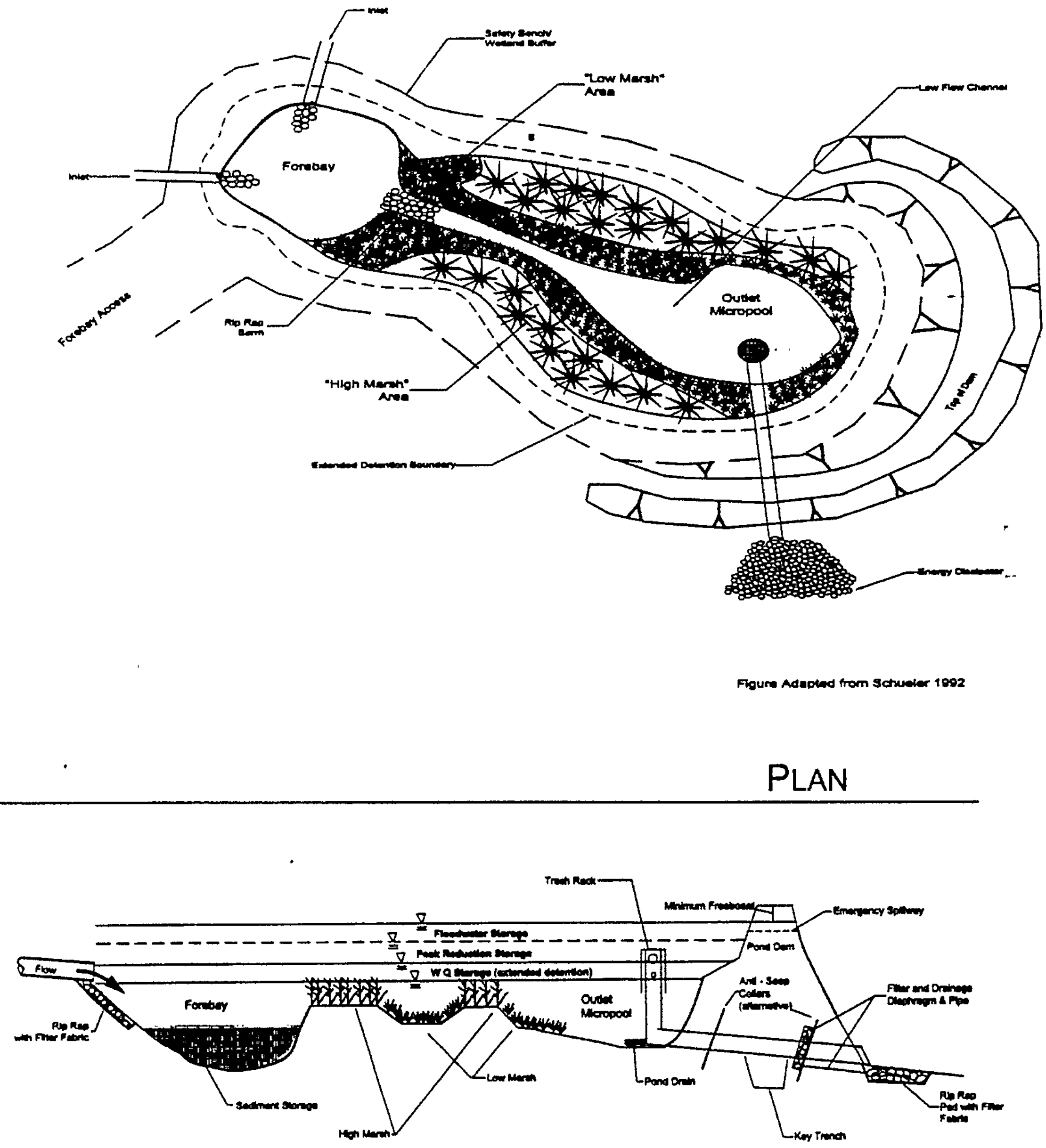
Although stormwater wetlands are modeled after natural wetlands, they have many differences. Generally, natural wetlands are self-maintaining while stormwater wetlands will not exist without human care (Schueler 1992). Because stormwater wetlands are located in the urban setting and do not contain natural wetland soils conducive to wetland plant growth, stormwater wetlands do not possess the diversity of wildlife and plant community that natural wetlands possess.

Applicability

Sustaining a moisture condition where the wetland plantings can survive is crucial to making stormwater wetlands successful. Therefore, stormwater wetland BMPs should be used for larger drainage areas (greater than 20 acres). It is also recommended to determine the water table elevation and examine the water balance to determine if the wetland can survive during dry weather. Permanent access to an irrigation supply may be necessary to sustain the wetland if the water balance in the wetland is insufficient.

Because wetland areas will attract a diverse wildlife and plant life, using the stormwater wetland for treatment in the urbanized and residential setting should be carefully considered. A wetland buffer as shown in Figure 3.7, is recommended to protect the wetland habitat and shield nearby land uses from potential nuisances (Schueler, 1992).

Figure 3.7: Example of Stormwater Wetland



Natural wetland areas will not be allowed to be converted to stormwater wetlands without the regulating approval of the US Army Corps of Engineers (US ACE) and the NC Division of Water Quality (NC DWQ). The removal of wetland soils and vegetation from natural wetlands to provide a "seedbank" for a stormwater wetland BMP is prohibited without consultation with the US ACE and NC DWQ. Once stormwater wetlands are created, they may become the jurisdiction of the US ACE and NC DWQ. Filling in or modification to the stormwater wetlands once they are established may be illegal without a permit.

Peak reduction storage may be incorporated into the wetland design above the temporary water quality volume storage if the plants proposed can sustain submergence for the required inundation period.

General Guidelines

Placement of wetlands in jurisdictional waters may require federal and state permits. It is suggested that wetlands not be constructed in perennial streams. As required for all BMPs used to meet water-supply watershed regulations, stormwater wetlands will be required to treat the total drainage area to the wetland, on-site and off-site.

When designing the dam and spillways, existing and potential future downstream development should be considered. Placing the dam upstream of highly developed or traffic areas should be avoided whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or if no conveyance is present, the discharge should be directed away from existing development.

The wetland should be easily accessible for maintenance. A 15' wide access easement shall be provided from the public street right-of-way to the wetland. A drainage maintenance and utility easement (DMUE) shall be paced over the wetland and extend 15' beyond the top of embankments. The access easement should be kept easily accessible for maintenance.

For ease of maintenance and safety, the wetland embankments are not to be steeper than 3H:1V with flatter slopes preferred. A 10-15' bench (max. slope 10%) placed around the wetland near the normal pool surface elevation, is encouraged. This bench will allow machinery gain closer access to the pond during cleanouts. This break in the grade will be a safety amenity and can make the wetland more aesthetically pleasing.

The wetland shall have a minimum 2:1 length to width ratio, with 3:1 preferred. *The distance between the inlets and outlets are to be maximized to increase the flowpath of the wetland.* The flowpath can be increased through use of internal berms and shelves used to create the varying depth zones within the wetland (Schueler, 1992).

It is encouraged to create a wetland that fits within the natural contours of the land but care should be taken to prevent "dead storage zones" (areas outside the flow path between the inlet and outlet) within the wetland. "Dead storage zones" are areas outside the flow path from the inlets to the outlets. Generally, the wetland should be narrower at the inlet forebay area and become wider at the outlet. Whenever possible one forebay should be created and all wetland inlet pipes discharge to the forebay area.

Creating a complex microtopography (varying depth zones) within the wetland will increase the pollutant removal efficiency of the wetlands (Schueler, 1992). These depth zones can be classified into the deep water zone, which consists of the forebay and outlet micropool, and the shallow water zone, which consists of the high marsh, and low marsh. Designing the wetland with various depth zones will help to prevent the wetland from being taken over by a dominant plant species (such as cattails).

To increase the aesthetic value of the wetland area, a wetland buffer should be established around the perimeter of the wetland. To promote a greater and more diverse wildlife habitat, a wetland buffer should consist of a variety of trees, shrubs, and plants (Schueler, 1992). The amount of open grass areas should be limited to prevent an overpopulation of geese. The buffer will also serve to distance adjacent residences/businesses from the wetland area.

It is encouraged where appropriate to use educational signs at the pond describing the function of the pond and the purpose it serves.

Treatment Sizing Criteria

Target Permanent Pool Depth Zone Allocation (based on surface area of the wetland)

Shallow water zone: 70%
35% - "high marsh" 0 to 9 inches depth
35% - "low marsh" 9 to 18 inches depth
Deep water zone: 30%
15-20% - forebay – 4 to 6 feet deep – sediment storage to be allocated to forebay
10-15% - outlet micropool – 4- 6 feet deep

Extended Detention storage: WQV

Extended Detention draw down time: 48 hrs

Wetland Surface Area/Drainage Area Ratio: see table 3.9

Table 3.9: Wetland Permanent Pool Surface Area to Drainage Area Ratio

PERCENT BUILT-UPON	10	20	30	40	50	60	70
SA/DA	0.59	0.97	1.34	1.73	2.00	2.39	2.75

Principal Spillway Capacity: 10 year 24 hour rain storm event

Emergency Spillway Capacity: Minimum 100 year 24-hour rain storm event (design to be consistent with the NC Dam Safety Requirements).

Dam freeboard: NC Dam Safety requires a one (1) foot minimum freeboard above the maximum flood pool elevation during the spillway design flood. The City encourages the designer to maximize the freeboard to the extent practicable.

Shallow Water Zones

The shallow water zone (0-18 inches depth) is designed to promote growth of emergent plantings. The shallow water zone should be sized to be approximately 70% of the wetland surface area. Half of this 70% should be designated as high marsh (0-9 inches depth) and the other half as low marsh (9-18 inches depth). Variations in depth will allow for a diversity of emergent wetland species to thrive. Generally, the bottom elevation across the width of the wetland should remain level to promote sheet flow and to prevent short circuiting and creating stagnant areas or dead zones.

Deep Water Zone

The deep water zone consist of the forebay and the outlet micropool. The function of these components are described below.

Forebay

The forebay serves to reduce incoming velocity which promotes initial settling of sediment, minimizing the amount of suspended sediment that enters the wetland area. The forebay serves to spread the flow equally over the width of the wetland. The forebay is to be separated from the remaining wetland by an earthen berm that is no lower than one foot below the normal pool. Sediment cleanout may be needed approximately every 5-10 years (depending on the condition of the drainage area).

Inlets are to discharge into the forebay. Inverts for inlet pipes should be at the elevation of the normal pool to allow the pool to dissipate the energy of the inflow to prevent erosion along the embankment slope. Inlets should be designed to discharge to the pond perpendicular to the pool surface to minimize potential erosion problems to the side embankment. Rip rap pads should be underlain with a gravel/sand filter or geotextile fabric which should extend from the pipe invert to the pond bottom.

An access to the forebay for future sediment cleanouts is to be provided. It is recommended that the access have a maximum slope of 15-20% extending from the top of the embankment to the toe. This access will allow construction equipment to getdown in the forebay and will minimize disturbance to the vegetation.

Outlet Micropool

The outlet micropool is required to allow adequate depth for the extended detention release outlet to function properly and to allow a drain to be installed low enough to drain the wetland. The outlet micropool should be 4 to 6 feet deep. The deep pool areas can be used to stock mosquito fish to help control the mosquito population.

Wetland Plantings

A wetland planting plan is to be developed as part of the wetland design. Selecting the proper plant species and planting locations is an important part in creating a successful stormwater wetland BMP. A wetland planting plan should be prepared by a qualified landscape architect and wetlands ecologist as part of the design of the wetland.

Plantings should be spaced at 3 feet at a minimum. If the wetland is not 50% to 75% established after the first growing season, reinforcement plantings will be needed.

Suitable planting soil shall be specified in wetland planting area. The soil should have adequate texture and organic matter to retain moisture for plant growth. A soil analysis should be performed on the soil before it is placed in the wetland.

Appropriate species must be selected for the high and low marsh areas and the wetland edge. Careful attention should be paid to the inundation tolerance of the plantings along with the depth of water experienced in extended detention. A well planned wetland will utilize a variety of emergent, submergent, and floating wetland plants as well as buffer trees and plantings.

It is suggested that various species of plantings be utilized to maximize plant diversity and increase the probability that the wetland plant growth will be successful. Examples of wetland plantings that may be used for stormwater wetlands and there inundation tolerance are listed in Appendix G.

Wetland Pond Dam

Notification of the proposed dam construction is to be made to the NC Dam Safety Office.

A concrete retaining wall may be used for the pond dam, but it shall not include more than 50% of the pond perimeter.

For earth dams, the top width of the dam should be 10 feet minimum.

For earth dams, a cutoff trench should be excavated and filled with highly impervious and well compacted material. Incorporating a chimney drain or drainage blanket should be considered to reduce the potential for seepage problems.

Treatment Orifices

Low flow orifice(s) shall be used to slowly release of the water quality volume over a period of 48 hours. Additional low flow orifice(s) or other appropriate provisions may be incorporated above the temporary pool to provide peak flow reduction. Refer to Appendix F for the preferred method for calculating the orifice drawdown time.

The low flow orifices are to be protected from clogging up with floating debris using a trash guard. The trash guard should be durable and secure and should extend at least six inches below the normal pool surface. A common method when using a riser/barrel is to extend the principal spillway trash rack assembly below the normal pool. When the low flow orifice will be placed in a concrete dam or spillway, an inverted or submerged orifice can be used or a half aluminum pipe bolted to the concrete (see Appendix H for examples or trash protection).

Principal Spillway

The principal spillway should be a riser/barrel, concrete free fall weir, or concrete chute with capacity to handle the 10-year 24 hour rain storm event, at a minimum. Of the available options for the riser/barrel material such as reinforced concrete, ductile iron, PVC, or corrugated aluminum piping, reinforced concrete and ductile iron pipes (being rigid pipes) are preferable for this application. A flexible pipe, such as corrugated aluminum piping may experience distortion of its cross-sectional shape during compaction of the soil around it and result in internal soil erosion problems potentially leading to failure of the embankment around and above the pipe.

The spillway should be equipped with a trash rack and an anti-vortex device.

Riser/barrel assemblies should be properly anchored to resist buoyancy forces.

A "filter and drainage diaphragm" or anti-seep collars should be used to prevent piping along the barrel within the earth fill, with the diaphragm being the preferred method (see Appendix J for NRCS design guidelines).

Appropriate energy dissipation should be used at the spillway exit to prevent erosive velocities for up to the 10-year peak discharge rate, at a minimum. Every effort should be made to discharge in defined conveyances and parallel to the existing flow to prevent bank erosion. Downstream channels may need to be modified and lined with rip rap to prevent erosion of the channel. Modifications to the downstream channel should be minimized as much as possible to prevent excessive disturbance in the channel.

Emergency Spillway

The emergency spillway should be designed to safely convey discharges resulting from storms up to the 100-year 24 hour storm, at a minimum. The spillway should be located where it will not adversely affect downstream property such as roadways and building structures. The emergency spillway may be incorporated into the principal spillway where accommodating the emergency spillway elsewhere is not feasible for the given site characteristics.

The emergency spillway should be cut into existing soils outside the fill section of the dam. The emergency spillway may be grass lined, when velocities permit, or lined with rip rap, concrete, or other erosion resistant materials. Grass lined spillways are to be planted with a dense cover of erosion resistant grasses.

Wetland Pond Drain

A pond drain should be provided to drain the wetland for routine maintenance or structural repairs in an emergency situation. It is recommended that the pond drain be designated to have the discharge capability to completely drain the pond in less than 48 hours, in the event of an emergency posed by impending failure of the dam. The upstream slope of the pond dam should be designed to be flat enough to prevent slope failure due to "quick drawdown" of the pond (NC Dam Safety Code specifies a factor of safety of 1.25) in an emergency. Care should be taken to minimize transport of settled sediment from the pond during draining.

3.4.11 Bioretention Areas

Description

The bioretention BMP is a relatively new concept. Prince George's County, Maryland was one of the first communities in the United States to use and promote bioretention to treat stormwater runoff (1987). This BMP was designed to mimic natural forest ecosystem with a combination of soil filtration and plant uptake. The bioretention area, which includes a planting soil layer, mulch, plantings, and an underdrain system, is designed to appear as a landscaped or natural area giving this BMP a very appealing image. Stormwater runoff enters the bioretention area and is temporarily stored in a shallow pond on top of the mulch layer. The ponded water then slowly filters downward through the made planting soil and is absorbed through the plantings. As the excess water filters through the system, it is collected by an underdrain pipe and discharged to a storm conveyance system.

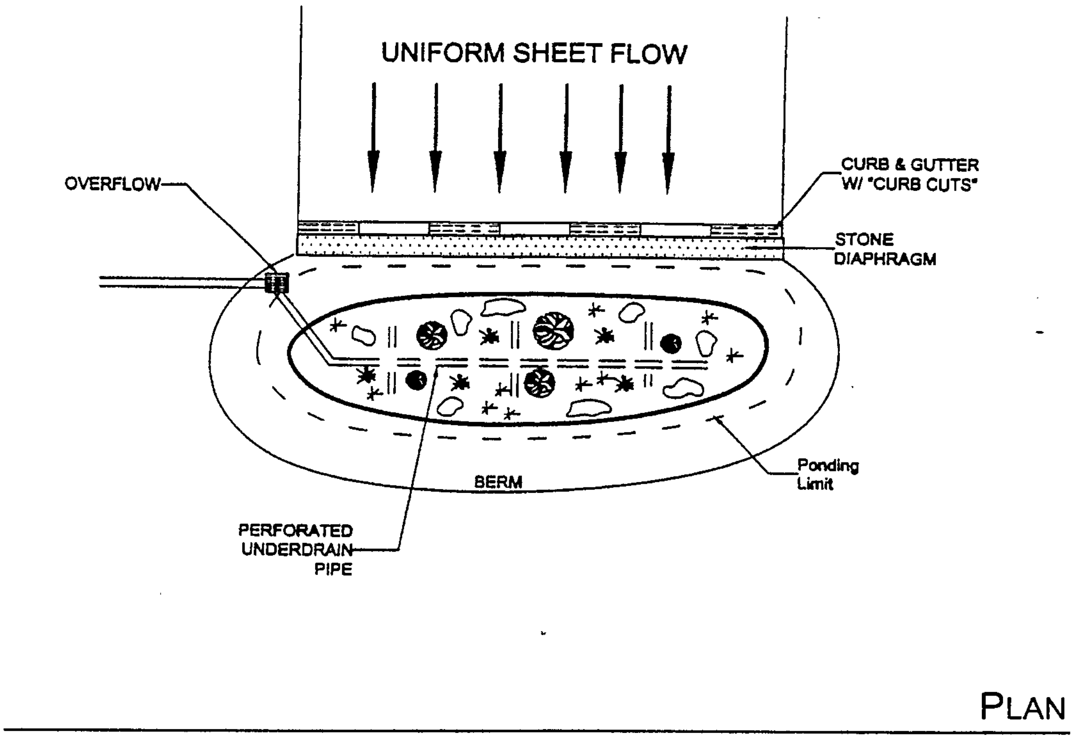
Applicability

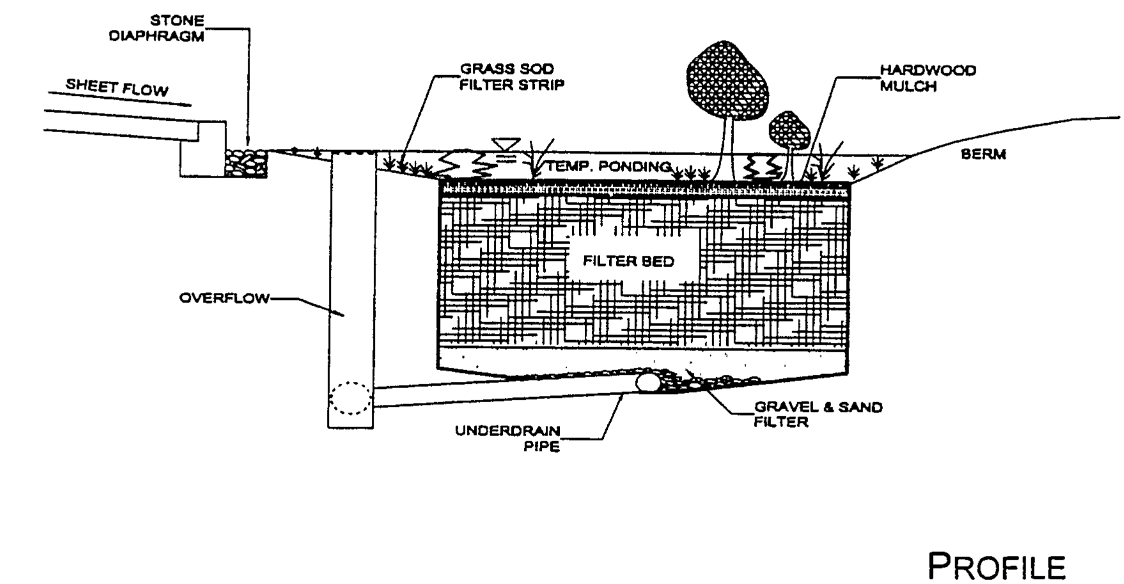
Bioretention areas work well on smaller sites, where stormwater runoff rates are low and aesthetics are important. Bioretention areas can be implemented to treat parking lot runoff, individual residential home sites, and small commercial facilities.

Bioretention areas can be used to save costs in other site development areas. For example, bioretention areas usually accept stormwater runoff as sheet flow; therefore, the designer can use bioretention to reduce the amount of storm sewer needed for the project. Bioretention areas also can also be incorporated as part of the required landscaping buffer.

The drainage area to individual bioretention cells should be relatively small (1 to 2 acre drainage area) and well stabilized to prevent excessive debris and sediment from collecting in the bioretention area. Keeping smaller drainage areas to the bioretention

Figure 3.8: Example of Bioretention Area





areas will make it easier to manage the pollutants that enter the cell during and after construction. For larger drainage area sites, a bioretention area consisting of multiple cells can be installed.

Constructing bioretention areas for large residential developments to meet water-supply watershed regulations is discouraged, except in cases where multiple cells are provided on the site, each receiving drainage from a small area. The City's water-supply watershed (Ch. 30) ordinance requires stormwater BMPs to be constructed before the certificate of compliance can be issued on the first house. Housing developments may sometimes require several years to build out, therefore, it is that much more difficult to implement aggressive erosion control over that period. Special attention is needed to manage the runoff from each individual lot while construction is taking place especially where there are different subcontractors doing the grading, house construction, road construction, etc, who may not be aware of the presence or function of the cells. Sediment that does escape the construction area can quickly clog the bioretention area, severely reducing or eliminating its filtering capacity.

Also careful consideration should be given where bioretention areas will be used to treat larger sites where construction takes place in phases. It may be desired by the developer to initially construct a wet detention pond BMP and after construction is complete, modify the pond to a bioretention cell. If this practice is desired, the developer should consult with the City.

Because bioretention systems are sensitive to fine sediments, they should not be placed on sites where the contributing drainage area will not be completely stabilized or is periodically being disturbed.

General Criteria

Bioretention areas work best when constructed off-line, capturing only the water quality volume, and excess runoff is diverted away from the BMP.

Bioretention areas should be designed to fit into the natural topography and complement surrounding landscaping.

Bioretention areas can be of any reasonable shape to fit the cell around tree conservation areas, driveways, etc. In order to establish a well planted bioretention area, the minimum width of the bioretention should be 10 feet.

The bioretention area should be easily accessible for maintenance. A 15' wide access easement shall be provided from the public street right-of-way to the bioretention area. A drainage maintenance and utility easement (DMUE) shall be paced over the bioretention area and extend 15' beyond its perimeter. The access easement should be kept easily accessible for maintenance.

Design Guidelines

*Bioretention Filter Bed Surface Area: 10% * Rv * Drainage Area (for 6" ponding depth)*
This formula is based on the sizing guidelines (which are based on the experience) of Prince George's County which specifies that the bioretention surface area should be 5% to 7% of the drainage area multiplied by the runoff coefficient based on infiltrating precipitation events of 0.5 to 0.7 inches occurring over a six hour period. In Greensboro, the BMP is required to control the **one inch rainfall (WQV).**

Ponding Depth: 6 inches maximum

Hardwood shredded mulch layer: Approximately 3 inches deep

Planting soil layer: 4 feet minimum

Plantings: 3 species of each trees, shrubs, and herbaceous species

Planting density: 1000 stems/acre minimum

Pretreatment
Pretreatment is necessary to reduce incoming velocities, spread flow over the bioretention area, and provide some removal of coarse suspended sediments. The pretreatment may be a gently sloping grass sod filter strip or a grass swale along the upstream side of the cell. A gravel diaphragm, landscape stone, or other energy dissipator should be used to reduce incoming energy of runoff from impervious areas and areas of concentrated flow, and to help spread the flow over the bioretention area.

Bioretention Filter Bed
The filter bed surface must be level to allow for uniform ponding over the cell. The maximum ponding depth should be specified at a maximum of 6 inches to allow the cell to drain within a reasonable time and to prevent long periods of inundation of the plantings.

The planting soil provides a medium for physical filtration for the stormwater runoff plus a source of water and nutrients for the plant life. *This soil should have adequate permeability (0.5 ft/day) and organic content to support plant life.* The City currently recommends the planting soil to be 50% sand, 20% leaf mulch, and 30% topsoil. The maximum clay content should be 10% or less. The recommendation is based on the satisfactory results obtained from the use of this mixture in Prince George's County, Maryland.

The soil should also have the following characteristics (State of NC BMP manual):

PH range: 5.5 – 6.5
Organic Matter: 1.5 – 3.0%
Magnesium: 35 lbs/acre

Phosphorus (p2O5): 100 lbs/acre
Potassium (K2O): 85 lbs/acre
Soluble salts: not to exceed 500 ppm

Mulch Layer
The mulch layer provides an environment for plant growth by reducing erosion of the planting soil bed, maintaining moisture, trapping fine sediments before it seals the planting soil surface, and allowing for the decomposition of organic matter (Schueler, 1996). Studies have been shown by Prince George's County that the mulch layer plays an important role in pollutant removal, and shredded hardwood mulch should be applied liberally.

Hardwood mulch or chips should be used because they resist floatation better than other landscape covers. Optimum age of the mulch is 12 months. The mulch should be very clean, free of weeds, soil, roots, plastic, etc.

Bioretention Plantings
A bioretention area landscape plan shall be prepared and include the type and number of plantings, their planting location, installation guidelines, and post-installation inspection and maintenance guidelines.

Consult with a landscape professional to help decide which species are best suited for the landscape and for installation guidelines. Table 3.10 shows commonly used bioretention plantings.

The proper selection of bioretention plantings is key to establishing a successful bioretention BMP. Factors such as inundation tolerance, drought, sun exposure, etc. should be considered to provide successful plantings. Using a variety of plantings (trees, shrubs, grasses) is recommended for a natural appearance and a higher chance for successful growth. The plantings should be placed in a random fashion and can be placed along the banks of the cell.

A minimum of 3 species of each trees, shrubs, and herbaceous plantings should be specified with a minimum planting density of 1000 stems/acre. A higher planting density may be desired for landscaping purposes. Figure 3.9 shows various planting zones for the bioretention area.

Underdrain System
The native soils in Guilford County do not generally allow for adequate infiltration. Therefore, all bioretention cells shall have an underdrain system placed beneath the planting soil. The underdrain may consist of perforated piping with a gravel jacket. Geotextile fabric should be placed at the bottom of the excavated cell to prevent clay from getting into the pipe. The pipe should be a sturdy pipe, such as Schedule **40** PVC and should be placed on top of the fabric. A run of pipe should be spaced every 10 feet and the bottom of the cell should have a positive slope toward the pipe. The

longitudinal slope should have an approximate grade of 0.5% and should connect to a storm sewer system or outfall to a channel in a non-erosive manner.

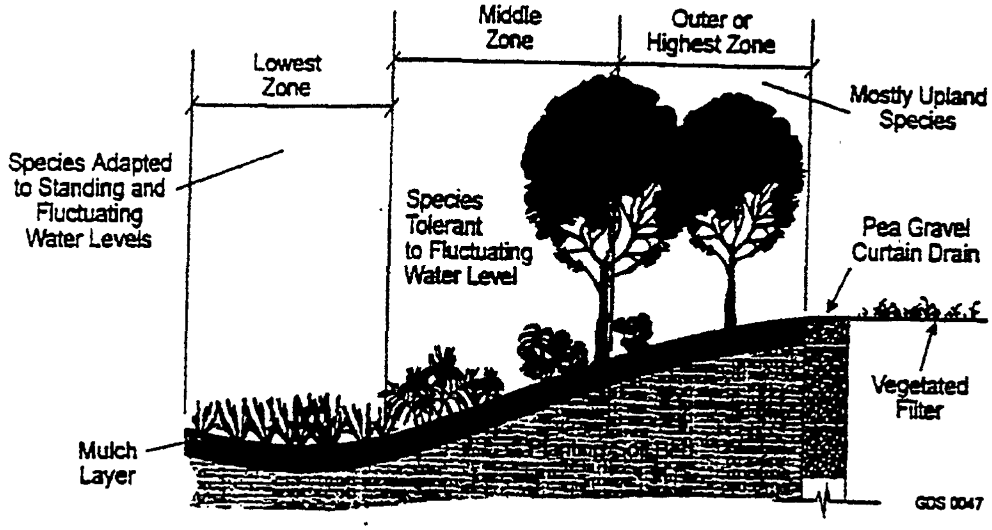
Non-perforated piping should be connected to the underdrain piping and extend to the surface of the planting soil for cleanouts.

Table 3.10: Examples of Plant Species Suitable for Bioretention

TREES	SHRUBS	HERBACEOUS SPECIES
Acer rubrum Red Maple	*Aesculus pariviflora* Bottlebrush Buckeye	*Andropogon virginicus* Broomsedge
Betula nigra River Birch	*Aronia arbutifolia* Red Chokeberry	*Eupatorium perpurea* Joe Pry Weed
Juniperus virginiata Eastern Red Cedar	*Fothergilla gardenii* Fothergilla	*Hemerocalis spp* Day Lily
Koelreuteria paniculata Golden Rain Tree	*Hamemelis virginiana* Witch Hazel	*Iris pseudacorus* Yellow Iris
Nyssa sylvatica Black Gum	*Hypericum densiflorum* Common St. Johns Wort	*Lobelia cardinalis* Cardinal Flower
PLATANUS ACERIFOLIA London Plane-Tree	*Ilex glabra* Inkberry	*Panicum virgatum* Switchgrass
Platanus occidentalis Sycamore	*Ilex verticillata* Winterberry	*Pennisetum alopecuroides* Fountaingrass
Quercus palustris Pin Oak	*Juniperus horizontalis* Creeping Juniper	*Rudbeckia laciniata* Greenhead Coneflower
Quercus phellos Willow Oak	*Lindera benzoin* Spicebush	*Scirpus cyperinus* Woolgrass
Salix nigra Black willow	*Myrica pennsylvnica* Bayberry	*Vernonia noveboracensis* New York Ironweed

SOURCE: COURTESY OF THE MARYLAND DESIGN MANUAL LOIDERMAN ASSOCIATES

Figure 3.9: Example Planting Zones for Bioretention Areas



SOURCE: COURTESY OF THE MARYLAND DESIGN MANUAL LOIDERMAN ASSOCIATES

Bioretention Overflow

An overflow bypass should be used to pass storms larger than the water quality volume away from the bioretention area. If the bioretention area collects sheet flow, such as from a parking area, a catch basin at the elevation of the normal pool can be placed in the parking lot. When the ponding limit in the bioretention area is exceeded, the stormwater runoff will be routed through the catch basin to the storm sewer inlet. To prevent the water quality volume from being flushed out of the bioretention cell before it has time to be treated, the overflow should be located on the upstream side of the bioretention area.

The same concept should apply to flows that enter via swale or pipe. Once the maximum ponding limit has been exceeded, a diversion should be placed within the vicinity of the inflow area to divert the extra runoff will be diverted away from the cell.

3.4.12 Sand Filtration Facilities

Description

Sand filtration systems used for stormwater treatment work similar to those that are used in the drinking water purification process. These systems remove pollutants through sedimentation, filtration, and microbial activity within the sand. Stormwater filtration systems consist mainly of a pretreatment, or sedimentation basin, and the filter area. Runoff first enters the sedimentation basin where the runoff velocity is reduced allowing larger pollutant particles to drop out. When the stormwater exits the sedimentation area it is spread evenly over the filter bed where it then flows downward through the filter. As the stormwater flows through the filter, the filtration media trap and absorb pollutants present in the stormwater. Sand filtration systems are beneficial when land space is scarce or expensive, because they can be designed to be placed underground or to border the perimeter of a parking lot or other impervious surface.

Applicability

Sand filtration facilities are best used for smaller sites (5 acres or less) where the percent imperviousness and the land value is high. Also, the facilities should be used on sites where the drainage area to the facility will remain well stabilized after the construction phase to prevent excess sediment and debris from prematurely clogging the filter. It is recommended that individual sand filtration facilities be sized to treat relatively small drainage areas (1 to 2 acres or less). By implementing several facilities on a site, this will prevent the entire site from being untreated if one filter facility happens to get clogged.

The cost of the construction of concrete underground sand filtration facilities is high in relation to other BMPs and the maintenance burden for the owner can be quite substantial. However, because the BMP can be placed underground, the construction and maintenance costs may be offset by the save in land space.

To prevent loose debris such as grass clippings, landscape debris, etc from entering the facility, it is highly recommended that sand filtration facilities treat only runoff from impervious surfaces. It is a good idea to implement pollution prevention BMPs, such as paved area sweeping and covering, to minimize the sediment and other pollutants that enter the BMP.

Sand filtration BMPs differ from bioretention, in the fact that the hydraulic head above the filtration bed can be significantly higher than the 6 inches allowed for bioretention. Thus a smaller filter bed surface area will be required.

There are three basic sand filtration BMP types: (1) underground sand filter, (2) perimeter sand filter, and (3) surface sand filter. The underground BMP is ideal to treat stormwater in the ultra-urban environment where land costs are high. The perimeter sand filter and surface sand filter are good to treat parking lot runoff.

Description of Various Sand Filter Types

Underground Sand Filter
There are several different configurations for a sand filtration facility placed in an underground basin. The most widely known type is the District of Columbia (DC) sand filter developed by Mr. Hung V. Truong of the D.C, Environmental Regulation Administration. This type BMP is designed for use in the ultra-urban setting where the drainage area is small (less than one acre). The DC facility consists of three chambers: a wet sedimentation chamber, sand filtration chamber, and outlet chamber (see Figure 3.10).

The wet sedimentation chamber serves to dissipate the incoming velocity and settle out grit. The sedimentation chamber also has a submerged orifice that serves to trap floating debris and prevent it from entering the sand filtration chamber. Mr. Truong points out that the sedimentation chamber can be replaced by a commercial hydrodynamic BMP (see section 3.4.13, Proprietary Stormwater Treatment Facilities). The sand filtration chamber consists of the 24 inch sand bed layer underlain by a gravel bed with perforated PVC drain pipes. An optional layer of geotextile (plastic filter cloth) liner can be placed on top of the sand bed to prevent debris from getting into the sand layer. The outlet chamber collects the effluent from the underdrain pipes, and flow from the by-pass pipe when the volume of the basin is exceeded.

Perimeter Sand Filter (Delaware Sand Filter)
The perimeter sand filter was originally developed by Mr. Earl Shaver of the Delaware Department of Natural Resources and Environmental Control. This type of facility was primarily intended to border the perimeter of parking lots and treat the runoff from it. The facility consists of two parallel concrete chambers; a wet sedimentation chamber and a sand filtration chamber (see Figure 3.11). Runoff in the form of sheet flow flows into the wet sedimentation chamber where the energy is dissipated, flow is dispersed, and coarse sediments drop out. The flow then overflows into the sand filtration chamber where it percolates through the sand medium and is collected by an underdrain system. An overflow weir should be implemented to safely bypass storms larger than the water quality volume.

Surface Sand Filter (SSF)
The City of Austin, Texas first developed and used sand filtration systems for treating stormwater runoff (see Figure 3.12). The sand filter can be placed in a concrete or earth basin. A sedimentation basin is needed to pretreat the incoming runoff and to bypass larger storm events. The City of Austin found that it was important to size the sedimentation chamber to remove suspended solids to prevent excessive sediment loading on the sand filtration chamber. Since the SSF is an open basin, it will generally cost less than the other enclosed sand filter types and is usually practical to treat a larger drainage area.

Figure 3.10: Example of Underground Sand Filter (DC Filter)

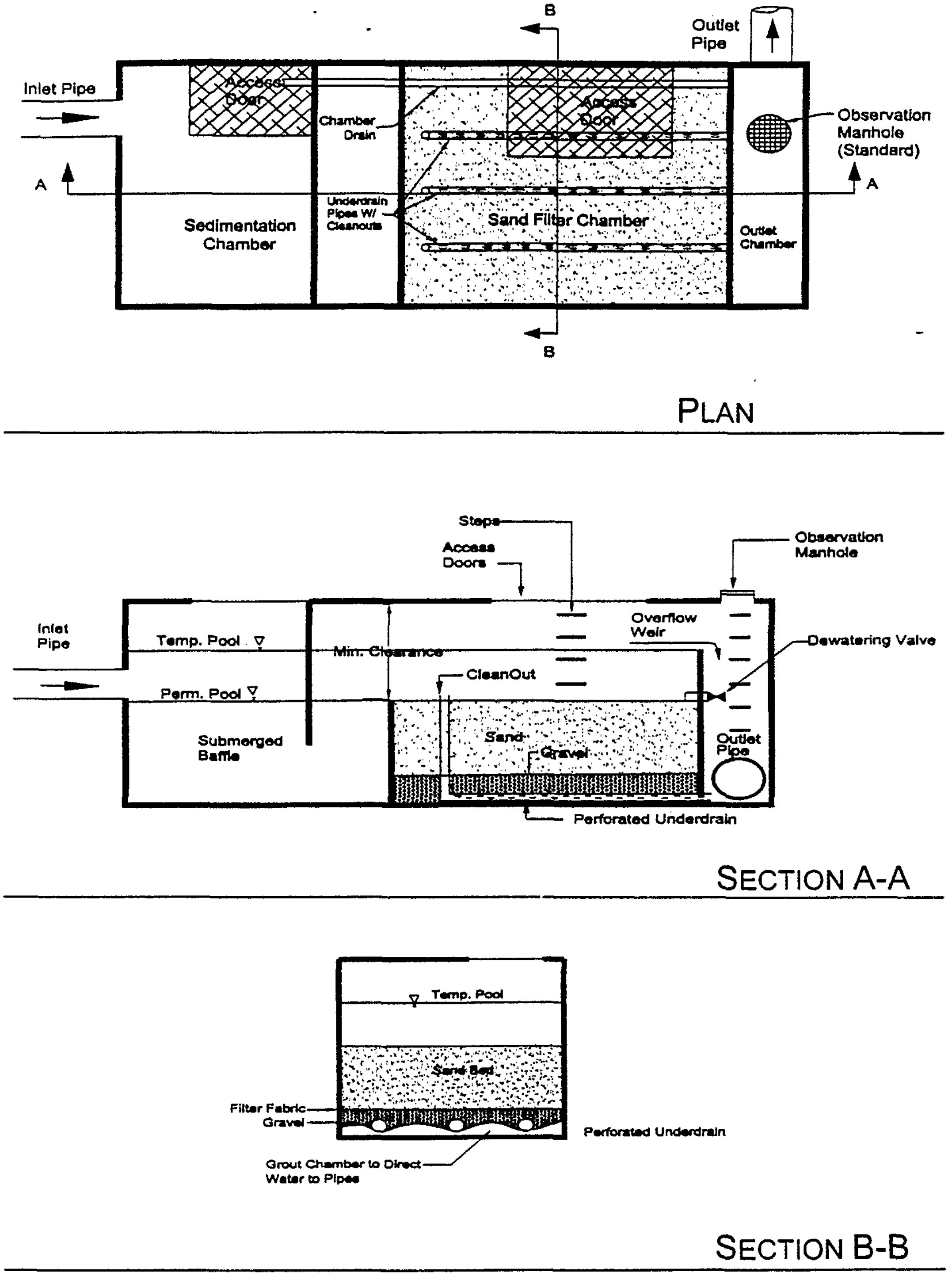


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Figure 3.11: Example of Perimeter Sand Filter (Delaware Sand Filter)

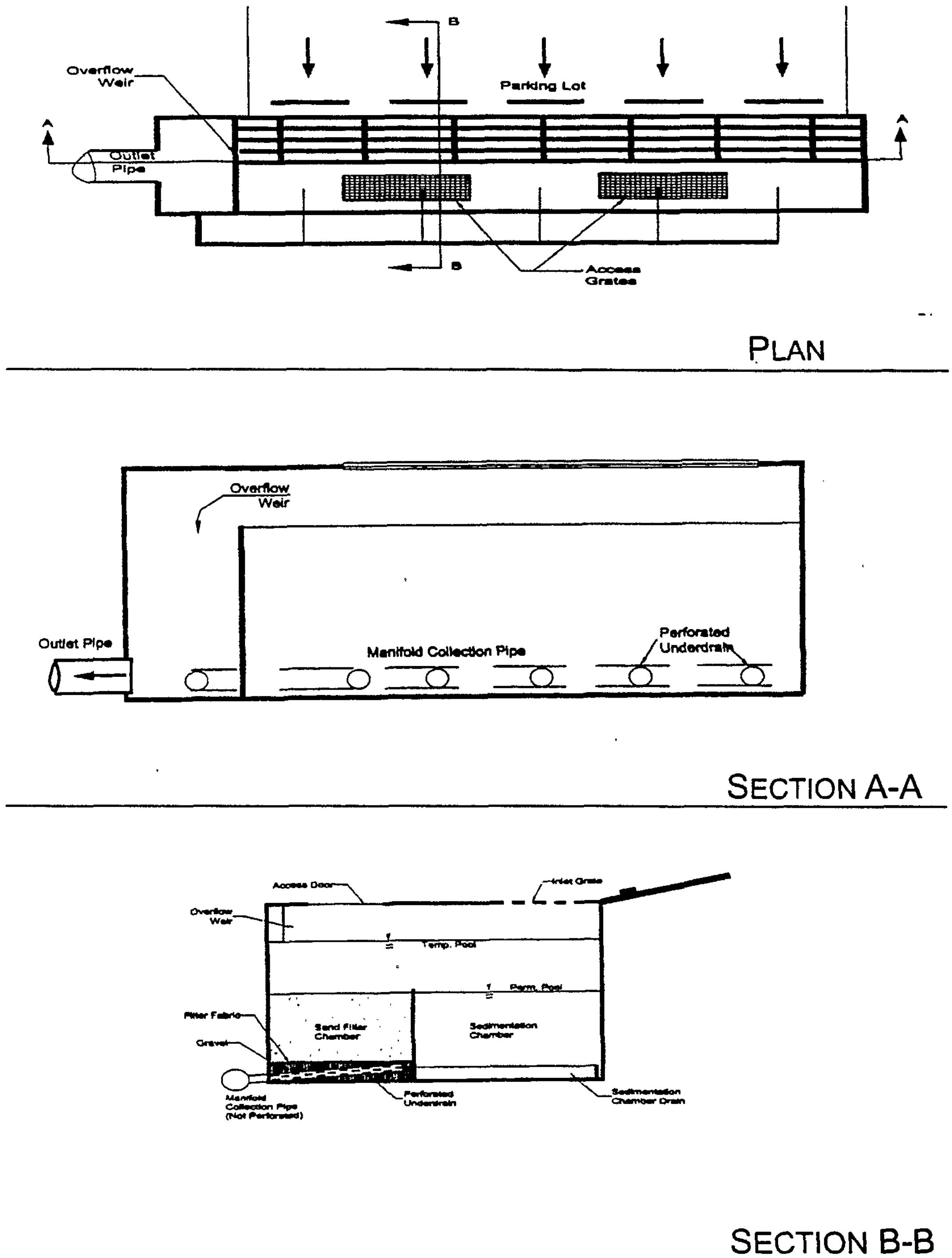
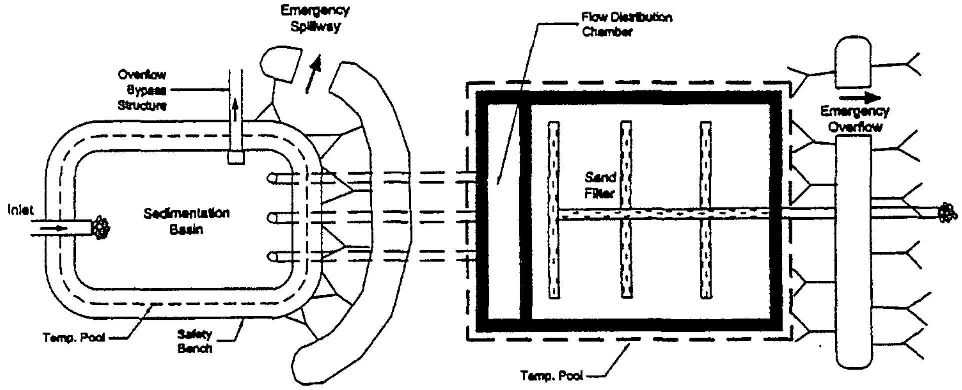
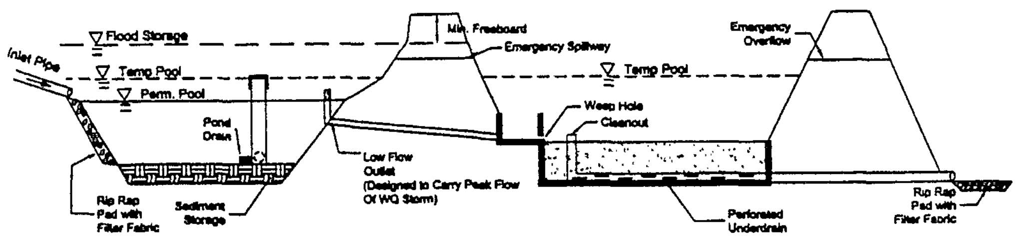


Figure 3.12: Example of Surface Sand Filter



PLAN



PROFILE

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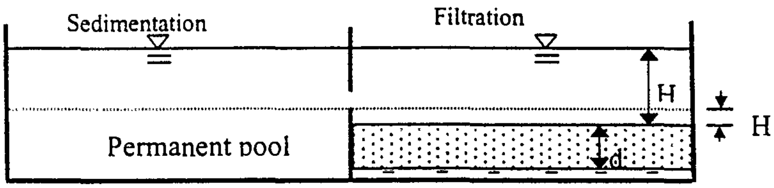
Design Guidelines

Entire facility should hold 75% of water quality volume (Schueler, 1996).
The volume may be allocated to the filter chamber and the sedimentation chamber (wet pool in sedimentation chamber may be included in the allocation). The justification for providing storage for a reduced portion of the WQV is that sand is a relatively permeable material (as compared to other filtering materials) and the filter bed is continually filtering water during the duration of the storm event. It is estimated that the median rain storm event for this region will take longer than 6 hours for the first one inch of rainfall to occur.

Sand Filter bed area (A_f): The required surface area for a sand filtration facility is determined from the following equation. The typical sand filter is designed to function as shown in Figure 3.13.

Figure 3.13: Sand Filter Schematic



$$A_f = \frac{(d)(A)[ln(H_1+d)-ln(H_2+d)]}{(k)(T)-(d)[ln(H_2+d)-ln(d)]}$$

For the specific case where $H_2 = 0$: $$A_f = \frac{(d)(A)[ln(H_1+d)-ln(d)]}{(k)(T)}$$

Where,

T = time required for the water quality volume to filter through the sand bed in days [40 hours or 1.67 days is recommended maximum (Schueler, 1996)].
A = total surface area in ft^2 (sand filter + sediment chamber)
A_f = surface area of the sand filter in ft^2
H_1 = maximum water depth above filter bed in feet (should not exceed 5 feet)
H_2 = height of invert of sediment chamber outlet above top of sand filter bed in ft.
d = the depth of filter material in feet [18 inches minimum (1.5) feet]
k = coefficient of permeability for sand bed in ft/day [3.5 ft/day (Schueler, 1996)]
ln = natural logarithm

At a minimum, the sedimentation chamber surface area be equal to the surface area of the sand filter bed. The equation used for sizing the surface area of the dry detention basin (Section 3.4.8) may be used to as a guideline for sizing the surface area of the sedimentation chamber.

Sedimentation Chamber

The efficiency of sedimentation chamber to settle suspended solids is based on the surface loading rate (outflow divided by basin surface area) and is relatively independent of depth. However, it is recommended that the sedimentation chamber remain wet and have a depth of 2 to 3 feet to minimize particle resuspension due to turbulence (Schueler, 1996).

To improve the removal efficiency of the sedimentation chamber, it is recommended that the sedimentation basin be designed to detain at least 50% of the water quality volume and be slowly released over a period of several hours. Providing this detention will allow more coarse sediments to settle out, which will help to prevent premature clogging of the sand bed.

Commercial hydrodynamic BMPs may also be considered to use to provide initial sedimentation instead of gravity settling chambers.

Sand Filter Chamber

Provisions should be made to distribute the flow from the sedimentation chamber uniformly across the sand filter chamber. The underground DC sand filter type and the perimeter Delaware sand filter type use overflow weirs along the width of the sand filter to accomplish this. When the flow from the sedimentation basin is outlets by pipe flow, a flow distribution chamber should be incorporated (see Figure 3.12).

The sand bed should be a minimum of 18 inches depth and the top of the bed should be completely level. The sand should be clean ASTM C-33 medium aggregate concrete sand.

For underground sand filter facilities, a 5 feet minimum height clearance should be provided between the top of the sand bed and the bottom of the slab to provide clearance for future maintenance.

It is recommended to use a dewatering valve placed just above the sand bed layer to drain the facility should the sand bed become clogged (see Figure 3.10).

Underdrain System

An underdrain system shall be used to collect water that has percolated through the sand filter. The preferred pipe is 6 inch perforated schedule 40 PVC piping placed in an 8 to 10 inch gravel jacket. Although some designs call for filter fabric between the gravel bed and sand layer, the City believes that this fabric could present a clogging problem, and recommends that a three inch layer of pea gravel be used instead. To ensure adequate drainage, the bottom of the chamber should be sloped toward the underdrain pipes which should be spaced approximately 10 feet along the filter bed. The underdrain may discharge to a main collector pipe or to an outlet chamber.

Overflow
Sand filtration facilities should be placed off-line (divert runoff from storms greater than the one inch rainfall before entering the facility) whenever possible. A by-pass structure can be used to direct flow away from the filtration facility once the treatment volume has been exceeded.

For on-line facilities, an overflow should be placed in the sediment chamber and be designed to carry the 10 year design storm at a minimum. The overflow needs to placed as far upstream of the filtration bed as possible to prevent the initial WQV from being flushed out by the subsequent runoff (see Figure 3.12).

Access for Sand Filtration Facilities
A 15' wide access easement shall be provided from the public street right-of-way to the sand filtration and pretreatment areas. A drainage maintenance and utility easement (DMUE) shall be paced over the entire facility and extend 15' beyond its perimeter. The access easement should be kept easily accessible for maintenance.

For sand filtration facilities that are underground, adequate access shall be provided into the facility for inspection and maintenance. It is preferred that large aluminum or steel doors be placed to access the sand filtration chamber. Steps will need to be provided for the underground facility. Also observation manholes or doors should be provided for underground overflow chamber and the sedimentation chamber. Maintenance to the underground sand filtration facility will involve entering a confined space and the appropriate provisions should be made to comply with OSHA confined space requirements.

3.4.13 Proprietary Stormwater Treatment Facilities

Description

The need for urban BMPs that are more efficient in pollutant removal and present less impact to development has spawned the introduction of innovative stormwater BMP technology. These technologies usually combine the processes of settling, filtration, and various biological processes into one controlled system housed in a modular unit. By combining different processes, these BMPs can be designed to focus on removing many different type pollutants and higher concentrations of these pollutants than conventional BMPs.

Applicability

Proprietary stormwater treatment facilities apparently possess several beneficial attributes which make these BMPs a potential viable solution for future use in this area. For example, units can be usually be placed almost anywhere on a site where it can receive concentrated flows, such as from a storm drainage structure. Also, many of the innovative proprietary BMPs are relatively safe because the stormwater is treated inside the unit, and is not open to the environment like a stormwater pond or wetland. Another benefit is that only minimal on-site construction is necessary since the units are usually assembled before they reach the site.

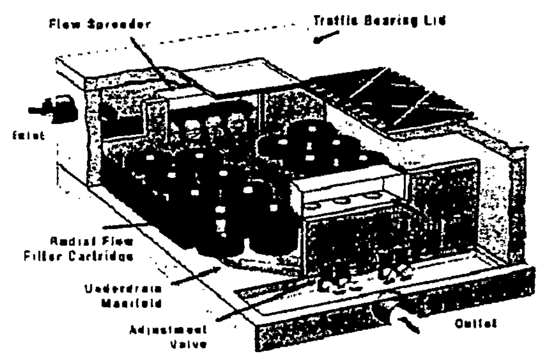
There may be several proprietary BMPs on the market that may be able to the quality control requirments for water-supply watershed protection, such as StormFilter™ by Stormwater Management®, Portland Oregon (1-800-548-4667 *or www.stormwatermgt.com*), StormTreat™ by StormTreat™ Systems, Sandwich Massachusetts (1-508-833-1033 or *www.stormtreat.com*) and Stormceptor®, manufactured by CSR Hydro Conduit, Thomasville, North Carolina (1-800-475-6302 or *www.csrstormceptor.com*) . Proprietary systems may be used to treat runoff in water-supply watersheds as long as they are designed to treat the first inch of rainfall and are proven to provide 85% TSS removal. *For application to meet water-supply watershed protection requirements, the City will require the owner to monitor (upon installation) the pollutant removal efficiency for proprietary systems that have not been used and proven in the City before. The City may be able to offer technical assistance with the monitoring requirements. If satisfactory results are found, the system may be used and no other monitoring studies will be required for subsequent installations within the City. If unsatisfactory results are found, the system must be replaced with an approved facility that meets the TSS removal requirement.*

Example Proprietary BMPs:

StormFilter™

The StormFilter™ facility provides treatment through rechargeable cartridges that are filled with a variety of filter media such as the CSF® media (see Figure 3.14). Captured stormwater flows through these cartridges which trap and absorb pollutants. StormFilter™ units may be cast-in-place, precast, and linear. The units typically consist of an inlet bay that serves to remove heavy suspended solids, a flow spreader for dispersing the flow uniformly to the cartridge bay , the cartridge bay, and the outlet bay. This system can also incorporate an overflow device to bypass larger storm events. The company will specify the type filter material required in order to achieve the desired pollutant removal.

Figure 3.14: Schematic of StormFilter™

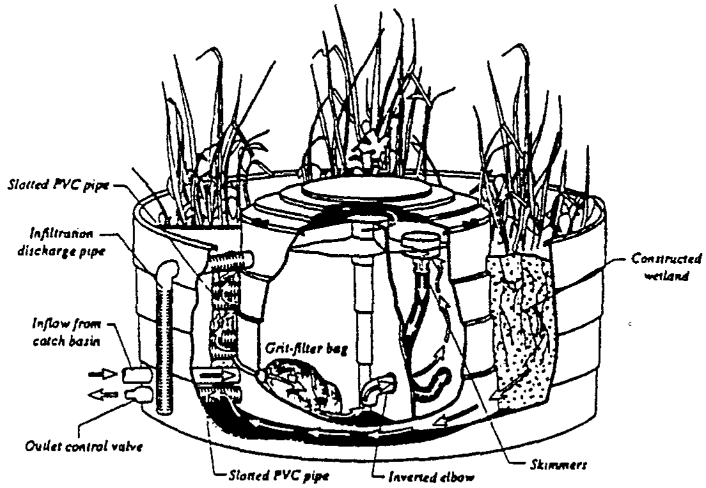


SOURCE: STORMWATER MANAGEMENT®

StormTreat™

The StormTreat™ facility provides treatment in a 9.5 foot diameter modular tank and treats runoff through sedimentation, filtration and constructed wetlands uptake (see Figure 3.15). The system is installed off-line and receives flow from an oversized catch basin that is designed to divert larger storms. The inflow is piped into a sedimentation chamber where large sediment is removed by a grit-filter bag and a series of skimmer devices. The sedimentation chamber is equipped with an inverted elbow to trap floatables. The water is then discharged to the subsurface of a gravel substrate "wetland." The wetland is comprised of a gravel substrate planted with bulrushes and other wetland plants (Horsely, 1998). Monitoring of this BMP is reported to have shown that it can achieve around 98% TSS removal when sized according to design criteria (Massachusetts Strategic Environmental Partnership).

Figure 3.15: Schematic Cross Section of StormTreat™ System



SOURCE: STORMTREAT™ SYSTEMS, INC

Other Proprietary BMPs

Other propriety systems may be available for stormwater treatment, such as hydrodynamic type BMPs such as Stormceptor®, Continuous Deflective separation (CDS) units by CDS Technologies and Storm King® by H.I.L. Technology. For use in the water-supply watershed areas, monitoring studies must indicate that the system can meet the TSS removal requirement of 85%. Even where certain BMPs may not be able to meet this requirement alone, many of these technologies could provide excellent pretreatment in a treatment series with another BMP such as a sand filter.

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3.5 Structural BMP Installation Guidelines

3.5.1 Introduction

Proper installation of stormwater BMPs and associated devices is crucial in creating a successful BMP. The following sections are provided to give some general guidelines on the installation of BMPs and construction timing.

Where BMPs are constructed to meet City regulations, the City will inspect the BMP to ensure that it is constructed according to plan and is functioning properly before the ownership responsibility is turned over to the property owner. The water-supply watershed (Ch. 30) ordinance and the 1999 stormwater management (Ch. 27) ordinance require that stormwater control facilities be substantially complete, have full design volume, and otherwise functioning properly prior to plat recordation or occupancy permit is granted for the property. The following sections describe specifically what aspects of BMP the City will inspect to approve the installation.

3.5.2 Grass Swales, Filter Strips

General Installation Guidelines

Rough graded swales and filter strips should be used to convey water during construction. Final grading should be done at the latest stage of construction possible to grade out erosion gulleys and to prevent excessive sediment from depositing within the permanent grass cover.

The drainage area to swales and filter strips should be stabilized (seeded with straw cover) at the same time as the swales and filter strips are.

It is recommended that swales be sodded or lined with erosion resistant temporary matting to allow a dense grass cover to be established. The sod should be securely fastened to the ground to keep them in place.

When check dams are used at the end of filter strips, a channel or swale should be constructed between the filter strip and check dam to route the flow to the spillways. The swale should be sodded or lined with temporary erosion resistant matting to allow a dense vegetation to establish.

Wood check dams should be pressure treated (rot resistant). The wood should be embedded several feet into the sideslopes.

Gravel trenches should be placed at the same time as the final grading of the filter strip is done. This is to prevent the excess sediments that runoff during the construction phase from prematurely filling the voids in the rock.

Installation Inspections by the City of Greensboro

The City will check to ensure that the BMP is constructed according to design, including proper slopes, dimensions, etc. The City will inspect to ensure that there are no current erosion problems and that the BMP is protected from potential erosion problems, such as use of temporary matting. The City will also inspect to make sure that there is no excessive sediment accumulation within the swale or filter strip.

3.5.3 Dry Detention Basins, Wet Detention Ponds

General Installation Guidelines

Dry detention basins and wet detention ponds may be used as sedimentation basins during construction as long as the construction sediment is removed and the design volume is restored prior to turning the maintenance responsibilities over to the property owner(s).

If a riser/barrel assembly is used, ensure that the soil is well compacted around the barrel and anti-seep collars (if used) to minimize weak zones and planes that become pathways for excessive seepage.

Riprap pads should not be just "dumped" and spread out at the end of pipe, but rather placed in the ground where the top of the rock is even with the adjacent grade. Geotextile fabric or sand and gravel bedding should be placed under all riprap protection. The filter fabric should be properly secured into the soil according to the manufacturer's specifications.

When constructing a dam on a stream, the loose material in the stream bed and banks should be removed prior to filling. This loose material can provide a path for excess seepage if not thoroughly cleaned out.

Installation Inspections by the City of Greensboro

Once construction on site is complete and areas draining to the pond are stabilized, the City will determine if the pond needs to have sediment removed. If construction sediment accumulation is not accounted for in the plans, dredging will be required when there is noticeable amounts of sediment accumulation on the pond bottom. If construction sediment is accounted for in the plans, dredging will be required when construction sediment levels exceed the design construction sediment allocation.

3.5.4 Stormwater Wetlands

General Installation Guidelines

The wetland should be initially graded approximately 6 inches below the final elevations. Grading should be conducted within acceptable tolerance limits in order to ensure sheet flow, prevent excessive velocities, prevent dead zones, and allow for proper planting depths as designed. It may be necessary to modify the wetland planting plan to correspond with the actual depth zones created in the field.

If the wetland bottom is above the water table elevation it is important to have a very low permeable soil layer for the wetland foundation to prevent the wetland from drying up in between rain events. The soil foundation should be compacted thoroughly at the appropriate moisture content to reduce infiltration. In some instances it may be necessary to install impermeable liners below the wetland area.

To better ensure success of the wetland, it is important that nutrient rich topsoil be added to the excavated wetlands (Schueler, 1992). It may be desirable to "disc up" the ground before adding the topsoil to incorporate the topsoil into the in situ soil. The final grading (use machinery that will not heavily compact topsoil) should be completed to ensure the proper depth zones. After the final grading, temporary ground cover should be established to reduce excessive erosion.

Riprap pads should not be just "dumped" and spread out at the end of pipe, but rather placed in the ground where the top of the rock is even with the adjacent grade. Geotextile fabric or sand and gravel bedding should be placed under all riprap protection. The filter fabric should be properly secured into the soil according to the manufacturer's specifications.

To get the soils thoroughly saturated, the wetland soils should be inundated for a period of time before the plantings are introduced.

A wetland specialist should be consulted regarding plantings. The construction of the wetland should coincide with the appropriate planting season for the species selected.

It is a general misconception that the plantings will have to be completely inundated to be able to survive. The water levels should gradually be increased to get the plantings accustomed to inundation (Hammer, 1997).

Unstablized areas of construction sites produce high concentrations of sediment loads even with conventional erosion control practices. Fine grading, adding topsoil, and plantings should not be completed until the drainage area of the wetland has been permanently and completely stabilized. If the wetland is utilized to meet water-supply watershed regulations, the wetland must be **completed in its entirety,** including planting, before the Certificate of Occupancy (C.O.) is issued.
If it is impossible for the site to be stabilized before the C.O. is desired, the wetland must be initially constructed as a wet detention pond. The wet detention pond may later be converted to the wetland after the site has been stabilized.

Installation Inspections by the City of Greensboro

The City of Greensboro needs to inspect the final grades of the wetland prior to planting and to ensure that all sediment has been cleaned out from the forebay area. The City will again inspect the site after the plantings have been planted prior to the maintenance responsibility being turned over to the property owner.

3.5.5 Bioretention Areas

General Installation Guidelines

Sediment transported by stormwater runoff from construction areas will quickly clog the surface of the bioretention cell. **The planting soil material and underdrain system should not be placed until the site has been completely stabilized and paved areas draining to the cell are flushed to remove loose sediment (must be controlled by an erosion control device).**

Once grading of the site is completed, pervious areas within the drainage area should be immediately seeded to allow time for grass to establish before the planting soil material is placed. Pervious areas draining to bioretention areas should be inspected periodically after seeding to ensure that a dense cover is established and that they are not disturbed by construction equipment.

The City strongly recommends that the filter material be placed at the latest stage of construction possible. If the bioretention cell is utilized as a sediment pit during construction, the cell must be completely mucked out before placing the planting soil material and the underdrain system. When the cell has been excavated, it is recommended that the design engineer should inspect the cell to assess the compactability of the underlying soil to ensure that the soil provides a stable foundation for the cell.

A geotextile fabric should be placed between the bottom of the cell and the underdrain system.

The bioretention planting soil is to be placed in one to two foot lifts and loosely compacted (tamp with back hoe). The soil surface should be level to promote uniform ponding.

The plantings for the bioretention area should be installed according to the bioretention landscape plan.

If any surrounding areas are disturbed during the installation of the bioretention cell, the cell must be protected from sedimentation from these areas. One way to protect the cell is to place a temporary silt fence around the cell. The developer is responsible for protecting the bioretention area from runoff from any subsequent construction activities that take place on-site.

Rip rap pads should not be just "dumped" and spread out at the end of pipe, but rather placed in the ground where the top of the rock is even with the adjacent grade. Geotextile fabric or sand and gravel bedding should be placed under all riprap protection. The filter fabric should be properly secured into the soil according to the manufacturer's specifications.

Installation Inspections by the City of Greensboro

The City of Greensboro needs to inspect the site before the filter materials are placed. All land disturbance and site stabilization activities are to be completed before the City inspects the site. After the filter material is placed, the City will test the initial draw down time and performance of the bioretention system.

3.5.6 Sand Filtration Facilities

General Installation Guidelines

Because the sediment in the runoff from construction areas will quickly clog the surface of the sand filter bed, the filter bed and filter underdrain system should not to be placed until the site has been completely stabilized and paved areas draining to sand filter are flushed.

Sediment is to be removed from the sedimentation and filtration chambers before placement of the filter material.

The City strongly recommends that the filter material be placed at the latest stage of construction possible. The developer is responsible for protecting the sand filter once the filter is placed from any subsequent construction activities that take place on-site.

The sand bed should be completely level to promote uniform ponding.

Installation Inspections by the City of Greensboro

The City of Greensboro is required to inspect the site before the filter material is placed in the chamber. All land disturbance and site stabilization activities are to be completed before the City inspects the site. Once the material is placed, the City will fill the structure with water to allow the City to monitor the filtration rate and draw down time.

3.5.7 Proprietary Stormwater Treatment Facilities
Follow the manufacturer's specifications for installing proprietary stormwater BMPs. The City will inspect to ensure that the BMPs are installed according to the specifications and is functioning as designed.

3.6 Structural BMP Maintenance and Inspection Guidelines

3.6.1 Introduction

The purpose of this section is to provide owners of structural BMPs with guidelines to help maintain the BMPs. It is often the case that owners do not fully understand what the BMP on their property is designed to do, much less how to properly maintain it. With different and more complex stormwater BMPs being introduced, it is even more crucial that owners know about the maintenance required for a particular BMP before they decide on one to implement. For owners to appreciate the need for maintenance, it is important that owners are aware that BMPs provide value to the quality of our surface waters and in many cases can be an amenity to their property.

Periodic inspections and maintenance are key factors in preserving the functionality of structural stormwater BMPs. Stormwater BMPs are not self maintaining systems, and over time the efficiency of structural BMPs to remove pollutants will diminish. Trapped sediments and other pollutants can potentially reduce the volume capacity of the BMPs, decrease filtration rates for filtering BMPs, and damage plantings used for treatment. The following guidelines are provided for the benefit of owners of structural BMPs to help ensure that the BMP will continue to meet the objectives they were designed for.

Besides inspecting and maintaining components in which a BMP's water quality functionality is to be sustained, attention must also be paid to the structural components to sustain its hydraulic functionality as well. Minimizing the risk of hydraulic malfunction (potentially leading to structural failure) is essential, especially for larger impondment structures such as wet detention ponds, since the majority of the stormwater BMPs in Greensboro are located in urbanized settings, where structural failure may jeopardize downstream life and property.

Maintenance is also important to prevent the decline in the appearance of the BMP. Unhealthy conditions (such as noxious vegetation, stagnant water, etc.) may occur within and around the BMP, which may affect the aesthetics and economic value of the surrounding property.

3.6.2 BMP Maintenance Requirements

The City's water-supply watershed (Ch 30) ordinance and the 1999 stormwater management (Ch 27) ordinance require that BMPs which are constructed to meet these requirements must be maintained by the property owner or owners' association. The BMPs must be maintained to continue to function to meet the regulations it was designed for. The City has the authority to inspect these BMPs periodically and require the BMP owner to perform maintenance activities, when necessary.

The City, as required by the State, will conduct periodic inspections of structural BMPs implemented for water-supply watershed protection. The City will advise the owner of recommended and required maintenance actions needed to maintain BMP functionality.

The design engineer and developer should be responsible for providing BMP owners with inspection and maintenance guidelines and educating them on it.

3.6.3 General Maintenance Guidelines

Dam Safety *(This section is applicable to all above ground BMPs that utilize a dam to permanently or temporarily retain or detain water).*

Preserving the structural integrity of the dam of a pond BMP is important in protecting downstream life and property. There are at least four aspects of the dam that require specific attention: (1) *assessment of hazard potential* due to changes in downstream development; (2) *seepage*; (3) *dam material problems*; and (4) *vegetation growth* on the dam embankments

Assessment of Hazard Potential
Before any dam is constructed, the design engineer is responsible for notifying the NC State Dam Safety Office of the proposed dam. If the dam falls under State Dam Safety jurisdiction, the dam must be constructed, maintained and operated according to their design and construction guidelines. Even if the dam does not fall under the NC Dam Safety Office's jurisdiction, the dam should be designed and constructed in accordance with current good engineering practice. The City has requirements concerning the maintenance of dams associated with required BMPs.

As new development occurs downstream of the BMP, the chance of significant property damage or danger to human life may increase if catastrophic failure of the dam occurs. Although the dam may be initially exempt from regulation by the State, the owner is responsible for reporting to the State Dam Safety Office downstream development that may affect the hazard classification of the dam.

Seepage
The downstream side of the dam should be inspected regularly for evidence of significant seepage. Seepage can emerge anywhere below the normal pool elevation, including the downstream slope of earth dams, areas beyond the toe of the dam, and around the spillway or pond outlet conduit. Indications of significant seepage include areas where the soil is saturated or where there is a flowing "spring" or leak. If "sinkholes" in the dam embankment are noticed, or if constant flowing water is noticed on the downstream side of the dam, then seepage has become excessive and professional engineering advice should be sought immediately to avert a major structural problem or a catastrophic failure of the dam.

Dam Material Problems
For earth dams, pronounced cracks on the embankment surface indicate the first stages of potential dam failure. Transverse cracks (running perpendicular to the embankment face)

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generally indicating differential settlement of the dam, can provide pathways for excessive seepage. Longitudinal cracks (running parallel to the embankment face) may be due to inadequate compaction of the dam during construction or shrinkage of the clay (desiccation) in the top of the embankment during prolonged dry conditions. These cracks may eventually lead to slope failure such as sliding or sloughing.

For reinforced concrete dams, the concrete should be checked for pronounced cracking, leakage from the joints, and displacement (noticeable leaning or bulging). Also, excessive seepage, leakage, or springs just downstream of the concrete dam could be indicative of potential seepage-related "piping" problems under the dam.

If such problems or other structural problems are observed, professional engineering advice should be sought.

Vegetative Growth
Trees and other woody vegetation are <u>not</u> permitted on the top slopes or dam embankments. Large root systems from woody vegetation can weaken the dam structure and provide seepage pathways. Thick vegetative cover can also provide a haven for burrowing animals such as the groundhog. These animals can create a network of burrows in the dam embankments that can significantly weaken the dam, by creating seepage paths, which may eventually lead to dam failure. Mowing of the dam embankments should occur, at a minimum, once every 6 months to prevent woody vegetation growth and cover for burrowing animals.

<u>Reduction of Pollutants Entering BMPs</u>

Stormwater BMPs are not 100% efficient in removing pollutants; therefore, when the amount of pollutants into the BMP is higher, the amount of pollutants discharged from the BMP will be higher. Also, increased amounts of pollutants to the BMP will increase the maintenance required to keep the BMP functioning properly. Maintenance to BMPs can be very expensive.

Pollution prevention activities
To assist the stormwater pond in stormwater quality enhancement, every effort should be made to reduce the pollutant load entering the pond system. Pollution prevention BMPs described in Section 3 of this manual should be implemented along with the following efforts:

- ⇨ Outside trash dumpsters should be kept covered, and the area around the dumpster should be kept neat and clean.
- ⇨ Chemicals, petroleum products and other pollution sources (such as machinery) should be stored in a covered area away from possible stormwater contact. Spent chemicals are to be properly disposed or recycled.
- ⇨ Fertilizers and pesticides should be used conservatively on the property grounds. Excessive amounts of these chemicals can be washed away with stormwater runoff increasing the nutrient load to the pond.

⇨ Chemicals such as copper sulfate used to inhibit algae growth in the water quality pond degrade water quality. Since the pond's main function is to enhance water quality, these chemicals should not be used. Rather, reducing the amount of fertilizer application and ensuring that the pond outlets are properly functioning so the pool is flushed periodically will help to deter algae growth.

⇨ Trash and vegetative floatables (grass clippings, leaves, limbs, etc.) should be cleaned from the pond surface and surroundings periodically to promote a healthy, aesthetically pleasing environment, and to prevent blockage of the pond outlets. Studies have shown that people are less likely to litter ponds that are aesthetically pleasing and support wildlife.

Stabilization of BMP drainage area

The area draining to the BMP pond should remain stabilized to prevent excessive sediment from entering the BMP facility. When the bare soil is directly exposed to precipitation the sediment concentration in runoff is much higher than for soil that is stabilized. A stabilized area is covered by impervious surfaces (pavement, buildings), grass cover, landscaped cover (mulch, pine straw), etc.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly "seal" the filtration bed, drastically decreasing its filtration capacity.

3.6.4 Grass Swales, Filter Strips

<u>Grass Cover</u>

After initial seeding, the grass should be watered, as needed.

The grass should be mowed periodically (usually when mowing the rest of the property). To maintain the filtering capability of the grass, it should not be mowed to close to the ground (three to four inches minimum).

The ground should be inspected to make sure there is dense growth on all portions of the control device. Bare spots or areas where there is sparse grass cover should be reseeded. It may be necessary to use a temporary erosion resistant matting or to use sod to repair these areas.

As always for grassed areas, fertilizers and pesticides should not be over-applied. Refer to product directions for correct application quantity.

The grass used should be erosion resistant and can tolerate frequent inundation (standing water). Tall fescue is an appropriate choice.

<u>Erosion Problems</u>

The inlet and outlet areas, side slopes (swales), and the rest of the conveyance area should be inspected for erosion problems.

Where water discharges from a pipe and where the stormwater runs off impervious area onto pervious area, there may be erosion problems. The BMP should have riprap protection at the end of pipes and a gravel trench at the edge of impervious areas to help prevent erosion. These devices should be inspected to ensure they are functioning properly. If erosion is noticed in within the rip rap pad or along the edges of the pad, more rock may be needed or it may have been improperly placed (no geotextile liner or improper placement of liner, rip rap not well graded, etc.) If the rock or gravel is displaced downstream, a larger size rock or gravel should be used.

Rill erosion (small channels or gulleys in the ground) is a common problem found in these control devices where the water runoff is naturally trying to channelize. Rill erosion can be repaired by filling in the rills with suitable (clayey) soils and reseeding. It may be necessary to use a temporary erosion resistant matting or to use sod to repair these areas.

Sediment Build-up

Because these BMPs are designed to slow stormwater flows down, sedimentation of coarse particles will occur. Over time the sediment level within the bottom of the swale or filter strip will increase, especially at the upstream area. Sediment will need to be removed periodically (once build-up exceeds one to two inches) from the BMP.

3.6.5 Dry Detention Basins, Wet Detention Ponds, Stormwater Wetlands

The following items should be inspected/maintained on a quarterly basis. These items are in addition to any NC Dam Safety requirements for dams regulated by that agency.

Buffer Vegetation

Strong rooted grasses that have a high tolerance for erosion should be planted on embankments around the pond. Good grass cover should be maintained around the pond perimeter to prevent excessive sediment from entering the pond. The following should be used as guidelines for maintaining buffer vegetation.

- ⇨ To sustain the structural integrity of the dam, no trees or woody vegetation should be allowed on the dam embankments or top of dam. These areas should be mowed on a quarterly basis.
- ⇨ To preserve the hydraulic capacity of the pond system and to prevent runoff from backing up, inlet and outlet areas should be kept clear of heavy vegetation.

⇨ To provide easy access to the pond, the maintenance access around the pond should be free of trees and mowed on a periodic basis.

⇨ Trees and brush, if desired, are acceptable on pond embankments other than the dam.

Erosion Problems

Unsuitable fill material, inadequate compaction, and/or poor stabilization of earth structures can result in accelerated erosion where high runoff velocities exist. High velocities usually occur on steep pond embankments, at pond inlet and outlet discharge areas, and where the water is constricted to channel flow. The entire pond area should be inspected quarterly for signs of erosion, paying special attention to the following areas:

Embankments

If pond embankments are not kept well vegetated with grasses, rill erosion (small channels formed in the embankment due to poor grass cover) may occur. Rill erosion can be repaired by filling the small channels with suitable soil, compacting, and seeding. It may be necessary to install temporary erosion control (such as hay bales) along heavily eroded areas to allow the repaired areas to stabilize. It is especially important to inspect for and immediately repair any erosion on the dam embankments.

Pipe Inlet and Outlet areas

Where erosion causes the undercutting of the downstream end of pipe, the undercut should be stabilized immediately to prevent the end pipe section from "breaking" off. Eroded areas should be filled with good compactable soil and covered with geotextile and riprap.

Open Channel Flow

Eroded areas should be seeded/sodded and protected with temporary velocity dissipation (such as excelsior matting, straw bales, etc.) If erosion continues, a more robust lining should be used.

Blockage of Outlets

Wet extended detention ponds are designed for the water to exit the pond through the low flow orifice(s), the principal spillway, and the emergency spillway. It is important to check all three outlets for blockage that would impair the pond's water quality and hydraulic functionality.

Low Flow Orifice(s)

Unless an inverted orifice is used, some type of trash guard is to be maintained over the low flow orifice(s) to prevent clogging. When the orifice becomes clogged the water level rises to the principal spillway elevation and the benefits associated with temporary storage and its gradual release are lost. To preserve "extended detention" the low flow orifice should be inspected for blockage **twice a month and after large storms.**

Principal and Emergency Spillway
Principal and emergency spillways are designed to safely convey larger than one inch storms that produce runoff which exceed the water quality volume of the BMP. If these spillways are blocked so they do not operate at full capacity, the risk of dam overtopping or other uncontrolled releases may result. To ensure the hydraulic capacity of the spillways, the spillways should be inspected for blockage **twice a month and after large storms.**

If a riser/barrel is used for the principal spillway, a trash rack is to be maintained on the riser. Vegetative growth in the riser should be removed promptly so that the design capacity of the spillway is maintained. Also, the outlet area where the barrel projects from the fill should be clear of tree limbs, sediment accumulation, etc.

Sediment Accumulation

To preserve the BMP's pollutant removal capability, sediment must be removed in areas where the capacity of the design sediment storage volume has been exceeded.

Dry Detention Basin
The sedimentation in dry detention basins will generally not be as much as in wet detention ponds or stormwater wetlands. Sediment accumulation will be less noticeable in dry basins that are open and have a vegetated bottom and embankments. Dry detention basins that have extended detention (24 hours or greater), will have more sedimentation. Sediment should be removed when the detention storage capacity is reduced or when aesthetics is a concern.

Wet Detention Pond
The forebay helps to improve the removal efficiency of the pond system by trapping the majority of coarser suspended solids behind the baffle. When sediment deposition in the forebay exceeds the designed sediment storage capacity for the forebay, the forebay must be dredged. An indication of when the forebay sediment capacity is exceeded is when sediment bars are visible near the inlet discharge or when the sediment level at the inlet to the pond is less than one foot below the normal pool surface (the elevation of the pool is at the bottom of the low flow orifice). Typically, forebays will need to be dredged every 5 to 10 years.

Depth measurements relative to the normal surface elevation (bottom of water quality orifice) should be taken at several locations around the pond. The sediment is to be removed when the measured depth is less than the design permanent pool depth. If a forebay is used at the inlet area of the pond and is regularly dredged, the frequency of dredging the entire pond could be greatly reduced.

Wetland
The forebay helps to trap the majority of suspended solids to prevent the sediment from entering the wetland area and suffocating the plantings. When sediment deposition in the forebay exceeds its designed sediment storage capacity, the forebay must be dredged. It may be necessary to drain down the wetland to measure the

depth of sediment deposited. It is projected that the wetland forebay will need dredging every 3 to 5 years.

Sediment accumulation should be monitored in the wetland area as well. A layer of peat will form in the wetland at a rate of 0.5 inches per year (Hammer 1997). When sediment deposition equals six inches or more the sediment should be removed. The wetland plantings that are destroyed during the cleanout are to be replaced.

Sediment from most sources is usually not hazardous or contaminated, however, it is very "soupy" and is difficult to manage. It is good idea to provide a storage area near the BMP to place sediment once it is dredged to allow it to dry. If desired, sediment may be land applied and seeded. If land applied on-site, it should be within the drainage area to the BMP so sediment that runs off can be recaptured.

Wetland Vegetation

It is likely that a portion of the initial plantings will not survive the first growing season due to factors such as the quality of the plantings, selection of plantings, variable water levels, lack of water, etc. Therefore, it will most likely be necessary for the owner to add additional plantings during the initial development stage of the wetland. Over the long term, drought or other factors may cause a portion of the wetland plantings to die off and need replacement.

Proper Water Balance

An important step to developing a successful wetland system is to ensure that the water balance in the wetland is appropriate to support plant life. The wetland must be able to sustain water and to provide a certain level of inundation after storm events. If the wetland is not sustaining an adequate water balance adjustments will be need to be made to the outflow rates. The slow release outlet should be equipped with a valve to control the water levels in the wetland.

It may be necessary to periodically irrigate the wetland if the wetland is unable to sustain a water level that is conducive to wetland plant growth.

3.6.6 Bioretention Areas

Paved Sweeping Program

A paved area sweeping program should be implemented for all properties that utilize bioretention BMPs. Sweeping paved areas on a periodic basis will help extend the life of the BMP by reducing the pollutant load and debris that enters it. Debris shall be swept away from the pretreatment component (filter strip, channel, or chamber).

Mowing/Landscaping Activities

Mowing/landscaping activities on the property should to be conducted in such a way to prevent lawn and plant clippings as well as eroded sediment from entering the bioretention cell. One way to prevent clippings from entering the cell is to use mulching mowers or bag and remove clippings, especially in areas that drain to the filter.

Minimum Inspection/Maintenance Requirements

The following inspection/maintenance activities should be conducted on a **quarterly** (i.e., 4 times per year) basis, unless noted otherwise.

Overall bioretention area

(a) Accumulated paper, trash, and debris should be removed from the bioretention area.
The bioretention area should remain clear of trash and debris to preserve the draw down rate and stormwater treatment function of the cell. The type of debris removed should be noted and their possible sources identified. Efforts should be made to reduce the amount of the debris entering the bioretention area.

(b) Observe the filtration performance of the cell (every six months at a minimum).
If the drawdown time of the filter bed is greater than the design drawdown time corrective maintenance is needed. Corrective maintenance to restore proper drawdown time and stormwater treatment performance of the filter bed includes:

1. Clean out the underdrain system.

2. Remove mulch and top few inches of planting soil and replace.

   The clogged material should be replaced with new material of the original specifications. Contaminated soil should be removed and disposed of at an approved site (landfill). Instead of replacing the top layer of planting soil, it may be possible to aerate or cultivate the first few inches to restore the draw down capacity of the cell.

3. If appropriate draw down time cannot be restored the owner will be required to remove and replace the filter bed and under drain system.

Pretreatment

(a) Inspect energy dissipators for proper functionality.
Energy dissipators (pea gravel diaphragm, riprap pads, check dams, etc) that are used to slow down and spread the runoff before it enters the bioretention cell should be inspected for proper functionality. Sediment build-up should be removed. Once the

voids become substantially filled with sediment, the rock must be removed, cleaned (away from bioretention area) and placed back in its original location. Larger rock or other measures may be required if the rock is being carried away by high water flows.

(b) Inspect sedimentation/diversion chambers (if applicable) for sediment build-up and blockage.

The sedimentation/diversion chamber should be cleaned out when sediment levels exceed the design level (12 inches accumulation depth is to be used if no design level is given). The sludge should be removed and disposed of at an approved site (landfill). All inlets and outlets to the chamber should be inspected for blockage.

(c) Inspect filter strips and channels for bare areas, rill or channel erosion.

A robust grass cover for the pretreatment areas must be maintained. Bare areas and eroded areas should be seeded or sodded immediately.

Plantings

(a) Replace plantings that are dead, diseased, or otherwise have failed to establish.

If replacing plantings frequently, the planting soil may need to be tested. Make sure that the plantings used are to able withstand the bioretention environment (i.e. frequent inundation).

(b) Pruning and weeding the bioretention cell may be aesthetically desired.

Make sure that all loose vegetation is removed from the bioretention cell so as not to interfere with the functionality of the cell.

Mulch Layer

(a) Inspect the cell for proper mulch cover.

Mulch needs to be reapplied in areas where erosion has displaced the mulch (mulch just may need spreading out). It will be necessary to replace the mulch layer every year when the mulch decays. The thickness of mulch should be approximately 3 inches.

Planting soil

(a) Test the pH of the soil (annually)

To keep plantings healthy, the planting soil shall be tested once a year to determine if the pH is in the acceptable range. If the pH is low than lime should be applied; if the pH is high then iron sulfate can be used.

(b) Test the toxicity of the soil (as needed, approximately once every 5 years)

After a few years of service, the quantity of heavy metals and other pollutants that is collected by the cell may reach toxic levels impairing plant growth and the effectiveness of the cell. If the toxic levels are too high, the soil will need to be replaced.

Outlet

(a) Verify that there is discharge from the underdrain when water is ponded in the cell. When the water level is above the filter bed, check the outlet area to ensure that the bioretention cell is functioning. If there is no discharge from the outlet, the system is nonfunctional and corrective maintenance is needed immediately to restore draw down.

(b) The overflow structure should be inspected to ensure it is not blocked with debris and is functioning properly.

(c) Inspect for and fix erosion problems at the outlet areas
The downstream areas from the outlets of the bioretention area should be checked to ensure there is no erosion. Eroded areas should be revegetated. An energy dissipator, if not already in place, may be needed if erosion continues to occur.

3.6.7 Sand Filtration Facilities

Paved Area Sweeping Program

A paved area sweeping program is recommended for all properties that utilize a sand filter. Sweeping paved areas on a periodic basis will help to extend the life of the filter by reducing the pollutant load and debris entering the filter. Sweeping should be done in such a manner as to prevent debris from entering inlets leading to the sand filter.

Mowing/Landscaping Activities

Mowing/landscaping activities on the property should be conducted in such a way to prevent lawn and plant clippings as well as eroded sediment from entering the filter facility. One way to prevent clippings from entering the facility is to use mulching mowers or to bag and remove clippings, especially in areas that drain to the filter.

Minimum Inspection/Maintenance Requirements

The following inspection/maintenance activities should be conducted on a **quarterly** (i.e., 4 times per year) basis, unless noted otherwise.

Overall Sand Filter Facility

(a) Accumulated paper, trash, and debris are removed from the filtration facility.
Large debris should be removed from each chamber within the sand filter facility to preserve the draw down rate and stormwater treatment function of the filter. Note the type debris is removed and identify possible sources. Efforts should be made to reduce the amount of the debris entering the filtration facility.

(b) Check to verify that there are no signs of cracking or deteriorating concrete (every 6 months at a minimum).
Check for signs of pronounced cracking in the concrete and other structural problems that may present a hazard to the public (especially underground filters that carry vehicle loading).

Sedimentation Chamber

(a) Check to verify that the perforated pipe or low flow orifice (if applicable) is clear of debris.
Some systems use low flow orifices or perforated pipes to slowly distribute water from the sedimentation chamber to the filtration chamber. To assure the capacity of the filter, these components are to be inspected quarterly and unclogged as necessary.

(b) Measure the sediment depth at several locations in the sedimentation chamber (every 6 months at a minimum)
The sedimentation chamber should be cleaned out when sediment levels exceed the design level (12 inches is to be used if no design level is given). The sludge should be disposed at an approved site (landfill). If the sedimentation chamber utilizes a submerged weir to trap floatables, any oil on the surface must be removed separately and recycled before the chamber is pumped.

Filtration Chamber

(a) Monitor the performance of the filter bed (every six months at a minimum).
If the draw down time of the filter bed is greater than twice the initial design drawdown time corrective maintenance is needed. Corrective maintenance to restore proper draw down time and stormwater treatment performance of the filter bed includes:

1. Clean out the under drain system.
2. Replace the top layer of the sand filter bed

Accumulated sediment on top of the sand bed and the top layer of discolored sand should be scraped off. The removed sand should be replaced with new sand of the original specifications. The sediment and contaminated sand should be disposed at an approved site (landfill).

If a filter fabric/screen is used on top of the sand layer, replace it with a new fabric/screen of the original specifications. If gravel is used on top of the filter fabric/screen, rinse the gravel well and reuse. The sediment rinsed from the gravel should be collected. The used filter/screen and collected sediment is to be disposed at the landfill. Before replacing the fabric/screen, be sure to check to see if the sand layer is contaminated.

3. If appropriate draw down time cannot be restored the owner will be required to remove and replace the filter bed and under drain system.

If the filter bed is not draining at all, the stagnated water must be released by the dewatering valve or pumped out before corrective maintenance can be done to the sand bed. If oil is present on the surface it should be removed separately and recycled.

Outlet Chamber/Outlets

(a) Check to verify that the outlet is discharging when water is present in the filtration chamber.
When the water level is above the filter bed, check the outlet area to ensure that the sand filter is functioning. If there is no discharge from the outlet, the system is nonfunctional and corrective maintenance is needed immediately to restore draw down.

(b) Check to verify that there is no erosion at the outlet areas.
The downstream areas from the outlets of the sand filter should be checked to ensure there is no erosion taking place. Eroded areas should be revegetated. A velocity dissipator, if not already in place, may be needed if erosion continues to occur.

3.6.8 Proprietary Stormwater Treatment Facilities

Consult with the manufacturer for proper inspection/maintenance specifications. Most manufacturers have prepared a detailed Operation and Maintenance manual and provide maintenance services. The City of Greensboro requires that the owner follow the maintenance requirements for these systems and provide documentation of all inspections and maintenance activities performed.

Access / Maintenance Easement: Refers to the required access and maintenance easement to a structural stormwater management improvement or facility from the public Right-of-Way (R.O.W.) and includes the Drainage Maintenance and Utility Easement (D.M.U.E.) around the improvement or facility.

Alternative Structural Best Management Practice: Typically facilities other than dry detention and wet detention pond facilities designed to reduce the pollutant loading of stormwater runoff and in some cases reduce the stormwater runoff discharge rate. The City encourages the implementation of alternative and innovative best management practices, where appropriate.

Anti-Seep Collar: A metal plate or other device that connects to the outside of a structure that extends through a dam and serves to redirect seepage pathways to minimize the quantity of seepage along the structure.

Anti-Vortex Device: A device placed in a outlet riser structure to prevent a vortex, or whirlpool, from occurring when the outlet is acting as an orifice.

Baffle: A berm or barrier made of earth, rock, etc., or other diversion used to direct flow or trap sediments within a structural BMP.

Best Management Practice (BMP): An activity, design or planning technique, or structural device that is used singularly or in combination to protect the quality of receiving surface waters, reduce the volume of stormwater runoff generated, and/or reduce the stormwater runoff discharge rate.

Bioretention Area: A structural BMP that removes pollutants in stormwater runoff through filtration and plant uptake. The bioretention BMP consists of a "made" planting soil layer, mulch, plantings, and an underdrain system.

Bioretention Area Landscape Plan: Plan required for City approval of this BMP for water-supply watershed protection, which shows the plant types, quantity, and location.

Building Certificate of Compliance: Permit issued by the City Building Inspections Department that signifies that the building is in compliance and may be occupied.

Built-Upon Area: Term used in City Ordinance Section 30-7, Water-Supply Watershed Districts, and Section 27-22, Stormwater Management Control. Defined as impervious or partially impervious cover including buildings, pavement, gravel areas, recreation facilities, such as tennis courts, etc.

Catch Basins: Structures, which are connected to storm sewer pipe, used to collect stormwater runoff from the land surface, such as roads and parking lots.

Channel: Man-made or naturally formed conveyance that is well defined and may convey stormwater runoff, intermittent, or perennial streams.

Check Dam: A dam placed within a conveyance such as a swale or channel to slow the velocity of flow or temporarily detain the flow.

Chimney Drain: A seepage control device used in earth dams.

Clustering: As it pertains to stormwater BMP, site development practice where development is concentrated away from environmentally sensitive areas and the amount of impervious surfaces is reduced as a result of concentrating the development in one place as opposed to spreading out over the entire site.

City of Greensboro Stormwater Master Plan: A comprehensive stormwater management master plan that is to include all major watersheds and sub-watersheds in the City. The master plan for a given watershed/sub-watershed will guide the development of on-site and/or off-site stormwater management facilities and practices to meet stormwater quantity and quality management goals, in addition to environmental and watershed restoration objectives, as determined by a group of representative stakeholders.

Conservation or Floodplain Easements: Easements provided along environmentally sensitive areas and/or major streams that have mapped floodplains.

Dam Hazard Potential: An estimate of the extent of damage that a dam would do if it were to fail. The hazard potential is classified by the State Dam Safety Office as low, intermediate, or high.

Dam Safety Regulations: Regulations (Dam Safety Law of 1967 and Administrative Code Title 15A Subchapter 2K) regarding the construction, repair, alteration, or removal of a dam. These regulations are enforced by the NC Dam Safety Office, Land Quality Section.

Dam: A structure and appurtenant works erected to impound or divert water, as defined by the Dam Safety Law of 1967.

Dead Storage Zones: Term used to describe areas within pond BMPs (wet detention ponds, stormwater wetlands) that are not within the flow path between the inlet and outlet. These areas may be created where the BMP is an irregular shape and/or where the pond width goes back and forth between narrow and wide.

Deep Water Zone: One of the depth zones in the stormwater wetland BMP. The deep water zone, which consists of a forebay and outlet micropool, comprises approximately 30% of the wetland surface area and is usually 4-6 feet deep.

Depth Zones: Tem used to describe the varying depths within a stormwater wetland BMP. The depth zones include the deep water zone, which consists of forebay and outlet micropool, and a shallow water zone, which consists of the low marsh, and high marsh.

Detention: Temporarily storing water and slowly releasing it.

Development: Any manmade change to real estate, including buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations; or storage of equipment or materials (from Water-supply watershed (Chapter 30) Ordinance).

Disconnection: Directing stormwater runoff from impervious surfaces to pervious surfaces to provide water quality improvement through contact with pervious cover, allow infiltration, and decrease peak discharge, before the runoff is discharged from the property or into a conveyance system.

Drainageways: Usually refers to areas where the topography forms a small "valley" that is not well defined and conveys stormwater runoff to streams or other water bodies.

Dry Detention Basin: A structural BMP that does not have a permanent pool but temporarily stores stormwater runoff and slowly releases it. This BMP has moderate pollutant removal capability but can provide an excellent means for reducing peak discharge rates.

Energy dissipator: A device such as rip rap pad, block baffles, etc. that is placed downstream of an pipe or channel outfall to reduce the velocity of the flow.

Enforcement Officer: City stormwater staff responsible for reviewing plans for compliance with the stormwater management requirements of this Ordinance.

Erosion: The wearing down or removal of land surface by flowing water, wind, ice, etc.

Extended Detention: To detain water for an extra length of time to achieve better pollutant removal efficiency (usually 24 hours or more).

FEMA: Acronym for the Federal Emergency Management Agency. This agency regulates development activities in designated floodplain areas.

FEMA Certificate of No Rise: Certification with supporting technical data that states that there will be no increase in flood levels as a result of a project that develops in the floodway.

FEMA Conditional Letter of Map Revision (CLOMR): FEMA's approval of the proposed changes to an effective FIRM for proposed placement of fill or other physical measures that result in changes to the floodplain elevation or floodway.

FEMA Flood Insurance Rate Map (FIRM): Map in which FEMA has delineated both the special flood hazard areas and the risk premium zones.

FEMA Floodplain: Area along designated streams that have the potential to flood during the 100-year storm event.

FEMA Floodway: Area along designated streams that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (for Greensboro, one (1) foot) (as defined by FEMA).

FEMA Letter of Map Revision (LOMR): FEMA's modification to an effective FIRM based on the placement of fill or other physical measures that result in changes to the floodplain elevation or floodway.

Fetch: Refers to the length across the surface of a pond, lake or reservoir, in which wind may act upon.

Filter and Drainage Diaphragm: A sand and gravel layer placed around a structure that extends through a dam, to capture seepage and safely convey it to the downstream side of the dam.

Filter Strip: A structural BMP that is designed to receive stormwater runoff that is in the form of sheet flow. The strip is a uniformly graded piece of land that is slightly sloped to provide positive drainage. The filter strip is densely planted with grass, which filters the stormwater as it flows across the strip.

First Flush: Term to describe the initial quantity of runoff from developed areas. It is generally accepted that the majority of pollutants are washed off by the initial runoff.

Floatable: Any material that floats on water such as oil, wood, leaves, paper or plastic litter, etc.

Floodplain: The area adjacent to the stream that is subject to flooding when the stream overtops its banks during storm events (usually associated with the area inundated by the 100 year storm event).

Flow Spreader: A device that takes flow that is concentrated or overland flow and spreads the flow to create sheet flow. The flow spreader may be a gravel diaphragm or trench.

Forebay: A feature in the wet detention pond and stormwater wetland. The forebay is placed at the inlet area of the pond and is separated from the rest of the pond by a baffle. The forebay serves to trap coarse sediments from the inflow to minimize accumulation in the remaining portion of the pond and wetland area, making sediment cleanouts easier and minimizing disturbance.

Freeboard: The difference between the maximum elevation of the water level during a specified storm and the top of impoundment or conveyance structure in which the water is contained.

Geographic Information System (GIS): An innovate computer system used to visualize, query, and analyze data that is spatial in nature.

Grass Paving: A technology that incorporates paver units that allow grass to grow between and is able to support vehicular loading. This technology was designed mainly to provide a developers a more aesthetically pleasing option to asphalt or concrete pavement, but also can provide benefits to stormwater management. Grass pavers are generally placed in areas that are infrequently used areas such as fire lanes, overflow parking, access roads, etc.

Herbaceous Plant: A plant whose stem above ground does not become woody.

High Marsh: Term to describe one of the depth zones in the stormwater wetland BMP. The high marsh has a depth of 0 to 9 inches and comprises approximately 35% of the wetland surface area.

High-Density Development: Term used in the City's Water-Supply Watershed Protection Ordinance. Defined as development where the built-upon area or density (single family detached homes) or the built-upon area (all other development) exceeds the applicable limits specified in the ordinance.

Hydrologic / Hydraulic Analysis: For purposes of this manual, hydrologic analysis involves procedures and techniques to estimate the transformation of precipitation or rainfall into surface stormwater runoff in terms of runoff volume and/or runoff rate. Hydraulic analysis generally refers to hydraulic engineering procedures and techniques to evaluate the storage and outflow (discharge) characteristics of stormwater runoff with respect to engineered structural stormwater facilities or improvements, analysis of closed conduit drainage systems, and/or a hydraulic backwater analysis necessary for determination of floodwater elevations for an open channel segment.

Hydrology: An earth science that encompasses the occurance, distribution, movement, and properties to the water of the earth.

Impervious surfaces: Generally man-made hard surfaces that are placed over natural soils or surfaces that do not allow infiltration of stormwater into the soils, or that greatly reduce the amount of infiltration, including building rooftops, pavement, paved or gravel roads/driveways/sidewalks/parking areas, and paved recreational areas.

Infiltration: Percolation of water into the ground.

Intermittent Streams: Refer to the definition in Ordinance Section 30-2-2.2.

Jurisdictional Streams/Wetlands: Streams and wetlands that are under the jurisdiction of the US Army Corps of Engineers.

Length to Width Ratio: Term used to describe the geometry of the stormwater BMP surface. Generally for pond BMPs (wet detention ponds, stormwater wetlands), the BMPs pollutant removal efficiency increases as the flow path between the inlets and outlets increases, therefore, for these BMPs the length to width ratio is defined as the length of the flow path to the width of the flow path.

Licensed Professional Engineer: A Professional Engineer (P.E.) duly licensed by the appropriate State Board in the State of North Carolina.

Low Flow Orifice: Outlet works that releases detained water to a desirable discharge rate or detention time.

Low-Density Development: Term used in the City's Water-Supply Watershed Protection Ordinance. Defined as development where the density (single family detached homes) or the built-upon area (all other development) does not exceed the applicable limits specified in the ordinance.

Maintenance Plan: Short-term and long-term inspection and maintenance activities that are generally necessary to maintain the functionality and safety of stormwater management facilities.

Microtopography: Term used to describe the varying depth zones within a stormwater wetland BMP. Microtopography is important in establishing a diverse wetland plantings, and extending the flow path between the inlet and outlet.

Municipal Separate Storm Sewer System (MS4) Discharge Permit: NPDES Stormwater Permit, that is required for municipalities with a population over 100,000 (Phase I). The Permit requires these municipalities to develop and implement a Stormwater Quality Management Program (SWQMP) to control the discharge of pollutants from the municipal separate storm sewer system to the maximum extent practicable.

New Development: Any land disturbance activity occurring on undisturbed land that results in vegetation/tree removal, grading, filling, placement of impervious surfaces or that otherwise decreases the infiltration capacity of the land.

Non-Structural BMPs: Techniques incorporated in site design/planning to reduce the volume of runoff generated, reduce runoff discharge rates and provide partial pollutant removal.

NPDES: Acronym for the EPA's National Pollutant Discharge Elimination System.

(One Hundred) 100-Year Storm: The precipitation volume or intensity that is has a 1% probability of being equaled or exceeded during a given year.

Open Vegetated Conveyance: Any ditch, channel, swale or flat strip of land that is covered with vegetation (forest, unmaintained growth, grass, or landscape covering) and conveys stormwater runoff.

Outfall: The end of a stormwater conveyance, such as a pipe, swale, channel, etc. where the flow is discharged to another conveyance system.

Outlet Micropool: Term to describe one of the deep water zones within a stormwater wetland BMP. The outlet micropool is a pool around the outlet to allow the low flow orifice and pond drain to operate properly.

Owner's Association: An association of property owners established when there is more than one owner of a permanent structural stormwater management facility or improvement. The association will be responsible for the obligations, liabilities, and maintenance activities associated with stormwater management improvement ownership.

Perennial Streams: Streams, and lakes and ponds along them, that are indicated as being perennial 1) on the most recent version of the US Geological Survey 1:24000 scale (7.5 minute quadrangle) topographic maps, 2) on the most recent version of the Soil Survey map developed by the USDA – Natural Resource Conservation Service, or 3) by an examination of site-specific evidence by the City Storm Water Services Division using criteria approved by the NC Division of Water Quality. However, if the above-mentioned map indicates an area as a perennial stream but the Storm Water Services Division finds no perennial water body actually exists on the ground, that area shall not be deemed a perennial stream. Ponds and lakes created for animal watering, crop irrigation, or other agricultural uses that are not part of a natural drainageway are not streams. If the City of Greensboro develops a detailed stream network map covering one or more watersheds, then within the watersheds covered by that map perennial streams shall thenceforth be as shown by that map.

Perimeter (Delaware) Sand Filter: A type of sand filtration facility developed in Delaware where the facility is placed underground along the perimeter of impervious areas such as parking lots.

Pollutant Loading: The quantity of pollutants that are discharged to surface waters by means of stormwater runoff, discharge of non-stormwater, or groundwater contamination.

Pollutant: Substances or chemicals that are harmful or degrade the quality of surface waters and associated habitat, such as sediment, nutrients, bacteria, chemicals, etc.

Pollution Prevention BMPs: Activities implemented to control pollution at the source by preventing pollutants from commingling with stormwater runoff.

Post-development peak discharge rates, 2-year: The peak flow rate of stormwater runoff that results from a land area *after* it is developed or redeveloped during a precipitation event based on an amount of precipitation that has a 50% probability of being equaled or exceeded in a given year.

Post-development peak discharge rates, 10-year: : The peak flow rate of stormwater runoff that results from a land area *after* it is developed or redeveloped during a precipitation event based on an amount of precipitation that has a 10% probability of being equaled or exceeded in a given year.

Pre-development peak discharge rates, 2-year: The peak flow rate of stormwater runoff that results from a land area *before* it is developed or redeveloped during a precipitation event based on an amount of precipitation that has a 50% probability of being equaled or exceeded in a given year.

Pre-development peak discharge rates, 10-year: The peak flow rate of stormwater runoff that results from a land area *before* it is developed or redeveloped during a precipitation event based on an amount of precipitation that has a 10% probability of being equaled or exceeded in a given year.

Proprietary Stormwater Treatment Facilities: Patented structural BMPs that have been developed to remove pollutants in stormwater runoff.

Public Waters: Surface stormwater runoff from (City-owned) public lands such as streets, parks, parking lots, etc.

Receiving Waters: Surface waters that receive stormwater runoff or groundwater seepage.

Redevelopment: Any land disturbance activity occurring on previously developed land that results in vegetation/tree removal, grading, filling, placement of impervious surfaces or otherwise decreased infiltration and retention capacity of the land.

Regional Stormwater Management Facility: A structural management practice established by one or more local governments for the purpose of managing stormwater from multiple properties.

Riser/barrel: An pond outlet works that consists of a vertical, standpipe (riser) on the upstream side of the dam to control the water level, connected to a pipe (barrel) that runs through the dam and discharges on the downstream side.

Runoff/Pollution Control BMPs: Site design/planning practices, or structural facilities that serve to reduce the total volume of runoff generated, reduce peak runoff discharge rates, and provide surface water quality improvement by minimizing impacts to environmentally sensitive areas and by removing pollutants from stormwater runoff.

Safety Bench: A recommended feature for all stormwater BMPs that have a permanent pool. The safety bench is a flat or gently sloped area around the permanent pool elevation and serves to separate the pool from the embankment.

Sand Filtration Facility: A structural BMP that removes pollutants in stormwater runoff through sedimentation and filtration. The sand filtration facility consists of sedimentation chamber/basin and sand filter chamber. There are three main designs: the underground or DC sand filter, perimeter or Delaware Sand Filter, and surface sand filter.

Scoresheet: Refers to the scoresheet provided in Section 30-7-1.11 of the Greensboro Code of Ordinances. Developments in the General Watershed Area that are classified as low density may be approved by the City for watershed protection if they have a passing score on the scoresheet.

Seepage: As it pertains to dam seepage, flow of water through the dam, foundation, or ground from the upstream side of the dam to the downstream side.

Sedimentation: The process of suspended particles settling out in slow moving receiving waters.

Sedimentation Chamber: The portion of a structural BMP (such as sand filtration facility) that is designed to settle out coarse sediments.

Shallow Water Zone: Term to describe one of the depth zones in the stormwater wetland BMP. The shallow water zone, which consists of the low marsh and high marsh, comprises approximately 70% of the wetland surface area and has a depth of 0 to 18 inches.

Sheet Flow Runoff: Runoff that is overland flow and is not concentrated into a conveyance system.

Skimmer Baffle: Baffle used in a structural BMP or spill containment structure, designed to trap floatable material, such as oil, litter, gasoline, leaves, etc. Usually consists of a sheet of metal or plastic or concrete wall that placed across the control structure and extending below the permanent pool trapping floatables on the upstream side of the baffle.

Spillway: Outlet works designed to discharge water during a storm event from a water body once it reaches a certain elevation.

Stabilization (Site): Condition where the soil is no longer exposed. For filtration BMPs it is crucial that the site is stabilized before placement of the filter material, which includes completion of paving and landscaping (seeding with straw and/or mulch).

Storm Sewer: Structures associated with collecting stormwater and conveying it subsurface to a downstream outfall. Structures include pipe, catch basins, and junction structures (manholes).

Storm Sewer Design Manual: Refers to the guidance manual developed by the City Engineering Division for storm sewer system design.

Storm Water Management Ordinance: Chapter 27 of the Greensboro Code of Ordinances provides Storm Water Services with the legal authority to administer the City's NPDES Stormwater Permit. Section 27-22 of this Ordinance, adopted by City Council in 1999, sets forth the stormwater management control requirements for new development.

Storm Water Services: Division under the City of Greensboro Environmental Services Department. Responsible for implementation and enforcing the City's Municipal Separate Storm Sewer System Discharge Permit and development of a comprehensive stormwater management program for the City.

Storm Water Utility Fee: Fee that is assessed to all City of Greensboro properties to fund the Storm Water Services Division. Residential properties are charged a flat rate, while the fee for non-residential properties is based on the amount of impervious surface that is on the property.

Stormwater: Precipitation.

Stormwater Conveyance System: System used to convey stormwater runoff to downstream receiving waters. The conveyance system may include storm sewer, open channels/swales, structural BMPs, etc.

Stormwater Infrastructure Management System (SWIMS): A proactive program developed by the City of Greensboro to optimize maintenance of the public storm sewer system through use of the information gathered by stormwater infrastructure and conveyance system inventory, land use data, and other sources.

Stormwater Management Control: Typically, a structural device used to manage the quality and/or quantity of stormwater runoff.

Stormwater Management Manual: Provides requirements and guidance for meeting the requirements of Ordinance Section 30-7, Water Supply Watershed Development, and Section 27-22 of the Storm Water Management Ordinance.

Stormwater Management Improvement: A stormwater management control, non-structural/structural BMP, upgrade to existing conveyance system, etc., implemented to reduce negative stormwater impacts associated with development.

Stormwater Management Plan: This plan is required for all proposed new development or redevelopment by Section 27-22 of the Greensboro Code of Ordinances, Stormwater Management Control Requirements. The plan must address the requirement specified in the ordinance and be prepared in accordance with the guidelines of the Stormwater Management Guidance Manual., such as engineering analysis of impacts to downstream storm sewer systems and property as a result of increased runoff, measures to control increased runoff to prevent flooding, drainage, or erosion problems, and buffers along streams and major drainageways.

Stormwater (Watershed) Master Plan: A comprehensive stormwater management master plan that is to include all major watersheds and sub-watersheds in the City. The master plan for a given watershed/sub-watershed will guide the development of on-site and/or off-site stormwater management facilities and practices to meet stormwater quantity and quality management goals, in addition to environmental and watershed restoration objectives, as determined by a group of representative stakeholders.

Stormwater Pollution Prevention Plan (SWPPP): Requirement of the NPDES Industrial Stormwater Permit. Details stormwater BMPs and other practices to eliminate discharge of pollutants from industrial facilities via stormwater runoff.

Stormwater Quality Management Program (SWQMP): Requirement of the municipal NPDES Stormwater Permit. Details activities that the City will implement to control the discharge of pollutants from the municipal separate storm sewer system to the maximum extent practicable, including, but not limited to, public education and awareness, stormwater runoff and stream monitoring, storm sewer and conveyance system inventory, identification of illicit discharges and improper disposals, and erosion and sedimentation control.

Stormwater Runoff: Rainfall that does not infiltrate into the ground and flows as surface water.

Stormwater Runoff Discharge Rate: The volumetric rate of runoff that leaves a particular area of interest over a specified time interval.

Stormwater Utility Credit Policy: City of Greensboro policy to issue credit to properties that implement on-site stormwater BMPs designed to reduce the discharge of pollutants to surface waters, and minimize stream and property damage by decreasing flowrates. The BMPs eligible for credit are referred to in this manual and the Stormwater Utility Credit Policy document.

Stormwater Utility Fee: Fee charged to all properties to fund the City Storm Water Services division. The fee is a flat fee for single family detached residential homes and based on the amount of impervious surfaces for other residential and non-residential properties.

Stormwater Wetlands: A structural BMP that consists of a permanent pool, temporary pool, and varying depth zones (microtopography) to establish wetland plantings.

Stream Buffers: Land along streams, drainageways, and other water bodies, which are provided to protect the quality of the surface waters, and minimize structure or improved property damage due to flooding or changes in the stream channel (for example, widening, deepening or meandering).

Stream: Natural body of concentrated flowing water in a natural low area or natural channel on the land surface (NC Division of Water Quality).

Structural BMPs: Defined as "engineered" stormwater management facilities designed to improve the quality of stormwater runoff and reduce stormwater runoff rates. They use processes such as sedimentation, plant uptake, filtration, microbial activity, etc. to remove pollutants from stormwater runoff. They can use the storage to control stormwater runoff to also help reduce peak discharges.

Sub-Basin (Sub-Watershed) Master Plan: A plan that identifies existing and potential future stormwater quality and quantity problems for a designated drainage basin within the city through hydrologic/ hydraulic and water quality/pollutant load modeling utilizing data collected on the City's land use, topography, surface water conveyance system, monitoring activities, etc., and identifies potential on-site and regional solutions to address the issues in a holistic and stakeholder driven manner.

Surface Sand Filter: A type of sand filtration facility where the facility is placed above ground.

Surface Waters: Refers to water that exists on the surface of the earth, such as streams, ponds, lakes, springs, wetlands, stormwater runoff from precipitation events, etc.

Swales: Man-made or natural open conveyance of stormwater runoff that is usually designed to convey or treat stormwater runoff has relatively flat side slopes and a wide bottom, as opposed to well defined channels or ditches.

Technical Review Committee (TRC): A committee consisting of representatives from various City of Greensboro departments that are responsible for reviewing and approving proposed development activities within the City's jurisdiction.

(Ten) 10-Year Storm: The precipitation volume or intensity that is has a 10% probability of being equaled or exceeded during a given year.

Time of concentration: As it refers to hydrology, the time required for 100 percent of a tract of land to contribute to the runoff at the outlet.

Trash rack: A device placed on outlet (pipe or box) spillways to prevent the outlet from being clogged with large debris.

(Two) 2-Year Storm: The precipitation volume or intensity that is has a 50% probability of being equaled or exceeded during a given year.

Underdrain System: A system of perforated pipes placed under the filter beds of filtering BMPs which serves to collect the filtered water and discharge it to the stormwater conveyance system.

Underground (DC) Sand Filter: A type of sand filtration facility, developed by Washington DC, where the facility is placed underground.

Underground Oversized Stormwater Sewer System: Underground chamber or pipe system used to provide temporary storage (dry detention) to reduce post-development peak runoff rates.

Urbanization: Development of land for use as commercial, industrial, residential, and/or other land uses associated with city growth. Urbanization causes increases in impervious surfaces, which in turn causes a decrease in surface water quality.

Water Balance: As it relates to structural BMPs, the net presence of water considering precipitation, dry weather flow, storage, evaporation and infiltration. For stormwater wetlands, it is very important to have a water balance that can sustain the plantings.

Water Quality Volume (WQV): The storage needed within a structural BMP to control the "first flush" of runoff during a storm event. The "first flush" is designated by the NC Division of Water Quality and City of Greensboro as the first inch of rainfall.

Watershed: Land area that contributes surface runoff to any point of interest.

Watershed Map: As it pertains to Section 2.2 of this manual, the Guilford County Designated Water Supply Watershed Map, dated June 30, 1991

Watershed Protection Plan: Plan required when developing, disturbing, or subdividing land that is in the City's water-supply watershed area. The plan must meet the requirements of the Water-Supply Watershed Protection Ordinance.

Water-Supply Watershed Protection Requirements (Ordinance): Requirements set forth to protect the City's water-supply lakes and watershed, such as limits on built-upon surfaces, use of stormwater BMPs, and buffer protection of lakes and streams.

Water-Supply Watershed: The land area that drains to a water source. Usually associated with water sources for treatment and distribution of drinking water.

Designated Water-Supply Watershed: Water-supply watersheds that are designated by the NC Environmental Management Commission for protection by their regulations.

Watershed Critical Area: The area designated around a water-supply reservoir, that is restricted further from development activities and land use than the General water-supply watershed area.

Watershed General Area: The area that is within a designated water-supply watershed area that is not watershed critical area.

Wet Detention Pond: A structural BMP that is used to remove pollutants from stormwater runoff and, if desired, provide peak reduction. The pond consists of a permanent pool; a temporary pool, which is designed to be above the permanent pool, to store the water quality volume; and a forebay, which is constructed at the inlet area to trap larger sediments.

Wetland Planting Plan: Plan required for City approval of this BMP for water-supply watershed protection, which shows the planting types, quantity, and location.

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United States
Environmental Protection
Agency

Office of Water
(4204)

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Storm Water Phase II Compliance Assistance Guide

R0010593

Compliance Guide Notice

The statements in this document are intended solely as guidance to aid regulated entities in complying with the Storm Water Phase II final rule. The guidance is not a substitute for reading the regulation and understanding all its requirements as it applies to your facility. This guidance does not constitute rulemaking by the EPA and may not be relied on to create a substantive or procedural right or benefit enforceable, at law or in equity, by any person. EPA may decide to update this guide without public notice to reflect changes in EPA's approach to implementing Storm Water Phase II or to clarify and update text. To determine whether EPA has revised this document and/or to obtain copies, go to EPA's web site at www.epa.gov/owm/sw/phase2.

1.0 INTRODUCTION

After reading this introduction, you should know whether you need to use this guide, what the guide covers, and where to get the latest information on the regulation.

The U.S. Environmental Protection Agency (EPA) published the regulation entitled "National Pollutant Discharge Elimination System - Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges" (*Federal Register*, Volume 64, Number 235, pages 68722-68852) on December 8, 1999 as required by Section 402(p) of the Clean Water Act (CWA). This guide explains how to tell if you are subject to the regulation and what to do if you are required to comply.

1.1 Who should use this guide?

This new rule regulates storm water discharges from two categories:

First, the rule covers storm water discharges to certain ***municipal separate storm sewer systems*** (MS4s). Public entities which operate these MS4s, such as cities, counties, States, and the Federal government, could be regulated under this rule. MS4 operators should read section 4 for more information.

Second, the rule also covers storm water discharges from ***construction activity*** generally disturbing between 1 and 5 acres. A construction operator could include the site owner, developer, contractor, or subcontractor. Construction site operators should read section 5 for more information.

The storm water Phase II final rule also provide regulatory relief for certain ***industrial facilities*** (currently permitted under EPA's storm water regulations) where storm water runoff is not exposed to industrial activities. Operators of industrial facilities interested in the no exposure exclusion should read section 6.

1.2 What Does this Guide Cover?

The purpose of this guide is to help the regulated community comply with the Storm Water Phase II Rule. This guide answers the following basic questions:

- Why is the Storm Water Phase II Rule important?
- Am I subject to the Storm Water Phase II Rule?
- What must I do to comply with the Storm Water Phase II Rule?

1.3 How Do I Use this Guide?

This guide is organized into seven major sections plus three appendices.

Section 1.0	Introduces you to this guide and the Storm Water Phase II Rule. Describes basic types of entities regulated so you can determine if you are affected by the rule.
Section 2.0	Provides background on why the Storm Water Phase II Rule is needed. Topics such as the environmental impacts of storm water and why storm water should be controlled are discussed. The history of the NPDES Storm Water program is briefly described.
Section 3.0	Delivers an overview of the Storm Water Phase II requirements. The basic components of the program are described and schedules and timelines are highlighted.
Section 4.0	Gives step-by-step procedures for operators of small MS4s to determine if they are subject to the regulation and provides information on how to demonstrate compliance.
Section 5.0	Gives step-by-step procedures for operators of small construction activities to determine if they are subject to the regulation and provides information on how to demonstrate compliance.
Section 6.0	Provides a discussion of how the Rule affects industrial facilities, including which industrial facilities are covered, and an explanation of the No Exposure exclusion and how to determine if you qualify.
Section 7.0	Documents the Compliance Assurance Process - Discusses how EPA will determine compliance, what happens if you or EPA discovers noncompliance, and the legal status of the guide.
Appendices	Provides additional references and where to go for more information on storm water.

1.4 Where Can I Get More Information on the Storm Water Phase II Rule?

Additional information on the NPDES storm water Phase II rule, including a series of fact sheets and a full copy of the final rule, can be found on EPA's web pages at http://www.epa.gov/owm/sw/phase2.

Compliance assistance will be covered in Section 7 of the guide. One source for compliance assistance and information on the rule is the Local Government Environmental Assistance Network (LGEAN). LGEAN is one of EPA's compliance assistance centers and can be found on the web at www.lgean.org or contacted by phone at 1-877-TO-LGEAN.

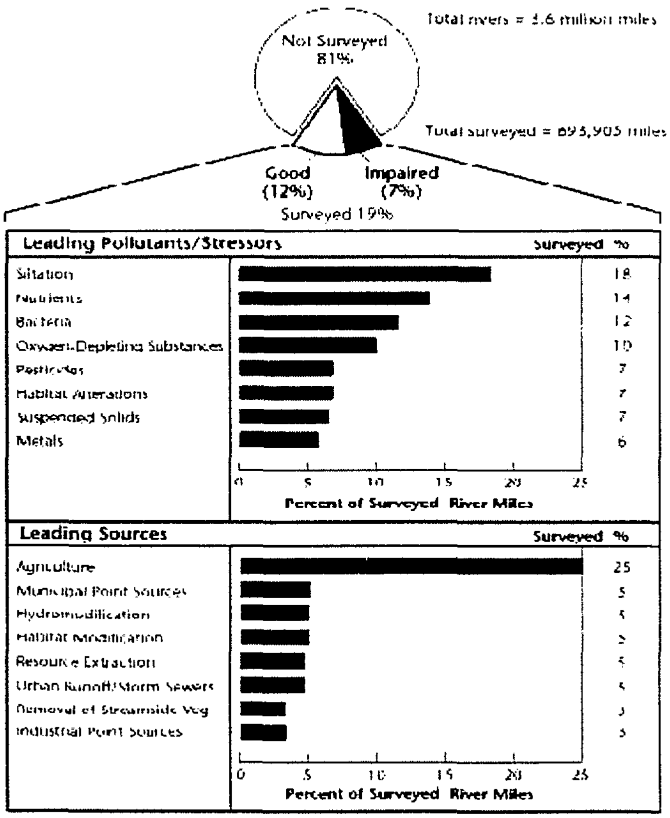
2.0 BACKGROUND

After reading section 2, you should understand the environmental impacts of storm water and the history of the storm water program, including existing regulations to control storm water (Phase I).

2.1 What are the Environmental Impacts from Storm Water Discharges?

Storm water runoff from lands modified by human activities can harm surface water and, in turn, cause or contribute to an exceedance of water quality standards by changing natural hydrologic patterns, accelerating natural stream flows, destroying aquatic habitat, and elevating pollutant concentrations and loadings. Such runoff may contain high levels of contaminants, such as sediment, suspended solids, nutrients (phosphorus and nitrogen), heavy metals, pathogens, toxins, oxygen-demanding substances (organic material), and floatables (U.S. EPA. 1992. *Environmental Impacts of Storm Water Discharges: A National Profile.* EPA 841-R-92-001. Office of Water. Washington, DC). After a rain, storm water runoff carries these pollutants into nearby streams, rivers, lakes, estuaries, wetlands, and oceans. Individually and combined, these pollutants impair water quality, threatening designated beneficial uses and causing habitat alteration and destruction.

SURVEYED River Miles: Pollutants and Sources



NOTE: Percentages do not add up to 100% because more than one pollutant or source may impair a river segment

The 1996 305(b) Report (U.S. EPA. 1998. The National Water Quality Inventory, 1996 Report to Congress. EPA 841-R-97-008. Office of Water. Washington, DC), provides a national assessment of water quality based on biennial reports submitted by the States as required under CWA section 305(b) of the CWA. In the CWA 305(b) reports, States, Tribes, and

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nonattainment of the designated uses assigned to their rivers, lakes, estuaries, wetlands, and ocean shores. The 1996 Inventory indicated that approximately 40 percent of the Nation's assessed rivers, lakes, and estuaries are impaired.

The 1996 Inventory also found urban runoff/discharges from storm sewers to be a major source of water quality impairment nationwide. Urban runoff/storm sewers were found to be a source of pollution in 13 percent of impaired rivers; 21 percent of impaired lakes, ponds, and reservoirs; and 45 percent of impaired estuaries (second only to industrial discharges). See Figures 2-1 and 2-2 for an illustration of the pollutants and sources of pollution for both rivers and estuaries. In addition to these waterbodies, urban runoff was found to be the leading cause of ocean impairment for those ocean miles surveyed.

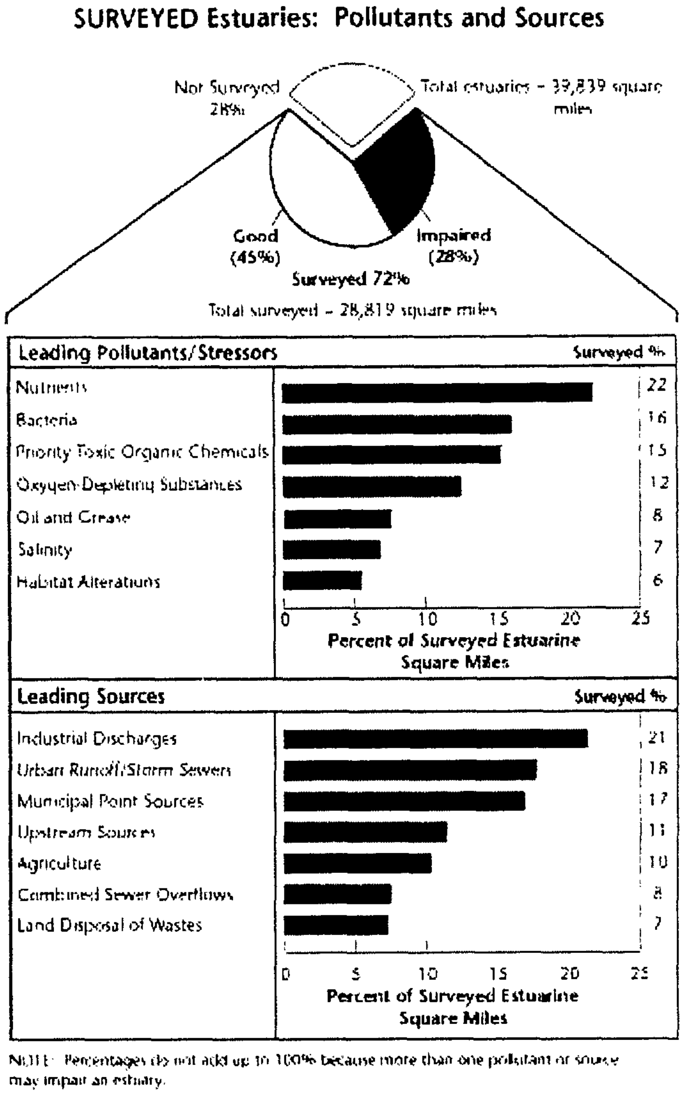

Figure 2-2. Pollutants and Sources in surveyed Estuaries (EPA, 1998)

Urbanization alters the natural infiltration capability of the land and generates a host of pollutants that are associated with the activities of dense populations, thus causing an increase in storm water runoff volumes and pollutant loadings in storm water discharged to receiving waterbodies (U.S. EPA, 1992). Urban development increases the amount of impervious surface in a watershed as farmland, forests, and meadowlands are converted into buildings with rooftops, driveways, sidewalks, roads, and parking lots with virtually no ability to absorb storm water. Storm water and snow-melt runoff wash over these impervious areas, picking up pollutants along the way while gaining speed and volume because of their inability to disperse and filter into the ground (see Figure 2-3 which illustrates the increased runoff resulting from increased impervious area). The resulting storm water flows are higher in volume, pollutants, and temperature than the flows in less impervious areas, which have more natural vegetation and soil to filter the runoff (U.S. EPA, 1997. *Urbanization and Streams: Studies of Hydrologic Impacts*.

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EPA 841-R-97-009. Office of Water. Washington, DC).

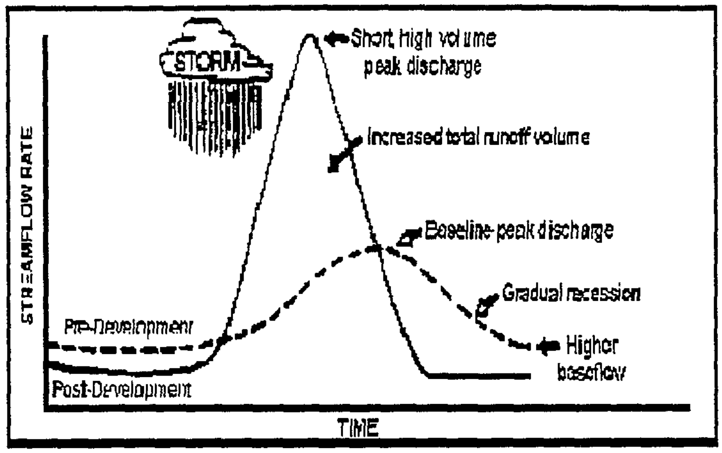

Figure 1. Impacts of urbanization on stream flow (Schueler, 1987).

In addition to the pollutants picked up by storm water runoff before it enters a storm drain, studies have shown that discharges from a storm drain system often include wastes and wastewater from non-storm water sources, referred to as illicit discharges. These discharges are 'illicit' because municipal storm sewer systems are not designed to accept, process, or discharge such wastes. Sources of illicit discharges can include sanitary wastewater illegally connected to the storm drain system; effluent from septic tanks; car wash, laundry, and other industrial wastewaters; improper disposal of auto and household toxics, such as used motor oil and pesticides; and spills from roadways.

Illicit discharges enter the system through either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the MS4 from cracked sanitary systems, spills collected by drain outlets, and paint or used oil dumped directly into a drain). The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses and bacteria into receiving waterbodies.

2.2 Summary of EPA's Storm Water Program

In 1972, Congress amended the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act (CWA)) to prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by an NPDES permit. The NPDES program is designed to track point sources and require the implementation of the controls necessary to minimize the discharge of pollutants. Initial efforts to improve water quality under the NPDES program primarily focused on reducing pollutants in industrial process wastewater and municipal sewage. These discharge sources were easily identified as responsible for poor water quality.

As pollution control measures for industrial process wastewater and municipal sewage were implemented and refined, it became increasingly evident that more diffuse sources of water pollution were also significant causes of water quality impairment. Specifically, storm water runoff was found to be a major cause of water quality impairment.

In 1987, Congress amended the CWA to require implementation, in two phases, of a comprehensive national program for addressing storm water discharges. The first phase of the program, commonly referred to as "Phase I," was promulgated on November 16, 1990 (55 FR 47990). Phase I requires NPDES permits for storm water discharge from a large number of priority sources including medium and large municipal separate storm sewer systems ("MS4s") generally serving populations of 100,000 or more and several categories of industrial activity, including construction activity that disturbs five or more acres of land.

The Phase I permits for municipal separate storm sewer systems mostly covere larger cities, and require them to develop a storm water management program, track and oversee industrial facilities regulated under the NPDES storm water program, conduct some monitoring, and submit periodic reports.

The operators of construction activities disturbing greater than 5 acres have been required to obtain NPDES permit coverage since 1992. General permits for large construction activity require construction operators to develop and implement a storm water pollution prevention plan to control erosion, sediment and other wastes on the site.

The Phase I industrial storm water program also regulates the following industrial sectors:

- facilities subject to EPA storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards
- heavy manufacturing facilities
- mining/oil and gas
- hazardous waste faciliites
- landfills
- recycling facilities
- steam electric power
- transportation facilities
- sewage treatment plants
- construction activity (described above), and
- light manufacturing facilities.

The second phase of the storm water program, which this guide addresses, requires permits for storm water discharges from certain small municipal separate storm sewer systems and construction activity generally disturbing between 1 and 5 acres. See Figure 2-4 for a summary of the federal storm water permit requirements under Phases I and II.

Figure 2-4. Summary of Federal Permit Requirements Under the NPDES Storm Water Program

	Municipal Separate Storm Sewer Systems (MS4s)	Construction Activity	Industrial Activity
Requirements in Effect Now (Phase I)	**Medium and Large MS4s** (§ 122.26(d)) • Storm Water Management Program: - Public education and outreach - Public participation efforts - Illicit discharge detection and elimination program - Construction and post-construction runoff control program for all construction activity (no size threshold) - BMPs to reduce pollutants from industrial, commercial, and residential areas • Track/oversee industrial facilities regulated under the NPDES storm water program • Conduct analytical and visual monitoring of MS4 discharges • Submit periodic program assessment reports	**Category (x) Construction Activity (5+ Acres)*** <u>CGP</u>: • Storm Water Pollution Prevention Plan (SWPPP) - Site description - Description of BMPs for erosion and sediment, post-construction storm water management, and other controls - Self-evaluation and reporting **Category (x) is one of the categories of "storm water discharges associated with industrial activity." Temporarily excluded from permitting: Category (x) construction activity operated by a municipality of <100,000 (ISTEA moratorium).*	**Ten Categories of Industrial Activity (Categories (i)-(ix),(xi))*** <u>MSGP</u>: • SWPPP - Site evaluation -Description of appropriate storm water management BMPs - Self-evaluation, monitoring, and reporting • If discharging into a medium or large MS4, notify the MS4 operator **Temporarily excluded from permitting: Industrial activity operated by a municipality of <100,000, except for power plants, airports, and uncontrolled sanitary landfills (ISTEA moratorium).*
Requirements that Will Be in Effect by 2003 (Phase II)	**Regulated Small MS4s** (§ 122.34 outlined here, but may choose permit coverage under § 122.26(d) instead) • Storm Water Management Program: - Public education and outreach - Public participation efforts - Illicit discharge detection and elimination program - Construction runoff control program for construction activity disturbing 1 acre or greater - Post-construction runoff control program for construction activity disturbing 1 acre or greater - Good housekeeping/pollution prevention for municipal operations • Conduct assessment of identified BMPs and measurable goals for each minimum control measure • Submit annual program assessment reports	**Small Construction Activity (≤1 and <5 Acres)** • Expected to be similar to Category (x) Construction Activity requirements above --- **Category (x) Construction Activity Operated by a Municipality of < 100,000** • Same requirements as for Category (x) Construction Activity above	**Industrial Activity Operated by a Municipality of <100,000*** • Same requirements as for Ten Categories of Industrial Activity above **Does not include: Power plants, airports, and uncontrolled sanitary landfills*

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3.0 REGULATION REQUIREMENTS

After reading section 3.0, you should understand the basic components and requirements of the Storm Water Phase II Rule and the rule's compliance schedule/timeline. This information is meant to serve as a basis for understanding the details of the Rule as discussed in further sections of this guidance.

3.1 What Does The Storm Water Phase II Rule Require?

This regulation can be divided into three main components, each with distinct requirements, affecting three types of entities. These components and the requirements for each are summarized below.

Regulated Small MS4s (see section 4.0)

A certain subset of operators of small MS4s (primarily those located in urbanized areas) are required to implement programs and practices to control polluted storm water runoff from the jurisdiction serviced by the MS4. The operator must design its storm water management program to satisfy applicable CWA water quality requirements and technology standards. The program must include the development and implementation of best management practices (BMPs) and measurable goals for the following six minimum measures, and include evaluation and reporting efforts:

- Public education and outreach,
- Public participation/involvement,
- Illicit discharge detection and elimination,
- Construction site runoff control,
- Post-construction runoff control, and
- Pollution prevention/good housekeeping for municipal operations.

Two waivers from coverage are available for small MS4s brought into the program by the Phase II regulation.

Small Construction Activity (see section 5.0)

All construction operators disturbing more than 1 acre and less than 5 acres are required to apply for an NPDES storm water permit for small construction activity. EPA already regulates construction activity disturbing more than 5 acres. A construction operator is usually the developer or landowner, but can also be the contractor or another party responsible for the operational control of erosion and sediment control practices on site.

Unlike the requirements for regulated small MS4s, the requirements for small construction activity (primarily activity disturbing between 1 and 5 acres of land) are not detailed in the Phase II regulation. Rather, the requirements are left to the discretion of the NPDES permitting authority when it develops the small construction activity permit. EPA expects the permit for small construction activity to be similar to the existing storm water general permits for large construction activity regulated under the Phase I program. EPA's existing Construction General Permit includes requirements to:

- Submit a Notice of Intent (NOI);
- Develop and implement a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP includes erosion and sediment controls, controls on waste at the site, self-inspection/monitoring, and reporting efforts; and
- Submit a Notice of Termination (NOT) when permit coverage is no longer necessary.

Two waivers from coverage are available for small construction activity.

Industrial Activity (see section 6.0)

Eleven categories of industrial activity are regulated under Phase I of the NPDES Storm Water Program. Under the Phase II Rule, no new categories of industrial activity are designated into the storm water program. The Rule does, however, include a revised no exposure exclusion that is available to all regulated categories of industrial activity (except category (x) - large construction activity) if the facility operator can certify that storm water runoff is not exposed to industrial activities.

Also, this regulation further extends the deadline to obtain permit coverage for those industrial activities operated by municipalities with populations of less than 100,000 that were temporarily exempted from permitting under the Intermodal Surface Transportation Enforcement Act (ISTEA) of 1991.

3.2 What Is the Phase II Rule's Compliance Schedule/Timeline?

The Phase II Final Rule was published in the *Federal Register* on December 8, 1999 (64 *FR* 68722). The following table lists milestones for EPA, the NPDES permitting authorities, and the regulated community under this program.

Storm Water Phase II Program Compliance Timeline

ACTIVITY	DEADLINE
Conditional No Exposure Exclusion option available in States where EPA is the NPDES permitting authority	February 7, 2000
Submission of No Exposure Certification	Every 5 years
EPA issues a menu of BMPs for small MS4 programs	October 2000
EPA issues a model general permit for small MS4s	October 2000
EPA issues guidance on measurable goals for small MS4 programs	October 2001
NPDES permitting authority determines designation of small MS4s located outside of an urbanized area that serve a jurisdiction with a population of 10,000 and population density of 1,000	By December 9, 2002; or by December 8, 2004 if apply designation criteria on a watershed basis under a comprehensive watershed plan
NPDES permitting authority determines waivers for regulated small MS4s in urbanized areas	By December 9, 2002
NPDES permitting authority issues general permits for regulated small MS4s and small construction activity	By December 9, 2002
Operators of regulated small MS4s and small construction activity designated by the rule must obtain permit coverage	By March 10, 2003
Operators of regulated small MS4s and small construction activity designated by NPDES permitting authority must obtain permit coverage	Within 180 days of notice
Temporarily exempted municipal operators of industrial activity must obtain permit coverage (ISTEA moratorium)	By March 10, 2003
The NPDES permitting authority may phase in coverage for small MS4s serving jurisdictions with a populations less than 10,000 on a schedule consistent with a State watershed permitting approach	Completion of phase-in by March 8, 2007
The regulated small MS4s must fully implement their storm water management programs	By the end of the first permit term – typically a 5-year period
Re-evaluation of the Phase II small MS4 regulations by EPA	By December 2012
NPDES permitting authority determination on a petition for designation of a non-regulated storm water discharger	Within 180 days of receipt

4.0 REGULATED SMALL MS4S

After reading section 4.0, you should understand what an MS4 is, which operators of MS4s are subject to the Phase II small MS4 regulations (including who may be waived from coverage), the small MS4 permit options, and the permit requirements for a small MS4 storm water management program. The discussion of these elements concludes with a step-by-step review of the process for compliance with the small MS4 program and possible funding options. Special concerns regarding Federal and State-operated small MS4s are also addressed.

4.1 MS4 DEFINITIONS

EPA's National Pollutant Discharge Elimination System (NPDES) storm water permitting program labels municipal separate storm sewer systems (MS4s) as either "small," " medium," or "large" for the purposes of regulation. The definitions of each are included herein. The Phase I storm water program covers medium and large MS4s. The Phase II storm water regulation covers a certain subset of small MS4s, known as "regulated small" MS4s. Regulated small MS4 coverage under the rule is discussed in section 4.2.

4.1.1 What is an "MS4"?

What constitutes a municipal separate storm sewer system (MS4) is often misinterpreted and misunderstood. The term MS4 does not solely refer to municipally-owned storm sewer systems, but rather is a term of art with a much broader application that can include, in addition to local jurisdictions, State departments of transportation, universities, local sewer districts, hospitals, military bases, and prisons. An MS4 also is not always just a system of underground pipes – it can include roads with drainage systems, gutters, and ditches. The regulatory definition of an MS4 is provided in the text box below.

According to 40 CFR 122.26(b)(8), "***municipal separate storm sewer*** means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2."

4.1.2 What is a "large" MS4?

A ***large* MS4** is any MS4 located in an incorporated place or county with a population of 250,000 or greater as of the 1990 Census. The Phase II Final Rule revised the original large MS4 definition (found in the 1990 Phase I regulations) by freezing it as of the 1990 Census so that no new large MS4s could be automatically designated based on the 2000 Census, or any subsequent Census. Listings of incorporated places and counties with populations of 250,000 or greater as of the 1990 Census are included in the revised Appendices F and H to Part 122, found in the Phase II Final Rule.

4.1.3 What is a "medium" MS4?

A ***medium* MS4** is any MS4 located in an incorporated place or county with a population between 100,000 - 249,999 as of the 1990 Census. The Phase II Final Rule revised the original medium MS4 definition (found in the 1990 Phase I regulations) by freezing it as of the 1990 Census so that no new medium MS4s could be automatically designated based on the 2000 Census, or any subsequent Census. Listings of incorporated places and counties with populations between 100,000 - 249,999 as of the 1990 Census are included in the revised Appendices G and I to Part 122, found in the Phase II Final Rule.

> **Important Note:** Many MS4s in areas below 100,000 in population have been individually brought into the Phase I program by NPDES permitting authorities. Such already regulated MS4s are considered Phase I MS4s and are not required to develop a Phase II program.

4.1.4 What is a "small" MS4?

A ***small* MS4** is any MS4 that is not already regulated under the Phase I storm water program. Unlike the definitions of medium and large MS4s, the definition of a small MS4: 1) is not dependant on a population threshold, and 2) includes Federally-owned systems, such as military bases and veterans hospitals.

4.2 COVERAGE: Who Is Subject to the Phase II Final Rule?

4.2.1 Are All Small MS4s Covered by the Phase II Final Rule?

No. The universe of small MS4s is quite large since it includes every MS4 except for the approximately 900 medium and large MS4s already regulated under the Phase I storm water program. Only a select sub-set of small MS4s, referred to as ***regulated* small MS4s**, are covered by the Phase II Final Rule, either through automatic nationwide designation by the rule or designation on a case-by-case basis by the NPDES permitting authority.

4.2.2 How Is A Small MS4 Designated as a Regulated Small MS4 under Phase II?

A *small* MS4 can be designated as a *regulated small* MS4, and thereby be subject to the Phase II rule, in any one of the three ways explained in the following subsections.

4.2.2.1 Automatic Nationwide Designation by the Rule

The Phase II Final Rule requires "automatic" nationwide coverage of all operators of small MS4s that are located within the boundaries of a Bureau of the Census-delineated "urbanized area" (UA) based on the latest decennial Census. This doesn't just include municipal operators of small MS4s, but also universities, highway departments, and any other operator of a storm sewer system that is located fully or partially within the UA. **Refer to section 4.3 for more information on how to determine if a particular small MS4 is located within a UA.**

> **Important Note:** Only the portion of the small MS4 that is located within the UA boundaries is regulated under Phase II. For example, if a county operates a small MS4 that serves the whole county but only half of the MS4 falls within the UA boundary, then the county must obtain permit coverage (and implement a storm water management program) only for the half of the MS4 in the UA.

Once a small MS4 is designated into the program based on the UA boundaries, it cannot be waived from the program if in a subsequent UA calculation the small MS4 is no longer within the UA boundaries. An automatically designated small MS4 remains regulated unless, or until, it meets the criteria for a waiver. See section 4.4 for more information on waivers from coverage for regulated small MS4s in urbanized areas.

An operator of a small MS4 located outside of a UA boundary may be designated as a regulated small MS4 if the NPDES permitting authority determines that the small MS4's discharges cause, or have the potential to cause, an adverse impact on water quality. See sections 4.2.2.2 and 4.2.2.3 below for more information on designations by the permitting authority.

Preamble of the Phase II Final Rule: Appendix 6

A listing of governmental entities that are located either fully or partially within a UA according to the 1990 Census can be found in Appendix 6 to the Preamble of the Phase II Final Rule. The list is a general geographic reference intended to help operators of small MS4s determine whether or not they are located in a UA and, consequently, required to comply with the regulation; it is not a list of all Phase II regulated MS4s and it may contain errors. For example, the list does not include small MS4 operators such as colleges and universities, Federal prison complexes, and State highway departments located within a UA.

4.2.2.2 Potential Designation by the NPDES Permitting Authority — Required Evaluation of 10,000/1,000 Areas

The Phase II Final Rule requires the NPDES permitting authority to develop a set of designation criteria and apply them, *at a minimum*, to all small MS4s located outside of a UA that serve a jurisdiction with a population of at least 10,000 and a population density of at least 1,000 people/square mile. The permitting authority is required to *evaluate* such small MS4s but is not required to *designate* them into the program unless they meet the designation criteria.

Recommended Designation Criteria

EPA recommends in the Phase II regulations that the NPDES permitting authority use a balanced consideration of the following designation criteria on a watershed or other local basis:

- ✔ Discharge to sensitive waters;
- ✔ High population density;
- ✔ High growth or growth potential;
- ✔ Contiguity to a UA;
- ✔ Significant contributor of pollutants to waters of the United States; and
- ✔ Ineffective protection of water quality concerns by other programs.

Preamble of the Phase II Final Rule: Appendix 7

A listing of governmental entities located outside of a UA that have a population of at least 10,000 and a population density of at least 1,000 people per square mile, can be found in Appendix 7 to the Preamble of the Phase II Final Rule. Similar to Appendix 6, the list is a geographic reference only – it is not a list of regulated entities and it may contain errors. Operators of small MS4s located within a listed area could be examined by their NPDES permitting authority for potential designation into the Phase II program. Furthermore, the NPDES permitting authority reserves the right to designate for regulation any small MS4 that is contributing pollutants to waters of the United States, whether or not its jurisdiction is found in Appendix 7.

Deadline for Designation

The NPDES permitting authority is required to designate small MS4s meeting the designation criteria by December 9, 2002, or by December 8, 2004 if a comprehensive State watershed plan is in place and the criteria are being applied on a watershed basis.

4.2.2.3 Potential Designation by the NPDES Permitting Authority — Physically Interconnected

The Phase II Final Rule requires the NPDES permitting authority to designate any small MS4 located outside of a UA that contributes substantially to the pollutant loadings of a *physically interconnected* MS4 that is permitted by the NPDES storm water program. This means the other MS4 could be a large, medium, or regulated small MS4.

Small MS4s located right outside the boundary of an urbanized area are the ones most likely to meet this criterion for designation and, therefore, should make an effort to become aware of whether they discharge pollutants directly into a regulated MS4. The sooner a small MS4 operator is prepared for potential designation and implementation of the Phase II program, the better.

> ***Physically interconnected*** means that one MS4 is connected to a second MS4 in such a way that it allows for *direct* discharges into the second system.

Deadline for Designation

The final rule does not set a deadline for designation of small MS4s meeting this criterion.

4.3 URBANIZED AREAS: What Are They and How Does a Small MS4 Operator Determine If It Is Located in One?

As discussed in section 4.2, the Phase II Final Rule covers all small municipal separate storm sewer systems (MS4s) located within an "urbanized area" (UA). Based on the 1990 Census, there are 405 UAs in the United States that cover 2 percent of total U.S. land area and contain approximately 63 percent of the Nation's population. These numbers include Puerto Rico — the only U.S. Territory with UAs.

UAs constitute the largest and most dense areas of settlement. UA calculations delineate boundaries around these dense areas of settlement and, in doing so, identify the areas of concentrated development. UA designations are used for several purposes in both the public and private sectors. For example, the Federal Government has used UAs to calculate allocations for transportation funding, and some planning agencies and development firms use UA boundaries to help ascertain current, and predict future, growth areas.

4.3.1. What Is the Definition of an Urbanized Area (UA)?

The Bureau of the Census determines UAs by applying a detailed set of published UA criteria (see 55 *FR* 42592, October 22, 1990) to the latest decennial census data. Although the full UA definition is complex, the Bureau of the Census' general definition of a UA, based on population and population density, is provided below.

> An ***urbanized area*** (UA) is a land area comprising one or more places – central place(s) – and the adjacent densely settled surrounding area – urban fringe – that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile. It is a calculation used by the Bureau of the Census to determine the geographic boundaries of the most heavily developed and dense urban areas.

UA Facts:

- The basic unit for delineating the UA boundary is the census block. Census blocks are based on visible physical boundaries, such as the city block, when possible, or on invisible political boundaries, when not. An urbanized area can comprise places, counties, Federal Indian Reservations, and minor civil divisions (MCDs - towns and townships).

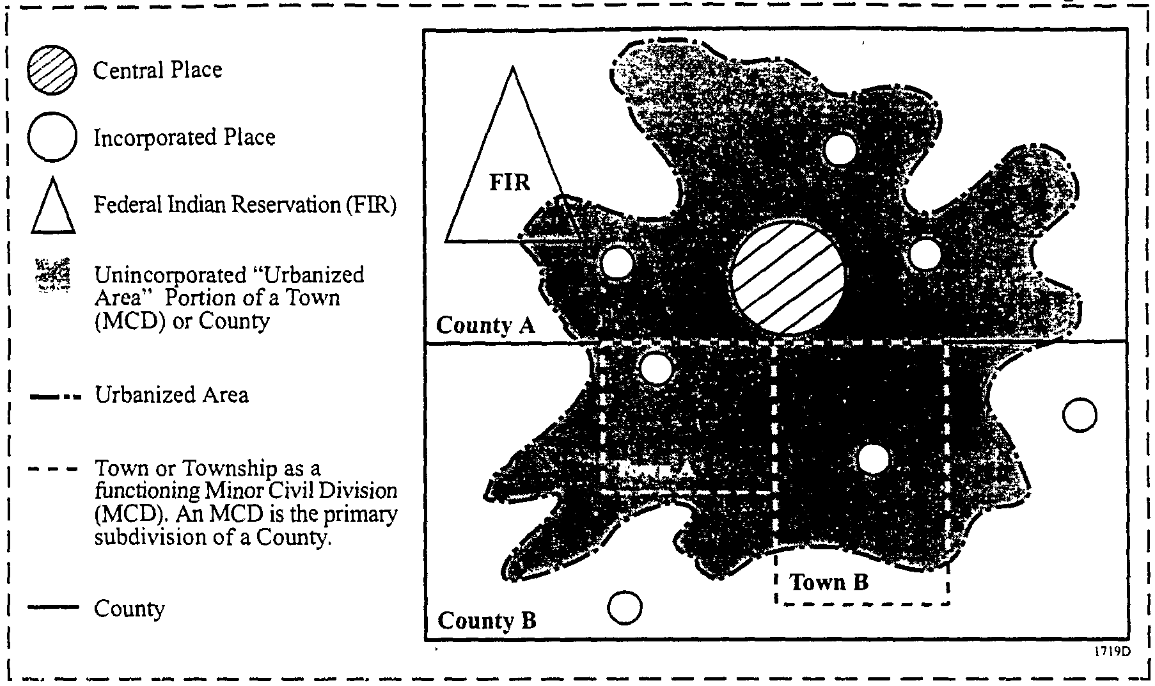
- A UA can include governmental entities of every population size: 200; 7,000; 15,000; 30,000, 200,000; or 3 million! Entities with small populations are commonly found in the urban fringe of the UA.

- Before the time of permit issuance (by December 9, 2002), new UA calculations based on the 2000 Census should be published. The regulated small MS4 universe then will be based on these new calculations.

4.3.2. What Does A UA Look Like?

The drawing below (see Figure 4-1) is a simplified UA illustration that demonstrates the concept of UAs in relation to the Phase II Final Rule. This "urbanized area" includes within its boundaries incorporated places, a portion of a Federal Indian reservation, an entire MCD, a portion of another MCD, and portions of two counties. Any and all operators of small MS4s located within the boundaries of the UA are covered under the Phase II Final Rule, regardless of political boundaries. Operators of small MS4s located outside of the UA are subject to potential designation into the Phase II MS4 program by the NPDES permitting authority, as explained in section 4.2.

Figure 4-1



4.3.3 How Can An Operator of a Regulated Small MS4 Determine If It Is Located Within a UA?

Operators of small MS4s can determine if they are located within a UA, and therefore covered under the Phase II storm water program, through the following two steps:

— STEP 1 —

Refer to a listing of incorporated places, MCDs, and counties that are located entirely or partially within a UA. Such a listing, based on the 1990 Census and including only those entities not regulated under Phase I, can be found in Appendix 6 to the Preamble of the Phase II Final Rule. If a small MS4 is located in a listed incorporated place, MCD, or county, then the operator of the small MS4 should follow step (2) below. It is important to note that Appendix 6 is general guidance only and may contain errors. For this reason, even if a particular small MS4 isn't located in a listed area, EPA recommends that the small MS4 operator follow Step 2.

— STEP 2 —

Some operators of small MS4s may find that they are located within an

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entity listed in Appendix 6 but not know if their systems are within the urbanized portion of the listed entity, or they are not on the list but want to confirm their status as recommended above. In such cases, they should contact one or more of the following institutions for more detailed information on the location of UA boundaries:

- ❑ **The State or NPDES Permitting Authority**

Storm Water Coordinators: The NPDES permitting authority may be the State or the U.S. EPA Region. The Storm Water Coordinators for each U.S. EPA Region are listed in Section 8. These regional contacts can assist with UA information and provide the names of State storm water contacts.

State Data Centers: Each State's Data Center receives listings of all entities that are located in UAs, as well as detailed maps and electronic files of UA boundaries. The Bureau of the Census web site includes a list of contact names and phone numbers for the Data Center in each State at www.census.gov/sdc/www.

State Planning/Economic/Transportation Agencies: These agencies typically use UAs to assess current development and forecast future growth trends and, therefore, should have detailed UA information readily available to help determine the UA boundaries in any given area.

- ❑ **County or Regional Planning Commissions/ Boards**

As with State agencies, these entities are likely to have detailed UA data and maps to help determine UA boundaries.

- ❑ **The Bureau of the Census**

Urbanized Areas Staff: 301 457-1099

Web Site: www.census.gov
The site provides information on purchasing UA maps and electronic files for use with computerized mapping systems. Obtain free UA cartographic boundary files (Arc/Info export format) for Geographical Information System (GIS) use at: www.census.gov:80/geo/www/cob/ua.html.

UA Maps: Detailed UA maps are available for purchase with a $25 minimum order ($5 per map sheet). Each map sheet measures 36 by 42 inches. For prices and a listing of UAs, visit www.census.gov/mp/www/geo/msgeo12.html. Order from the Department of Commerce, Bureau of the Census (MS 1921), P.O. Box 277943, Atlanta, GA 30384-7943 (Phone: 301 457-4100; Toll-free fax: 1-888-249-7295).

- ❑ **U.S. EPA**

EPA is currently modifying a web-based geographic program called *Enviromapper* for use in determining UA boundaries. This program will allow users to enter a location (by name, zip code, or street address) and see a map that will show if the location is within a UA boundary. EPA is committed to using Enviromapper to create a tool that, someday, will be the only tool necessary to determine the location of UA boundaries. Information about *Enviromapper* will be available at www.epa.gov/owm/phase2.

4.3.4 How Will the Year 2000 Census Affect the Determination of Status as a Regulated Small MS4?

The listing of incorporated places, MCDs, and counties located within UAs in the United States and Puerto Rico, found in Appendix 6, is based on the 1990 Census. New listings for UAs based on the 2000 Census are scheduled to be available by August of 2001. Once the official 2000 Census listings are published by the Bureau of the Census, operators of small MS4s located within the revised boundaries of former 1990 UAs, or in any newly defined 2000 UAs, become regulated small MS4s and must develop a storm water management program.

Any additional automatic designations of small MS4s based on subsequent census years is governed by the Bureau of the Census' definition of a UA in effect for that year and the UA boundaries determined as a result of the definition.

Once a small MS4 is designated into the Phase II storm water program based on the UA boundaries, it can not be waived from the program if in a subsequent UA calculation the small MS4 is no longer within the UA boundaries. An automatically designated small MS4 will remain regulated unless, or until, it meets the criteria for a waiver.

4.4 WAIVERS: Which Regulated Small MS4s May Obtain a Waiver From Coverage?

Two waiver options are available to operators of regulated small MS4s in urbanized areas if the NPDES permitting authority determines that their discharges do not cause, or have the potential to cause, water quality impairment.

> **Important Note:** The waivers are granted by the NPDES permitting authority, the operator of the regulated small MS4 can not determine for itself that it meets the waiver criteria. If the permitting authority is not proactive in assessing small MS4s for potential waivers, an operator may petition for a waiver assessment.

If a permitting authority decides to grant waivers, it is required to do so by December 9, 2002 to coincide with the expected date of the small MS4 permit issuance. The permitting authority is also required to periodically review any waivers granted to small MS4 operators to determine whether any information required for granting the waiver has changed. Minimally, such a review needs to be conducted once every five years. The waiver options are described in the following two subsections.

Deadline for Waivers

The NPDES permitting authorities are required to make their waiver determinations by March 9, 2002 to coincide with the expected issuance of their small MS4 general permit. If the permit authority chooses to phase in permit coverage based on a comprehensive watershed plan (see section 4.5.2.2), then regulated small MS4s may be waived on the same schedule. The phase-in of permit coverage and waivers is to be completed no later than March 8, 2007.

4.4.1 Option 1: Less than 1,000 Population in a UA

The first waiver option applies where:

(1) the jurisdiction served by the system is less than 1,000 people;

(2) the system is not contributing substantially to the pollutant loadings of a physically interconnected regulated MS4; and

(3) if the small MS4 discharges any pollutants identified as a cause of impairment of any water body to which it discharges, storm water controls are not needed based on wasteload allocations that are part of an EPA approved or established "total maximum daily load" (TMDL) that addresses the pollutant(s) of concern.

> ***TMDLs*** are water quality assessments that determine the source or sources of pollutants of concern for a particular waterbody, consider the maximum amount of pollutants the waterbody can assimilate, and then allocate to each source a set level of pollutants that it is allowed to discharge (i.e., a "wasteload allocation"). Small MS4s that are not given a wasteload allocation would meet the third criterion above.

The third criterion of this waiver option need only be met if the small MS4 is discharging into a impaired water body and the discharge contains a pollutant or pollutants that are the cause of the impairment (i.e., the "pollutants of concern").

4.4.2 Option 2: Less than 10,000 Population in a UA

The second waiver option applies where:

(1) the jurisdiction served by the system is less than 10,000 people;

(2) an evaluation of all waters of the U.S. that receive a discharge from the system shows that storm water controls are not needed based on wasteload allocations that are part of an EPA approved or established TMDL that addresses the pollutant(s) of concern or an equivalent analysis; and

(3) it is determined that future discharges from the small MS4 do not have the potential to result in exceedances of water quality standards.

> ***Pollutants of Concern*** include biochemical oxygen demand (BOD), sediment or a parameter that addresses sediment (such as total suspended solids, turbidity or siltation), pathogens, oil and grease, and any pollutant that has been identified as a cause of impairment in any water body to which the MS4 discharges.

This waiver option differs from the first option in that: 1) it applies to a larger jurisdiction size (up to 10,000 rather than 1,000), 2) it requires a determination that the discharges are not affecting the receiving water body, whether the water body is impaired or not (in the first option an assessment is only necessary if the water body is impaired and the MS4 is discharging a pollutant of concern), 3) the determination must be based on a TMDL <u>or</u> an equivalent analysis (the first option does not allow for an equivalent analysis), and 4) an assessment of the impacts of future discharges must be performed (no such assessment is necessary under the first option).

4.5 PERMITTING OPTIONS: What Permitting Choices are Available?

The Storm Water Phase II Final Rule requires operators of a particular subset of small MS4s in urbanized areas to obtain National Pollutant Discharge Elimination System (NPDES) permit coverage because their storm water discharges are considered "point sources" of pollution. All point source discharges, unlike nonpoint sources such as agricultural runoff, are required under the Clean Water Act (CWA) to be covered by federally enforceable NPDES permits. Those MS4s already permitted under the NPDES Phase I storm water program, even MS4s serving less than 100,000 people, are not required to be permitted under the Phase II storm water program.

NPDES storm water permits are issued by an NPDES permitting authority, which may be an NPDES-authorized State or a U.S. EPA Region in non-authorized States. Once a permit application is submitted by the operator of a regulated small MS4 and a permit is obtained, the conditions of the permit must be satisfied (i.e., development and implementation of a storm water management program) and periodic reports must be submitted on the status and effectiveness of the program. This section addresses the flexible permit options the Phase II regulations allow for the regulated small MS4 operator, as well as for the permitting authority. The permit requirements are discussed in section 4.6.

4.5.1 For Regulated Small MS4 Operators

4.5.1.1 The Types of Permit Coverage Available

Unlike the Phase I program that requires individual permits for medium and large MS4s, the Phase II approach allows operators of regulated small MS4s to choose from as many as three permitting options as listed below. Each NPDES permitting authority reserves the authority to determine, however, which options are available to the regulated small MS4s in their jurisdiction.

1) General Permits

- General permits are strongly encouraged by EPA. The Phase II program has been designed specifically to accommodate a general permit approach.

- General permits prescribe one set of requirements for all applicable permittees. General permits are drafted by the NPDES permitting authority, then published for public comment before being finalized and issued.

- A Notice of Intent (NOI) serves as the application for the general permit. The regulated small MS4 operator complies with the permit application requirements by submitting an NOI to the NPDES permitting authority that describes the storm water management plan, including best management practices (BMPs) and measurable goals. The operator has the flexibility to develop an individualized storm water program that addresses the particular characteristics and needs of its system, provided the requirements of the general permit are satisfied.

- For general permit coverage, the regulated small MS4 operator must follow the Phase II permit application requirements (see section 4.6.2).

2) Individual Permits

- Individual permits are required for Phase I medium and large MS4s, but not recommended by EPA for Phase II program implementation.

- Individual permits prescribe a particular set of requirements for a particular permittee or a group of co-permittees. Individual permits require the submission of a more comprehensive permit application than an NOI that is submitted under a general permit. Once the permit application is received, an individual permit is drafted by the NPDES permitting authority, then published for public comment before being finalized and issued.

- The Phase II rule allows a regulated small MS4 to submit an individual application for coverage under either the:

- Phase II MS4 regulation (see § 122.34 of the Phase II rule), or
- Phase I MS4 regulation (see 40 CFR §122.26(d)).

3) Modification of an Existing Phase I Individual Permit – A Co-Permittee Option with Medium and Large MS4s

The operator of a regulated small MS4 could participate as a limited co-permittee in a neighboring Phase I MS4's storm water management program by seeking a modification of the existing Phase I individual permit. As a limited co-permittee the small MS4 operator would be responsible for compliance with the permit's conditions applicable to its jurisdiction.

Note: A list of Phase I medium and large MS4s can be obtained from the EPA Office of Wastewater Management (OWM) or downloaded from the OWM web site.

The permittee must comply with the applicable terms of the modified Phase I individual permit rather than the minimum control measures in the Phase II Final Rule.

4.5.1.2 Co-permittee with Another Operator of a Regulated Small MS4

Section 4.5.1.1 explained the permitting option of a modification of an existing Phase I individual permit in order to be a co-permittee with a medium or large MS4. Regulated small MS4 operators may also choose to share responsibilities for meeting the Phase II program requirements with another regulated small MS4 operator under a general or individual permit. Those operators choosing to do so may submit jointly an NOI or individual permit application that identifies who will implement which minimum measures within the area served by the MS4s.

4.5.1.3 Relying on Another Entity to Satisfy One or More of the Minimum Control Measures

Under either a general or individual permit, the Phase II small MS4 permittee has the option of relying on other entities that are already performing one or more of the minimum control measures to implement the measure(s) on the permittee's behalf. This is only allowable where the existing control measure, or component thereof, is at least as stringent as the Phase II rule requirements (under § 122.34(b)) and the other entity has agreed to the arrangement.

For example, a county may already have an illicit discharge detection and elimination program in place and may allow an operator of a regulated small MS4 within the county's jurisdiction to rely on the county program instead of formulating and implementing a new program. In such a case, the permittee would not need to implement the particular measure, but would still be ultimately responsible for its effective implementation. For this reason, EPA recommends that the permittee enter into a legally binding agreement with the other entity. If the permittee chooses to rely on another entity, they must note this in their permit application and subsequent reports.

Note: Also, the other entity does not necessarily need to be a governmental entity. For example, a permittee could rely on a non-profit organization that is performing public education efforts on environmental issues to satisfy the public education and outreach minimum measure.

A Phase II permittee also has the option to rely on another entity to satisfy all of the permittee's small MS4 permit obligations – but only if the other entity is a governmental entity permitted under the NPDES storm water program. Should this option be chosen, the permittee must note this in its NOI, but does not need to file the otherwise required periodic reports on the status of the program. Again, it is important to note that the permittee would remain ultimately liable under the small MS4 permit. This option is particularly beneficial for operators that serve a low population, have limited resources or legal authority, or are surrounded by an NPDES regulated municipality. For example, let's assume a college campus or a veteran's hospital are operators of small MS4s and they are located in the middle of a Phase II regulated city. Negotiating with the city to implement the storm water management program for them in their jurisdictions could be a cost-effective and less burdensome option than for each to implement their own programs.

4.5.2 For the NPDES Permitting Authority

4.5.2.1 Alternative Options for Writing Permit Requirements

Two permitting options tailored to minimize duplication of effort by the regulated small MS4 permittee can be incorporated into the general or individual permit by the NPDES permitting authority:

1) Recognizing Another Governmental Entity's Program

The permitting authority can recognize in a small MS4 permit that another governmental entity is responsible under an NPDES permit for implementing any or all of the minimum control measures. In such a case, responsibility for implementation of the measure(s) would rest with the other governmental entity, thereby relieving the small MS4 permittee of its responsibility to implement that particular measure(s). See Table 4-1 for examples of both this option and the following option.

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STORM WATER PHASE II RULE SMALL MS4 FLEXIBLE PERMITTING OPTIONS

	Referencing a QUALIFYING LOCAL PROGRAM (QLP)	RECOGNIZING an NPDES-Regulated Entity	RELYING on Another Entity	CO-PERMITTEE with an NPDES-Regulated Entity
NPDES PERMITTING AUTHORITY Responsibilities	• PA assesses local, State, and Tribal NPDES and non-NPDES programs to determine if their requirements are equivalent to one or more Phase II minimum measures for regulated small MS4s • PA chooses whether to reference a QLP in small MS4 permit. Requires permittee to follow requirements of QLP rather than new permit requirements. • PA does not need to notify the administrator of the QLP or obtain permission since referencing the QLP has no bearing/no affect on the administrator.	• PA assesses entities that are, or will be, performing the equivalent of 1 or more of the small MS4 minimum measures under an NPDES permit. • PA chooses whether to recognize such an entity in a small MS4 permit.	N/A	N/A
SMALL MS4 OPERATOR Responsibilities	• The operator should already be complying with any QLP referenced in the permit. • Compliance with the QLP is considered compliance with the NPDES permit; therefore operator held liable if doesn't comply with the QLP.	• Operator has no responsibility to perform the measure(s) that is being done by the recognized entity. • Not held liable if the other entity fails to perform the measure effectively; however, PA may then require the operator to implement the measure itself.	• Operator chooses, under its own permit, whether to rely on another entity to implement 1 or more minimum measure on its behalf can be a non-NPDES regulated entity. • Operator notes in NOI or indiv. permit application that it is relying on another entity to implement a measure. • Remain liable if other entity fails to perform the measure effectively.	• Operator chooses whether to be a co-permittee with another regulated MS4 and submits a single NOI or individual permit application • The operators determine who will do what and include this information in the permit application
EXAMPLES	The QLP in the small MS4 permit could be a State program that requires MS4 operators to detect & eliminate illicit discharges into their systems.	A county doing educational outreach for the whole county under a Phase I NPDES permit could be recognized, thereby relieving all small MS4s in the county from having to have their own educational outreach programs.	1. An environmental group is doing educational outreach on the impacts of storm water runoff. 2. A county is already implementing a construction runoff control program under a Phase I NPDES permit.	

2) Referencing a Qualifying Local Program

The NPDES permitting authority can include conditions in a small MS4 permit that direct a permittee to follow the requirements of an existing qualifying local program rather than the requirements of particular minimum control measure(s). A qualifying local program is defined as a local, State or Tribal municipal storm water program that imposes requirements that are equivalent to those of the Phase II MS4 minimum measures (as found in § 122.34(b) of the rule). Unlike in Option 1 above, under this option the permittee remains responsible for the implementation of the minimum measure through its compliance with the qualifying local program.

4.5.2.2. Alternative Option for Permit Coverage: Phase-in Coverage for Regulated Small MS4s with Populations under 10,000

Permitting authorities may phase-in permit coverage for regulated small MS4s serving jurisdictions with a population under 10,000 on a schedule consistent with a State watershed permitting approach. Under this alternative option, the permitting authority must develop and implement a schedule to phase-in permit coverage for approximately 20 percent annually of all regulated small MS4s that qualify, completing the phase-in schedule in no more than five years. In such a case, the regulated small MS4 operators would be notified by the permitting authority concerning the operator's deadlines for permit coverage.

Deadlines for Phase-In
- Permitting authorities are required to have their phase-in schedule approved by the USEPA Regional Administrator no later than December 10, 2001.
- Under the phase-in option, all regulated small MS4s are required to have coverage under an NPDES permit no later than March 8, 2007.

4.6 REQUIREMENTS: What Requirements Are Regulated Small MS4s Subject To?

A regulated small MS4 operator is required to submit a permit application and obtain coverage under a NPDES storm water permit. Under the permit, the operator will be required to develop and implement a storm water management program that includes six minimum control measures, evaluation/assessment and reporting efforts, and recordkeeping, as described herein. This section begins by highlighting the standards an operator must meet to ensure compliance with the Phase II regulations.

4.6.1 Applicable Standards

A Phase II small MS4 operator must design a storm water management program so that it:

- ❑ Reduces the discharge of pollutants to the "maximum extent practicable"

(MEP);

- ❑ Protects water quality; and
- ❑ Satisfies the appropriate water quality requirements of the Clean Water Act.

The standard of MEP is the same standard applied to Phase I medium and large MS4 programs. There is no regulatory definition of MEP in order to allow the permitting authority and regulated MS4s maximum flexibility in their interpretation of it as appropriate.

Compliance with the technical standard of MEP requires the successful implementation of approved BMPs. The Phase II Final Rule considers narrative effluent limitations that require the implementation of BMPs and the achievement of measurable goals as the most appropriate form of effluent limitations to achieve the protection of water quality, rather than requiring that storm water discharges meet numeric effluent limitations.

EPA intends to issue Phase II NPDES permits consistent with its August 1, 1996, Interim Permitting Approach policy, which calls for BMPs in first-round storm water permits and expanded or better tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. In cases where information exists to develop more specific conditions or limitations to meet water quality standards, these conditions or limitations should be incorporated into the storm water permit. Monitoring is not required under the Phase II Rule, but the NPDES permitting authority has the discretion to require monitoring if deemed necessary.

4.6.2 Permit Application Requirements

The permit application requirements differ depending on the type of permit chosen. The following subsections describe the applicable requirements for each type of permit option allowable under the Phase II regulation.

Deadline for Submission of Permit Application

The deadline for submission of each type of permit application is the same – it must be done no later than March 10, 2003 unless the NPDES permitting authority chooses to phase-in permit coverage on a watershed basis and establishes other deadlines (see section 4.5.2.2).

4.6.2.1 General Permit Under Phase II Regulations

Operators of regulated small MS4s are required to submit in their NOI the following information:

❑ Best management practices (BMPs) for each of the six minimum control measures:

❶ Public education and outreach on storm water impacts
❷ Public participation/involvement
❸ Illicit discharge detection and elimination
❹ Construction site storm water runoff control
Post-construction storm water management in new development/ redevelopment
❻ Pollution prevention/good housekeeping for municipal operations

❑ Measurable goals for each minimum control measure (i.e, narrative or numeric standards used to gauge program effectiveness);

❑ Estimated months and years in which actions to implement each measure will be undertaken, including interim milestones and frequency; and

❑ The person or persons responsible for implementing or coordinating the storm water program.

The operator of a regulated small MS4 has the flexibility to determine the BMPs and measurable goals, for each minimum control measure, that are most appropriate for the system. The chosen BMPs and measurable goals, submitted in the permit application, become the required storm water management program; however, the NPDES permitting authority can require changes in the mix of chosen BMPs and measurable goals if all or some of them are found to be inconsistent with the provisions of the Phase II Final Rule. Likewise, the permittee can change its mix of BMPs if it determines that the program is not as effective as it could be. Section 4.6.2 fully describes the minimum control measures, including sample BMPs and measurable goals for each, while section 4.6.3 describes the permit requirements concerning evaluation/assessment and recordkeeping activities.

4.6.2.2 Individual Permit Under the Phase II Regulation

For individual permit coverage under Phase II, the regulated small MS4 operator must follow the requirements of 40 CFR § 122.21(f) and the Phase II permit application requirements as described in section 4.6.2.1 above. The operator must also provide an estimate of the square mileage served by the system and any additional information requested by the NPDES permitting authority. A storm sewer map that satisfies the requirements of § 122.34(b)(3)(i) of the Phase II rule will satisfy the map requirements of § 122.21(f)(7).

4.6.2.3 Individual Permit Under the Phase I Regulation

For individual permit coverage under Phase I, the regulated small MS4 operator must follow the permit application requirements detailed at 40 CFR § 122.26(d). The operator must submit both Part 1 and Part 2 of the application requirements in §§ 122.26(d)(1) and (2) by March 10, 2003. The operator would not need to submit the information required by §§ 122.26(d)(1)(ii) and (d)(2) regarding legal authority unless it wanted the permitting authority to take that information into account when developing the individual permit.

4.6.2.4 Modification of an Existing Phase I Individual Permit

Under this permit option, the operator of a regulated small MS4 must follow Phase I permit application requirements in § 122.26(d), with some exclusions, rather than Phase II permit application requirements. The operator would not need to follow the application requirements of §§ 122.26(d)(1)(iii) and (iv) and (d)(2)(iii) – *discharge characterization.* The operator may satisfy the requirements in §§ 122.26(d)(1)(v) and (d)(2)(iv) – *identification of a management program* – by referring to the Phase I MS4's storm water management program.

EPA Recommendations

In referencing a Phase I's MS4's storm water management program, the operator should briefly describe how the existing plan will address discharges from the small MS4 or would need to be supplemented in order to adequately address the small MS4 discharges. The small MS4 operator should explain their role in coordinating storm water pollutant control activities in their MS4 service area and detail the resources available to accomplish the plan.

If a small MS4 is considering this option, it should find out when the Phase I MS4's permit is scheduled for renewal and become thoroughly familiar with the Phase I MS4's permit conditions. This co-permitting approach will be most successful if both MS4s have had thorough discussions of their storm water programs and if the small MS4 submits it's application at the time that the Phase I MS4 is submitting its reapplication.

4.6.2 Program Requirements: The Six Minimum Control Measures

If coverage is obtained under a general permit or an individual permit under the Phase II regulations, the operator of a regulated small MS4 is required to implement a storm water management program that includes, at a minimum, the six minimum control measures described in the following subsections. As you read these subsections, keep in mind that the operator has a great deal of flexibility in determining the best management practices they will use to accomplish each measure. The rule allows the operators to chose the BMPs and measurable goals for each measure as appropriate for their particular MS4 service area – as long as the chosen BMPs and measurable goals result in effective control of pollutants in storm water runoff. Otherwise, the permitting authority may require changes in the chosen mix of BMPs and measurable goals to result in a more effective program.

4.6.2.1 Public Education and Outreach on Storm Water Impacts

Why Is Public Education and Outreach Necessary?

An informed and knowledgeable community is crucial to the success of a storm water management program since it helps to ensure the following:

Greater support for the program as the public gains a greater understanding of the reasons why it is necessary and important. Public support is particularly beneficial when operators of small MS4s attempt to institute new funding initiatives for the program or seek volunteers to help implement the program; and

Greater compliance with the program as the public becomes aware of the personal responsibilities expected of them and others in the community, including the individual actions they can take to protect or improve the quality of area waters.

What Is Required?

To satisfy this minimum control measure, the operator of a regulated small MS4 must:

- ❑ Implement a public education program to distribute educational materials to the community, or conduct equivalent outreach activities about the impacts of storm water discharges on local waterbodies and the steps that can be taken to reduce storm water pollution; and

- ❑ Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure. Some program implementation approaches, BMPs (i.e., the program actions/activities), and measurable goals are suggested below.

What Are Some Guidelines for Developing and Implementing This Measure?

Three main action areas are important for successful implementation of a public education and outreach program:

➊ *Forming Partnerships*
Operators of regulated small MS4s are encouraged to enter into partnerships with other governmental entities to fulfill this minimum control measure's requirements. It is generally more cost-effective to use an existing program, or to develop a new regional or state-wide education program, than to have numerous operators developing their own local programs. Operators also are encouraged to seek assistance from non-governmental organizations (e.g., environmental, civic, and industrial organizations), since many already have educational materials and perform outreach activities.

❷ *Using Educational Materials and Strategies*
Operators of regulated small MS4s may use storm water educational information provided by their State, Tribe, EPA Region, or environmental, public interest, or trade organizations instead of developing their own materials. Operators should strive to make their materials and activities relevant to local situations and issues, and incorporate a variety of strategies to ensure maximum coverage. Some examples include:

Brochures or fact sheets for general public and specific audiences;

Recreational guides to educate groups such as golfers, hikers, paddlers, climbers, fishermen, and campers;

Alternative information sources, such as web sites, bumper stickers, refrigerator magnets, posters for bus and subway stops, and restaurant placemats;

A library of educational materials for community and school groups;

Volunteer citizen educators to staff a ***public education task force;***

Event participation with educational displays at home shows and community festivals;

Educational programs for school-age children;

Storm drain stenciling of storm drains with messages such as "Do Not Dump - Drains Directly to Lake;"

Storm water hotlines for information and for citizen reporting of polluters;

Economic incentives to citizens and businesses (e.g., rebates to homeowners purchasing mulching lawnmowers or biodegradable lawn products);and

Tributary signage to increase public awareness of local water resources.

❸ *Reaching Diverse Audiences*
The public education program should use a mix of appropriate local strategies to address the viewpoints and concerns of a variety of audiences and communities, including minority and disadvantaged communities, as well as children. Printing posters and brochures in more than one language or posting large warning signs (e.g., cautioning against fishing or swimming) near storm sewer outfalls are methods that can be used to reach audiences less likely to read standard materials. Directing materials or outreach programs toward specific groups of commercial, industrial, and institutional entities likely to have significant storm water impacts is also recommended. For example, information could be provided to restaurants on the effects of grease clogging storm drains and to auto garages on the effects of dumping used oil into storm drains.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are intended to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, should reflect the needs and characteristics of the operator and the area served by its small MS4. Furthermore, they should be chosen using an integrated approach that fully addresses the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following measurable goals:

Target Date	Activity
1 year............	Brochures developed (bilingual, if appropriate) and distributed in water utility bills; a storm water hotline in place; volunteer educators trained.
2 years..........	A web site created school curricula developed; storm drains stenciled.
3 years..........	A certain percentage of restaurants no longer dumping grease and other pollutants down storm sewer drains.
4 years..........	A certain percentage reduction in litter or animal waste detected in discharges.

4.6.2.2 Public Participation/Involvement

Why Is Public Participation and Involvement Necessary?

EPA believes that the public can provide valuable input and assistance to a regulated small MS4's municipal storm water management program and, therefore, suggests that the public be given opportunities to play an active role in both the development and implementation of the program. An active and involved community is crucial to the success of a storm water management program because it allows for:

Broader public support since citizens who participate in the development and decision making process are partially responsible for the program and, therefore, may be less likely to raise legal challenges to the program and more likely to take an active role in its implementation;

Shorter implementation schedules due to fewer obstacles in the form of public and legal challenges and increased sources in the form of citizen volunteers;

A broader base of expertise and ***economic benefits*** since the community can be a valuable, and free, intellectual resource; and

A conduit to other programs as citizens involved in the storm water program development process provide important cross-connections and relationships with other community and government programs. This benefit is particularly valuable when trying to implement a storm water program on a watershed basis, as encouraged by EPA.

What Is Required?

To satisfy this minimum control measure, the operator of a regulated small MS4 must:

- ❑ Comply with applicable State, Tribal, and local public notice requirements; and
- ❑ Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure. Possible implementation approaches, BMPs (i.e., the program actions and activities), and measurable goals are described below.

What Are Some Guidelines for Developing and Implementing This Measure?

Operators of regulated small MS4s should include the public in developing, implementing, and reviewing their storm water management programs. The public participation process should make every effort to reach out and engage all economic and ethnic groups. EPA recognizes that there are challenges associated with public involvement. Nevertheless, EPA strongly believes that these challenges can be addressed through an aggressive and inclusive program. Challenges and example practices that can help ensure successful participation are discussed below.

Implementation Challenges

The best way to handle common notification and recruitment challenges is to know the audience and think creatively about how to gain its attention and interest. Traditional methods of soliciting public input are not always successful in generating interest, and subsequent involvement, in all sectors of the community. For example, municipalities often rely solely on advertising in local newspapers to announce public meetings and other opportunities for public involvement. Since there may be large sectors of the population who do not read the local press, the audience reached may be limited. Therefore, alternative advertising methods should be used whenever possible, including radio or television spots, postings at bus or subway stops, announcements in neighborhood newsletters, announcements at civic organization meetings, distribution of flyers, mass mailings, door-to-door visits, telephone notifications, and multilingual announcements. These efforts, of course, are tied closely to the efforts for the public education and outreach minimum control measure.

In addition, advertising and soliciting for help could and should be targeted at specific population sectors, including ethnic, minority, and low-income communities; academia and educational institutions; neighborhood and community groups; outdoor recreation groups; and business and industry. The goal is to involve a diverse cross-section of people who could offer a multitude of concerns, ideas, and connections during the program development process.

Possible Practices (BMPs)

There are a variety of practices that could be incorporated into a public participation and involvement program, such as:

Public meetings/citizen panels allow citizens to discuss various viewpoints and provide input concerning appropriate storm water management policies and BMPs;

Volunteer water quality monitoring gives citizens first-hand knowledge of the quality of local water bodies and provides a cost-effective means of collecting water quality data;

Volunteer educators/speakers who can conduct workshops, encourage public participation, and staff special events;

Storm drain stenciling is an important and simple activity that concerned citizens, especially students, can do;

Community clean-ups along local waterways, beaches, and around storm drains;

Citizen watch groups can aid local enforcement authorities in the identification of polluters; and

"Adopt A Storm Drain" programs encourage individuals or groups to keep storm drains free of debris and to monitor what is entering local waterways through storm drains.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are intended to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, would greatly depend on the needs and characteristics of the operator and the area served by its small MS4. Furthermore, they should be chosen using an integrated approach that fully addresses the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following measurable goals:

Target Date	Activity
1 year............	Notice of a public meeting in several different print media and bilingual flyers; citizen panel established; volunteers organized to locate outfalls/illicit discharges and stencil drains.
2 years..........	Final recommendations of the citizen panel; radio spots promoting program and participation.
3 years..........	A certain percentage of the community participating in community clean-ups.
4 years..........	Citizen watch groups established in a certain percentage of neighborhoods; outreach to every different population sector completed.

4.6.2.3 Illicit Discharge Detection and Elimination

What Is An "Illicit Discharge"?

Federal regulations define an illicit discharge as "...any discharge to an MS4 that is not composed entirely of storm water..." with some exceptions. These exceptions include discharges from NPDES-permitted industrial sources and discharges from fire-fighting activities. Illicit discharges (see Table 4-2) are considered "illicit" because MS4s are not designed to accept, process, or discharge such non-storm water wastes. It is important to note that "illicit" does not mean "illegal." Not every illicit discharge is necessarily a prohibited illegal discharge.

Why Are Illicit Discharge Detection and Elimination Efforts Necessary?

Discharges from MS4s often include wastes and wastewater from non-storm water sources. A study conducted in 1987 in Sacramento, California, found that almost one-half of the water discharged from a local MS4 was not directly attributable to precipitation runoff. A significant portion of these dry weather flows were from illicit and/or inappropriate discharges and connections to the MS4.

Table 4-2

Sources of Illicit Discharges
Sanitary wastewater
Effluent from septic tanks
Car wash wastewaters
Improper oil disposal
Radiator flushing disposal
Laundry wastewaters
Spills from roadway accidents
Improper disposal of auto and household toxics

Illicit discharges enter the system through either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the MS4 from cracked sanitary systems, spills collected by drain outlets, or paint or used oil dumped directly into a drain). The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria to receiving waterbodies. Pollutant levels from these illicit discharges have been shown in EPA studies to be high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health.

What Is Required?

Recognizing the adverse effects illicit discharges can have on receiving waters, the final rule requires an operator of a regulated small MS4 to develop and implement an illicit discharge detection and elimination program. This program must include the following:

- ☐ A storm sewer system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls;

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- ❑ Through an ordinance, or other regulatory mechanism, a prohibition (to the extent allowable under State, Tribal, or local law) on non-storm water discharges into the MS4, and appropriate enforcement procedures and actions;
- ❑ A plan to detect and address non-storm water discharges, including illegal dumping, into the MS4;
- ❑ The education of public employees, businesses, and the general public about the hazards associated with illegal discharges and improper disposal of waste; and
- ❑ The determination of appropriate best management practices (BMPs) and measurable goals for this minimum control measure. Some program implementation approaches, BMPs (i.e., the program actions/activities), and measurable goals are suggested below.

Does This Measure Need to Address All Illicit Discharges?

No. The illicit discharge detection and elimination program does not need to address the following categories of non-storm water discharges or flows unless the operator of the regulated small MS4 identifies them as significant contributors of pollutants to its MS4:

- ❑ Water line flushing
- ❑ Landscape irrigation
- ❑ Diverted stream flows
- ❑ Rising ground waters
- ❑ Uncontaminated ground water infiltration
- ❑ Uncontaminated pumped ground water
- ❑ Discharges from potable water sources
- ❑ Foundation drains
- ❑ Air conditioning condensation
- ❑ Irrigation water
- ❑ Springs
- ❑ Water from crawl space pumps
- ❑ Footing drains
- ❑ Lawn watering
- ❑ Individual residential car washing
- ❑ Flows from riparian habitats and wetlands
- ❑ Dechlorinated swimming pool discharges
- ❑ Street wash water.

What Are Some Guidelines for Developing and Implementing This Measure?

The objective of the illicit discharge detection and elimination minimum control measure is to have regulated small MS4 operators gain a thorough awareness of their systems. This awareness allows them to determine the types and sources of illicit discharges entering their system, and establish the legal, technical, and educational means needed to eliminate these discharges. Permittees could meet these objectives in a variety of ways depending on their individual needs and abilities, but some general guidance for each requirement is provided below.

The Map

The storm sewer system map is meant to demonstrate a basic awareness of the intake and discharge areas of the system. It is needed to help determine the extent of discharged dry weather flows, the possible sources of the dry weather flows, and the particular waterbodies these flows may be affecting. An existing map, such as a topographical map, on which the location of major pipes and outfalls can be clearly presented would demonstrate such an awareness.

EPA recommends collecting all existing information on outfall locations (e.g., review city records, drainage maps, storm drain maps), and then conducting field surveys to verify locations. It probably will be necessary to walk (i.e., wade through small receiving waters or use a boat for larger waters) the streambanks and shorelines for visual observation. More than one trip may be needed to locate all outfalls.

Legal Prohibition and Enforcement

EPA recognizes that some permittees may have limited authority under State, Tribal or local law to establish and enforce an ordinance, or other regulatory mechanism, prohibiting illicit discharges. In such a case. the permittee is encouraged to obtain the necessary authority, if at all possible. Otherwise, the NPDES permitting authority assumes responsibility for implementation of this component of the minimum measure, yet the permittee would remain ultimately responsible for the quality of its MS4 discharge. Model ordinances, including examples of amendments to local codes or existing ordinances, will be provided in the Phase II storm water guidance for regulated small MS4s, which is part of EPA's planned implementation "tool box" for the rule.

The Plan

The plan to detect and address illicit discharges is the central component of this minimum control measure. The plan is dependant upon several factors, including the permittee's available resources, size of staff, and degree and character of its illicit discharges. EPA envisions a plan similar to the one recommended for use in meeting Michigan's general storm water NPDES permit for small MS4s. As guidance only, the four steps of a recommended plan are outlined below:

➊ **Locate Problem Areas**
EPA recommends that priority areas be identified for detailed screening of the system based on the likelihood of illicit connections (e.g., areas with older sanitary sewer lines). Some methods that could be used to locate problem areas include: public complaints; visual screening; water sampling from manholes and outfalls during dry weather; and use of infrared and thermal photography.

➋ **Find the Source**
Once a problem area or discharge is found, additional efforts usually would be

necessary to determine the source of the problem. Some methods that could be used to find the source of the illicit discharge include: dye-testing buildings in problem areas; dye- or smoke-testing buildings at the time of sale; tracing the discharge upstream in the storm sewer; employing a certification program that shows that buildings have been checked for illicit connections; implementing an inspection program of existing septic systems; and using video to inspect the storm sewers.

❸ **Remove/Correct Illicit Connections**
Once the source is identified, the offending discharger should be notified and directed to correct the problem. Education efforts and working with the discharger can be effective in resolving the problem before taking legal action.

❹ **Document Actions Taken**
As a final step, all actions taken under the plan should be documented. Doing so would illustrate that progress is being made to eliminate illicit connections and discharges. Documented actions should be included in the required annual reports and include information such as: the number of outfalls screened; any complaints received and corrected; the number of discharges and quantities of flow eliminated; and the number of dye or smoke tests conducted.

Educational Outreach

Outreach to public employees, businesses, property owners, the general community, and elected officials regarding ways to detect and eliminate illicit discharges is an integral part of this minimum measure that will help gain support for the permittee's storm water program. Suggested educational outreach efforts include:

- Developing ***informative brochures, and guidances*** for specific audiences (e.g., carpet cleaning businesses) and school curricula;
- Designing a program to ***publicize and facilitate public reporting*** of illicit discharges;
- ***Coordinating volunteers*** for locating, and visually inspecting, outfalls or to stencil storm drains; and
- Initiating ***recycling programs*** for commonly dumped wastes, such as motor oil, antifreeze, and pesticides.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are intended to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, should reflect the needs and characteristics of the operator and the area served by its small MS4. Furthermore, they should be chosen using an integrated approach that would fully address the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following measurable goals:

Target Date	Activity
1 year...........	Sewer system map completed; recycling program for household hazardous waste in place.
2 years..........	Ordinance in place; training for public employees completed; a certain percentage of sources of illicit discharges determined.
3 years..........	A certain percentage of: illicit discharges detected; illicit discharges eliminated; and households participating in quarterly household hazardous waste special collection days.
4 years..........	Most illicit discharge sources detected and eliminated.

The educational outreach measurable goals for this minimum control measure could be combined with the measurable goals for the Public Education and Outreach minimum control measure.

4.6.2.4 Construction Site Storm Water Runoff Control

Why Is The Control of Construction Site Runoff Necessary?

Polluted storm water runoff from construction sites often flows to MS4s and ultimately is discharged into local rivers and streams. Of the pollutants listed in Table 4-3, sediment is usually the main pollutant of concern. Sediment runoff rates from construction sites are typically 10 to 20 times greater than those of agricultural lands, and 1,000 to 2,000 times greater than those of forest lands. During a short period of time, construction sites can contribute more sediment to streams than can be deposited naturally during several decades. The resulting siltation, and the contribution of other pollutants from construction sites, can cause physical, chemical, and biological harm to our nation's waters. For example, excess sediment can quickly fill rivers and lakes, requiring dredging and destroying aquatic habitats.

Table 4-3

Pollutants Commonly Discharged From Construction Sites
Sediment
Solid and sanitary wastes
Phosphorous (fertilizer)
Nitrogen (fertilizer)
Pesticides
Oil and grease
Concrete truck washout
Construction chemicals
Construction debris

What Is Required?

The Phase II Final Rule requires an operator of a regulated small MS4 to develop, implement, and enforce a program to reduce pollutants in storm water runoff to their MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. The small MS4 operator is required to:

- ❑ Have an ordinance or other regulatory mechanism requiring the implementation of proper erosion and sediment controls, and controls for other wastes, on applicable construction sites;

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- ❑ Have procedures for site plan review of construction plans that consider potential water quality impacts;

- ❑ Have procedures for site inspection and enforcement of control measures;

- ❑ Have sanctions to ensure compliance (established in the ordinance or other regulatory mechanism);

- ❑ Establish procedures for the receipt and consideration of information submitted by the public; and

- ❑ Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure. Suggested BMPs (i.e., the program actions/activities) and measurable goals are presented below.

What Are Some Guidelines for Developing and Implementing This Measure?

Further explanation and guidance for each component of a regulated small MS4's construction program is provided below.

Regulatory Mechanism

Through the development of an ordinance or other regulatory mechanism, the small MS4 operator needs to establish a construction program that requires controls for polluted runoff from construction sites with a land disturbance of greater than or equal to one acre. Because there may be limitations on regulatory legal authority, the small MS4 operator is required to satisfy this minimum control measure only to the maximum extent practicable and allowable under State, Tribal, or local law. If an operator is unable to establish an enforceable construction program due to a lack of legal authority, and is unsuccessful in trying to obtain the necessary authority, the NPDES permitting authority would then assume responsibility.

EPA intends to develop a model ordinance that a small MS4 operator could use as a basis for its construction program. Alternatively, amendments to existing erosion and sediment control programs, or other ordinances, can also provide the basis for the program.

Site Plan Review

The small MS4 operator is required to include in its construction program requirements for the implementation of appropriate BMPs on construction sites to control erosion and sediment, as well as waste at the site. To determine if a construction site is in compliance with such provisions, the small MS4 operator should review the site plans submitted by the construction site operator before ground is broken.

Site plan review aids in compliance and enforcement efforts since it alerts the small MS4 operator early in the process to the planned use or non-use of proper BMPs and provides a way to track new construction activities. The tracking of sites is useful not only for the small MS4 operator's recordkeeping and reporting purposes, which will be required activities under their NPDES storm water permit (see Fact Sheet 2.9), but also for members of the public interested in ensuring that the sites are in compliance.

Inspections and Penalties

Once construction commences, the BMPs should be in place and the small MS4 operator's enforcement activities should begin. To ensure that the BMPs are properly installed, the small MS4 operator is required to develop procedures for site inspection and enforcement of control measures to deter infractions. Procedures could include steps to identify priority sites for inspection and enforcement based on the nature and extent of the construction activity, topography, and the characteristics of soils and receiving water quality. Inspections give the MS4 operator an opportunity to provide additional guidance and education, issue warnings, or assess penalties. To conserve staff resources, one possible option for small MS4 operators could be to have these inspections performed by the same inspector that visits the sites to check compliance with health and safety building codes.

Information Submitted by the Public

A final requirement of the small MS4 program for construction activity is the development of procedures for the receipt and consideration of public inquiries, concerns, and information submitted regarding local construction activities. This provision is intended to further reinforce the public participation component of the regulated small MS4 storm water program and to recognize the crucial role that the public can play in identifying instances of noncompliance.

The small MS4 operator is required only to *consider* the information submitted, and may not need to follow-up and respond to every complaint or concern. Although some form of enforcement action or reply is not required, the small MS4 operator is required to demonstrate acknowledgment and consideration of the information submitted. A simple tracking process in which submitted public information, both written and verbal, is recorded and then given to the construction site inspector for possible follow-up would suffice.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are intended to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, should reflect the needs and characteristics of the operator and the area served by its small MS4. Furthermore, they should be chosen using an integrated approach that fully addresses the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following measurable goals:

Target Date	Activity
1 year...........	Ordinance or other regulatory mechanism in place; procedures for information submitted by the public in place.
2 years..........	Procedures for site inspections implemented; a certain percentage rate of compliance achieved by construction operators.
3 years..........	Maximum compliance with ordinance; improved clarity and reduced sedimentation of local waterbodies.
4 years..........	Increased numbers of sensitive aquatic organisms in local waterbodies.

Am I Correct in Thinking that Construction Sites Are Already Covered Under the NPDES Storm Water Program?

Yes. EPA's Phase I NPDES storm water program requires operators of construction activities that disturb five or more acres to obtain a NPDES construction storm water permit. General permit requirements include the submission of a Notice of Intent and the development of a storm water pollution prevention plan (SWPPP). The SWPPP must include a site description and measures and controls to prevent or minimize pollutants in storm water discharges. The Phase II Final Rule similarly regulates discharges from smaller construction sites disturbing equal to or greater than one acre and less than five acres.

Even though all construction sites that disturb more than one acre are covered nationally by an NPDES storm water permit, the construction site runoff control minimum measure for the small MS4 program is needed to induce more localized site regulation and enforcement efforts, and to enable operators of regulated small MS4s to more effectively control construction site discharges into their MS4s.

To aid operators of regulated construction sites in their efforts to comply with both local requirements and their NPDES permit, the Phase II Final Rule includes a provision that allows the NPDES permitting authority to reference a "qualifying State, Tribal or local program" in the NPDES general permit for construction. This means that if a construction site is located in an area covered by a qualifying local program, then the construction site operator's compliance with the local program would constitute compliance with their NPDES permit. A regulated small MS4's storm water program for construction could be a "qualifying program" if the MS4 operator requires a SWPPP, in addition to the requirements summarized in this fact sheet.

The ability to reference other programs in the NPDES permit is intended to reduce confusion between overlapping and similar requirements, while still providing for both local and national regulatory coverage of the construction site. The provision allowing NPDES permitting authorities to reference other programs has no impact on, or direct relation to, the small MS4 operator's responsibilities under the construction site runoff control minimum measure profiled in this fact sheet.

Is a Small MS4 Operator Required to Regulate Construction Sites that the Permitting Authority has Waived from the NPDES Construction Program?

No. If the NPDES permitting authority waives requirements for storm water discharges associated with small construction activity (see § 122.26(b)(15) of the Phase II rule), the small MS4 operator is not required to develop, implement, and/or enforce a program to reduce pollutant discharges from such sites.

4.6.2.5 Post-construction Storm Water Management in New Development/ Redevelopment

Why Is The Control of Post-Construction Runoff Necessary?

Post-construction storm water management in areas undergoing new development or redevelopment is necessary because runoff from these areas has been shown to significantly effect receiving waterbodies. Many studies indicate that prior planning and design for the minimization of pollutants in post-construction storm water discharges is the most cost-effective approach to storm water quality management.

There are generally two forms of substantial impacts of post-construction runoff. The first is caused by an increase in the type and quantity of pollutants in storm water runoff. As runoff flows over areas altered by development, it picks up harmful sediment and chemicals such as oil and grease, pesticides, heavy metals, and nutrients (e.g., nitrogen and phosphorus). These pollutants often become suspended in runoff and are carried to receiving waters, such as lakes, ponds, and streams. Once deposited, these pollutants can enter the food chain through small aquatic life, eventually entering the tissues of fish and humans. The second kind of post-construction runoff impact occurs by increasing the quantity of water delivered to the waterbody during storms. Increased impervious surfaces interrupt the natural cycle of gradual percolation of water through vegetation and soil. Instead, water is collected from surfaces such as asphalt and concrete and routed to drainage systems where large volumes of runoff quickly flow to the nearest receiving water. The effects of this process include streambank scouring and downstream flooding, which often lead to a loss of aquatic life and damage to property.

What Is Required?

The Phase II Final Rule requires an operator of a regulated small MS4 to develop, implement, and enforce a program to reduce pollutants in post-construction runoff to their MS4 from new development and redevelopment projects that result in the land disturbance of greater than or equal to 1 acre The small MS4 operator is required to:

- ☐ Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs);

- ❑ Have an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls to the extent allowable under State, Tribal or local law;
- ❑ Ensure adequate long-term operation and maintenance of controls;
- ❑ Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

What Is Considered a "Redevelopment" Project?

The term "redevelopment" refers to alterations of a property that change the "footprint" of a site or building in such a way that the disturbance of equal to or greater than 1 acre of land results. The term does not include such activities as exterior remodeling. Because redevelopment projects may have site constraints not found on new development sites, the rule provides flexibility for implementing post-construction controls on redevelopment sites that consider these constraints.

What Are Some Guidelines for Developing and Implementing This Measure?

This section includes some sample non-structural and structural BMPs that could be used to satisfy the requirements of the post-construction runoff control minimum measure. It is important to recognize that many BMPs are climate-specific, and not all BMPs are appropriate in every geographic area. Because the requirements of this measure are closely tied to the requirements of the construction site runoff control minimum measure (see Fact Sheet 2.6), EPA recommends that small MS4 operators develop and implement these two measures in tandem. Sample BMPs follow.

❑ **Non-Structural BMPs**

- **Planning and Procedures.** Runoff problems can be addressed efficiently with sound planning procedures. Master Plans, Comprehensive Plans, and zoning ordinances can promote improved water quality by guiding the growth of a community away from sensitive areas and by restricting certain types of growth (industrial, for example) to areas that can support it without compromising water quality.
- **Site-Based Local Controls.** These controls can include buffer strip and riparian zone preservation, minimization of disturbance and imperviousness, and maximization of open space.

❑ **Structural BMPs**

- **Storage Practices.** Storage or detention BMPs control storm water by gathering runoff in wet ponds, dry basins, or multichamber catch basins and slowly releasing it to receiving waters or drainage systems. These practices both control storm water volume and settle out particulates for pollutant removal.

- **Infiltration Practices**. Infiltration BMPs are designed to facilitate the percolation of runoff through the soil to ground water, and, thereby, result in reduced storm water quantity and reduced mobilization of pollutants. Examples include infiltration basins/trenches, dry wells, and porous pavement.

- **Vegetative Practices**. Vegetative BMPs are landscaping features that, with optimal design and good soil conditions, enhance pollutant removal, maintain/improve natural site hydrology, promote healthier habitats, and increase aesthetic appeal. Examples include grassy swales, filter strips, artificial wetlands, and rain gardens.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are intended to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, should reflect needs and characteristics of the operator and the area served by its small MS4. Furthermore, the measurable goals should be chosen using an integrated approach that fully addresses the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following goals:

Target Date	Activity
1 year............	Strategies developed that include structural and/or non-structural BMPs.
2 years..........	Strategies codified by use of ordinance or other regulatory mechanism.
3 years..........	Reduced percent of new impervious surfaces associated with new development projects.
4 years..........	Improved clarity and reduced sedimentation of local waterbodies.

4.6.2.6 Pollution Prevention/Good Housekeeping for Municipal Operations

Why Is Pollution Prevention/Good Housekeeping Necessary?

The Pollution Prevention/Good Housekeeping for municipal operations minimum control measure is a key element of the small MS4 storm water management program. This measure requires the small MS4 operator to examine and subsequently alter own actions to help ensure a reduction in the amount and type of pollution that (1) collects on streets, parking lots, open spaces, and storage and vehicle maintenance areas and is discharged into local waterways; and (2) results from actions such as environmentally damaging land development and flood management practices or poor maintenance of storm sewer systems.

While this measure is meant primarily to accomplish the goal of improving or protecting the quality of receiving waters by altering the performance of municipal or facility operations, it also can result in a cost savings for the small MS4 operator, since proper and timely maintenance of storm sewer systems can help avoid repair costs from damage caused by age and neglect.

What Is Required?

Recognizing the benefits of pollution prevention practices, the rule requires an operator of a regulated small MS4 to:

- Develop and implement an operation and maintenance program with the ultimate goal of preventing or reducing pollutant runoff from municipal operations into the storm sewer system;
- Include employee training on how to incorporate pollution prevention/good housekeeping techniques into municipal operations such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and storm water system maintenance. To minimize duplication of effort and conserve resources, the MS4 operator could use training materials that are available from EPA, their State or Tribe, or relevant organizations;
- Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure. Some program implementation approaches, BMPs (i.e., the program actions/activities), and measurable goals are suggested below.

What Are Some Guidelines for Developing and Implementing This Measure?

The intent of this control measure is to ensure that existing municipal, State or Federal operations are performed in ways that will minimize contamination of storm water discharges. EPA encourages the small MS4 operator to consider the following components when developing their program for this measure:

Maintenance activities, maintenance schedules, and long-term inspection procedures for structural and non-structural controls to reduce floatables and other pollutants discharged from the separate storm sewers;

Controls for reducing or eliminating the discharge of pollutants from areas such as roads and parking lots, maintenance and storage yards (including salt/sand storage and snow disposal areas), and waste transfer stations. These controls could include programs that promote recycling (to reduce litter), minimize pesticide use, and ensure the proper disposal of animal waste;

Procedures for the proper disposal of waste removed from the separate storm sewer systems and the areas listed in the bullet above, including dredge spoil, accumulated sediments, floatables, and other debris; and

- ***Ways to ensure that new flood management projects assess the impacts on water quality*** and examine existing projects for incorporation of additional water quality protection devices or practices. EPA encourages coordination with flood control managers for the purpose of identifying and addressing environmental impacts from such projects.

The effective performance of this control measure hinges on the proper maintenance of the BMPs used, particularly for the first two bullets above. For example, structural controls, such as grates on outfalls to capture floatables, typically need regular cleaning, while non-structural controls, such as training materials and recycling programs, need periodic updating.

What Are Appropriate Measurable Goals?

Measurable goals, which are required for each minimum control measure, are meant to gauge permit compliance and program effectiveness. The measurable goals, as well as the BMPs, should consider the needs and characteristics of the operator and the area served by its small MS4. The measurable goals should be chosen using an integrated approach that fully addresses the requirements and intent of the minimum control measure. An integrated approach for this minimum measure could include the following measurable goals:

Target Date	Activity
1 year...........	Pollution prevention plan (the new BMPs and revised procedures) completed; employee training materials gathered or developed; procedures in place for catch basin cleaning after each storm and regular street sweeping.
2 years..........	Training for appropriate employees completed; recycling program fully implemented.
3 years..........	Some pollution prevention BMPs incorporated into master plan; a certain percentage reduction in pesticide and sand/salt use; maintenance schedule for BMPs established.
4 years..........	A certain percentage reduction in floatables discharged; a certain compliance rate with maintenance schedules for BMPs; controls in place for all areas of concern.

4.6.3 Program Requirements: Evaluation/Assessment & Reporting

If coverage is obtained under a general permit or an individual permit under the Phase II regulations, the operator of a regulated small MS4 is required to comply with the evaluation/assessment and reporting requirements summarized in this section.

Frequency of Reports

Reports must be submitted annually during the first permit term – permit terms are typically a 5-year period. For subsequent permit terms, reports must be submitted in years 2 and 4 only, unless the NPDES permitting authority requests more frequent reports. Reports do not need to be submitted if the operator of the regulated small MS4 is relying on another entity to satisfy all permit obligations (see section 4.5.1.3)

Required Report Content

The reports must include the following:

- ❑ The status of compliance with permit conditions, including an assessment of the appropriateness of the selected BMPs and progress toward achieving the selected measurable goals for each minimum measure;
- ❑ Results of any information collected and analyzed, including monitoring data, if any;
- ❑ A summary of the storm water activities planned for the next reporting cycle;
- ❑ A change in any identified best management practices or measurable goals for any minimum measure; and
- ❑ Notice of relying on another governmental entity to satisfy some of the permit obligations (if applicable – see section 4.5.1.3).

A Change in Selected BMPs

If, upon evaluation of the program, improved controls are identified as necessary, permittees should revise their mix of BMPs to provide for a more effective program. Such a change, and an explanation of the change, must be noted in a report to the NPDES permitting authority.

Recordkeeping Requirements

Records required by the NPDES permitting authority must be kept for at least 3 years and made accessible to the public at reasonable times during regular business hours. Records need not be submitted to the NPDES permitting authority unless the permittee is requested to do so.

4.7 SMALL MS4 PROGRAM COMPLIANCE PROCESS: What Do I Need to Do To Comply?

Sections 4.1 through 4.6 of this guidance have provided a details on who's covered and what's required under the Phase II regulations for regulated small MS4s. Now that you are familiar with the Phase II program, this section walks you through the process, from beginning to end, that an operator of a regulated small should take to comply with the regulation. This step-by-step "walk-through" references the appropriate sections of the guidance along the way as a means for understanding how the information in sections 4.1 through 4.6 fits together.

The last page of this section includes a permitting decision tree to help operators of MS4s determine if they need an NPDES storm water permit. By starting in the upper left hand corner, an operator can follow the decision tree to determine if they fall under Phase I or Phase II, and if they are eligible for a waiver.

Step 1: Determine if you are an operator of an MS4 (see section 4.1.1).

Step 2: As an operator of an MS4, determine if you are an operator of a small MS4 (see section 4.1.4).

Step 3: As an operator of a small MS4, determine if you are an operator of a regulated small MS4 (see section 4.2). You need to find out if you are:

A. Automatically designated by the rule

- First, determine if your system is located partially or fully within an urbanized area (See section 4.3),
- Second, determine if you may qualify for a waiver (waivers are at the discretion of the permitting authority). If you qualify for a waiver, stop here. (See section 4.4)

B. Potentially designated by the NPDES permitting authority

- Determine if your system, located outside of a UA, may fit the criteria for potential designation. Since designations are at the discretion of the permitting authority, a final determination is made by the permitting authority and not the small MS4 operator. If designated, continue with Step 4.

Step 4: Read Phase II Rule and guidance materials to get a sense of the permitting options (see section 4.5) and program requirements (see section 4.6).

Step 5: Determine which neighbors are regulated as Phase I MS4s (refer to list on the EPA web site) or Phase II MS4s (refer to Appendix 6 and maps of your UA). This information will be used to base your decision as to whether to:

- Be a co-permittee with another regulated MS4. (See section 4.5.1.2)
- Rely on another regulated MS4 for partial or full implementation of the minimum measures on your behalf. (See section 4.5.1.3)

Step 6: Determine if programs similar to one or more of the minimum measures is already being performed by another entity. This information will be used to decide whether you wish to rely on another entity for partial implementation of the minimum measures on your behalf. (See section 4.5.1.3)

Step 7: Determine which permit option to choose (depends on which are made available by the your NPDES permitting authority) (See section 4.5.1)

- General permit under the Phase II regulation
- Individual permit under the Phase I or Phase II regulation
- Modification of a Phase I individual permit (Co-permittee with a large or medium MS4)

In determine which option to choose, think about...

— If you wish to be a co-permittee and share responsibilities based on information from Step 5

— If, instead of the co-permittee option, you wish to have own permit but rely on another entity for implementing a measure or measures based on information from Steps 5 & 6.

Step 8: Begin planning and development of your storm water management program

- Use menu of BMPs as a guide (provided by EPA or the permitting authority). The EPA web site will also have references and links to helpful guidance on every facet of a storm water management program for MS4s.

- Meet with staff who will be responsible for implementing the storm water management program (may be a multi-departmental team). Task them with:
  - — Assessing the storm water management characteristics and needs of the area served by the regulated small MS4.
  - — Determining appropriate BMPs and measurable goals
  - — Determining who will be responsible for what under the program

- Form a citizen advisory panel to help develop the program and give them similar tasks as those given to the staff.

- Meet with local Phase I and Phase II MS4 operators to discuss co-permittee status or sharing of resources, such as: hiring one enforcement inspector for multiple areas, co-sponsoring household hazardous waste collection events, or sharing a street sweeper, recycling truck, illicit discharge detection cameras, or any other equipment. (Note: Nothing listed here is required by the Phase II rule -- they are only examples)

- Meet with other entities that you may rely on to implement one or more of the minimum measures to discuss the arrangement and any legal agreements.

Step 9: **A. Under a General Permit:**

1) Once a general permit is issued, read it carefully. You may not be

required to implement every minimum measure due to the permitting authority recognizing or referencing other similar programs (see section 4.5.2.1). For this reason, before the permit is issued (which is expected to be no later than December 9, 2002) follow Step 8 but only do a preliminary storm water management program until the final permit requirements are know. Once the permit is issued, if you have chosen this option you will need to make final decisions on the following issues and complete the development of your storm water management plan:

- Do you want to be a co-permittee with another regulated small MS4?
- Do you want to rely on another entity for some or all of the permit requirements?
- Which BMPs and measurable goals will you use for each minimum measure you will be implementing?

2) Fill out an NOI in accordance with the Phase II regulation. (See section 4.6.2.1)

B. Under an Individual Permit (new or modified):

If you have chosen one of the individual permit options (i.e., under Phase II, under Phase I, or modified existing Phase I), you will need to continue efforts in Step 8, as applicable, and complete development of your permit application in accordance with the Phase II regulation. (See sections 4.6.2.2 through 4.6.2.4)

Step 10: Submit your NOI under a general permit or your individual permit application to the NPDES permitting authority by March 10, 2003; unless your NPDES permitting authority phases-in permit coverage and establishes alternative deadlines (see section 4.5.2.2).

Step 11: Implement your storm water management program in accordance with applicable standards (see section 4.6.1). The Phase II rule allows you up to five years to fully implement your program, although the exact timeframe is at the discretion of the your NPDES permitting authority.

Step 12: Write annual reports in your first permit term assessing the effectiveness of BMPs and if measurable goals were met, and submit the reports to your NPDES permitting authority. You may change the mix of BMPs originally selected if you find that such a change is necessary to ensure a more effective program. This step, as required in the Phase II regulations at § 122.34(g) and described in section 4.6.3, is not applicable if you sought coverage under an individual permit under the Phase I regulations or under a modification of an existing Phase I MS4 permit.

Step 13: Be aware that you may need to take over implementation of a minimum control measure if you are relying on another entity for its implementation and the other entity fails to perform it effectively. This is why EPA encourages a legally-binding agreement when choosing to rely on another entity. Also, the permitting authority may chose to change your mix of BMPs and measurable goals as submitted in you permit application if it determines that your program is not effectively controlling pollutant discharges.

4.8 FEDERAL AND STATE-OPERATED REGULATED SMALL MS4S: Unique Program Implementation Issues

In addition to local government jurisdictions, small MS4s include certain Federal and State-operated MS4s. Federal facilities were not designated for regulation by the NPDES Phase I storm water program for MS4s. The Phase II Final Rule, however, includes the "United States" in the definition of a small MS4, thereby including Federal MS4 operators in the NPDES Phase II storm water program. Federal and State-operated small MS4s can include universities, prisons, hospitals, roads (i.e., departments of transportation), military bases (e.g., State Army National Guard barracks), parks, and office buildings/complexes.

The small MS4 program, largely designed with municipally-operated small MS4s in mind, raises a number of implementation issues for Federal and State operators of regulated small MS4s who must obtain an NPDES permit that requires the development and implementation of a storm water management program that includes the six minimum control measures. This section highlights potential implementation issues related to the minimum control measures, and then discusses the implementation options included in the rule that may help resolve these issues.

4.8.1 What Are Some Implementation Concerns?

This section profiles the three most common implementation issues raised in the public comments submitted regarding Federal/State implementation of the small MS4 program.

How Does the Final Rule Account for Unique Characteristics?

Federal and State small MS4s possess a number of characteristics that set them apart from their municipal counterparts. For example, whereas municipally-operated MS4s largely serve resident populations, many Federal or State-operated MS4s, such as medical clinics and departments of transportation (DOTs), do not. Other types of Federal and State MS4s, such as military bases, prisons, and State universities, serve populations that are different from a typical municipal population. Their unique characteristics might lead Federal or State MS4 operators to question either the need to implement the entire suite of minimum control measures or their ability to comply fully with their Phase II storm water permit. The flexibility within the minimum measures allows Federal and State MS4s to develop a storm water program that comprises the minimum measures in a way that makes sense for their circumstances.

What If the Operator Lacks Legal Authority?

Three of the minimum control measures (illicit discharge detection and elimination, and the two construction-related measures) require enforceable controls on third party activities to ensure successful implementation of the measure. Some Federal and State operators, however, may not have the necessary legal regulatory authority to adopt these enforceable controls in the same manner as do local governments.

For example, a State DOT that is responsible for the portions of its roads running through urbanized areas may not have the legal authority to impose restrictions on, and penalties against, illicit (i.e., non-storm water) discharges into its MS4 if the source of the discharge is outside the DOT's right-of-way or jurisdiction. As in the case of local governments that lack such authority, State and Federal MS4s are expected to utilize the authority they do possess and to seek cooperative arrangements.

How Can the Program Be Implemented in Areas Where There Are Multiple Regulated Entities?

Since the final rule provides automatic coverage of all small MS4s within an urbanized area, regardless of political boundaries, coverage of multiple governments and agencies in a single area is likely. For example, a city government that operates a small MS4 within an urbanized area must obtain permit coverage alongside the county, State, and Federal DOTs if they all operate a portion of the roads (i.e., MS4s) in the city. All four entities are responsible for developing a storm water management program for their MS4s (or portions thereof) within the urbanized area. EPA encourages State and Federal small MS4 operators to establish cooperative agreements with cities and counties in implementing their storm water programs.

4.8.2 Are There Implementation Strategies that Help Facilitate Program Implementation?

This section offers two hypothetical strategies for resolving the implementation issues raised above. The best solution may include a creative combination of strategies.

STRATEGY #1
A Focus on Choosing Appropriate BMPs

The final rule requires the permittee to choose *appropriate* best management practices (BMPs) for each minimum control measure. In other words, EPA expects Phase II permittees to tailor their storm water management plans and their BMPs to fit the particular characteristics and needs of the permittee and the area served by its MS4. Therefore, the Federal or State operator of a regulated storm sewer system can take advantage of the flexibility provided by the rule to utilize the most suitable minimum control measures for its MS4. Below is an example of tailored activities and BMPs that

Federal or State operators can implement for each measure:

- **Public Education and Outreach**. Distribute brochures and post fliers to educate employees of a Federal hospital about the problems associated with storm water runoff and the steps they can take to reduce pollutants in storm water discharges. For example, employees could be advised against carelessly discarding trash on the ground or allowing their cars to leak oil/fluids in the parking lot.

- **Public Participation/Involvement**. Provide notice of storm water management plan development and hold meetings at which employees of a Federal office complex are encouraged to voice their ideas and opinions about the effort. Request volunteers to help develop the plan.

- **Illicit Discharge Detection and Elimination**. Develop a map of the storm sewer system on a military base. Perform visual dry weather monitoring of any outfalls to determine whether the storm sewer system is receiving any non-storm water discharges from the base. If a dry weather flow is found, trace it back to the source and stop the discharge. Should a Federal military base identify an illicit discharge, the source of which is traced to the boundary of its system, the Federal operator should refer the discharge to the adjoining regulated MS4 for further action.

- **Construction Site Runoff Control**. Require the implementation of erosion and sediment controls, and control of waste, for any Federal or State DOT road construction. The DOT would review site plans for proper controls, perform inspections, and establish penalties in the construction contract if controls are not implemented. If construction is done directly by the regulated DOT instead of a private contractor, the DOT could be penalized by the NPDES permitting authority for non-compliance with its small MS4 permit in the event that controls are not properly implemented.

- **Post-Construction Runoff Control**. Require the implementation of post-construction storm water controls for any new construction on the grounds of a prison. This can be required as part of a construction contract, instituted as internal policy, and considered during site plan review.

- **Pollution Prevention/Good Housekeeping for Municipal Operations**. Train maintenance staff at a State university to employ pollution prevention techniques whenever possible. For example, routinely pick up trash/litter from the university grounds, use less salt on the parking lots and access roads in the winter, perform any maintenance of university vehicles under shelter only, limit pesticide use to the minimum needed, use vegetative buffer strips in the parking lots to filter runoff, and keep dumpster lids closed.

STRATEGY #2
Working with Other Entities

There may be instances when the Federal or State permittee has limited capabilities to satisfy one or more of the minimum control measures. As discussed above, the permittee may lack the proper legal authority to enforce controls (although it should try to obtain the necessary legal authority if at all possible).

In the case of limited capabilities, the permittee can work with neighboring operators of regulated small MS4s, preferably on a watershed basis, to form a shared storm water management program in which each permittee is responsible for activities that are within individual legal authorities and abilities. The final rule allows the permittee to rely on other entities, with their permission, to implement those minimum measures that the permittee is otherwise unable to implement. Three examples are:

- A State DOT with limited regulatory legal authority can reference a local sewer district's illicit detection and elimination program in its permit application, provided the program sufficiently addresses illicit discharges into the DOT's storm sewer system.
- The permittee or NPDES permitting authority can reference such programs as coastal nonpoint pollution control programs, State or local watershed programs, State or local construction programs, and environmental education efforts by public or private entities.
- The permittee can become a co-permittee with a neighboring Phase I MS4 through a modification of the Phase I MS4's individual permit. This may be the most logical and preferable option for those Federal and State entities located in close proximity to Phase I MS4s.

Choosing to work with other governmental entities as a co-permittee, or referencing parts of each other's plans, can help resolve issues that may arise where multiple regulated jurisdictions exist in the same area. Permittees can avoid duplicative efforts, as well as territorial or regulatory disputes, by working together to implement the storm water program.

Suggested Steps for Working with Other Entities

(1) Identify the boundaries of the urbanized area.

(2) Identify the operators of storm sewer systems or portions of the systems within the urbanized area such as local, State, Tribal or Federal governments or other entities.

(3) In seeking permit coverage:

Identify where another entity's program may satisfy one or more minimum control measure. If a program has requirements that are equivalent to a minimum control measure's required elements, the operator of the regulated small MS4 may reference the program in its permit application, provided the other entity gives it permission to do so. While such an arrangement relieves the operator from performing the minimum measure itself, the operator remains ultimately responsible for the measure's effective implementation.

OR

Team with an operator of a Phase I MS4 and become a co-permittee on its existing Phase I individual permit.

4.9 FUNDING OPTIONS

Possibly the biggest challenge for an operator of a regulated small MS4 in implementing a storm water management program is finding funding for the program. Funding is needed to maintain the staff, equipment and materials necessary to develop and implement an effective program. Adequate funding is critical to the success of the program but attaining it can be difficult as many other important programs compete for the same limited revenues from a general fund. Therefore, the operator of a regulated small MS4 will need to consider alternative funding options. This section provides brief introductions to some of the various funding options currently in use across the country. The following information on funding options was written by the American Public Works Association (AWPA) as part of their Storm Water Phase II workshops:

Debt Financing: Typically used for capital-intensive projects, local governments can issue debt to finance storm water management programs and facilities. Revenue bonds - or bonds that rely on ongoing source of revenue may be used. Alternatively, a general obligation bond can be issued which are backed by the full faith and credit of your municipality (based on your ability to generate revenues though taxes and other fees).

Grants and Loans: Federal, State, or Regional grant or loan funds may be available for some elements of the storm water program, depending on the BMP's selected and the location. Grants and loans are usually applicable to specific projects and not on-going activities, such as operation and maintenance.

Users /Utility Fees: Utility services charges are rates billed to customers for providing storm water management services. The service charges may be flat rates, or variable rates based on classes of customers. Utility service charges may represent a dedicated source of funding and an ongoing method of funding some or all storm water management programs.

Special Assessment: Properties can be assessed annually to fund storm water management programs. Often, special assessments are used to fund a special district or authority that can implement all or portions of a region's storm water management program.

Local Improvement Under this type of funding system, individual properties benefitted by storm water projects are assessed to fund the project. Some states require special enabling legislation to establish this type of special benefits district.

General Fund: General fund monies are used for may storm water programs. If storm water programs are funded from your General Fund, the programs are at risk in each budget cycle. In addition, in order to increase funding levels for your program, other local government services may be affected or a general tax increase may be required.

Inspection Fees: Plan review and inspection fees allows the community to recover some or all of the direct cost associated with performing design reviews for pre and post construction BMP's.

Developer Fees: The developers construct needed facilities as a condition of development and bear associated costs.

Alternative Fees: Instead of constructing on-site facilities to meet development requirements, developers may be given the option of paying a comparable fee to be used by the local government to build regional facilities that are designed to meet the same objectives as the developer-constructed on-site mitigation.

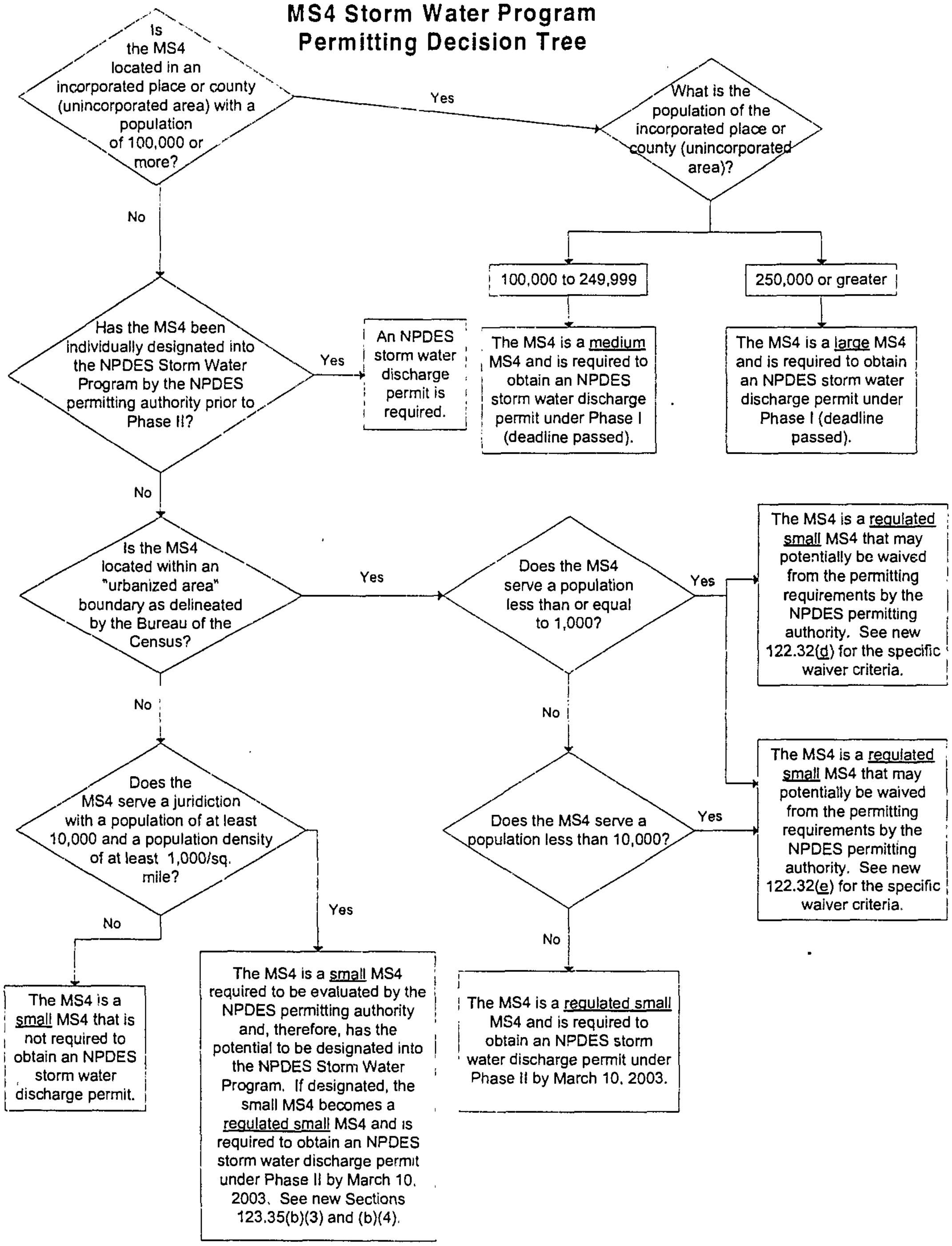
Connection Fees: A one time charge assessed at the time of development to recover a proportionate share of the cost of existing facilities and planned future facilities. The applicability depends upon legislation in each state.

Additional Resources

- Storm Water Utilities: Innovative Financing for Storm Water Management. 1992. U.S. EPA, Office of Policy, Planning, and Evaluation. Washington, D.C.
- State and Local Funding of Nonpoint Source Control Programs. 1992. U.S. EPA, Office of Water, Assessment and Watershed Protection Division. Washington, D.C.
- Storm Water Management Utility Implementation Manual. South Carolina Land Resources Commission, Columbia, S.C.

- Storm Water Maintenance and Financing Options (draft). 1987. State of Maryland, Maryland Department of Natural Resources.

MS4 Storm Water Program Permitting Decision Tree



1. See Appendices F, G, H, and I to Part 122 (as revised by the Phase II Final Rule) for the list of incorporated places and counties (unincorporated areas) with a population of 100,000 or greater. If the MS4 is located in a listed entity, then the answer to this question is "Yes" and the MS4 is covered under the Phase I MS4 program as a medium or large MS4.

5.0 SMALL CONSTRUCTION ACTIVITY

After reading Section 5.0, you should understand what type of construction activity is subject to the Phase II small construction activity regulations (including who may be waived from coverage), who is considered an operator of small construction activity, the permit options and requirements for small construction activity, and the interaction of the NPDES storm water program for construction with the NPDES storm water program for regulated MS4s. The discussion of these elements concludes with a step-by-step review of the process for compliance with the Phase II regulations for small construction activity.

5.1 COVERAGE: Who Is Subject to the Phase II Rule?

The NPDES Storm Water Program defines construction activities as "small" and "large" for the purposes of regulation. The Phase I storm water program covers large construction activity. The Phase II storm water regulation covers small construction activity. To understand who is covered under the Phase II Rule, it is necessary to understand who is already covered under the Phase I Rule. Toward this end, this section provides a definition of the type of construction activity covered by Phase I and Phase II, as well as other definitions essential to understanding the construction component of the NPDES Storm Water Program.

5.1.1 What Type of Construction Activity Is Covered Under the Phase I Regulations?

The Phase I Rule identifies eleven categories of industrial activity in the definition of "storm water discharge associated with industrial activity" that must obtain an NPDES storm water discharge permit (see section 6.1). Category (x) of this definition includes construction activity (including clearing, grading and excavation) that results in ***a total land disturbance of 5 acres or greater***. Disturbances of less than 5 acres are also regulated under category (x) if they are part of a "larger common plan of development or sale" with a planned land disturbance of 5 acres or greater. Phase I construction activity is commonly referred to as "large"

Construction activities can include road building, construction of residential houses, office buildings, industrial sites, or demolition.

Land Disturbance means exposed soil due to clearing, grading, or excavation activities.

Larger common plan of development or sale describes a situation in which multiple construction activities are occurring, or will occur, on a contiguous area.

An operator is the person or persons that has either operational control of construction project plans and specifications, or day-to-day operational control of activities necessary to ensure compliance with storm water permit

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construction activity. The Phase I rule requires all operators of large construction activity to obtain an NPDES storm water discharge permit before discharging storm water runoff to a municipal separate storm sewer system or waters of the United States.

5.1.2 What Type of Construction Activity Is Covered Under the Phase II Regulations?

In 1992, the Ninth Circuit court remanded for further proceedings the portion of EPA's Phase I storm water regulation related to category (x) construction activity (NRDC v. EPA, 966 F.2d at 1292). EPA responded to the court's decision by designating under Phase II storm water discharges from construction site activities that ultimately will result in a ***land disturbance of equal to or greater than 1 and less than 5 acres*** as "storm water discharges associated with *small construction* activity" (see § 122.26(b)(15)). The Phase II rule requires all operators of small construction activity to obtain an NPDES storm water discharge permit before discharging storm water runoff to a municipal separate storm sewer system or waters of the United States.

Construction activities disturbing less than 1 acre are also included in Phase II of the NPDES storm water program if they are part of a larger common plan of development or sale with a planned disturbance of equal to or greater than 1 acre and less than 5 acres, or if they are designated by the NPDES permitting authority. The NPDES permitting authority or EPA Region may designate construction activities disturbing less than 1 acre based on the potential for contribution to a violation of a water quality standard or for significant contribution of pollutants to waters of the United States.

The definition of small construction activity does not apply where the construction operator can certify to one of two waivers – see section 5.2 for more information on waiver options.

5.1.3 What is meant by the terms "land disturbance," "larger common plan of development or sale," and "operator" of a construction site?

The definitions of "land disturbance," "larger common plan of development or sale," and "operator" of a construction site are key in understanding coverage under the NPDES Storm Water Program for construction activity. These definitions originate from the NPDES storm water general permit for large construction activity.

- **Land disturbance** refers to exposed soil resulting from activities such as clearing, grading and excavating.

- **Larger common plan of development or sale** is a contiguous area where multiple separate and distinct construction activities are occurring under one plan (e.g., the operator is building on three half-acre lots in a 6-acre development). The "plan" in a common plan of development or sale is broadly defined as any announcement or piece of documentation (including a sign, public notice or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor markings, etc.) indicating that construction activities may occur on a specific plot.

- **An operator** of a construction site is the person (or persons) responsible for obtaining coverage under an NPDES storm water permit for construction activity, and complying with the permit requirements. An operator is the person or persons that meet either of the following criteria:

  - Has operational control of construction project plans and specifications, including the ability to make modifications to those plans and specifications; or

  - Has day-to-day operational control of those activities at a project which are necessary to ensure compliance with a storm water pollution prevention plan (SWPPP) for the site or other permit conditions (e.g., they are authorized to direct workers at a site to carry out activities required by the SWPPP or comply with other permit conditions).

  There may be more than one party at a site responsible for "operational control." Depending on the project and the distinction between the parties' (e.g., owner's vs. developer's) responsibilities, there can either be a single party acting as a site operator needing permit coverage or there can be two (or more) operators who may share permit responsibilities. In cases where there are two or more operators , both parties will need permit coverage if they choose to keep the responsibilities as described in the above bullets separate, or they choose to separately maintain operational control for different portions of the site, etc. In such cases both operators should obtain permit coverage as co-permittees by co-submitting separate Notice of Intent forms, and should share in meeting permit conditions (e.g., generating the storm water pollution prevention plan, performing inspections, etc.). The option to have one sole operator who is willing to assume complete responsibility / liability for all permit requirements still exists and, in many cases, may be the less overall burdensome way to comply with storm water requirements.

  There are other instances where parties conduct earth disturbing activities at a site but do not need their own permit coverage. Examples for whom this may apply include a subcontractor who is under the supervision of the operator, or an entity that is neither a subcontractor nor has operational control (e.g., a utility line installer).

  Additional information on the responsibilities of operators can be found in Part III.E of EPA's NPDES Construction General Permit, published on February 17, 1998 (63 FR 7858). Part II of the fact sheet contained in the NPDES Construction General Permit also provides answers to common questions regarding roles and responsibilities of different parties involved on a construction site.

Important note: NPDES-authorized States may use a different definition of "operator" than the one provided above.

5.2 WAIVERS: Which Small Construction Activity Sites May Obtain a Waiver From Coverage?

Under the Phase II Rule, NPDES permitting authorities have the option of providing a waiver from Phase II coverage and requirements to operators of small construction activity who certify to one of two conditions:

- Low predicted rainfall potential (i.e., activity occurs during a negligible rainfall period), where the rainfall erosivity factor ("R" in the Revised Universal Soil Loss Equation [RUSLE]) would be less than 5 during the period of construction activity.
- A determination that storm water controls are not necessary based on either:

    (A) A "total maximum daily load" (TMDL) that address the pollutant(s) of concern for construction activities; **OR**

    (B) For nonimpaired waters that don't require TMDLs, an equivalent analysis that determines allocations for small construction sites for the pollutants of concern or determines that such allocations are not needed to protect water quality based on consideration of instream concentrations, expected growth in pollutant concentrations from all sources, and a margin of safety.

Pollutants of concern include sediment or a parameter that addresses sediment (such as total suspended solids, turbidity, or siltation) and any other pollutant that has been identified as a cause of impairment of a receiving waterbody.

The intent of these waiver provisions (see §§ 122.26(b)(15)(A) and(B)) is to waive only those sites that are highly unlikely to have a negative effect on water quality. Therefore, before applying for a waiver, operators of small construction activity are encouraged to consider the potential water quality impacts that may result from their project and to carefully examine such factors as proximity to water resources and sensitivity of receiving waters. Small construction activities disturbing less than 1 acre that are designated by the permitting authority are not eligible for these waivers.

5.2.1 Waiver 1: The Rainfall Erosivity Factor Waiver

The Rainfall Erosivity Factor waiver is based on the potential for a construction activity to occur in an area, or during a certain period of time, where there is low predicted rainfall potential and, therefore, less likelihood of causing impacts. This waiver is time-sensitive and is dependent on when during the year a construction activity takes place, how long it lasts, and the expected rainfall and intensity during that time. It creates an incentive for construction site operators to build during the dry part of the year.

How would an operator qualify for, and certify to, this waiver?

To qualify for this waiver, the construction site operator must determine the value of the rainfall erosivity factor (R factor) in the Revised Universal Soil Loss Equation (RUSLE) and then certify to the permitting authority that the value of the factor is less than 5 during the period of construction. The RUSLE is a refinement of the Universal Soil Loss Equation (USLE), which is a method developed by the U.S. Department of Agriculture to measure soil loss from agricultural lands at various times of the year on a regional basis. The R factor varies based on location and time period during the year.

A construction site operator will need site-specific data to calculate the values for rainfall erosivity using the RUSLE. The rainfall erosivity factor is determined in accordance with Chapter 2 of *Agriculture Handbook Number 703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE).* This handbook is no longer in print but Chapter 2 can be obtained from EPA's web site or by contacting EPA's Water Resource Center.

5.2.1 Waiver 2: The Water Quality Waiver

The Water Quality waiver consists of: 1) a component for small construction sites that will discharge to an impaired waterbody where total maximum daily load (TMDL) assessments have been performed, and 2) a component for small construction sites that will discharge to non-impaired waters where an analysis equivalent to the TMDL assessments have been performed.

For impaired waters where technology-based controls required by NPDES permits are not achieving State water quality standards, the CWA requires implementation of the TMDL process.

> The **TMDL process** establishes the maximum amount of pollutants a waterbody can assimilate before water quality is impaired, then requires that this maximum level not be exceeded. A TMDL assessment determines the source or sources of a pollutant of concern, considers the maximum allowable level of that pollutant for the waterbody, then allocates to each source or category of sources a set level of the pollutant that it is allowed to discharge into the waterbody. Allocations to point sources are called

A TMDL is developed for each pollutant that is found to be contributing to the impairment of a waterbody or a segment of a waterbody. To allow a waiver for construction activities, a TMDL would need to address sediment, or a parameter that addresses sediment such as total suspended solids, turbidity, or siltation. Additional TMDLs addressing common pollutants from construction sites such as nitrogen, phosphorus, and oil and grease also may be necessary to ensure water quality protection and allow a waiver from the NPDES storm water program. More information on TMDLs can be found at http://www.epa.gov/owow/tmdl/.

Non-impaired waterbodies do not require TMDL assessments. However, construction site operators that discharge to non-impaired waterbodies are still eligible for this waiver. A construction site operator is eligible for a waiver if an analysis equivalent to a TMDL assessment is conducted for the pollutants of concern and it is determined through this analysis that small construction sites would not have to control their contribution of pollutants of concern to the waterbody to protect water quality. The analysis may also determine that allocations are not needed to protect water quality based on consideration of variables including existing in-stream concentrations; expected growth in pollutant contributions from all sources; and a margin of safety. In this situation, the construction site operator also qualifies for a waiver.

How would an operator qualify for, and certify to, this waiver?

EPA expects that when TMDLs, or equivalent analyses are completed, there may be a determination that certain classes of sources, such as small construction sites, would not have to control their contribution of pollutants of concern to the waterbody in order for the waterbody to be in attainment with water quality standards (i.e., these sources were not assigned wasteload allocations). In such a case, to qualify for the Water Quality waiver, the operator of the construction site would need to certify that its construction activity will take place, and the storm water discharges will occur, within the area covered either by the TMDLs or equivalent analysis. A certification form would likely be provided by the NPDES permitting authority.

5.3 PERMIT OPTIONS

The Storm Water Phase II Rule requires operators of small construction activities to obtain National Pollutant Discharge Elimination System (NPDES) permit coverage because their storm water discharges are considered "point sources" of pollution. Point source pollutant discharges, unlike nonpoint sources such as agricultural runoff, are required under the Clean Water Act (CWA) to be covered by federally enforceable NPDES permits.

NPDES storm water permits are issued by an NPDES permitting authority, which may be an NPDES-authorized State or a U.S. EPA Region in non-authorized States (see *Appendix A* for a list of U.S. EPA Regions). Once a permit application is submitted by the operator of a small construction activity, the conditions of the permit must be satisfied (i.e., implementation of a storm water pollution prevention plan). This section addresses the permit options under the Phase II regulations for operators of small construction activity, as well as for the permitting authority. The permit requirements are discussed in Section 5.4.

5.3.1 For Operators of Small Construction Activity: What Types of Permit Coverage Are Available?

Similar to the Phase I program for large construction activity, the Phase II approach allows operators of small construction activities to choose between two permitting options. Each NPDES permitting authority has the discretion, however, to determine which options are available to operators of small construction activities in their jurisdiction.

1) General Permits

General permits are strongly encouraged by EPA for small construction activity. EPA anticipates that the existing general permit for large construction activity will serve as a model for small construction activity general permits.

General permits prescribe one set of requirements for all applicable permittees. General permits are drafted by the NPDES permitting authority, then published for public comment before being finalized and issued.

A Notice of Intent (NOI) serves as the application for the general permit. Under the Phase II Rule, NPDES permitting authorities have the discretion to not require submittal of an NOI under a general permit for small construction activity.

Small construction operators must submit an NOI and obtain coverage under a general permit by March 10, 2003 or an earlier date set by the permitting authority (if this option is available).

2) Individual Permits

NPDES permitting authorities may deny coverage under general permits and require operators to submit an individual NPDES permit application based on information such as water quality data.

In the event that an NPDES permitting authority decides to issue an individual construction permit for small construction activity, operators are subject to the individual application requirements found at 40 CFR §122.26(c)(1)(ii).

For any discharges of storm water associated with small construction activity identified in §122.26(b)(15) that are not authorized by a general permit, an individual permit application must be submitted to the permitting authority by

March 10, 2003.

5.3.2 For the NPDES Permitting Authority

5.3.2.1 Alternative Option for Writing Permit Requirements: Referencing a Qualifying State, Tribal or Local Erosion and Sediment Control Program

Under §122.44(s) of the Phase II Rule, permitting authorities have the flexibility to develop permit conditions that incorporate by reference qualifying State, Tribal, or local erosion and sediment control programs into permits for large and small construction activity.

To be considered a qualifying State, Tribal, or local program, the program must require construction site operators to:

- Implement appropriate erosion and sediment control BMPs;
- Control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the site that may cause adverse impacts to water quality;
- Submit a site plan for review that incorporates consideration of potential water quality impacts; and
- Develop and implement a storm water pollution prevention plan (SWPPP) containing elements similar to those required by other NPDES construction storm water permits.

In addition to these elements, a qualifying program for large construction activities must also include any additional requirements necessary to achieve the applicable technology-based standards of "Best Available Technology" (BAT) and "Best Conventional Technology" (BCT) based on the best professional judgment of the permit writer.

> **Important Note:** Not all the construction programs administered by NPDES-permitted MS4s would qualify. A primary reason for this is because NPDES-permitted MS4s are not obligated under their permit to require construction operators to develop a SWPPP.

Should a State, Tribal, or local program include one or more, but not all, of the elements listed above, the NPDES permitting authority can reference the program in the permit, provided it also lists the missing element(s) as a condition in the permit.

5.3.2.2 Permit Application: Optional Use of NOIs

Under the Phase II Rule, EPA is providing NPDES permitting authorities with the discretion to not require NOIs under a general permit for discharges from small construction activity, if desired. EPA does, however, recommend the use of NOIs for tracking permit coverage and prioritizing inspections and enforcement. This alternative option does not apply to general permits for large construction activity.

5.4 PERMIT REQUIREMENTS

The Phase II Rule requires operators of small construction sites, nationally, to obtain an NPDES permit and implement practices to minimize pollutant runoff. The Phase II Rule directs permitting authorities to develop and issue permits for small construction activity no later than December 9, 2002. Operators of small construction activity will be required to obtain permit coverage by March 10, 2003, or an earlier date set by the permitting authority. However, operators may have to comply with local, State, or Tribal construction runoff control programs (see section 4.6.2.4 for information on the Phase II small MS4's construction program).

For the Phase II small construction program, EPA has taken an approach similar to Phase I where the program requirements are not fully defined in the rule but rather in the NPDES permit by the NPDES permitting authority. EPA recommends that the NPDES permitting authorities use their existing Phase I NPDES construction general permits as a guide to developing their Phase II construction permits. In doing so, the Phase II requirements would be similar to the Phase I requirements described in subsection 5.4.2, although the applicable standards for small construction activity are different as outlined in subsection 5.4.1.

5.4.1 Applicable Water Quality Standards

Unlike the technology-based standards of BAT and BCT that are applicable to large construction activity, an operator of small construction activity is required to design its pollutant control plan so that it:

- Protects water quality (under CWA section 402(p)(6)); and
- Satisfies the appropriate water quality requirements of the CWA.

The water quality standards for large and small construction activity are different because they were designated into the NPDES storm water program under two separate sections of the CWA with differing standards Practically, though, the standard for small construction activity would be substantively the same as the standard for large construction activity.

5.4.2 Potential Small Construction Activity Permit Requirements

EPA currently has only one type of permit available for construction activity operators, the NPDES Construction General Permit. This permit provides coverage to large construction activities only. EPA expects any general permit for small construction activity to be very similar to the CGP. To gain familiarity with the CGP, the three main elements of the CGP are included below.

> **Important note:** This section on the CGP requirements is included for informational purposes only in order to provide a sense of what the permit requirements for small construction activity may be – these are not the requirements for small construction activity.

5.4.2.1 Notice of Intent

A complete and accurate NOI must be submitted to the NPDES permitting authority. An NOI includes general information and a certification that the activity will not impact endangered or threatened species. This certification is unique to EPA's NOI and is not a requirement of most NPDES-delegated State's NOIs.

An NOI must be postmarked at least two days prior to commencement of any work on site (if the operator has control over plans and specifications) or two days prior to commencement of the operator's portion of the work (if the operator has only day-to-day operational control).

5.4.2.2 Storm Water Pollution Prevention Plan (SWPPP)

The most important requirement of the CGP is the construction storm water pollution prevention plan (SWPPP) that includes the appropriate BMPs to minimize the discharge of pollutants from the site. The CGP requires at least one SWPPP for each construction project or site.

The construction site operator, or operators, must develop the SWPPP prior to submitting the NOI to obtain permit coverage. Unlike the NOI and other reporting forms, the operator(s) does not submit the SWPPP to the permitting authority. Instead, the SWPPP remains onsite and made accessible according to the requirements described in the CGP.

The SWPPP comprises several elements:

- **Site description.** This will contain a description of potential pollutant sources and other information.
- **Controls (BMPs).** This part of the SWPPP must clearly describe not only the controls, but also the timing and responsible permittee for implementing the controls in the following categories:
    - Erosion and Sediment Controls
    - Storm Water Management Controls

- Other Controls

- **Inspections.** Another critical element of the SWPPP is regular inspections of disturbed areas of the site that has not been stabilized; exposed materials storage areas; structural controls; and vehicle entrances and exits.

- **Maintenance.** The SWPPP also requires that operators perform maintenance on the controls (BMPs) to ensure they are in effective operating condition.

- **Signatures.** The SWPPP must be signed by at least one of the persons responsible for submitting an NOI for the project.

- **Accessibility.** The CGP requires the operator(s) to retain a copy of the SWPPP at the construction site or other local location accessible to the permitting authority.

More information on the construction SWPPP requirements can be found in the CGP, published on February 17, 1998 (63 *FR* 7858, p. 7906). EPA has also issued a construction general permit for Regions IV and VI. Contact your EPA Regional office or State environmental agency for information on construction permits in your State. In addition, EPA published a construction SWPPP guidance in a document entitled *Storm Water Management for Construction Activities: Developing Storm Water Pollution Prevention Plans and Best Management Practices* (EPA 832-R-92-005, September 1992).

5.4.2.3 Notice of Termination (NOT)

A completed Notice of Termination (NOT) must be submitted to the NPDES permitting authority within 30 days after one or more of the following conditions have been met:

- Final stabilization has been achieved on all portions of the site for which the permittee is responsible;

- Another operator/permittee has assumed control over all areas of the site that have not been finally stabilized; or

- For residential construction only: temporary stabilization of a lot has been completed prior to transference of ownership to the homeowner, with the homeowner being made aware of the need to perform final stabilization.

5.5 INTEGRATION OF NPDES PROGRAM FOR CONSTRUCTION WITH NPDES PROGRAM FOR MS4S

There is often confusion about the interaction between the NPDES Storm Water Program for construction activity, which has been the topic of discussion in this section, and the construction runoff control program implemented by NPDES-regulated MS4s, which was the topic of discussion in section 4.6.2.4.

- These are two separate and distinct construction programs.

- A construction operator is subject to requirements under BOTH programs if it is located in an NPDES-regulated MS4's jurisdiction.

The NPDES Storm Water Program for Construction is administered by the NPDES permitting authority, either the State or an EPA Regional Office.

- This program requires the construction site operator to seek coverage under an NPDES storm water discharge permit for construction. The current permit, the Construction General Permit, requires the operator to submit an NOI, develop a SWPPP, and comply with other applicable NPDES storm water discharge permit requirements.

- The Construction General Permit (CGP) currently only applies to large construction activity disturbing greater than 5 acres. Permits for small construction activity will be issued by each NPDES permitting authority by December 9, 2002.

The NPDES Storm Water Program for MS4s: MS4 Construction Runoff Control Programs are administered by the MS4 operator. The MS4 operator's NPDES storm water discharge permit requires it to establish requirements to control storm water discharges from construction activity and new development and redevelopment.

- Regulated small MS4s must control 1 acre and above.

- Medium and large MS4s have no particular size thresholds that they must control – differs among MS4s

- The specific requirements of the construction programs will vary among MS4s. An MS4 permit typically does not specify that the MS4 operator must require a SWPPP or that a permit application be submitted.

5.6 SMALL CONSTRUCTION ACTIVITY COMPLIANCE PROCESS: What Do I Need To Do To Comply?

Sections 5.1 through 5.5 of this guidance have provided details on who's covered, who may be waived, and what may be required under the Phase II regulations for small construction activity. Now that you are familiar with the Phase II program, this section walks you through the process, from beginning to end, that an operator of a small construction activity should take to comply with the regulation. This step-by-step "walk-through" assumes the issuance of a general permit for small construction activity that is similar to the CGP. Remember, the general permit for small construction activity may have different requirements, timeframes, and deadlines than what is noted here. Repeat the steps for each individual construction site.

The last page of this section includes a permitting decision tree to help operators of construction activity determine if they need an NPDES storm water permit. By starting in the upper left hand corner, an operator can follow the decision tree to determine if they fall under Phase I, Phase II, or are eligible for a waiver.

Step 1: Determine if your construction site will discharge storm water runoff into a MS4 (see section 4.1.1 for definition) or to waters of the United States. If so, proceed to Step 2. If not, stop here.

> ***Waters of the United States*** include interstate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce. (Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA are not waters of the United States.) A complete definition can be found at 40 CFR 122.2.

Step 2: Determine if your construction site's storm water discharge will meet the definition of a "storm water discharge associated with small construction activity." If so, proceed to Step 3. If not, stop here. (See section 5.1.2)

Step 3: If your site meets the definition of small construction activity, determine if it qualifies for a waiver from the permit requirements. If so, stop here. If not, proceed to Step 4. (See section 5.2)

Step 4: Obtain and read the applicable storm water discharge permit for small construction activity (or the CGP until the small construction permit has been issued to get a sense of the upcoming permit requirements). The small construction permit should be issued by the NPDES permitting authority by December 9, 2002. (See section 5.4.2 for potential requirements)

Step 5: Determine which parties are considered *operators* and, therefore, are responsible for complying with the requirements described in the storm water permit for small construction activity (See section 5.1.3)

Step 6: Develop a SWPPP. (See section 5.4.2.2)

- SWPPPs must be developed prior to submitting the NOI.
- You do not need to submit the SWPPP to your NPDES permitting authority, however, it should be accessible to the public.

Step 7: Complete and submit an NOI. (See section 5.4.2.1)

- Your NPDES permitting authority may or may not require a NOI. If so, the Phase II regulation requires that you submit your NOI no later than March 10, 2003 (or 90 days after the NPDES permitting authority issues the permit, whichever comes first).
- Submit a completed NOI to your NPDES permitting authority two days prior to beginning work at the construction site.

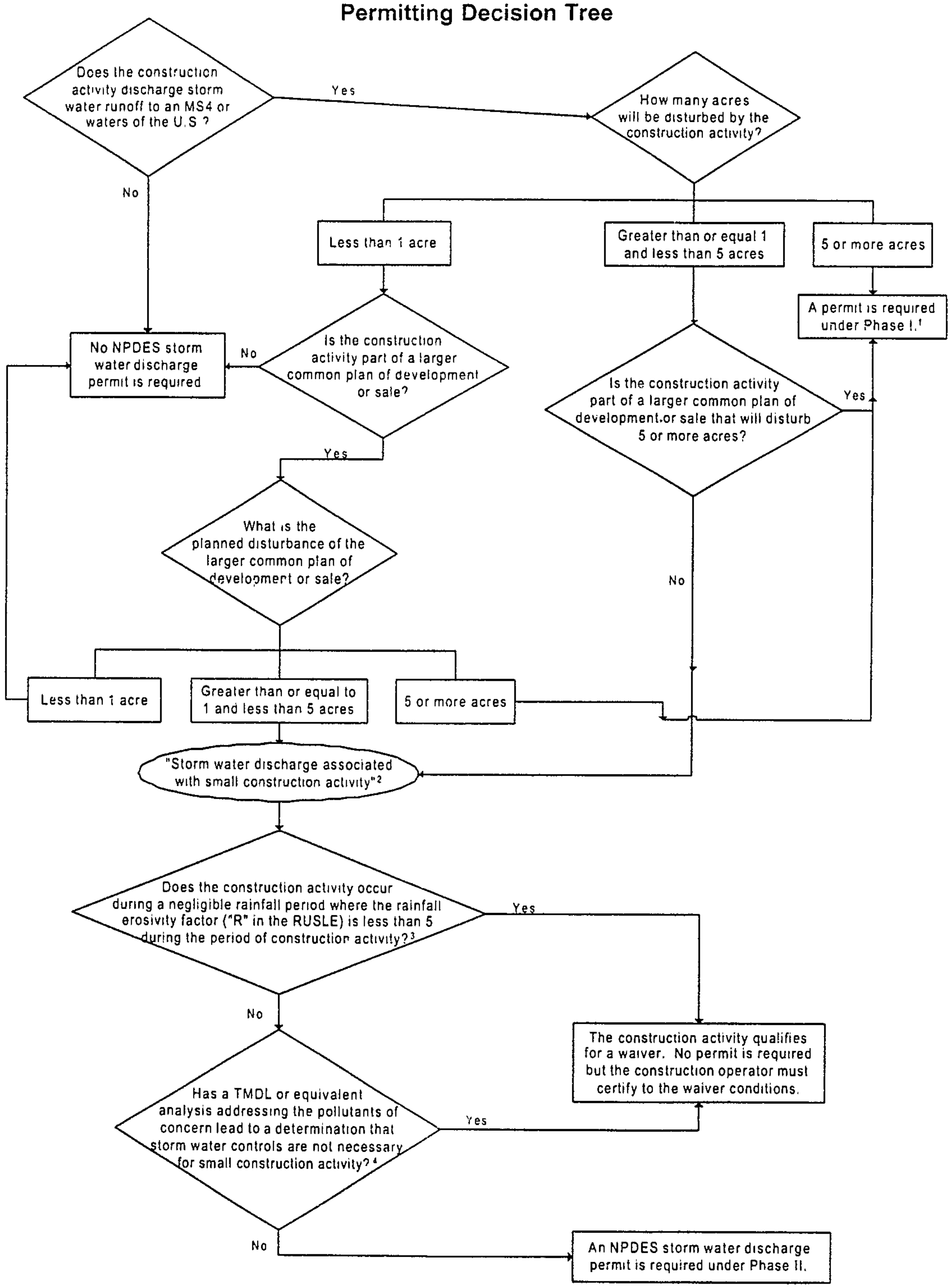
Step 8: Implement the SWPPP.

- Includes generation of inspection reports that are to be kept on-site.

Step 9: Complete and submit an NOT. (See section 5.4.2.3)

- Submit a completed NOT to your NPDES permitting authority within 30 days after one or more of the appropriate conditions have been met.

Construction Activities Storm Water Program Permitting Decision Tree



1. Construction activity disturbing, or part of a planned disturbance of five or more acres is a "storm water discharge associated with industrial activity" under category (x). See 40 CFR 122.26(b)(14)(x)
2. See new 122.26(b)(15) for the definition of "storm water discharge associated with small construction activity."
3. See new 122.26(b)(15)(i)(A) for more details
4. See new 122.26(b)(15)(i)(B) for more details.

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6.0 INDUSTRIAL ACTIVITY

After reading section 6.0, you should understand the basic components and requirements of the Phase II regulations as they affect the categories of industrial activity covered by the Phase I regulations. Phase II revises the original Phase I industrial no exposure exemption and also sets a new deadline for permit coverage for the municipally-owned industrial activity that had been temporarily exempted from storm water permit coverage.

6.1 PHASE I INDUSTRIAL ACTIVITY: What Industrial Activities are Covered by Phase I of EPA's Storm Water Program?

The 1990 storm water regulations for Phase I of the federal storm water program identify eleven categories of industrial activities under the definition of a "storm water discharge associated with industrial activity" that must obtain a National Pollutant Discharge Elimination System (NPDES) permit. The categories contain industries listed either by reference to an industry's Standard Industrial Classification (SIC) code, or by a short narrative description of the activity found at the industrial site (see text box at right for more detailed descriptions). For facilities that match the SIC codes or description in one of the categories, only those that have a storm water discharge to a *municipal separate storm sewer system (MS4)* or *waters of the United States* are required to seek permit coverage. The NPDES permit requirements vary between individual and general permits, but in general involve the development of a storm water pollution prevention plan based upon site assessments, monitoring and reporting data on storm water discharges, and mitigating any possible effects of discharges on endangered species and national historic properties (for EPA issued permits).

Storm Water Discharge Associated with Industrial Activity (40 CFR 122.26(b)(14)(i) - (xi))

- Facilities subject to storm water effluent limitation guidelines; new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N.
- "Heavy" industrial facilities with SIC codes listed in 40 CFR 122.26(b)(14)(ii), (iii), and (vi)
- "Light" industrial facilities with SIC codes listed in 40 CFR 122.26(b)(14)(xi), which conduct the activities specified in that sections.
- Hazardous waste treatment, storage, or disposal facilities.
- Landfills, land application sites, and open dumps that receive or have received industrial waste.
- Steam electric power generating facilities.
- Sewage treatment works.
- Construction activity (including clearing, grading, and excavation) disturbing five or more acres of land, or less than five acres of land if it is part of a larger common plan of development or sale of five acre or greater.

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Under the Phase I regulations, operators of facilities within category eleven (xi), commonly referred to as "light industry," were exempted from the definition of "storm water discharge associated with industrial activity," and the subsequent requirement to obtain an NPDES permit, provided their industrial materials or activities were not "exposed" to storm water. This Phase I no exposure exemption from permitting was limited to those facilities identified in category (xi), and did not require category (xi) facility operators to submit any information supporting their no exposure claim.

In 1992, the Ninth Circuit court remanded to EPA for further rulemaking the no exposure exemption for light industry after making a determination that the limited exemption was arbitrary and capricious. The result was a revised no exposure exemption (now an "exclusion") as part of the Phase II regulation.

6.2 PHASE II NO EXPOSURE EXCLUSION: What is the Conditional No Exposure Exclusion for Industrial Activity as Revised by this Regulation?

The intent of the no exposure provision is to provide a simplified method for complying with the Clean Water Act to all industrial facilities that are entirely indoors. This includes facilities that are located within a large office building, or at which the only items permanently exposed to precipitation are roofs, parking lots, vegetated areas, and other non-industrial areas or activities.

As revised in the Phase II regulation, if a condition of No Exposure exists at a Phase I industrial facility, then permits will not be required for storm water discharges from these facilities. All industrial facilities that have no exposure of materials to storm water, including the "light industrial" facilities, must submit a certification to the permitting authority. The facility must certify that a condition of No Exposure exists at its facility and either maintain a condition of no exposure or obtain a permit. The following subsections discuss who is eligible for the revised no exposure exclusion, the definition of no exposure, and the requirement to submit a written certification of no exposure in place of a permit application.

6.2.1 Who is Eligible to Qualify for the No Exposure Exclusion?

The Phase II Conditional No Exposure Exclusion represents a significant expansion in the scope of the original no exposure provision in terms of eligibility. Now, all Phase I industrial categories with a condition of no exposure, except for construction activity, are eligible for the no exposure exclusion. The exclusion from permitting is available on a facility-wide basis only, not for individual outfalls

6.2.2 What is the Definition of No Exposure?

The Phase II regulatory definition of no exposure is as follows:

> ***No exposure*** means all industrial materials and activities are protected

by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff. Industrial materials or activities include, but are not limited to, material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products, or waste products.

A storm resistant shelter is not required for the following industrial materials and activities:

- Drums, barrels, tanks, and similar containers that are tightly sealed, provided those containers are not deteriorated and do not leak. "Sealed" means banded or otherwise secured and without operational taps or valves;
- Adequately maintained vehicles used in materials handling;
- Final products, other than products that would be mobilized in storm water discharges (e.g., rock salt).

The term "storm-resistant shelter," as used in the no exposure definition, includes completely roofed and walled buildings or structures, as well as structures with only a top cover but no side coverings, provided material under the structure is not otherwise subject to any run-on and subsequent runoff of storm water.

While the intent of the no exposure provision is to promote a condition of permanent no exposure, certain machinery, such as trucks, may become temporarily exposed to rain and snow while passing between buildings. Adequately maintained mobile equipment (e.g., trucks, automobiles, forklifts, trailers, or other such general purpose vehicles found at the industrial site that are not industrial machinery, and that are not leaking contaminants or are not otherwise a source of industrial pollutants) also can be exposed to precipitation or runoff. Such activities alone would not prevent a facility from certifying to no exposure. Similarly, trucks or other vehicles awaiting maintenance at vehicle maintenance facilities that are not leaking contaminants or are not otherwise a source of industrial pollutants, would not be considered exposed.

EPA recognizes that there are circumstances where permanent no exposure of industrial activities or materials is not possible and, therefore, under such conditions, materials and activities could be sheltered with temporary covers (e.g., tarps) between periods of permanent enclosure. The No Exposure provision does not specify every such situation, but NPDES permitting authorities can address this issue on a case-by-case basis.

The Phase II regulation also addresses particulate matter emissions from roof stacks/vents. If regulated by, and in compliance with, other environmental protection programs (i.e., air quality control programs) and not causing storm water contamination, they are considered not exposed. Particulate matter or visible deposits of residuals from roof stacks and/or vents not otherwise regulated (i.e., under an air quality control program) and evident in storm water outflow are considered "exposed." Likewise, visible "track out" (i.e., pollutants carried on the tires of vehicles) or windblown raw materials are considered "exposed." Leaking pipes containing contaminants exposed to storm water are deemed "exposed," as are past sources of storm water contamination that remain onsite. General refuse and trash, not of an industrial nature, is not considered exposed as long as the container is completely covered and nothing can drain out holes in the bottom, or is lost in loading onto a garbage truck. Industrial refuse and trash that is left uncovered, however, is considered "exposed."

6.2.3 What Do I Need To Know About Certifying to a Condition of No Exposure?

In order to obtain the Conditional No Exposure exclusion, you will have to submit written certification that your facility meets the definition of "no exposure," even if you are a category (xi) facility operator. The Phase II Rule included as an appendix to the preamble a four-page No Exposure Certification form to be used for this purpose in areas where EPA is the NPDES permitting authority. EPA's certification form uses a series of yes/no questions which you must answer regarding the your industrial activity. You may certify to no exposure if you can answer "no" to all of the questions.

> **Important note:** EPA's No Exposure Certification form applies only in areas where EPA is the NPDES permitting authority. Where a State is the NPDES permitting authority, the State will issue its own form. Since most aspects of EPA's form are also regulatory requirements as to what must be included within a written certification of no exposure, you may expect the State forms to be very similar to EPA's.

The Certification form serves two purposes: 1) as an aid to help you in determining whether you have a condition of No Exposure at your facility or site, and 2) as the necessary written certification of No Exposure, provided you are able to answer all the questions in the negative.

- ❑ If, after you have completed the form, you find that you answered "yes" to one or more of the questions about possible exposure, you must make the appropriate changes at the facility if you still wish to apply for the conditional exclusion. These changes must remove the particular material, process, or activity at the facility or site from exposure to storm water.

- ❑ If, after completing the form, you find that you were able to check "no" to every question, you qualify for the no exposure exclusion and must sign and submit the form to your NPDES permitting authority.

Certification Facts:
- The certification must be completed and submitted to your permitting authority once every 5 years, and can only be done so if the condition of no exposure continues to exist at the facility.
- The Certification must be provided for each facility qualifying for the no exposure

exclusion.

- The form is non-transferable. If a new operator takes over your facility, they must complete, sign, and submit a new form to claim the no exposure exclusion when they assume control over the operations of the facility.

6.2.4 Are There Any Concerns Related to Water Quality Standards?

Yes. An operator certifying that its facility qualifies for the conditional no exposure exclusion may, nonetheless, be required by the permitting authority to obtain permit authorization. Such a requirement would follow the permitting authority's determination that the facility's discharge is likely to have an adverse impact on water quality.

Many efforts to achieve no exposure can employ simple good housekeeping and contaminant cleanup activities such as moving materials and activities indoors into existing buildings or structures. In limited cases, however, industrial operators may make major changes at a site to achieve no exposure. These efforts may include constructing a new building or cover to eliminate exposure or constructing structures to prevent run-on and storm water contact with industrial materials and activities. Major changes undertaken to achieve no exposure, however, can increase the impervious area of the site, such as when a building is placed in a formerly vegetated area. Increased impervious area can lead to an increase in the volume and velocity of storm water runoff, which, in turn, can result in a higher concentration of pollutants in the discharge, since fewer pollutants are naturally filtered out.

The concern of increased impervious area is addressed in one of the last questions on the Certification form, which asks, "Have you paved or roofed over a formerly exposed, pervious area in order to qualify for the no exposure exclusion? If yes, please indicate approximately how much area was paved or roofed over." This question is intended to aid the NPDES permitting authority in assessing the likelihood of such actions interfering with water quality standards. Where this is a concern, the facility operator and its NPDES permitting authority should take appropriate actions to ensure that water quality standards can be achieved.

6.2.5 Industrial Program Compliance Process: What Do I Need To Do To Obtain the No Exposure Exclusion and Comply with Applicable Requirements?

Sections 6.1 through 6.2.4. of this guidance have provided information necessary to understand the conditional no exposure exclusion. Now that you are familiar with the no exposure exclusion, this section walks you through the process, from beginning to end, that an operator of industrial activity will need to take to comply with the Phase II regulation. This step-by-step "walk-through" assumes the issuance of a no exposure certification form that is similar to EPA's form. Remember, a State's certification form may have different requirements and deadlines than what is noted here. Repeat the steps for each individual facility or site.

Step 1: Determine if your industrial activity meets the definition of a "discharge associated with industrial activity." If so, proceed to Step 2. If not, stop here. (See section 6.1)

- If you are a regulated industrial operator, you need to **either** apply for a storm water permit, **or** submit a no exposure certification, in order to be in compliance with the NPDES storm water regulations. Any storm water permit you may currently hold becomes null and void once a completed conditional no exposure certification form is submitted

Step 2: Obtain the no exposure certification form from your NPDES permitting authority. Determine if your regulated industrial activity meets the definition of " no exposure" and qualifies for the exclusion from permitting. If it does, proceed to Step 3. If not, stop here and obtain industrial storm water permit coverage (probably through the multi-sector general permit or similar permit).

- The conditional no exposure exclusion option is currently available only for facilities in areas where EPA is the NPDES permitting authority. In all other areas, where the State is the NPDES permitting authority, the facility operators will need to wait until the State makes the option available.

Step 3: Submit the certification form to your NPDES permitting authority -- a new form must be submitted once every 5 years.

- Be aware that even when you certify to no exposure, your NPDES permitting authority still retains the authority to require you to apply for an individual or general permit if it has determined that your discharge is contributing to the violation of, or interfering with the attainment or maintenance of, water quality standards, including designated uses.

Step 4: Submit a copy, upon request, of the certification form to the municipality in which the facility is located.

Step 5: Allow your NPDES permitting authority or, if discharging into a municipal separate storm sewer system, the operator of the system, to (1) inspect the facility and (2) make such inspection reports publicly available upon request.

Step 6: Maintain a condition of no exposure.

- The no exposure exclusion is conditional and not an outright exemption. Therefore, if there is a change in circumstances that causes exposure of industrial activities or materials to storm water, the you are required to comply immediately with all the requirements of the NPDES Storm Water Program, including applying for and obtaining a storm water discharge permit.

- Failure to maintain the condition of no exposure or obtain coverage under an NPDES permit can lead to the unauthorized discharge of pollutants to waters of the United States, resulting in penalties under the CWA.

6.3 ISTEA MORATORIUM: How Has this Regulation Affected the Municipally-Operated Industrial Activity Subject to the Intermodal Surface Transportation Enforcement Act (ISTEA) Moratorium?

Provisions within ISTEA temporarily delayed the deadline for Phase I industrial activities operated by municipalities with populations of less than 100,000 people to obtain an NPDES storm water discharge permit. Congress delayed the permitting deadline to allow small municipalities additional time to comply with NPDES requirements. This moratorium on permitting did not apply to power plants, airports, and uncontrolled sanitary landfills operated by small municipalities.

The Phase II Rule slightly extended this temporary exemption from permitting and set a deadline of no later than March 10, 2003 for all ISTEA-exempted municipally-operated industrial activities to obtain NPDES permit coverage. Of course, like any other regulated industrial activity, these municipally-operated industrial activities are eligible to qualify for the no exposure exclusion from permitting if a condition of no exposure exists. Municipal-operators must follow the same procedures outlined in Section 6.2.4 in order to obtain an exclusion from permitting.

Many of the small municipalities that will now have to obtain permit coverage for their industrial activity will also have to obtain permit coverage for their small MS4 (see section 4.0) and small construction activity (see section 5.0). The Phase II regulation deadlines for industrial, small MS4, and small construction permit coverage are all the same – no later than March 10, 2003 – to allow the NPDES permitting authority to issue one individual permit that covers all three components if it chooses to do so.

7.0 THE COMPLIANCE ASSURANCE PROCESS

After reading section 7, you should understand how EPA will determine compliance, what happens if you or the EPA discovers noncompliance, and where to go for compliance assistance information.

7.1 How Will EPA Determine Compliance?

EPA employs several approaches to monitor compliance with its environmental regulations, including both EPA-initiated and facility-initiated methods.

1. **Inspections** – EPA may conduct periodic inspections at facilities subject to this regulation. Inspections may be initiated by disclosures to EPA, randomly selecting facilities, or a variety of targeting methods. Inspections may be used, for instance, to monitor recordkeeping requirements, visit sites where storm water controls should be in place, and/or verify that facilities have permits.

2. **Permits, Records, and Reports** – Permits are not required for small construction sites and regulated small MS4s for up to three years and 90 days from the effective date of the final rule. After general permits are issued, the NPDES permitting authorities intend to use the data in storm water permit applications, construction waiver certifications, storm water pollution prevention plans (SWPPPs), no exposure certifications, records, and reports (as required by the Phase II regulation) to set appropriate permit conditions and track discharges covered by a storm water permit. Compliance and enforcement authorities will use the information to assess the regulated entity's level of compliance.

3. **Review of No Exposure Certifications** – Operators of industrial facilities that are eligible for a no exposure exclusion from the NPDES permitting requirements may prepare, and submit for review, a no exposure certification. NPDES authorities will use the information contained in the certification in determining compliance with the no exposure provisions. This information will particularly assist in determining compliance with the no exposure certification in conjunction with complaints from the public.

4. **Self-audit and Self Disclosure** – Facilities have the primary responsibility for ensuring that they are in continuous compliance. EPA encourages the facility to take advantage of EPA's Audit Policy, Small Business Policy, or Small Community Policy (these will be discussed in more detail in section 7.2).

   In addition to this document, to aid in determining whether it is in compliance, the facility might use a document currently being developed by EPA entitled "Protocol for Conducting Environmental Compliance Audits under the Storm

Water Program." This protocol, which is a part of a set containing other statute-specific audit protocols, is a tool to assist and encourage businesses and organizations to perform environmental audits and disclose violations in accordance with EPA's Audit Policy. The protocol provides guidance on key requirements, defines regulatory terms, gives an overview of the federal laws affecting a particular environmental management area, and includes a checklist for review of the facility: EPA anticipates making the document available for public use in summer 2000. To see a sample of protocols that have been completed under other statutes (RCRA, EPCRA, CERCLA), visit the Internet site: http://es.epa.gov/oeca/ccsmd/profile.html.

7.2 If I Discover a Violation, How Can I Work With The Agency to Correct It?

EPA promotes environmental compliance by providing incentives. By participating in compliance assistance programs or voluntarily disclosing violations and promptly correcting violations, businesses may get penalty waivers or reductions. EPA has three policies that potentially apply to entities regulated by the Storm Water Phase II Rule. These policies do not apply if an enforcement action has already been initiated.

Audit Policy. The first of these policies is *"Incentives for Self-Policing: Discovery, Disclosure, Correction and Prevention of Violations"* (60 FR 66706), known as the "Audit Policy". EPA initiated this policy to provide entities of all sizes with incentives to voluntarily discover and promptly disclose and correct violations of environmental regulations. For a more detailed description of the Audit Policy, visit the Internet site at: www.epa.gov/oeca/polguid/polyguid1.html.

Small Business Policy. EPA's *"Policy on Compliance Incentives for Small Business"* was developed to help small businesses with 100 or fewer employees achieve environmental compliance by creating benefits for businesses that make a good faith effort to comply with environmental regulations before a government agency discovers a violation or otherwise takes an enforcement action. The Policy currently provides incentives, such as penalty waivers or penalty reduction, for businesses that participate in on-site compliance assistance programs or conduct environmental audits to discover, disclose, and correct violations. The Policy is presently being modified to broaden when and how a small business can take advantage of the Policy. Revisions are expected in spring of 2000. Please see www.epa.gov/oeca/polguid or contact Ginger Gotliffe (202-564-7072) for more information.

Small Community Policy. The *"Policy on Flexible State Enforcement Responses to Small Community Violations"* (November 1995) promotes alternative strategies for communities to achieve environmental and economic goals. States are encouraged to use multimedia compliance assistance and prioritize compliance issues to address specific needs of their small communities. As long as states work within the parameters of the Policy, EPA will generally defer to their decision to waive part or all of the penalty for a small community's environmental violations. This approach allows small communities to apply their limited resources to fixing their environmental problems, rather than to paying penalties. The policy applies to communities generally comprised of fewer than 2,500 residents. In the context of the Storm Water Phase II Rule, small MS4s that are not eligible for waivers from their regulatory requirements would be most likely to take advantage of this policy. For a more detailed description of the Small Communities Policy, visit the Internet sites: www.epa.gov/oeca/scpolcy.html or www.epa.gov/oeca/ccsmd/mun.html.

7.3 Where Can I Go for Compliance Assistance on the Storm Water Phase II Rule?

The permitting authority is the leading source for information on the Storm Water Phase II Rule. EPA is also developing a "tool box" to assist States, Tribes, municipalities, and other parties involved in the Phase II program. This tool box will facilitate implementation of the storm water program in an effective and cost-efficient manner. The tool box is available on EPA's web page at http://www.epa.gov'owm/sw/phase2 and consists of the following eight major components:

- Fact Sheets
- Guidance Documents
- Menu of BMPs
- Training and Outreach Efforts
- Information Clearinghouse
- Technical Research
- Support for Demonstration Projects
- Compliance Monitoring/Assistance Tools

In addition, EPA provides widely available compliance assistance through the establishment of national compliance assistance centers, in partnership with industry, academic institutions, and other federal and state agencies. Centers have been established that provide services for several industries that contain many small businesses. Compliance assistance centers offer a range of communications services, including Web sites, e-mail groups, fax-back systems, and telephone assistance lines. Each Center is targeted to a specific sector and explains relevant federal environmental regulations. For instance, local governments can use the services of the Local Government Environmental Assistance Network (LGEAN). LGEAN is a "first-stop shop" providing environmental management, planning, and regulatory information for local government elected and appointed officials, managers, and staff. It provides 24-hour access to regulatory and pollution prevention information, message boards, regulatory updates, grants and information, and more. It is a good source for compliance assistance information on the Storm Water Phase II Rule.

For more information on EPA's compliance assistance centers, please contact Tracy Back (202-564-7076). You can access all the centers through www.epa.gov/oeca/mcfac.html or individually at:

EPA's Compliance Assistance Centers

Center	Phone	Web Address
Local Government Environmental Assistance Network (LGEAN)	1-877-TO-LGEAN	www.lgean.org
National Metal Finishing Resource Center	1-800-AT-NMFRC	www.nmfrc.org
Printers' National Environmental Assistance Center	1-888-USPNEAC	www.pneac.org
CCAR-Greenlink (the Automotive Compliance Information Assistance Center)	1-888-GRN-LINK	www.ccar-greenlink.org
National Agriculture Compliance Assistance Center	1-888-663-2155	www.epa.gov/oeca/ag
Printed Wiring Board Resource Center	1-734-995-4911	www.pwbrc.org
ChemAlliance	1-800-672-6048	www.chemalliance.org
Transportation Environmental Resource Center	1-888-459-0656	www.transource.org
Paints and Coatings Resource Center	1-800-286-6372	www.paintcenter.org

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7.4 If the Agency Discovers a Violation, What Might Be Its Response?

To maximize compliance, EPA implements a balanced program of compliance assistance, compliance incentives, and traditional law enforcement. EPA knows that small businesses which must comply with complicated new statutes or rules often want to do the right thing, but may lack the requisite knowledge, resources, or skills. Compliance assistance information and technical advice helps small businesses to understand and meet their environmental obligations. Compliance incentives, such as our Small Business Policy, encourage persons to voluntarily discover, disclose, and correct violations before they are identified by the government. EPA's strong law enforcement program protects all of us by targeting persons who neither comply nor cooperate to address their problems.

EPA uses a variety of methods to determine whether regulated entities are complying, including inspecting facilities, reviewing records and reports, and responding to citizen complaints. If we learn an entity is violating the law, EPA (or a State, if the program is delegated) may file an enforcement action seeking penalties of up to $27,500, per violation, per day. While the statutory maximum penalty is currently $27,500, it may be increased periodically based on inflation in accordance with the Debt Collection Improvement Act of 1996. The proposed penalty in a given case will depend on many factors, including the number, length, and severity of the violations, the economic benefit obtained by the violator, and its ability to pay. EPA has polices in place to ensure penalties are calculated fairly. These policies are available to the public. In addition, any company charged with a violation has the right to contest EPA's allegations and proposed penalty before an impartial judge or jury.

EPA recognizes that we can achieve the greatest possible protection by encouraging businesses and organizations to work with us to discover, disclose, and correct violations. That is why we have issued Audit, Small Business, and Small Community policies to eliminate or reduce penalties for small and large entities which cooperate with EPA to address compliance problems. To help the regulated community in understanding their requirements for compliance with the rule, EPA provides compliance assistance through its regional offices, Office of Enforcement and Compliance Assurance at Headquarters, and national compliance assistance centers partners.

ABBREVIATIONS:

BAT	Best Available Technology Economically Achievable (applies to non-conventional and toxic pollutants)
BCT	Best Conventional Pollutant Control Technology (applies to conventional pollutants)
BMP	Best Management Practice
BPJ	Best Professional Judgment
BPT	Best Practicable Control Technology Currently Available (generally applies to conventional pollutants and some metals)
CFR	Code of Federal Regulations
CGP	Construction General Permit
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflow
CWA	Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972)
CZARA	Coastal Zone Act Reauthorization Amendments
D.O.	Dissolved Oxygen
DMR	Discharge Monitoring Report
ELG	Effluent Limitations Guidelines
EPA	Environmental Protection Agency
FR	Federal Register
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
MSGP	Multi Sector General Permit
NOI	Notice of Intent
NOT	Notice of Termination
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPS	Non-point Source
O&M	Operation and Maintenance
OW	Office of Water
OWM	Office of Wastewater Management
PA	Permitting Authority
POTW	Publicly Owned Treatment Works
SIC	Standard Industrial Classification
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UA	Urbanized Area

DEFINITIONS:

Best Available Treatment(BAT)/Best Control Technology (BCT): A level of technology based on the very best (state of the art) control and treatment measures that have been developed or are capable of being developed and that are economically achievable within the appropriate industrial category.

Best Management Practices (BMPs): Activities or structural improvements that help reduce the quantity and improve the quality of storm water runoff. BMPs include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Category (xi) facilities: Specific facilities classified as light industry with equipment or materials exposed to storm water.

Clean Water Act (Water Quality Act): (formerly the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972). Public law 92-500; 33 U.S.C. 1251 et seq.; legislation which provides statutory authority for the NPDES program. Also know as the Federal Water Pollution Control Act.

Conveyance: The process of water moving from one place to another.

Discharge: The volume of water (and suspended sediment if surface water) that passes a given location within a given period of time.

Erosion: When land is diminished or worn away due to wind, water, or glacial ice. Often the eroded debris (silt or sediment) becomes a pollutant via storm water runoff. Erosion occurs naturally but can be intensified by land clearing activities such as farming, development, road-building, and timber harvesting.

Excavation: The process of removing earth, stone, or other materials from land.

General Permit: A permit issued under the NPDES program to cover a certain class or category of storm water discharges. These permits reduce the administrative burden of permitting storm water discharges.

Grading: The cutting and/or filling of the land surface to a desired slope or elevation.

Illicit Connection: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water and is not authorized by an NPDES permit, with some exceptions (e.g., discharges due to fire fighting activities).

Industrial Activity: Any activity which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant.

Large Municipal Separate Storm Sewer System (MS4): An MS4 located in an incorporated place or county with a population of 250,000 or more, as determined by the latest U.S. Census

Light Manufacturing Facilities: Described under Category (xi) of the definition of "storm water discharges associated with industrial activity." [40 CFR 122.26(b)(14)(xi)] Under the Phase I NPDES Storm Water Program, these facilities were eligible for exemption from storm water permitting requirements if certain areas and activities were not exposed to storm water. As a result of the Phase II Final Rule, these facilities must now certify to a condition of no exposure.

Maximum Extent Practicable (MEP): A standard for water quality that applies to all MS4 operators regulated under the NPDES Storm Water Program. Since no precise definition of MEP exists, it allows for maximum flexibility on the part of MS4 operators as they develop and implement their programs.

Medium Municipal Separate Storm Sewer System (MS4): MS4 located in an incorporated place or county with a population of 100,000 or more but less than 250,000, as determined by the latest U.S. Census.

Municipal Separate Storm Sewer System (MS4): A publically-owned conveyance or system of conveyances that discharges to waters of the U.S. and is designed or used for collecting or conveying storm water, is not a combined sewer, and is not part of a publicly-owned treatment works (POTW).

Multi-Sector General Permit (MSGP): An NPDES permit that regulates storm water discharges from eleven categories of industrial activities.

No exposure: All industrial materials or activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff. Industrial materials or activities include, but are not limited to, material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products, or waste products. Material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product or waste product.

Non-authorized States: any State that does not have the authority to regulate the NPDES Storm Water Program.

Non-point Source (NPS) Pollutants: Pollutants from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water.

Notice of Intent (NOI): An application to notify the permitting authority of a facility's intention to be covered by a general permit; exempts a facility from having to submit an individual or group application.

NPDES: "National Pollutant Discharge Elimination System" the name of the surface water quality program authorized by Congress as part of the 1987 Clean Water Act. This is EPA's program to control the discharge of pollutants to waters of the United States (see 40 CFR 122.2).

O&M Expenditures: The operating and maintenance costs associated with the continual workings of a project.

Outfall: The point where wastewater or drainage discharges from a sewer pipe, ditch, or other conveyance to a receiving body of water.

Permitting Authority (PA): The NPDES-authorized state agency or EPA regional office that administers the NPDES Storm Water Program. PAs issue permits, provide compliance assistance, and inspect and enforce the program.

Physically interconnected MS4: This means that one MS4 is connected to a second MS4 in such a way that it allows for direct discharges into the second system.

Point Source Pollutant: Pollutants from a single, identifiable source such as a factory or refinery.

Pollutant Loading: The total quantity of pollutants in storm water runoff.

Qualifying local program: A local, State or Tribal municipal storm water management program that imposes, at a minimum, the relevant requirements of one or more of the minimum control measures includes in 122.34(b).

Regulated MS4: Any MS4 covered by the NPDES Storm Water Program (regulated small, medium, or large MS4s).

Retrofit: The modification of storm water management systems through the construction and/or enhancement of wet ponds, wetland plantings, or other BMPs designed to improve water quality

Runoff: Drainage or flood discharge that leaves an area as surface flow or as pipeline flow. Has reached a channel or pipeline by either surface or sub-surface routes.

Sanitary Sewer: A system of underground pipes that carries sanitary waste or process wastewater to a treatment plant.

Sediment: Soil, sand, and minerals washed from land into water, usually after rain. Sediment can destroy fish-nesting areas, clog animal habitats, and cloud waters so that sunlight does not reach aquatic plants.

Sheet flow: The portion of precipitation that moves initially as overland flow in very shallow depths before eventually reaching a stream channel.

Site Plan: A graphical representation of a layout of buildings and facilities on a parcel of land.

Site Runoff: Any drainage or flood discharge that is released from a specified area.

Small Municipal Separate Storm Sewer System (MS4): Any MS4 that is not regulated under Phase I of the NPDES Storm Water Program and Federally-owned MS4s.

Stakeholder: An entity that holds a special interest in an issue or program -- such as the storm water program -- since it is or may be affected by it.

Standard Industrial Classification (SIC) Code: A four digit number which is used to identify various types of industries.

Storm Drain: A slotted opening leading to an underground pipe or an open ditch for carrying surface runoff.

Storm Water: Precipitation that accumulates in natural and/or constructed storage and storm water systems during and immediately following a storm event.

Storm Water Management: Functions associated with planning, designing, constructing, maintaining, financing, and regulating the facilities (both constructed and natural) that collect, store, control, and/or convey storm water.

Storm Water Pollution Prevention Plan (SWPPP): A plan to describe a process whereby a facility thoroughly evaluates potential pollutant sources at a site and selects and implements appropriate measures designed to prevent or control the discharge of pollutants in storm water runoff.

Surface Water: Water that remains on the surface of the ground, including rivers, lakes, reservoirs, streams, wetlands, impoundments, seas, estuaries, etc.

Total Maximum Daily Load (TMDL): The maximum amount of pollutants which can released into a water body without adversely affecting the water quality.

Tool Box: A term to describe the activities and materials that EPA plans to perform/produce to facilitate implementation of the storm water program in an effective and cost-efficient manner. The eight components include: 1)fact sheets; 2) guidance documents; 3) menu of BMPs; 4) compliance assistance; 5) information clearing house; 6) training and outreach efforts; 7) technical research; and 8) support for demonstration projects.

Urbanized Area (UA): A Bureau of the Census determination of a central place (or places) and the adjacent densely settled surrounding territory that together have a minimum residential population of 50,000 people and a minimum average density of 1,000 people/square mile. This is a simplified definition of a UA, the full definition is very complex.

Urban Runoff: Storm water from urban areas, which tends to contain heavy concentrations of pollutants from urban activities.

Watershed: That geographical area which drains to a specified point on a water course, usually a confluence of streams or rivers (also known as drainage area, catchment, or river basin).

Wet Weather Flows: Water entering storm drains during rainstorms/wet weather events.

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Fax: (206) 553-0149
Toll free: (800) 424-4372

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Storm Water Phase II Final Rule Fact Sheet Series, January 2000
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Building a Balance: Housing Affordability and Environmental Protection in the USA

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Abstract

Current trends in household formation and housing development in the United States are creating pressures on communities to provide adequate infrastructure services for a growing population. Homeownership rates are the highest in history. All indications suggest this rate will continue to increase over the next few years. Builders and developers respond to this need by constructing housing units in suburban fringe and rural areas because of the availability of cheaper land and the lack of attractive sites in more urban areas. Environmental regulations are frequently cited as barriers to development and impediments to affordability. This paper reviews the literature of potential linkages between housing affordability and environmental protection and reports on a project in which focus groups were conducted with developers, environmental regulators, and others. Content analysis of focus group transcripts showed much agreement from various sides of the complicated and interconnected issues that are related to sustainable development.

Introduction

Since enactment of the first major environmental legislation in the United States in 1972, an increasing number of laws have been passed for the purpose of improving air and water quality and protecting biodiversity. Although Americans agree environmental protection is essential (Dunlap, 1992), there is considerable controversy over what constitutes an acceptable level of regulation and how the economic burden of environmental regulation should be distributed (Branconi, 1996).

With escalating levels of environmental regulation has come an increasing estrangement between environmental protection and business interests. An uneasy coexistence has evolved into a heated battle pitting the federal government, state governments, business, and the environmental community against each other in a contest over control and use of the nation's natural resources. The eventual outcome of this conflict will have a substantial affect on generations of future Americans as well as on the global community at large.

Perhaps nowhere has this controversy been more visible than in the building industry. Land use restrictions, impact fees, mitigation and other compliance costs, and delays precipitated by permitting procedures are given as the means by which environmental protection has stymied builders and adversely affected their livelihoods (Branconi, 1996). Housing researchers, as well, maintain that financial burdens imposed by environmental regulations have played a large part in driving the cost of new homes beyond what can be borne by most first-time buyers, thereby helping to create an affordability crisis (Olenik and Cheng, 1994; Meeks, 1992).

This paper reviews some perceptions about housing affordability, environmental protection, and the public's attitude toward the environment in hopes of contributing to the development of a new, more realistic perspective on what has become an increasingly muddled situation.

Homeownership Rates, Prices, and Affordability

A decline in homeownership during the 1980's, viewed against a backdrop of housing prices that had been steadily increasing since the early 1960's, has been interpreted by many housing analysts as an indication of a housing affordability "crisis." Due to the amount of attention given to this issue, a widespread perception has developed that a serious, generalized affordability problem was beleaguering the nation's housing markets. To many, the cause of this alleged affordability problem seemed clear: housing prices had finally risen to the point that many American households simply could not afford to purchase.

A review of the literature, however, indicates a division of opinion as to the merits of this conclusion. Some see the existence of a crisis in affordability as hinging on differing interpretations of home ownership trends. While many believe the decline in homeownership is an indication of an affordability problem, others view it as being more the result of changing demographics (Koebel and Zappettini, 1993).

While earlier generations tended to marry and begin families in their twenties, recent years have seen these events postponed or forsaken altogether. The number of single-parent families has risen sharply. Other less traditional types of households, such as those composed of non-relatives and individuals who simply choose to live alone, have also increased. These fundamental societal changes are seen as having had a profound effect on home ownership rates (Koebel and Zappettini, 1993).

This demographic view of lower home ownership rates is countered by other theories such as that of Linneman and Megbolugbe (1992) which seek to explain the phenomenon in economic terms. In defining the scope and causation of the so-called affordability crisis, these authors present three points that offer a very useful lens for examining this issue.

First, Linneman and Megbolugbe (1992) reject the notion that an affordability crisis has ever existed for affluent young households. The decline in home ownership within this segment of housing markets is attributed to demographic changes. Secondly, they admit that low-income households have experienced affordability problems, but these are seen as being due to income inadequacy, incomes too low to keep up with concurrent increases in housing prices (which are seen as having been caused mainly by a substantial increase in the quality of housing stock). Affordability for low-income families is a long-term problem, one which, although undoubtedly exacerbated by rising home prices and economic upheavals in the 1970's and 80's, was not caused by them.

Thirdly, Linneman and Megbolugbe (1992) identify the real focus of affordability concerns as being on the middle class, which in the 1970's began to confront decreasing housing affordability for the first time. Indeed, it seems to have only been when this group began experiencing problems that the notion of a crisis surfaced and the issue of affordability moved to the forefront in housing policy circles. This phenomenon attracted the attention of housing researchers (and the housing industry) because the middle class, unlike low-income households, was a group that had not previously experienced such problems (Linneman and Megbolugbe, 1992). This is seen as the crux of the affordability crisis.

Linneman and Megbolugbe's (1992) interpretation of the problem therefore, is that middle-class households in some parts of the country, those households having low levels of job skills and education, began to experience affordability problems not because of the mere fact that housing prices had risen, but because their incomes became stagnant or in many cases declined.

The degree of financial security such households had previously enjoyed was based largely on income from relatively well paying manufacturing jobs. This changed when the global economy took hold and manufacturing jobs in the United States went to developing countries, being largely replaced by lower-paying jobs in the service industry. Wage earners in affected households were not able to find jobs in the service industry paying wages comparable to those offered by the lost manufacturing jobs. The resulting income disparity precipitated the decline in home ownership (Linneman and Megbolugbe, 1992).

Yet another economic interpretation of falling home ownership rates is posited by Mayer and Englehardt (1996). While they admit the role of such factors as increasing real house prices, changing demographics, declining incomes, and rising interest rates result in the decline of home ownership, these authors contend that these factors alone cannot explain the phenomenon. Statistics showing an increased reliance by first-time homebuyers on financial gifts to make down payments, along with longer periods of time needed to accumulate down payments, are presented to show that, even when income may be adequate to make mortgage payments, down payments may present a substantial obstacle for many potential home buyers (Mayer and Englehardt, 1996).

Mayer and Englehardt (1996) do not emphasize the relationship between declining home ownership rates and the simple fact that homes were more expensive relative to the past. The focus here is on a specific demand-side problem: the difficulty in providing a down payment. This in turn is seen as due to the well-known propensity of Americans not to save money, as well as to restraints on saving represented by increasing credit card and other consumer debt.

As evidenced by even this truncated review of the literature, there is little agreement that the decline in home ownership experienced in the 1980's constituted a "crisis" or that is was due simply to house prices that had risen so sharply as to preclude purchase. The varying interpretations present in the literature, if merged, produce a more likely view in which changing lifestyles and tastes, along with income and related demand-side variables such as higher levels of consumer debt and low personal savings rates, controlled homeownership rates more than house price increases.

The widespread, lopsided perception that buyers were simply priced out of the market still exists in spite of evidence supporting a more complete and plausible explanation for decreased home ownership. Given this, solutions for bolstering ownership rates tended to focus on specific factors seen as contributing to escalating house prices, one of these factors being the cost of environmental protection.

House Price Increases and Environmental Protection

To the extent that house prices have increased, what role might environmental protection have played? Downs (1992) states outright that federal environmental regulations, specifically the Endangered Species Act and wetlands regulations, are not significant contributors to the increase in housing costs.

Branconi (1996) examines the escalation of house prices between 1963 and 1993 and determines that environmental regulations may have played a role in the increase. He feels that factors which should have positively affected housing affordability by moderating further price increases were offset, at least partially, by an increase in costs associated with environmental protection.

In rebuttal to Branconi (1996) Evans (1996) argues that there is no direct connection between increased environmental regulation and house price increases. In support of this thesis, he points out that during the first one-third of the period studied, environmental regulations affecting housing were all but nonexistent and yet house prices rose. Given this, the author concludes that the observed rise in prices cannot be explained by environmental protection costs. This argument is bolstered by the fact that the home ownership rate in the U.S. is currently at a record high of 66.8 percent (Seiders, 1998), and that this has occurred without a significant rollback in environmental regulations.

Evans (1996) also sees as significant the disparity between regional house price activity and environmental progressivity. This too, is believed to indicate that increasing environmental regulation and escalating house prices are largely unrelated. As an example, real house prices in the environmentally progressive Northeastern part of the United States dropped substantially between 1973 and 1983 in spite of the fact that a wide range of new environmental regulations were being implemented during the period. Conversely, in the South and West (excluding the West Coast), which are less environmentally progressive, real house prices rose during the same period. Evans (1996) believes the opposite result would be expected if the cost of environmental protection did exert substantial upward pressure on house prices.

While not denying the possibility that environmental regulations have contributed to house price increases over the last thirty years, Evans (1996) believes that the connection between implementation of environmental regulations and price increases, when compared to other forces at work, is minuscule at best.

Meyer (1998) makes the environmental protection/development controversy more specific by examining one of the most controversial federal environmental programs, the Endangered Species Act (ESA) and its affect on the building industry. Meyer (1998) analyzed economic impacts of (ESA) from two perspectives. First, he examined potential relationships between listings of the spotted owl in the Pacific Northwest of the United States and prices for lumber and single family homes. He then observed rates of growth in state real estate markets, after controlling for a number of variables, and compared this growth with increases in listings of protected species.

In the first part of his analysis, Meyer (1998) plotted Douglas Fir production against housing starts. The latter variable historically follows a cyclical pattern (REF), as was illustrated in this study for the period 1970-1995, when Douglas Fir production cycles matched those of housing starts. The author correctly concluded that while there may have been some impact of the spotted owl listing on Douglas Fir production, that impact is minuscule by comparison with the long-standing relationship between that production and housing starts. He went further in this stage of analysis and compared median prices of new homes with Douglas Fir prices. Again he presented convincing evidence that no relationship exists, and that home price increases are more likely related to size and amenity increases in new homes.

In the second stage of his analysis, Meyer (1998) regressed each state's growth in its real estate industry against appropriate industry indicators. After regressing numbers of listed endangered species against those same variables, he plotted the residuals from both sets of equations to demonstrate increased real estate activity with increases in endangered species listing. While this result may initially appear confusing, Meyer's (1998) conclusion is that in robust real estate markets, increased encroachment on wildlife habitats is expected but markets adjust and are not adversely affected. This is a key finding from this study--markets adjust.

Linneman and Megbolugbe (1992) consider that housing price increases have been due mainly to significant increases in the quality of housing stock. These authors also point to inflation in the 1970's and 1980's and the increasingly speculative nature of homeownership in response to inflation, as contributing factors. Koebel and Zappattini (1993) too, identify the increasing quality of houses and their amenity levels as a factor in price increases. Evans (1996) identifies a number of factors as being responsible for increased house prices including demand and demographics. Other contributing factors he cites are increases in house size and quality, rising interest rates, and general price inflation.

Seiders (1998), citing the results of a survey of builders, points to subdivision controls as being most responsible for unnecessarily increasing housing costs. Echoing this,

Downs (1992) identifies local zoning regulations as the greatest regulatory barrier to the development of less expensive housing.

An important factor which must underscore any debate on this issue is that systematic studies of relationships between environmental protection efforts and house prices are scant, and that it is extremely difficult to accurately quantify the effect of a given regulation or regulatory program on a specific housing development (Suchman, 1996a; Branconi, 1996; Engel, Stromberg, and Turner, 1996). In light of this uncertainty, it is puzzling how many individuals and organizations have been able to so confidently make the sweeping generalization that environmental regulations have had profoundly negative effects on housing affordability (Suchman, 1996b; Olenik, 1994). Clear, specific, and reliable scientific data supporting this conclusion simply do not exist.

Public Support for Environmental Protection

Substantial increases in the membership of environmental organizations over the last twenty years indicate a widespread concern for the environment. Results from a number of surveys show that the American public is overwhelmingly in favor of environmental protection (Dunlap, 1992). Such surveys indicate that many in fact, feel the government should be spending more on protecting the environment, and substantial numbers of survey respondents indicated a willingness to pay more for products and services that are produced and provided in more environmentally sensitive ways (Dunlap, 1992). Surprisingly large numbers of those surveyed voiced the opinion that they would be willing to see economic growth sacrificed to protect the environment, and that environmental improvements must be pursued regardless of the cost (Dunlap, 1992).

Dunlap (1992) interprets these data and others as strongly suggesting that public concern for the environment is more solid today than in 1970, that environmental protection has become a consensual issue with overwhelming public support, and that its only opposition comes from a small but vocal minority.

Analysis

To investigate issues related to housing development and environmental protection and to better understand perspectives of those directly involved with these issues, the focus group technique was chosen as a means of data collection. This is an appropriate method for obtaining qualitative and quantitative information about a complex topic and is useful for identifying specific areas for further research.

The use of focus groups has been defined as a style of interviewing small groups whose participants provide information about complex topics from a variety of perspectives (Berg, 1998). Moderators solicit opinions through a series of open-ended questions that encourage the expression of individual opinions and interaction among participants. Sessions are typically tape recorded, transcribed, and analyzed through research methods such as content analysis (Tesch, 1995). Findings can be useful for observing and identifying trends, patterns, themes and commonalities.

As a data-collection technique, the focus group has been utilized since the beginning of World War II, when the effectiveness of radio programs on troop morale was studied by military psychologists (Berg, 1998). While marketing researchers have long relied on the methodology since that time, widespread use of the technique by social scientists did not occur until the 1980s. In conjunction with qualitative analytical tools, focus groups have been used extensively over the past decade to investigate human perceptions of numerous issues (Shelton and Atiles, 1995).

Shelton and Atiles (1995) discussed issues related to findings from qualitative research and noted that these are significant to the extent that they are valid. Such validity is attained when there is agreement between a study's intentions and its outcomes. This is best achieved through unobtrusive data collection techniques and precautions against the introduction of a researcher's biases or preexisting theories.

To investigate various points of view on the numerous issues that affect housing affordability and environmental protection, two, two-hour focus groups were conducted in the Fall of 1997—one in Seattle, Washington to represent the West Coast, and one in Gainesville, Florida to represent the Southern half of the Eastern Seaboard. The focus group participants included developers, environmental regulators, affordable housing advocates, environmental advocates, Congressional staffers, students of construction management, and faculty in academic programs of construction management. The

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specific composition of each group is listed in Table 1.

Questions posed to each focus group elicited comments about the loss of species, housing affordability, equity, property rights, regulatory burdens, and other issues. In both groups conversations covered issues many participants had direct experiences with. For example, in Gainesville the university researcher discussed recent findings about the rate at which endangered species are predicted to be lost; the developer shared his experiences with environmental regulators and endangered species; and the environmental regulator talked about his frustrations with the process through which species become listed as endangered. A consensus that emerged in both sessions, however, was that this type of discussion, with various interests represented, was useful for gaining an understanding of alternative views on these issues.

TABLE 1. Composition of the Focus Groups

Seattle	Gainesville
Moderators (2)	Moderators (2)
Student	Student
Congressional Staffer	University Researcher
Builder/Developer	Community College Faculty
National Audubon Society Director	U.S. Fish & Wildlife Service Regulator
College Professor	Affordable Housing Center Director
	Developer
	Home Builders Association Director

Transcripts of the discussions were examined through content analysis software (Ethnograph). Key categories were coded which allowed for identification of passages in which common themes emerged. The key categories, frequencies of their being mentioned during the discussions, and rankings are presented in Table 2.

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Table 2. Frequencies and Rankings of Key Categories

Categories	Seattle	Gainesville
Affordability	10 (6)	18 (2)
Balance	29 (2)	8 (6)
Confusing Regulations	8 (7)	8 (6)
Education	6 (9)	11 (5)
Environmental	32 (1)	18 (2)
Equity	12 (4)	12 (4)
Excessive Regulations	6 (9)	20 (1)
Low Income	6 (9)	4 (8)
Needs	12 (4)	2 (10)
Property	7 (8)	5 (7)
Public	11 (5)	5 (7)
Research	0 (10)	5 (7)
Species	11 (5)	5 (7)
Sustainability	11 (5)	16 (3)
Wetlands	14 (3)	3 (9)

The frequencies in Table 2 refer to occurrence rates of concepts that can be categorized by the listed terms, whether the terms were explicitly stated or not. Numbers in parentheses indicate how many times the issue was mentioned during the focus group. Note that in the Seattle group, Environmental issues ranked first as the most frequently mentioned issue, while Excessive Regulations ranked first in the Gainesville group. Affordability tied for second place in the Gainesville group and ranked sixth in the Seattle group.

Following are selected quotes from the discussions that provide a sampling of perspectives on the issues covered. The first quote is from the Seattle group and was coded in the Balance Category:

> "... You have to build what the market wants. You have to be careful that you can do it under the government's rules and regulations. But ... the developer who resists the government tends to have more problems than the developer who does not. And the developer who resists and has more problems with the government increases his costs a fair amount because he is going to spend his time in court. ... I think you can make a living and still follow regulations. The important thing is to understand up-front what they are and plan accordingly."
>
> Managing partner of a large building firm.

An important point in the preceding quote is "understanding up-front." This theme emerged later in this session under the Equity Category:

> "...As a developer you ... analyze that piece of ground and make a decision and purchase based on the rules and regulations in place at the time. Wetlands rules came into play in the mid-80s, roughly. ... The rules and regulations on wetlands changed substantially, even from the time the wetlands rules went into place. Should those landowners be held accountable for a major change in rules and regulations to benefit the public in general--not benefit the developer?... The landowner is stuck with a social cost."
>
> Managing partner of a large building firm.

At several points in both sessions, equitable distribution of the social cost of species or wetlands protection was discussed. During the Gainesville discussion, an unintended consequence of the Endangered Species Act was mentioned:

> "Unfortunately, what I see happening is people using the federal endangered species act as a growth management issue, as a local land use issue. Instead of going to the local governments, going to the state government, going to the local communities, and saying, ... 'Do we care about this issue? And how can we plan with it? How can we get the quality of life issues or the sustainability issues or the economic issues integrated into land use for city use?' As opposed to what we see as the old model, or what people see as the old model--which is whatever goes. And there are some people who say , 'I can't really do anything I ... want to do to my property...' I think that is where planning comes into play."
>
> Federal environmental regulator.

Issues related to planning were brought up at many points in both focus groups and were coded in categories that included Environment, Need, Affordability, and others. Sprawl, transportation problems, and inner city decay, are mentioned in the following quote from the Gainesville group:

> "There is a limit to how far cities can grow out before the whole idea collapses. It is starting to reach a point where people are miserable. They drive an hour back and forth to work because they are pushed so far out that (the) inner circle starts collapsing. People start forming the second circle. Of course, the second circles have already started forming, so now they are forming this third circle. ... It can only go so far. I think it would be really great to start concentrating on and invigorating the interior of the cities. Because we have already established ourselves there. ... You would not be going on pristine land or virgin land."
>
> Student of construction management.

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The fact that affordability was not the most frequent category in either discussion suggests that focus group participants were more concerned with other aspects of environmental regulations, including Excessive and Confusing Regulations, Balance, Environmental issues, and Wetlands, among others. A surprising amount of agreement was seen in points made by the developers, environmental advocates, environmental regulators, and academics. Property rights were seen as essential, with the main problems viewed as lost property rights without compensation when laws change or species-related restrictions are placed on land after a purchase has been made. A point made in both focus groups was that confusing layers of regulations should be made easier to understand through more coordination among federal, state, and local agencies. The faculty and students of construction management expressed much interest in the issues discussed as well as concern that they are not currently integrated into programs of construction management.

Conclusions and Implications

Several important points emerge from the literature review and analysis. There are a variety of perspectives as to the extent and reality of a housing affordability crisis. Strong evidence points to a conclusion that what has been perceived as a crisis in affordability was more likely a reflection of demographic trends. The decline in home ownership rates was more accurately explained by changes in tastes and lifestyles and not necessarily economic hardship. Stagnant incomes due to economic restructuring, difficulties in amassing down payments because of neglected savings, and higher consumer debt loads led to the inability of many to purchase homes, the prices of which had indeed risen, but mainly because of substantial increases in size, quality, and amenities.

Examining the literature also makes it quite clear that sufficient data do not exists to draw definitive conclusions regarding the negative impacts of environmental regulations on housing affordability. Arguments that such regulations result in higher housing costs and that they play a significant role in preventing the development of affordable housing lack credibility. And the analysis demonstrated that when the topic of environmental regulations is discussed in focused interviews, housing affordability is not a primary concern. Finally, the state of public opinion on environmental issues indicates strong support among the American public for environmental protection efforts.

This paper has not sought to give an authoritative answer to the question of environmental regulation and affordable housing, but to show that no such answer exists because of insufficient research. The only clear conclusion that can be reached regarding this is that claims of environmental regulation having been a substantial contributor to a housing affordability crisis can be legitimately questioned from a number of perspectives.

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Monday September 04 12:32 PM EDT

Study Nails Building Costs

By Janice Billingsley
HealthSCOUT Reporter

MONDAY, Sept. 4 (HealthSCOUT) -- It's square feet, not soil erosion, that is adding to the increase in new home prices, a Cornell University study says.

A review of more than 100 studies on housing affordability found no evidence to support the popular belief that the cost of complying with environmental regulations is largely responsible for the increase in housing prices.

The median price of a new home in this country has tripled since 1977, according to study author Joseph Laquatra, associate professor of design and environmental analysis at Cornell, but you can't blame environmental regulations.

The study showed "those costs are miniscule," he says. "In a development of 100 houses, a builder will have to pay $50,000 for permits. What really is causing the increase in housing prices is the increase in the size of houses and amenities."

The size of the average new home has increased by about one-third over the last two decades, from 1,645 square feet in 1975 to 2,190 square feet in 1999, Laquatra says, and along with bigger houses have come higher price tags. The average house price increased from $62,500 in 1978 to $195,000 in 1999.

Builders and developers must comply with federal regulations that include the Clean Water Act, the Federal Water Pollution Control Act and the Endangered Species Act. Most have long assumed that these environmental regulations have thwarted development and driven the costs of new homes beyond what first-time buyers can afford.

That is partly true, says Susan Asmus, assistant staff vice president for environmental policy at the National Association of Home Builders (NAHB) in Washington, D.C.

A 1998 NAHB survey found the cost of environmental compliance added, on average, 10 percent to the cost of building a new house, which, she says, can be a big burden for smaller builders working on affordable new housing.

"The high-end builder is able to put in amenities and pass along" regulatory costs, she says. "But the guy who is trying to build affordable housing has a narrower window. Every time you add $1,000 to the price of a home, less people can afford your product. Although you try to pass costs along to the buyers, you can't always do it, and if you can't do it often enough, you don't have a business."

Another problem with the environmental regulations, Asmus says, is the cost of overlapping permits from different government agencies.

"No one [government agency] wants to give up the ability to decide what's going up. So, for instance, there are local, state and federal laws regarding sediment and erosion, which mean increasing costs [for filing duplicate permits] but no real, positive results," she says.

But Laquatra and fellow researcher Gregory Potter found in their review that environmental compliance costs have little impact on new-home prices. "The numbers are very difficult to compile," says Laquatra, "But while the regulations may have some impact [on housing prices], it is negligible at best."

The study appeared in the recent Earth Day 2000 issue of the *Electronic Green Journal*.

In the studies and in two focus groups researchers held with a cross-section of housing professionals from builders to environmental advocates, they found widespread support for environmental protections in home building.

"The public is overwhelmingly in favor of environmental protection and thinks the government should be spending even more on protecting the environment," Laquatra says.

"We are not anti-environment," Asmus counters, "but let's make regulations" that are "workable and meaningful, that make sense."

What To Do

Go to the Electronic Green Journal to read the study.

A rundown of the federal government's regulatory laws regarding the environment can be found at The Environmental Protection Agency.

And if you have Adobe Acrobat Reader(available through downloading), you can access the National Association of Homebuilders' 1998 report detailing the costs of building a new house by going to NAHB.

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Economic Issues in Water Quality Regulation

by

Adrian Griffin, Ph.D., Senior Economist, State Water Resources Control Board

The views presented in this paper are those of the author and may not represent the policy of the State Water Resources Control Board or the views of Board management

In recent years, there has been growing public concern over the effect of regulation on the economy. While most people are agreed that environmental quality is important, there is often reluctance to support regulatory actions because of the belief that they increase the cost of products and reduce job opportunities. This trend is not surprising considering the difficult times Californians have gone through in the last several years. Real wages—that is, wages adjusted for inflation—have remained stagnant over the past two decades, and by some measures, have actually fallen. This situation is in stark contrast to experience in the 1950s and 1960s when real wages advanced steadily. In the past few years, California has done particularly badly. We used to be significantly better off than the rest of the U.S. Per capita income was 15-20 percent higher in California than in the U.S. as a whole during the 1960s and 1970s. In 1993, this gap was 5 percent.

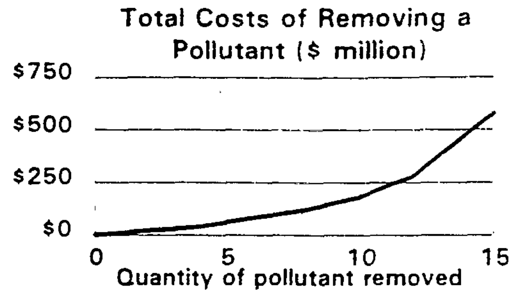
Because of these developments, it is important that we demonstrate to the public that we are giving them good value for money from water quality regulation. It is impractical to make a detailed economic analysis of every board action. However, common sense suggests that we should try to improve water quality up to the point where costs begin to exceed benefits. Finding this point is much more easily said than done because the economic value of protecting and improving water quality is not known with certainty. For example, an action which protects groundwater quality may allow a local water utility the option of using the groundwater as a water source in dry years. We cannot put a dollar value on this option without doing a comprehensive study of the utility's operations. Protecting water quality in a river will result in a variety of aesthetic and recreational benefits. These benefits have a significant value. However, because scenic quality and access for recreational use are not bought and sold in a marketplace like other goods and services, it is difficult to assess the value that the public puts on these benefits as compared with other goods and services. Assessing the costs of regulatory action also presents difficulties. The cost of the process used for treatment of discharges may be known, but all too often, there are concerns that reduction in discharges may result in indirect costs on other industries, job losses, and impacts on the local economy.

Nevertheless, considering these questions gives some framework for decision-making. The following pages contains a discussion of a few issues which may be helpful in bringing economic factors into the decision-making process.

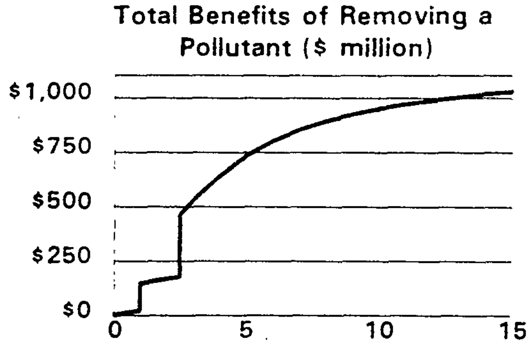
Optimal Pollution Levels

Determining the desired level of protection often presents difficulties. Treatment costs typically increase at higher levels of removal as dischargers must turn to more advanced treatment methods. Typically, the benefits of removing the pollutant decrease after a certain level of water quality has been achieved.

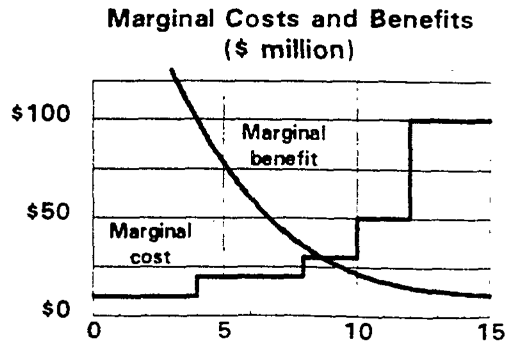
The graphs show the cost and benefits of removing a hypothetical pollutant from a water body. The uppermost graph shows that costs are modest at low amounts of removal from current levels, but climb rapidly as dischargers must switch to more advanced treatment. The bottom graph shows the incremental, or marginal, cost of removing an additional unit of pollutant. This cost increases in steps as the limits of each type of treatment are reached. Removing up to 4 units can be achieved at a cost of $10 million/unit. The cost of removal then climbs to $20 million/unit, eventually reaching $100/unit.



The middle graph shows the benefits of removing the pollutant. At first, benefits climb rapidly as the water body becomes capable of supporting a wider variety of uses and as its aesthetics improve. However, as removal levels increase, there are diminishing returns from further increases in removal amounts. At high levels of removal, benefits increase slowly with further removal of the pollutant. The incremental, or marginal, benefits of removing an additional unit of pollutant are shown in the lower graph. The line shows that the benefits of removing an additional unit of pollutant are high at low levels of removal, but fall rapidly as removal levels increase.



From an economic point of view, the most desirable level of pollution is that where the cost of further increases in removal begins to exceed the benefits of further removal. Provided that the marginal cost and benefit curves capture all of the costs and benefits of removing the pollutants, this point is where the two lines cross on the lowest graph. There is no reason to expect this point to correspond to the best available technology (which corresponds to the top step on the benefits curve in this example), or what a discharger may feel is affordable.



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This example [illegible] simple benefit-cost ratios can lead us astray. For example, a removal level of 15 [illegible] would cost $600 million, yield benefits of just over $1 billion, and have a benefit-cost ratio of 1.7. However, this level of removal would not be desirable economically. If we were to drop back to the optimum level of 9 units, we would save over $400 million in costs but lose only $100 million in benefits. This kind of analysis can be useful in the board's role in balancing economic and environmental impacts.

Should Intangible Benefits be Compared with Costs?

Often it is argued that, because of the intangible nature of environmental benefits, it is inappropriate to compare costs and benefits in the way outlined in the preceding section. However, we make similar comparisons implicitly in a wide variety of everyday decisions. For example, when a consumer decides how much to donate to a charity, he is weighing the intangible satisfaction of giving against the goods and services that he could otherwise buy with his donation. This type of decision is no different in principle from a comparison of the intangible benefits of improved water quality with the costs of pollution control. In both cases, a comparison is made between an intangible benefit and other goods and services forgone as a result of spending to achieve this benefit.

Environmental decision-making is always easier if accurate estimates of benefits are available. However, it may be impractical to quantify intangible benefits to the extent that they can be confidently compared with costs. Nevertheless, it is usually wise to make some comparison of costs and benefits and to assess whether the same goals can be achieved by less costly means.

The absence of this kind of scrutiny may lead to wasteful regulation. Recently, a northern California county passed an ordinance requiring a the installation of outlets for charging electric cars in all new residential garages. The cost of these additional outlets is only about $50. However, only a small proportion of these outlets will be used. Assuming a market penetration of 2 percent for electric cars, $2,500 will be spent for each outlet actually used.

This ordinance may be have been motivated by the feelings that the costs per household are small and that clean air is important for aesthetic and health reasons, so economic analysis is unnecessary. However the requirement to install outlets, most of which will never be used, results in a consumption of resources that are now no longer available for other purposes, including other environmental programs.

Economic Impacts: Some Traps for the Unwary

The effect of board action on the economy in general is always a concern. Often, it is feared that the costs imposed on a discharger will affect other industries and spread throughout the economy, resulting in widespread economic impacts. In some cases, these fears are exaggerated and arise from misinterpreting economic analyses. Some of the more common sources of error are as follows:

Double Counting. Care must be taken to avoid adding together impacts which are not additive. In many cases, the cost of a regulation will be split in an unknown manner between an industry directly affected by the action, industries purchasing from this industry, and consumers. Studies commissioned by interest groups may assume that all of the costs fall on one particular group. Consider for example, a regulation requiring operators of truck stops to treat runoff from paved areas. If the market for truck stop services is highly competitive, truck stops will not be able to raise their prices and the cost of the treatment will be borne entirely by truck stop operators. However, there will be no impacts on the trucking industry. If market conditions are not competitive, truck stops will be free to pass on increased costs to their customers. In this case, there will no impacts on truck stop operators and the entire cost will be borne by the trucking industry. The full impacts cannot fall on both industries at the same time. When reviewing studies by affected groups, it is essential to determine whether the impacts presented are a part of the total impact or a worst case for a particular group.

Misinterpretation of Job Losses. Job impacts are an important concern in water quality regulation. All too often, estimates of job losses resulting from regulatory action are presented without any discussion of the duration of these job losses. This may gives the impression that a lost job represents one person-year of unemployment, or even a permanent job loss in the region. However, if a business cuts back its operations as a result of regulatory action, any workers laid off will not be unemployed indefinitely. The length of time that these displaced workers are without work will depend on the local labor market. If the demand for their skills is poor, they may be unemployed for many months. However, we should not assume that this is always the case. In a strong labor market, displaced workers will find new jobs without delay and job losses will merely be a temporary job displacement.

Use of Gross Output as a Measure of Impacts. Economic impact studies often present estimates of the effect of regulatory action on the gross output or sales revenues. However, these can be misleading figures. The true measure of the economic impact of regulatory action is its effect on income. The value of an industry's gross output reflects the cost of materials and components and other production expenses, as well as the income of employees and proprietors. If an industry curtails its output, many of these expenses will be reduced. Thus, impacts on gross output are always greater than actual income losses.

In some cases, multipliers are applied to impacts on the affected industry to give an estimate of impacts on gross regional output. The resulting figure should not be interpreted as the total cost of the regulation to the region since it is significantly larger than overall impact on income in the region.

Misuse of Multipliers. Job multipliers are often used to estimate the indirect economic impacts. A job multiplier for an industry shows the total number of jobs that are supported by each job in the industry. These multipliers are often used without an understanding of their limitations. In some cases, state or even national multipliers are used to estimate local economic impacts. This is a serious misuse of multipliers, since state and national multipliers are nearly always larger than county multipliers.

Multipliers are often smaller than generally imagined. There seem to be the widespread belief that job multipliers are generally around 3.0. This is true for industries such as automobile and computer manufacturing operating in established industrial centers where they buy parts and components from other industries in the area. But for most industries, multipliers are much smaller. For example, the job multiplier for apparel manufacturing in Los Angeles County is 1.8. Multipliers are still smaller in rural counties where a higher proportion of spending by businesses and consumers is on goods and services produced outside the area.

Multipliers usually overestimate indirect economic effects because the methods used to develop them assume fixed trading patterns between industries. That is to say, each industry in an area buys from local and outside industries in fixed proportions and production by suppliers automatically rises and falls with production in the purchasing industry. In reality, there is more flexibility in the economy, so economic impacts are softened.

Businesses are always adapting to changing conditions. For example, if a plant closes or cuts back its output, suppliers will generally make up some of their losses in business by finding new markets in other areas. Growth in other parts of the economy will often provide opportunities for these firms. Consequently, there is rarely a fixed proportional relationship between jobs lost at a plant affected by a regulation and jobs lost at suppliers. Job multipliers give an upper limit on the jobs lost due to a plant closure or cutback, rather than the most reasonable estimate of this figure.

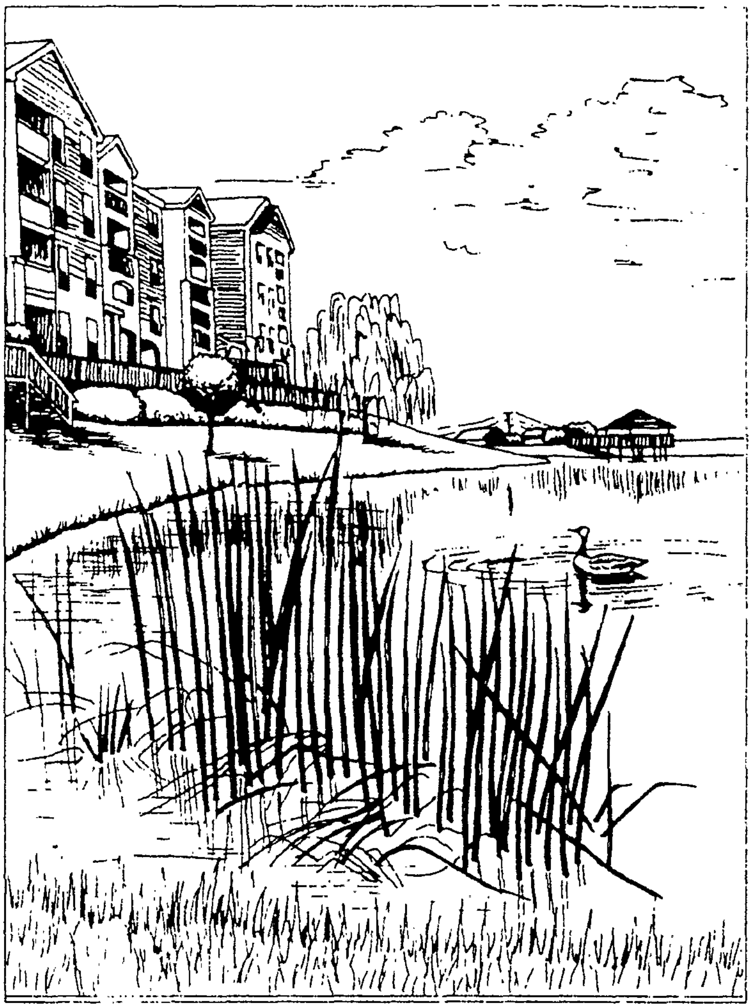
Lack of Comparisons. Estimates of economic impacts sometimes show hundreds of lost jobs and millions of dollars in lost output. These impacts may sound severe, but they should always be compared with regional totals and, more importantly, normal fluctuations in these numbers. California had nearly 12 million jobs in 1995. This number varies by several thousand from month to month. California's gross state product is nearly $950 billion. Labor markets are also affected by migration. Los Angeles County has lost people in recent years, but in the 1980s, net in-migration ranged up to 80,000 annually. Even in smaller counties, 100 lost jobs may be equivalent to only a few months' net in-migration. Impacts should always be put in context by comparing them with economic statistics for the area affected.

EPA

Economic Benefits of Runoff Controls

Even though urban runoff management costs money, properly designed runoff systems can provide economic benefits that counterbalance or even outweigh those costs.

This report describes the economic impacts of various types of urban runoff controls and presents case studies of developments where the implementation of runoff control requirements has provided economic benefits to developers and property owners.



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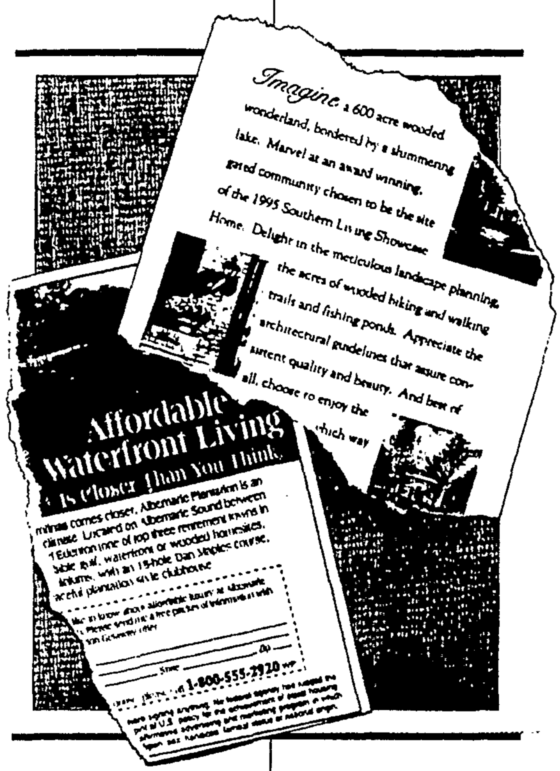
Overview

PEOPLE HAVE a strong emotional attachment to water, arising from its aesthetic qualities—tranquility, coolness, and beauty. As a result, most waterbodies within developments can be used as marketing tools to set the tone for entire projects *(Tourbier and Westmacott, 1992)*. A recent study conducted by the National Association of Home Builders indicates that "whether a beach, pond, or stream, the proximity to water raises the value of a home by up to 28 percent." A 1991 American Housing Survey conducted by the Department of Housing and Urban Development and the Department of Commerce also concurs that "when all else is equal, the price of a home located within 300 feet from a body of water increases by up to 27.8 percent" *(NAHB, 1993)*. Dick Dillingham, President of the National Association of Realtors' Residential Sales Council, declares, "Water makes a difference . . . there is such a very small supply of properties that can claim a water location and it is something you cannot add" *(Lehman, 1994)*.



Although there are a limited number of natural waterfront sites adjacent to lakes, rivers, streams, estuaries, or open ocean, many opportunities exist to create waterfront property. Homes and businesses can be sited along hydroelectric or water supply impoundments or near the banks of artificial lakes created for wildlife, recreational, or aesthetic reasons. A practice becoming more prevalent is to site developments around man-made ponds, lakes, or wetlands created to control flooding and reduce the impacts of urban runoff on neighboring natural streams, lakes, or coastal areas. When designed and sited correctly, artificial lakes or wetlands can help developers reduce negative environmental impacts caused by the development process and increase the value of the property.

The purpose of this report is to show that certain urban runoff management controls can be incorporated into a development in a way that provides aesthetic and economic benefits. Table 1 summarizes the findings of this report. Urban runoff controls that are pleasing to the eye and safe for children can lead to increased property values. Because the beauty of natural surroundings can increase real property values and enhance the quality of life, location of land areas adjacent to waterways and detention ponds should be considered an integral part of planning by developers. For existing runoff controls that are unsightly, corrective renovations can be made to increase the property value and quality of life.

People have a strong emotional attachment to water, arising from its aesthetic qualities—tranquility, coolness, and beauty.

Table 1: Examples of real estate premiums charged for property fronting urban runoff controls

Location	*Base Costs of Lots/Homes*	*Estimated Water Premium*
Chancery on the Lake, Alexandria, Virginia	*Condominium: $129,990 - $139,990*	*Up to $7,500*
Centex Homes at Barkley, Fairfax, Virginia	*Home with lot: $330,000 - $368,000*	*Up to $10,000*
Townhomes at Lake Barton, Burke, Virginia	*Townhome with lot: $130,000 - $160,000*	*Up to $10,000*
Lake of the Woods, Orange County, Virginia	*Varies*	*Up to $49,000*
Dodson Homes, Layton, Faquier County, Virginia	*Home with lot: $289,000 - $305,000*	*Up to $10,000*
Ashburn Village, Loudon County, Virginia	*Varies*	*$7,500 - $10,000*
Weston Development, Broward County, Florida	*Home with lot: $110,000 - $1,000,000*	*$6,000 - $60,000 depending on lake size, location, and the percent of lakefront property in the neighborhood*
Silver Lakes Development, Broward County, Florida	*Varies*	*$200 - $400 per linear foot of waterfront, depending on lake size and view*
Highland Parks, Hybernia, Illinois	*Waterfront lot: $299,900 - $374,900*	*$30,000 - $37,500*
Waterside Apartments, Reston, Virginia	*Apartment Rental*	*Up to $10/month*
Village Lake Apartments, Waldorf, Maryland	*Apartment Rental*	*$5 - $10/month depending on apartment floor plan*
Lake Arbors Towers, Mitchellville, Maryland	*Apartment Rental*	*$10/month*
Marymount at Laurel Lakes Apartments, Laurel Lakes, Maryland	*Apartment Rental*	*$10/month*
Lynne Lake Arms, St. Petersburg, Florida	*Apartment Rental: $336 - $566/month*	*$5 - $35/month depending on lake size*
Sale Lake, Boulder, Colorado	*Waterfront lot $[illegible]4,000*	*Up to $35,000*
The Landing, Wichita, Kansas	*Waterfront lot $[illegible],000 - $40,000*	*Up to $20,000*
Fairfax County, Virginia	*Commercial Office Space Rental*	*Up to $1/square foot*
Laurel Lakes Executive Park, Laurel, Maryland	*Commercial Office Space Rental*	*$1 - $1.50/square foot*

Impacts and Controls

Urbanization causes changes and impacts to the environment and our communities. Many effects of urbanization are positive, such as new places for people to live and work, increased recreational opportunities, and economic growth. However, some of the impacts might be negative if they are not handled with foresight.

Most local governments require some form of urban runoff management for new development.

Development leads to an increase in the amount of pollutants in an area. Sediment from construction sites can end up in streams and rivers, choking plant and animal life. Oil and gas from vehicles can leak onto roads and parking lots. Fertilizers and pesticides, if not applied properly, can wash off lawns. Pesticides are often found in higher concentrations in urban areas than in agricultural areas *(USGS, 1995)*. Pet waste, if not properly disposed of, can enter storm drains that lead to wetlands, streams, or rivers. Household chemicals, such as paints and cleaning products, can leak if not stored or disposed of properly. All of these pollutants can wash away when it rains and end up in streams, rivers, lakes, estuaries, or ground water. Many pollutants also bind to the sediment, so when sediment washes away it takes the pollutants with it.

Urbanization also leads to loss of pervious areas (porous surfaces) that allow rainwater to soak into the ground. This can increase the amount and velocity of rainwater flowing to streams and rivers, as illustrated in Figures 1 and 2. This increased speed and volume of water can have many impacts, including eroded stream banks, increased turbidity and pollution, increased stream water temperature, and increased water flow. All of these can have an adverse effect on the fish and other organisms living in the stream and the receiving waters. When rainwater cannot soak into the ground, the result can be a loss of drinking water because many areas of the country rely on rainwater soaking into the ground to replenish underground drinking water supplies.

Loss of trees due to urbanization can have negative impacts. Trees are important for controlling the water temperature along the shorelines of waterbodies. Since many aquatic plant and animal species are sensitive to changes in water temperature (trout, for example), it is important to keep stream temperatures as close to natural levels as possible. When the shade of trees is lost, the water temperature can increase.

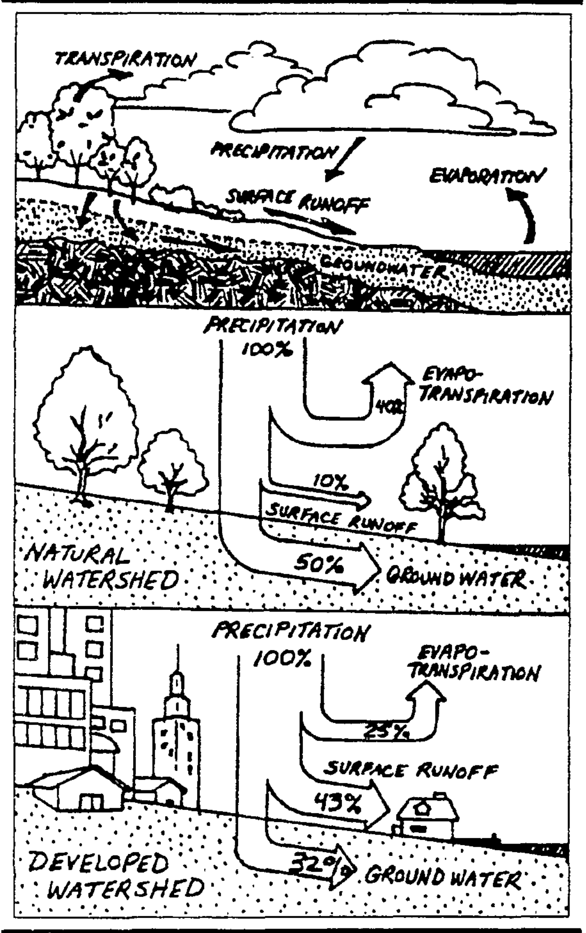


Figure 1. Development decreases the amount of rainwater that can soak into the ground. (L.B. Leopold, USGS Circular 554, 1968, cited in NYSDEC, 1992)

"Best management practices," or BMPs, help address these impacts. BMPs are designed to help reduce the amount of pollution in urban runoff. Some help to control the volume and speed of runoff before it enters receiving waters. Many help to increase the amount of rainwater that soaks into the ground to restore groundwater. There are two general types of BMPs: structural and nonstructural. Structural controls involve building a "facility" for controlling urban runoff. There are a variety of structural controls and most require some level of routine maintenance. This report discusses two types of structural controls that have been documented as providing economic benefits: urban runoff ponds and constructed wetlands. Nonstructural BMPs do not require construction of a facility. For example, planning a development so that there are buffers along stream banks and minimizing the amount of impervious area are types of nonstructural controls. Structural and nonstructural controls can be used in combination to manage runoff.

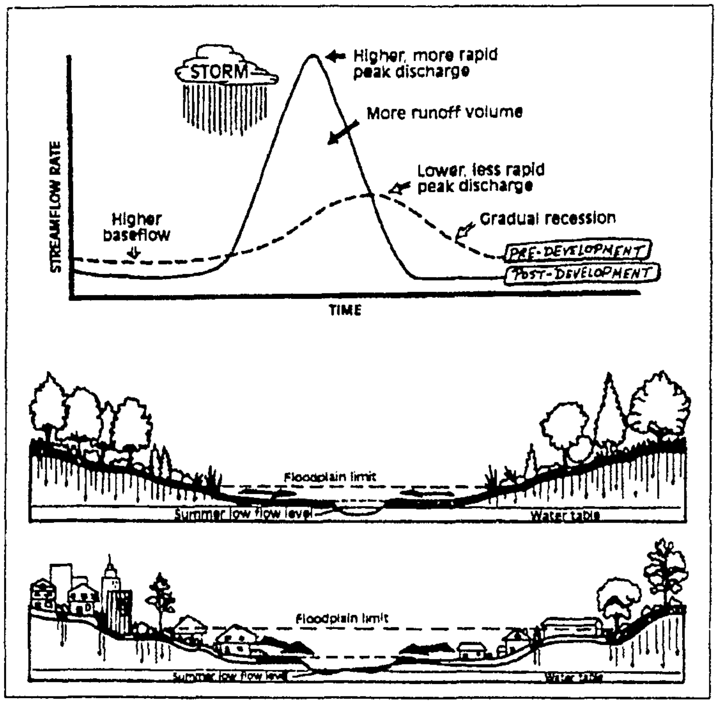


Figure 2: Development can alter an area's hydrology by increasing the amount of impervious surface. (adapted from Schueler, 1987).

Urban runoff management controls are now widely accepted due to lessons learned from not planning properly for the impacts associated with increased urbanization. Most local governments require some form of urban runoff management for new development. They require such controls for two reasons: to prevent pollution and to prevent flooding caused by increased runoff, mostly from impervious areas. Usually they require structural controls although some local governments give credit for nonstructural controls.

Methodology

A LITERATURE REVIEW was conducted to examine the impacts of urban runoff management ponds on property values. Many experts in the real estate field and experts involved in management of urban BMPs/runoff controls were contacted. Discussions with organizations including the Urban Land Institute, the American Planning Association, and the National Association of Home Builders proved valuable in identifying developments that have incorporated urban runoff management requirements into site development and have realized an economic benefit. Regional personnel of the U.S. Environmental Protection Agency (EPA) were contacted and provided information on their region of the country as well as potential case study examples. Developers and realtors provided comparative values and information on premiums charged for various properties nationwide.

"Why not take an environmental negative and turn it into a positive, into a visual asset?"

(Don Basile in Tourbier and Westmacott, 1992)

Information regarding case studies was compiled through literature reviews, site visits, and discussions with developers and realtors. After the information-gathering process was completed, case studies were selected. The case studies are

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[illegible] impacts on new development, existing development, and commercial property. Conclusions were made based on information gathered and discussions with experts in the fields of real estate and urban runoff controls.

Ponds and Wetlands for Urban Runoff Control

MOST STRUCTURAL urban runoff BMPs function on the principle that it is best to hold runoff for a period of time. This approach serves two functions. It controls the peak flow rates of water released from a site, thereby controlling downstream flooding, and it allows pollutants to be removed from the water column. There are many different types of urban BMPs, many of which add value to adjacent property. This report focuses on two types of BMPs that are often used: urban runoff "wet ponds" and constructed wetlands, as illustrated in Figure 3.

"Preservation is not a problem for developers; it's a golden opportunity."

(David Hoffman in Tourbier and Westmacott, 1992)

Wet Ponds

Wet ponds, as their name implies, are runoff holding facilities that have water in them all the time. Storm flows are held in the pond temporarily and then released to maintain healthy downstream habitats. Sediment and other pollutants settle out of the water and are not discharged to the receiving waters. Wet ponds are usually vegetated, and the plants' roots hold sediment and use the nutrients that are often contained in urban runoff. The ponds are designed to be big enough to control onsite and offsite flooding in the event of a major storm. This helps to control impacts on downstream habitats.

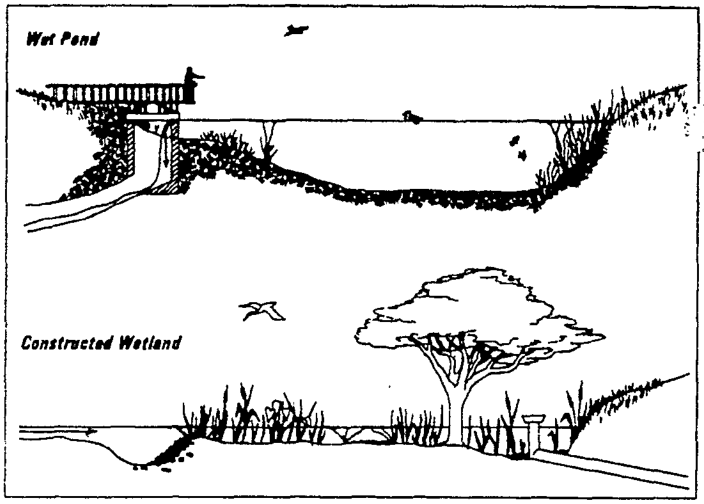


Figure 3: Wet ponds and constructed wetlands are two types of runoff controls.

Many of the "lakes" in developments are actually detention or retention wet ponds. Developers can design the wet ponds to look like natural lakes. Wet ponds can be highly effective in removing sediment and in reducing nutrients if they are properly constructed and maintained. They can usually be used for large drainage areas. Wet ponds can be incorporated into new development site plans and can enhance the value of surrounding property. Old wet ponds can also add value to the surrounding property once they have been aesthetically improved.

Constructed Wetlands

Wetlands serve an important function in controlling the impacts of urban runoff. Because wetlands are heavily vegetated, they serve as a natural filter for urban runoff. They also help to slow the flow of water to the receiving waters and replenish groundwater. When properly designed, constructed wetlands have many advantages as an urban BMP, including reliable pollutant removal, longevity, adaptability to many development sites, ability to be combined with other BMPs, and excellent wildlife habitat potential (MWCOG, 1992).

Making Urban Runoff Management Work for You

IN MANY CASES, developers are able to realize additional profits (and quicker sales) from units that are adjacent to a wet pond (Harden 1995; MWCOG, 1983). If the urban runoff management control is also developed to allow passive recreation (e.g., a walking path around a lake or pond), the recreational area and the wet pond/constructed wetland can become the feature attraction when advertising the property (Figure 4). Adding walking trails, fitness equipment, gazebos, bird houses, and other facilities to enhance a detention area can be costly, but eventually additional profits are realized (Sala, 1995).

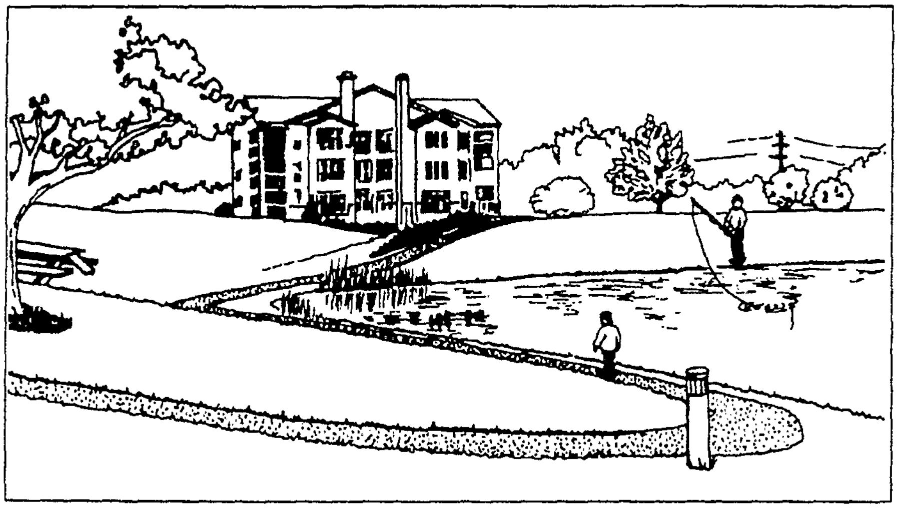


Figure 4: Urban runoff controls can be assets to a development.

The impacts of urban runoff management controls on property values are site-specific (CDM, 1982). Controls can affect property values in one of three ways: increase the value, decrease the value, or have no impact. "Urban runoff controls are greeted with varying degrees of skepticism and acceptance by residential versus commercial property owners," according to Judith Costello Pearson, Manager, Market Research, Fairfax County (Virginia) Economic Development Authority. One must consider the appeal of an attractive urban runoff management control along with the liability of open water. A childless adult might perceive a wet pond as an amenity, but a family might view it as a potential hazard to children.

"Whether a beach, pond, or stream, the proximity to water raises the value of a home by up to 28 percent."

(Lehman, 1994)

Factors That Lead to Increases in Property Value

Urban runoff systems with standing water often appear to be natural systems. A clean lake or pond offers benefits to developers by creating an ideal setting for model units and for the sales office. If located close to the entrance and visible from the road, it will have considerable curb appeal and can repay installation costs through faster sales, in addition to raising the value of adjacent lots (Tourbier and Westmacott, 1992). Developers can charge premiums (extra charges) for property with water views, views of wooded land, or other amenities.

Many ponds planned for urban runoff control are also designed to provide recreational facilities. They are often surrounded by walking trails and picnic areas complete with gazebos and outdoor grills. The ponds also can be used by nonmotorized boats like canoes and are excellent areas for bird-watching. This natural setting creates a home for a variety of birds and animals that homeowners find appealing (Figure 5). Fountains, often included in plans, also add to the aesthetic qualities of the pond.

"Higher sales prices for properties with views of the water have been consistent for 23 years."
(Wade, 1995)

Many developers have capitalized on urban runoff regulations by designing aesthetic wet ponds and marketing them as if they were natural lakes or ponds. A Pennsylvania developer has said, "We are required to build urban runoff management basins. Why not take an environmental negative and turn it into a positive, into a visual asset?" (Tourbier and Westmacott, 1992). In an effort to incorporate landscape design into stormwater management planning to enhance the value and quality of development, General Telephone of Marion, Ohio, created an attractive wet pond ornamented with plantings, stones, and pedestrian paths. Runoff from the Hyatt Regency Ravina hotel complex in Atlanta, Georgia, flows into a series of beautifully designed wet ponds linked together by streams and waterfalls that are kept flowing by recirculating pumps. A carefully designed wet pond at the Woods in Rhinebeck, New York, provides flood control and water quality benefits, and the waterfront created by the impoundment enhances the value of surrounding townhouses (NYSDEC, 1992).

Figure 5: Constructed wetlands provide wildlife habitat and are aesthetically pleasing.

Factors That Lead to Decreases in Property Value

Residential lots located near an urban runoff pond are often a concern to home buyers with young children. Parents fear their children will be attracted by the water or wildlife and drown. Incidents of drowning in urban runoff management areas have occurred in residential as well as commercial areas. Children who fall through frozen ponds or fall into the water without knowing how to swim are usually the victims (Suit filed, 1990; Woellert, 1993). Adults have also drowned in detention ponds. A Chicago man fell into an 18-foot-deep retention pond located on the property of a junkyard and drowned (OSHA probing, 1994). According to one real estate appraiser, safety is the only issue regarding urban runoff management controls that adversely affects property value (Jablonski, 1995).

One solution is to construct a fence surrounding the pond to deter entry and reduce accident potential. Chain-link fencing is often used. Rusting, poorly maintained chain-link fencing reduces any aesthetic qualities of the area, but fencing that has a black or green protective coating is more attractive and can improve the appearance of the runoff control. Prince William County, Virginia, has a fencing ordinance for constructed ponds aimed at preventing entry of children under 4 years of age (Guzman, 1995; MWCOG, 1983). A "protective device" of the developer's choice must be placed around ponds near residential areas with over 2 feet of standing water or more than 2 hours of drainage time. The protective device may be fencing or plantings of bushes and trees (Figure 6); in some cases, flat slopes or shallow beaches extending at least 20 feet from the perimeter of the pond are acceptable. These flat slopes or beaches provide protection for children who could roll down steep slopes directly into the pond.

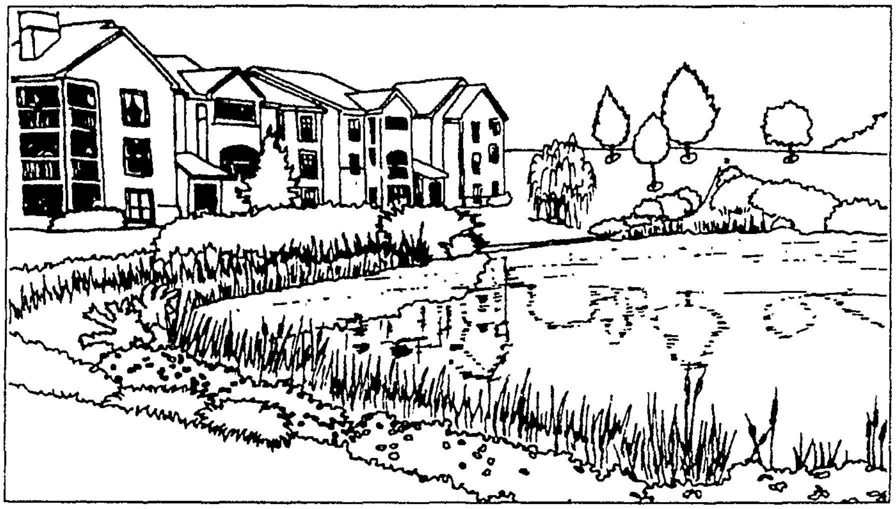


Figure 6: Natural "fencing" can be used as a protective device.

Using flat slopes reduces the amount of land available for development, however, and is the least used option. Fencing is the most inexpensive solution and is used frequently. It has been reported to be an "attractive nuisance," however, because some older children feel challenged to climb fences and enter restricted areas (MWCOG, 1983).

Requirements to construct wet ponds for urban runoff management are a concern for developers, who lose the potential profit from this otherwise buildable land. This unrealized profit, or foregone value, can be substantial if, for example, a builder is no longer able to construct several planned townhomes (Rolband, 1995). Developers often increase the number of homes built in the area available for development and reduce the size of individual homes to recoup the foregone value of the property.

Urban runoff management controls are now widely accepted due to lessons learned from not planning properly for the impacts associated with increased urbanization.

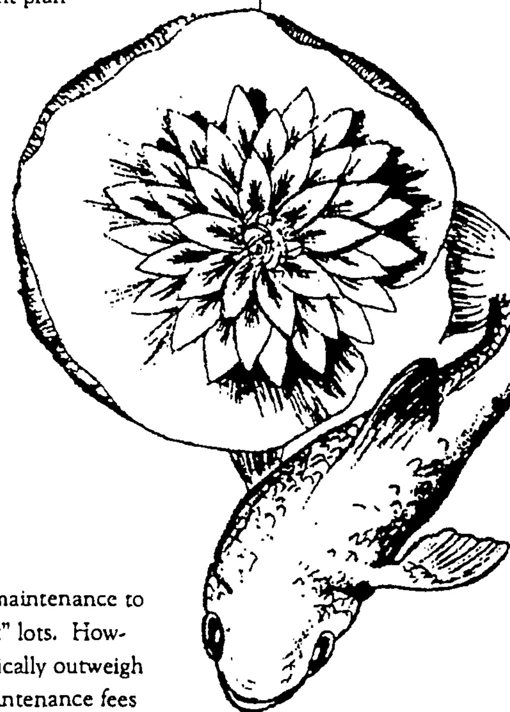
Poorly maintained wet ponds or constructed wetlands are often unsightly due to excessive algal growth or garbage build-up. These conditions are considered detriments by area residents and people passing through the areas. Wet ponds and constructed wetlands can also become mosquito breeding grounds. Mosquito problems usually can be reduced or eliminated by designing the wet pond so that all portions of the basin are connected to open water to allow natural predators to control the mosquito larvae (Tourner and Westmacott, 1992). Generally mosquitoes are not a problem in the presence of a good biological community. Organic controls such as mosquito-eating fish or insecticidal bacteria like *Bacillus thuringiensis israelensis* (Bti), however, are also options where mosquitoes need to be controlled.

When designed and sited correctly, artificial lakes or wetlands can help developers reduce negative environmental impacts caused by the development process and increase the value of the property.

Improving the Acceptance of Urban Runoff Facilities

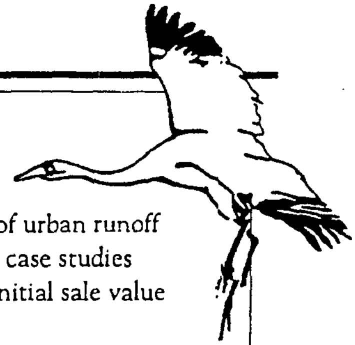
Effective landscaping can do much to overcome the disadvantages of urban runoff systems and improve the appearance of facilities. Banks of urban runoff storage areas and drainage ditches should be graded smoothly into adjacent areas where feasible. Steep slopes should be protected against erosion by stabilization techniques, such as gabions, rip-rap, or other practices that detract as little as possible from the natural setting. Planting and preservation of trees, shrubs, and other vegetation should also be a part of the improvement plan (Poertner, 1974).

Sediment accumulation and waterlogging of otherwise usable land areas can be avoided by the use of proper design, construction, and operation techniques. Ponds used for urban runoff control can be spared from excessive sediment accumulation by the use of forebays for silt collection. The amount of silt transported can be reduced by directing runoff through vegetated areas or specially designed runoff filters. Waterlogging of land surrounding urban runoff storage areas can be minimized by sloping the ground toward storage areas, eliminating water pockets, and minimizing the frequency and duration of ponding on areas otherwise suitable for multipurpose use (Poertner, 1974).



Operation and Maintenance

Wet ponds and constructed wetlands require periodic maintenance to preserve environmental and monetary benefits of "waterfront" lots. However, the benefits of higher resale value and quality of life typically outweigh the combined costs of the initial lot premium and annual maintenance fees charged by homeowners' associations. In fact, operation and maintenance costs of urban runoff retention ponds can be as low as $62 per year for homeowners (MWCOG, 1983).



Case Studies

THE FOLLOWING CASE studies highlight developments where the incorporation of urban runoff controls resulted in economic benefits to the local homeowners or developers. The case studies detail how the presence of aesthetically designed runoff controls affected both the initial sale value of new developments and the resale values for existing developments.

New Development

Columbia, Maryland *A landmark survey by the National Institute for Urban Wildlife indicated that 75 percent of the residents of Columbia, Maryland, a community planned for a population of 100,000, prefer urban runoff ponds that contain permanent pools of water, wetlands, and wildlife over the dry ponds many municipalities prescribe for their subdivisions. Residents (94 percent) overwhelmingly believed that managing future runoff basins for fish and wildlife as well as for flood and sediment control would be desirable. Residents (92 percent) considered the view of birds and other wildlife to be particularly important and felt that the sight of them outweighed any nuisances they created. Perhaps most importantly, 75 percent of Columbia homeowners felt that permanent bodies of water added to real estate values and* ***73 percent said they would pay more for property located in a neighborhood with stormwater control basins designed to enhance fish or wildlife use.*** *The study in Columbia covered an area that contained 3 lakes, 22 runoff ponds with a permanent pool of water, and 9 dry detention basins (Adams et al., 1984; Tourbier and Westmacott, 1992).*

For further information contact Charles Rhodehamel, Columbia Association, Land Management Division, 9450 Gerwig Lane, Columbia, Maryland 21046; phone (410) 381-0288.

Champaign-Urbana, Illinois *Residents of seven Champaign-Urbana, Illinois, subdivisions with urban runoff detention ponds were questioned about the role the pond played in their decision to purchase their home. Sixty-three percent of the respondents living adjacent to a wet pond identified the pond as what they liked most about their neighborhood. Seventy-four percent of homeowners surveyed believed that wet ponds contributed positively to the image of a subdivision as a desirable place to live. Only 3.5 percent felt a wet pond had a negative influence on the image of their neighborhood. Overall, respondents believed that* ***lots adjacent to a wet pond were worth an average of 21.9 percent more than comparable nonadjacent lots in the same subdivision.*** *Eighty-two percent of all respondents said they would, in the future, be willing to pay a premium for a lot adjacent to a wet pond (Emmerling-DiNovo, 1995).*

Boulder, Colorado *Built in 1993, the Sale Lake subdivision of single-family homes surrounds a 4-acre constructed wetland. Sale Lake demonstrates environmental sensitivity in suburban development.* ***Lots located alongside the wetland sold for as much as $134,000, up to a 30 percent premium over lots with no water view*** *(St. Germain, 1995).*

For further information contact Will St. Germain, St. Germain Construction, Inc., 2709 Pine Street, Boulder, Colorado 80302; phone (303) 449-1379.

Highland Parks, Illinois

"Preservation is not a problem for developers; it's a golden opportunity," insists the president of the development company for **Hybernia**, *a community of 122 single-family houses on a 133.5-acre site in Highland Parks, Illinois. The site, zoned for 40,000-square-foot lots, was laid out around a constructed pond/stream system and 27 acres of land approved as a state nature preserve. The site includes 16.5 acres of ponds. Forebays at urban runoff inlets catch sediments (Tourbier and Westmacott, 1992).*

Hybernia is a an example of ecological landscape planning. ***Waterfront lots, which now sell for $299,900 to $374,900, draw a 10 percent premium above those with no water view*** *(Margolin, 1995).*

For further information contact Peter Margolin, Hybernia Homeowners Association, c/o Red Seal Development Corporation, 425 Huehl Road, Building 18, Northbrook, Illinois 60062; phone (708) 272-5600.

Alexandria, Virginia

Chancery on the Lake, *a condominium development in Alexandria, Virginia, is a residential project with an attractive 14-acre urban runoff detention area. Realtors are currently promoting the wet pond as the development's feature selling point. The wet pond will be surrounded by a walking trail, and a gazebo and fishing pier will also be built. According to Ginger Harden, Sales Associate of Chancery Associates LP, condominiums are priced between $129,990 and $139,990.* ***Condominiums that front the lake are selling at a $7,500 premium.*** *For the first four buildings on the market, a $5,000 premium was charged for units fronting the lake. The lakefront units were the only units selling, and now the premium has been raised to $7,500 (Harden, 1995).*

For further information contact Eric Yakuchev, sales manager, 6540 S. Van Dorn Street, Alexandria, Virginia 22315; phone (703) 922-7171

St. Petersburg, Florida

A development consisting of apartments and townhouses in St. Petersburg, Florida, **Lynne Lake Arms**, *has four urban runoff detention ponds on site. Three of the ponds are 3 to 5 acres in size, and the fourth is a 25-acre pond with a large fountain in the center. Apartments or townhouses rent for between $336 and $566 a month.* ***Units facing the three smaller ponds have a $15 per month waterfront premium; units facing the large pond are rented at a $35 per month premium*** *(McInturf, 1995). A small channel connects the large detention pond and one of the smaller ponds. Even apartments fronting this channel have a $5 per month waterfront premium.*

For further information contact Mark Mahaffey, leasing agent, 5800 Lynn Lake Drive South, St. Petersburg, Florida 33712; phone (813) 823-3399.

Wichita, Kansas

The owner of a 72.3-acre parcel of land had plans to fill deteriorating wetlands before building a subdivision. He was persuaded to enhance them instead and now promotes enhanced and constructed wetlands as the feature selling point of **The Landing**. *A lake with 3,750 feet of shoreline provides aesthetic and recreational value, as well as [illegible] detention of urban runoff.* ***Waterfront lots currently sell for $18,000 to $40,000, a premium of up to $21,000 (150 percent) above comparable lots with no water view*** *(Baird, 1995).*

For further information contact Sally Baird, sales agent, 520 S [illegible] Suite 401, Wichita, Kansas 67209, phone (316) 722-0777.

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Existing Development

Fairfax County, Virginia *Since their construction in 1971, units facing the constructed pond in the townhouse community of* ***Pinewood Lakes*** *have sold at a premium. Of the 497 units, all with exactly the same square footage according to tax records, only 20 have direct water views in either the front or the rear. Figures show the average 1994 sales price of townhouses lacking the water amenity to be $93,833. The average waterfront sales price is $100,000, a premium of $6,117.* ***Higher sales prices for properties with views of the water have been consistent for 23 years*** *(Wade, 1995).*

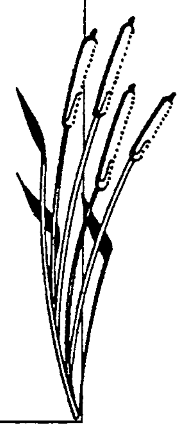
Evans Mills *is an upscale community of 41 townhouses in the Tysons Corner area built around an existing pond. Fairfax County tax records show Evans Mills waterfront townhouses sell at higher prices.* ***In 1994, waterfront homes sold for an average $17,467 premium above the average*** *$419,200 price of homes not facing the pond (Wade, 1995).*

Single-family homes can have higher initial sale values as well as higher resale values when they face urban runoff detention areas. County tax records reveal that land values in ***Franklin Farms****, an established residential neighborhood in northern Virginia, are highest when located in view of its 5-acre urban runoff detention area, which is surrounded by a walking path furnished by the developer.* ***"Waterfront" homes in this neighborhood sold for 10 to 20 percent more initially and again at resale than land with no water view*** *(Downham, 1995). (These percentages might be slightly higher than actual premiums due to possible additional amenities in the waterfront homes.)*

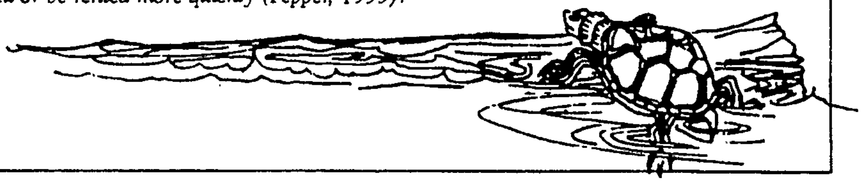
Commercial Property

Prince George's County, Maryland ***Laurel Lakes Executive Park****, commercial property in Laurel, Maryland, also has created an attractive wet pond system.* ***Office space fronting the water rents at a premium of $100 to $200 per month*** *depending on the size and layout of the office space (Kalish, 1995). On average, first-class office space located in Prince George's County with a lakefront view rents for between $17.50 and $20.00 per square foot, whereas properties without a view rent for between $16.50 and $18.50 per square foot (Duncan, 1995).*

Fairfax County, Virginia *Commercial office space also can be valued higher when it fronts aesthetically designed runoff retention ponds. The lakefront* ***Lakeside at Avion*** *and* ***Tysons Pond****, both located in Fairfax County, Virginia, are examples of commercial projects that took advantage of the requirement to implement urban runoff management controls by enhancing a retention pond and then capitalizing on the presence of the pond when naming the project.* ***In Fairfax, Virginia, the average cost of commercial office space without water as an amenity is approximately $15 per square foot. The average leasing rate for commercial waterfront office space is $16 per square foot*** *(Consum. 1995 Goeller, 1995).*



In a soft commercial real estate market, where office space is overabundant, it can be difficult to ask for a premium of any kind. However, ***real estate brokers agree that, when all else is equal, commercial waterfront property rents considerably faster than space that does not front water*** *(Berman, 1995; Constam, 1995; Goeller, 1995; Pepper, 1995). Although a tenant might not be charged for a water amenity, it can provide a steadier flow of income and fewer vacancies for the realtor (Berman, 1995). Mike Pepper, Vice President of CB Commercial Real Estate Group, Inc., declares that "There is absolutely a premium associated with commercial lakefront property. Anything adding to the aesthetic value is going to raise a property's value." Mr. Pepper concedes that in the saturated market of northern Virginia, property with a water view might or might not rent for a $1-$3 per square foot premium, but will always sell or be rented more quickly (Pepper, 1995).*



Conclusion

ENVIRONMENTAL BENEFITS are not the only valid reason for encouraging developers to incorporate urban runoff controls into new residential and commercial developments. Increased property values can result from aesthetically landscaped controls. Both homeowners and developers have realized benefits from beautification of areas adjacent to waterways and detention ponds. Residents find the beauty and tranquility of water, as well as fish, birds, and other wildlife, highly desirable. The beauty of natural surroundings increases real residential property values by up to 28 percent while also enhancing the quality of life. Commercial property owners, too, can benefit when their property is adjacent to an aesthetically designed urban runoff control. They can realize lower vacancies, lower tenant turnover, and high rental prices. Real estate professionals agree that the more amenities a property has, the faster it will sell or rent. Of course, to maintain higher property values, aesthetics must be considered during the operation and maintenance of wet ponds and constructed wetlands over the years. Moreover, for runoff controls to be successful, they must have the support of people in the community as well as developers (Adams et al., 1984). Then, everyone can benefit.

(2) For any group application submitted in accordance with paragraph (c)(2) of this section:

(i) Part 1 of the application shall be submitted to the Director, Office of Water Enforcement and Permits by March 18, 1991;

(ii) Based on information in the part 1 application, the Director will approve or deny the members in the group application within 60 days after receiving part 1 of the group application.

(iii) Part 2 of the application shall be submitted to the Director, Office of Water Enforcement and Permits no later than 12 months after the date of approval of the part 1 application.

(iv) Facilities that are rejected as members of a group by the permitting authority shall have 12 months to file an individual permit application from the date they receive notification of their rejection.

(v) A facility listed under paragraph (b)(14) (i)-(xi) of this section may add on to a group application submitted in accordance with paragraph (e)(2)(i) of this section at the discretion of the Office of Water Enforcement and Permits, and only upon a showing of good cause by the facility and the group applicant; the request for the addition of the facility shall be made no later than February 18,1992; the addition of the facility shall not cause the percentage of the facilities that are required to submit quantitative data to be less than 10%, unless there are over 100 facilities in the group that are submitting quantitative data; approval to become part of group application must be obtained from the group or the trade association representing the individual facilities.

(3) For any discharge from a large municipal separate storm sewer system;

(i) Part 1 of the application shall be submitted to the Director by November 18, 1991;

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application;

(iii) Part 2 of the application shall be submitted to the Director by November 16, 1992.

(4) For any discharge from a medium municipal separate storm sewer system;

(i) Part 1 of the application shall be submitted to the Director by May 18, 1992.

(ii) Based on information received in the part 1 application the Director will approve or deny a sampling plan under paragraph (d)(1)(iv)(E) of this section within 90 days after receiving the part 1 application.

(iii) Part 2 of the application shall be submitted to the Director by May 17, 1993.

(5) A permit application shall be submitted to the Director within 60 days of notice, unless permission for a later date is granted by the Director (*see* 40 CFR 124.52(c)), for:

(i) A storm water discharge which the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator, determines that the discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States (see paragraph (a)(1)(v) of this section);

(ii) A storm water discharge subject to paragraph (c)(1)(v) of this section.

(6) Facilities with existing NPDES permits for storm water discharges associated with industrial activity shall maintain existing permits. New applications shall be submitted in accordance with the requirements of 40 CFR 122.21 and 40 CFR 122.26(c) 180 days before the expiration of such permits. Facilities with expired permits or permits due to expire before May 18, 1992, shall submit applications in accordance with the deadline set forth under paragraph (e)(1) of this section.

(f) *Petitions.* (1) Any operator of a municipal separate storm sewer system may petition the Director to require a separate NPDES permit (or a permit issued under an approved NPDES State program) for any discharge into the municipal separate storm sewer system.

(2) Any person may petition the Director to require a NPDES permit for a discharge which is composed entirely of storm water which contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

(3) The owner or operator of a municipal separate storm sewer system may petition the Director to reduce the Census estimates of the population served by such separate system to account for storm water discharged to combined sewers as defined by 40 CFR 35.2005(b)(11) that is treated in a publicly owned treatment works. In municipalities in which combined sewers are operated, the Census estimates of population may be reduced proportional to the fraction, based on estimated lengths, of the length of combined sewers over the sum of the length of combined sewers and municipal separate storm sewers where an applicant has submitted the NPDES permit number associated with each discharge point and a map indicating areas served by combined sewers and the location of any combined sewer overflow discharge point.

(4) Any person may petition the Director for the designation of a large or medium municipal separate storm sewer system as defined by paragraphs (b)(4)(iv) or (b)(7)(iv) of this section.

(5) The Director shall make a final determination on any petition received under this section within 90 days after receiving the petition.

6. Section 122.28(b)(2)(i) is revised to read as follows:

§ 122.28 General permits (applicable to State NPDES programs, see § 123.25).

* * * * *

(b) * * *

(2) *Requiring an individual permit.* (i) The Director may require any discharger authorized by a general permit to apply for and obtain an individual NPDES permit. Any interested person may petition the Director to take action under this paragraph. Cases where an individual NPDES permit may be required include the following:

(A) The discharger or "treatment works treating domestic sewage" is not in compliance with the conditions of the general NPDES permit;

(B) A change has occurred in the availability of demonstrated technology or practices for the control or abatement of pollutants applicable to the point source or treatment works treating domestic sewage;

(C) Effluent limitation guidelines are promulgated for point sources covered by the general NPDES permit;

(D) A Water Quality Management plan containing requirements applicable to such point sources is approved;

(E) Circumstances have changed since the time of the request to be covered so that the discharger is no longer appropriately controlled under the general permit, or either a temporary or permanent reduction or elimination of the authorized discharge is necessary;

(F) Standards for sewage sludge use or disposal have been promulgated for the sludge use and disposal practice covered by the general NPDES permit; or

(G) The discharge(s) is a significant contributor of pollutants. In making this determination, the Director may consider the following factors:

(*1*) The location of the discharge with respect to waters of the United States;

(*2*) The size of the discharge;

(*3*) The quantity and nature of the pollutants discharged to waters of the United States; and

(*4*) Other relevant factors;

* * * * *

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7. Section 122.42 is amended by adding paragraph (c) to read as follows:

§ 122.42 Additional conditions applicable to specified categories of NPDES permits (applicable to State NPDES programs, see § 123.25).

* * * * *

(c) *Municipal separate storm sewer systems.* The operator of a large or medium municipal separate storm sewer system or a municipal separate storm sewer that has been designated by the Director under § 122.26(a)(1)(v) of this part must submit an annual report by the anniversary of the date of the issuance of the permit for such system. The report shall include:

(1) The status of implementing the components of the storm water management program that are established as permit conditions;

(2) Proposed changes to the storm water management programs that are established as permit condition. Such proposed changes shall be consistent with § 122.26(d)(2)(iii) of this part; and

(3) Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under § 122.26(d)(2)(iv) and (d)(2)(v) of this part;

(4) A summary of data, including monitoring data, that is accumulated throughout the reporting year;

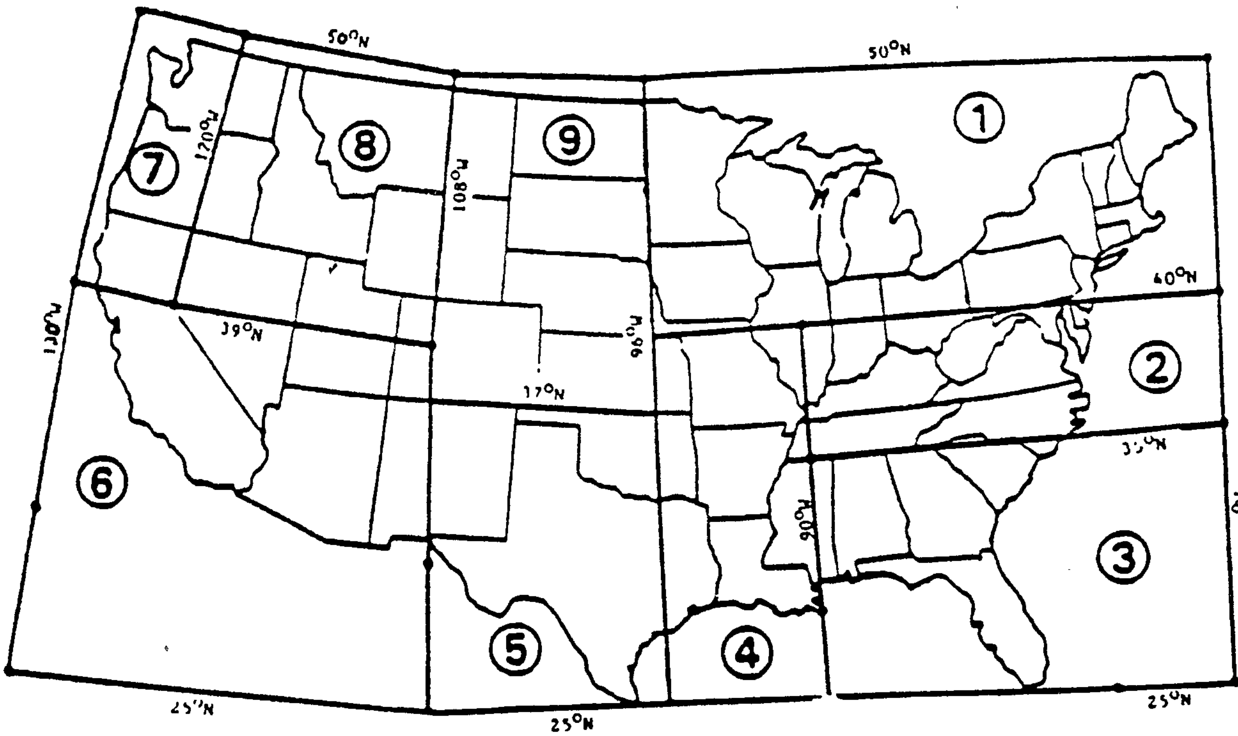
(5) Annual expenditures and budget for year following each annual report;

(6) A summary describing the number and nature of enforcement actions, inspections, and public education programs;

(7) Identification of water quality improvements or degradation;

7a. Part 122 is amended by adding appendices E through I as follows:

Appendix E to Part 122—Rainfall Zones of the United States



Not Shown: Alaska (Zone 7); Hawaii (Zone 7); Northern Mariana Islands (Zone 7); Guam (Zone 7); American Samoa (Zone 7); Trust Territory of the Pacific Islands (Zone 7); Puerto Rico (Zone 3) Virgin Islands (Zone 3).

Source: Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality, prepared for U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Division, Washington, DC, 1986.

Appendix F to Part 122—Incorporated Places With Populations Greater Than 250,000 According to Latest Decennial Census by Bureau of Census.

State	Incorporated place
Alabama	Birmingham.
Arizona	Phoenix.
	Tucson.
California	Long Beach.
	Los Angeles.
	Oakland.
	Sacramento.
	San Diego.
	San Francisco.
	San Jose.

State	Incorporated place
Colorado	Denver.
District of Columbia	
Florida	Jacksonville.
	Miami.
	Tampa.
Georgia	Atlanta.
Illinois	Chicago.
Indiana	Indianapolis.
Kansas	Wichita.
Kentucky	Louisville.
Louisiana	New Orleans.
Maryland	Baltimore.
Massachusetts	Boston.
Michigan	Detroit.
Minnesota	Minneapolis
	St. Paul.

State	Incorporated place
Missouri	Kansas City
	St. Louis.
Nebraska	Omaha.
New Jersey	Newark.
New Mexico	Albuquerque.
New York	Buffalo.
	Bronx Borough.
	Brooklyn Borough.
	Manhattan Borough.
	Queens Borough.
	Staten Island Borough
North Carolina	Charlotte.
Ohio	Cincinnati.
	Cleveland.
	Columbus.
	Toledo.
Oklahoma	Oklahoma City
	Tulsa.
Oregon	Portland.
Pennsylvania	Philadelphia
	Pittsburgh.
Tennessee	Memphis.
	Nashville/Davidson.
Texas	Austin.
	Dallas.
	El Paso.
	Fort Worth.
	Houston.
	San Antonio
Virginia	Norfolk.
	Virginia Beach
Washington	Seattle.
Wisconsin	Milwaukee

Appendix G to Part 122—Incorporated Places With Populations Greater Than 100,000 and Less Than 250,000 According to Latest Decennial Census by Bureau of Census

State	Incorporated place
Alabama	Huntsville.
	Mobile.
	Montgomery
Alaska	Anchorage
Arizona	Mesa.
	Tempe.
Arkansas	Little Rock.
California	Anaheim.
	Bakersfield
	Berkeley.
	Concord.
	Fremont.
	Fresno.
	Fullerton.
	Garden Grove
	Glendale.
	Huntington Beach.
	Modesto.
	Oxnard.
	Pasadena.
	Riverside.
	San Bernadino
	Santa Ana.
	Stockton.
	Sunnyvale.
	Torrance.
Colorado	Aurora.
	Colorado Springs.
	Lakewood.
	Pueblo.
Connecticut	Bridgeport.
	Hartford.
	New Haven.
	Stamford.
	Waterbury.
Florida	Fort Lauderdale.
	Hialeah.
	Hollywood.
	Orlando.
	St. Petersburg.
Georgia	Columbus.
	Macon.
	Savannah.
Idaho	Boise City.
Illinois	Peoria.
	Rockford.
Indiana	Evansville.
	Fort Wayne.
	Gary.
	South Bend.
Iowa	Cedar Rapids.
	Davenport.
	Des Moines.
Kansas	Kansas City
	Topeka.
Kentucky	Lexington-Fayette
Louisiana	Baton Rouge.
	Shreveport.
Massachusetts	Springfield.
	Worcester
Michigan	Ann Arbor.
	Flint.
	Grand Rapids
	Lansing.
	Livonia.
	Sterling Heights.
	Warren.
Mississippi	Jackson.
Missouri	Independence
	Springfield.
Nebraska	Lincoln.
Nevada	Las Vegas
	Reno.
New Jersey	Elizabeth.
	Jersey City
	Paterson.
New York	Albany.
	Rochester
	Syracuse.
	Yonkers.
North Carolina	Durham.
	Greensboro
	Raleigh.
	Winston-Salem
Ohio	Akron.
	Dayton.
	Youngstown
Oregon	Eugene.
Pennsylvania	Allentown
	Erie.
Rhode Island	Providence
South Carolina	Columbia.
Tennessee	Chattanooga
	Knoxville.
Texas	Amarillo.
	Arlington.
	Beaumont.
	Corpus Christi
	Garland.
	Irving.
	Lubbock.
	Pasadena.
	Waco.
Utah	Salt Lake City
Virginia	Alexandria.
	Chesapeake.
	Hampton.
	Newport News
	Portsmouth.
	Richmond.
	Roanoke.
Washington	Spokane.
	Tacoma.
Wisconsin	Madison.

Appendix H to Part 122—Counties with Unincorporated Urbanized Areas With a Population of 250,000 or More According to the Latest Decennial Census by the Bureau of Census

State	County	Unincorporated urbanized population
California	Los Angeles	912,864
	Sacramento	449,056
	San Diego	304,758
Delaware	New Castle	257,184
Florida	Dade	781,949
Georgia	DeKalb	366,379
Hawaii	Honolulu	688,178
Maryland	Anne Arundel	271,458
	Baltimore	601,308
	Montgomery	447,993
	Prince George's	450,188
Texas	Harris	409,601
Utah	Salt Lake	304,632
Virginia	Fairfax	527,178
Washington	King	336,800

Appendix I to Part 122—Counties With Unincorporated Urbanized Areas Greater Than 100,000, But Less Than 250,000 According to the Latest Decennial Census by the Bureau of Census

State	County	Unincorporated urbanized population
Alabama	Jefferson	102,917
Arizona	Pima	111,479
California	Alameda	187,474
	Contra Costa	158,452
	Kern	117,231
	Orange	210,693
	Riverside	115,719
	San Bernardino	148,844
Florida	Broward	159,370
	Escambia	147,892
	Hillsborough	238,292
	Orange	245,325
	Palm Beach	167,089
	Pinellas	194,389
	Polk	104,150
	Sarasota	110,009
Georgia	Clayton	100,742
	Cobb	204,121
	Richmond	118,529
Kentucky	Jefferson	224,958
Louisiana	Jefferson	140,838
North Carolina	Cumberland	142,727
Nevada	Clark	201,775
Oregon	Multnomah	141,100
	Washington	109,348
South Carolina	Greenville	135,398
	Richland	124,684
Virginia	Arlington	152,599
	Henrico	161,204
	Chesterfield	108,348
Washington	Snohomish	103,493
	Pierce	196,113

PART 123—STATE PROGRAM REQUIREMENTS

8. The authority citation for part 123 continues to read as follows:

Authority: Clean Water Act, 33 U.S.C. 1251 *et seq.*

9. Section 123.25 is amended by revising paragraph (a)(9) to read as follows:

§ 123.25 Requirements for permitting.

(a) * * *

(9) § 122.26—(Storm water discharges);

* * * * *

PART 124—PROCEDURES FOR DECISIONMAKING

10. The authority citation for part 124 continues to read as follows:

Authority: Resource Conservation and Recovery Act, 42 U.S.C. 6901 *et seq.*; Safe Drinking Water Act, 42 U.S.C. 300f *et seq.*; Clean Water Act, 33 U.S.C. 1251 *et seq.*; and Clean Air Act, 42 U.S.C. 1857 *et seq.*

11. Section 124.52 is revised to read as follows:

§ 124.52 Permits required on a case-by-case basis.

(a) Various sections of part 122, subpart B allow the Director to determine, on a case-by-case basis, that certain concentrated animal feeding operations (§ 122.23), concentrated aquatic animal production facilities (§ 122.24), storm water discharges (§ 122.26), and certain other facilities covered by general permits (§ 122.28) that do not generally require an individual permit may be required to obtain an individual permit because of their contributions to water pollution.

(b) Whenever the Regional Administrator decides that an individual permit is required under this section, except as provided in paragraph (c) of this section, the Regional Administrator shall notify the discharger in writing of that decision and the reasons for it, and shall send an application form with the notice. The discharger must apply for a permit under § 122.21 within 60 days of notice, unless permission for a later date is granted by the Regional Administrator. The question whether the designation was proper will remain open for consideration during the public comment period under § 124.11 or § 124.118 and in any subsequent hearing.

(c) Prior to a case-by-case determination that an individual permi is required for a storm water discharge under this section (*see* 40 CFR 122.26 (a)(1)(v) and (c)(1)(v)), the Regional Administrator may require the discharger to submit a permit application or other information regarding the discharge under section 308 of the CWA. In requiring such information, the Regional Administrator shall notify the discharger in writing and shall send an application form with the notice. The discharger must apply for a permit under § 122.26 within 60 days of notice, unless permission for a later date is granted by the Regional Administrator. The question whether the initial designation was proper will remain open for consideration during the public comment period under § 124.11 or § 124.118 and in any subsequent hearing.

Note: The following form will not appear in the Code of Federal Regulations.

BILLING CODE 6560-50-M

R0010728

APPENDIX C:
ADEQUATE LEGAL AUTHORITY

contrivance for the elimination or destruction of human waste, within those portions of the watershed of the city contiguous to the intake of the city's water supply, as hereinafter described, or by placing any foul or putrescible substance, whether solid or liquid, and whether the same be buried or not, within the limits of the portion of the watershed so described.

Sec. 49-6. Application for permit.

(a) Any person who desires to use or develop any vegetated wetland and on and after January 1, 1983, any nonvegetated wetland, within this city, other than for those activities specified in section 49-3 above, shall first file an application for a permit with the wetlands board.

Sec. 49-22. Application for permit.

(a) Any person who desires to use or alter any coastal primary sand dune within this city, other than for those activities specified in section 49-20 above, shall first file an application for a permit with the wetlands board.

1.6 Authority to Meet Part 2 Permit Requirements

The NPDES stormwater permit application regulations require an assessment of whether existing legal authority is sufficient to meet the criteria for Part 2 of the permit application provided in *40 CFR 122.26(d)(2)(i)* as follows:

40 CFR 122.26(d)(2)(i)

A demonstration that the applicant can operate pursuant to legal authority established by statute, ordinance or series of contracts which authorizes or enables the applicant at a minimum to:

(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer system by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;

(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer;

(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water;

(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;

(E) Require compliance with conditions in ordinances, permits, contracts or order; and

(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer.

The City Code sections identified above are referenced in an assessment of the individual Part 2 legal authority criteria.

(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer system by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity. Section 39.1-19 of the City Code prohibits the discharge of sanitary sewer flow to the storm sewer system. Section 39.2-5 of the City Code prohibits the discharge of any sewage from a private sewage disposal facility on any public or private property in the City. Section 41.1-4 of the City Code prohibits pollutants to be discharged to the storm sewer system including the discharge of industrial process water, wash water, or other unpermitted industrial discharges in Section 41.1-4(c). Section 41.1-5 of the City Code provides the City with authority to order the correction of drainage problems on any site in the City. Sections 9-10, 30-69, 41-16, and 41-17 of the City Code prohibit pollution of waters of the City and littering. Sections 42-20.1 and 42-20.2 of the City Code prohibit the obstruction of drains or drainage areas. Sections 42-24, 42-25, and 42-46 of the City Code establish regulations for protecting the City from spills or deposits of liquid wastes. Section 46-28 of the City Code prohibits pollution of the City's water supply.

For development or redevelopment of industrial sites, the City's Zoning Ordinance establishes lot size, yard size, and maximum lot coverage requirements for industrial activity. Chapter 15 of the City Code establishes erosion and sedimentation control regulations. If development or redevelopment of industrial sites occurs within a Chesapeake Bay Preservation Area, Section 494 of the City's Zoning Ordinance and Chapter 32.2 of the City Code establish stringent criteria for stormwater management, protection of water quality, and use of Best Management Practices. Chapter 49 of the City Code protects development within wetlands or coastal primary sand dunes by requiring a permit application with the wetlands board.

Enforcement provisions and penalties for violations of the referenced sections of City Code are also provided in specific chapters. Chapter 27 of the City Code provides additional authority for the abatement of nuisances.

(B) Prohibit through ordinance, order or similar means, illicit discharges to the municipal separate storm sewer. Section 39.1-19 of the City Code prohibits the discharge of sanitary sewer flow to the storm sewer system. Section 39.2-5 of the City Code prohibits the discharge of any sewage from a private sewage disposal facility on any public or private property in the City. Section 41.1-4 of the City Code prohibits pollutants to be discharged to the storm sewer system. Section 41.1-5 of the City Code provides the City with authority to order the correction of drainage problems on any site in the City. Sections 9-10, 30-69, 41-16, and 41-17 of the City Code prohibit pollution of waters of the City and littering. Sections 42-20.1 and 42-20.2 of the City Code prohibit the obstruction of drains or drainage areas. Sections 42-24, 42-25, and 42-46 of the City Code establish regulations for protecting the City from spills or deposits of liquid wastes. Section 46-28 of the City Code prohibits pollution of the City's water supply.

Enforcement provisions and penalties for violations of the referenced sections of City Code are also provided in specific chapters. Chapter 27 of the City Code provides additional authority for the abatement of nuisances.

(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water. Section 39.1-19 of the City Code prohibits the discharge of sanitary sewer flow to the storm sewer system. Section 39.2-5 of the City Code prohibits the discharge of any sewage from a private sewage disposal facility on any public or private property in the City. Section 41.1-4 of the City Code prohibits pollutants to be discharged to the storm sewer system. Sections 9-10, 30-69, 41-16, and 41-17 of the City Code prohibit pollution of waters of the City and littering. Sections 42-24, 42-25, and 42-46 of the City Code establish regulations for protecting the City from spills or deposits of liquid wastes. Section 46-28 of the City Code prohibits pollution of the City's water supply.

Enforcement provisions and penalties for violations of the referenced sections of City Code are also provided in specific chapters. Chapter 27 of the City Code provides additional authority for the abatement of nuisances.

(D) Control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system. The City of Norfolk owns the entire separate storm water system and is an individual NPDES permit applicant.

The City of Norfolk relies on its In-Town Reservoir System as a vital part of the water supply system. To protect water quality within the In-Town Reservoir System, the City of Norfolk will seek an intermunicipal agreement with the City of Virginia Beach to control nonpoint source pollution for the areas of the In-Town Reservoir System bordering and located within the jurisdiction of the City of Virginia Beach. After approval of Part 1 of the application by the EPA, the City of Norfolk will meet with the City of Virginia Beach to discuss the development of an agreement before submittal of Part 2 of the application on November 16, 1992.

(E) Require compliance with conditions in ordinances, permits, contracts or order. Enforcement provisions and penalties for violations of the referenced sections of City Code are provided in specific chapters. Chapter 27 of the City Codes provides additional authority for the abatement of nuisances.

(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer. Chapter 41.1, entitled "Storm Water Management", provides authority for the City's Director of Public Works to establish procedures and enforce regulations pertaining to the storm water system in Section 41.1-3. Authority to prohibit and inspect for illicit connections to the storm sewer system is provided to the Department of City Planning and Codes Administration in Section 39.1-19. Authority to enforce violations of private sewage disposal regulations is provided to the Department of Health in Section 39.2-1 of the City Code. For development and redevelopment, the Department of City Planning and Codes Administration has authority over erosion and sediment control plans, the site review process, and stormwater management regulations required for activity within the Chesapeake Bay Preservation Area. Additional authority for enforcement of erosion and sediment control regulations and stormwater management is being established for the Department of Public Works in an ordinance currently under review by the state. Authority to enforce regulations and permits of the City's Tree Ordinance is provided in Section 30-23 of the City Code.

1.7 Legal Authority Overview

Overall, the City of Norfolk has the existing legal authority, or is in the process of modifying existing City Code with ordinances, to control discharges to the municipal storm sewer system and meet the legal authority requirements of *40 CFR 122.26(d)(2)(i)*.

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EPA

Preliminary Data Summary of Urban Storm Water Best Management Practices

R0010735

6.0 Costs and Benefits of Storm Water BMPs

Storm water best management practices (BMPs) are the primary tool to improve the quality of urban streams and meet the requirements of NPDES permits. They include both the structural and non-structural options reviewed in Section 5.2 of this report. Some BMPs can represent a significant cost to communities, but these costs should be weighed against the various benefits they provide. This chapter will focus on reviewing available data on the costs and potential benefits of both structural and non-structural BMPs designed to improve the quality of urban and urbanizing streams, and the larger water bodies to which they drain.

As described in previous chapters, storm water runoff can contribute loadings of nutrients, metals, oil and grease, and litter that result in impairment of local water bodies. The extent to which these impairments are eliminated by BMPs will depend on a number of factors, including the number, intensity, and duration of wet weather events; BMP construction and maintenance activities; and the site-specific water quality and physical conditions. Because these factors will vary substantially from site to site, data and information are not available with which to develop dollar estimates of costs and benefits for individual types of BMPs. However, EPA's national estimates of costs and benefits associated with implementation of the NPDES Phase II rule are discussed in Section 6.4.

6.1 Structural BMP Costs

The term structural BMPs, often referred to as "Treatment BMPs," refers to physical structures designed to remove pollutants from storm water runoff, reduce downstream erosion, provide flood control and promote groundwater recharge. In contrast with non-structural BMPs, structural measures include some engineering design and construction.

Structural BMPs evaluated in this report include:

- Retention Basins
- Detention Basins
- Constructed Wetlands
- Infiltration Practices
- Filters
- Bioretention
- Biofilters (swales and filter strips).

The two infiltration systems focused on in this report are infiltration trenches and infiltration basins. Although bioretention can serve as a filtering system or infiltration practice, it is discussed separately because it has separate cost data and design criteria. In this report, wet swales are assumed to have the same cost as biofilters, because there are little cost data available on this practice. Additional information about these structural BMPs, including descriptions, applicability and performance data can be found in Chapter 5 of this report. Other BMPs include experimental and proprietary products, as well as some conventional structures such as water quality inlets. They are not included in this analysis because sufficient data are not available to support either the performance or the cost of these practices.

6.1.1 Base Capital Costs

The base capital costs refer primarily to the cost of constructing the BMP. This may include the cost of erosion and sediment control during construction. The costs of design, geotechnical testing, legal fees, land costs, and other unexpected or additional costs are not included in this estimate. The cost of constructing any BMP is variable and depends largely on site conditions and drainage area. For example, if a BMP is constructed in very rocky soils, the increased excavation costs may substantially increase the cost of construction. Also, land acquisition costs vary greatly from site to site.[4] In addition, designs vary slightly among BMP types. A wet pond may be designed with or without various levels of landscaping, for example. The data in Table 6-1 represent typical unit costs (dollars per cubic foot of treated water volume) from various studies, and should be considered planning level. In the case of retention and detention basins, ranges are used to reflect the economies of scale involved in designing these BMPs.

[4] Land cost is the largest variable influencing overall BMP cost.

Table 6-1. Typical Base Capital Construction Costs for BMPs

BMP Type	Typical Cost* ($/cf)	Notes	Source
Retention and Detention Basins	0.50-1.00	Cost range reflects economies of scale in designing this BMP. The lowest unit cost represents approx. 150,000 cubic feet of storage, while the highest is approx. 15,000 cubic feet. Typically, dry detention basins are the least expensive design options among retention and detention practices.	Adapted from Brown and Schueler (1997b)
Constructed Wetland	0.60-1.25	Although little data are available to assess the cost of wetlands, it is assumed that they are approx. 25% more expensive (because of plant selection and sediment forebay requirements) than retention basins..	Adapted from Brown and Schueler (1997b)
Infiltration Trench	4.00	Represents typical costs for a 100-foot long trench.	Adapted from SWRPC (1991)
Infiltration Basin	1.30	Represents typical costs for a 0.25-acre infiltration basin.	Adapted from SWRPC (1991)
Sand Filter	3.00-6.00	The range in costs for sand filter construction is largely due to the different sand filter designs. Of the three most common options available, perimeter sand filters are moderate cost whereas surface sand filters and underground sand filters are the most expensive.	Adapted from Brown and Schueler (1997b)
Bioretention	5.30	Bioretention is relatively constant in cost, because it is usually designed as a constant fraction of the total drainage area.	Adapted from Brown and Schueler (1997b)
Grass Swale	0.50	Based on cost per square foot, and assuming 6 inches of storage in the filter.	Adapted from SWRPC (1991)
Filter Strip	0.00-1.30	Based on cost per square foot, and assuming 6 inches of storage in the filter strip. The lowest cost assumes that the buffer uses existing vegetation, and the highest cost assumes that sod was used to establish the filter strip.	Adapted from SWRPC (1991)

* Base year for all cost data: 1997

In some ways there is no such value as the "average" construction cost for some BMPs, because many BMPs can be designed for widely varying drainage areas. However, there is some value in assessing the cost of a typical application of each BMP. The data in Table 6-2 reflect base capital costs for typical applications of each category of BMP. It is important to note that, since many BMPs have economies of scale, it is not practical to extrapolate these values to larger or smaller drainage areas in many cases.

Table 6-2. Base Costs of Typical Applications of Storm Water BMPs[1]

BMP Type	Typical Cost ($/BMP)	Application	Data Source
Retention Basin	$100,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Wetland	$125,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Infiltration Trench	$45,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Infiltration Basin	$15,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Sand Filter	$35,000-$70,000[2,3]	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Bioretention	$60,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Grass Swale	$3,500	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)
Filter Strip	$0-$9,000[3]	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)

1. Base costs do not include land costs.
2. Total capital costs can typically be determined [illegible] these costs by approximately 30%.
3. A range is given to account for design variations

Although various manuals report construction cost estimates for storm water ponds, EPA has identified only three studies that have systematically evaluated the construction costs associated with structural BMPs since 1985. The three studies used slightly different estimation procedures. Two of these studies were conducted in the Washington, DC region and used a similar methodology (Wiegand et al, 1986; Brown and Schueler, 1997b). In both studies, the costs were determined based on engineering estimates of construction costs from actual BMPs throughout the region. In the third study, conducted in Southeastern Wisconsin, costs were determined using standardized cost data for different elements of the BMP, and assumptions of BMP design (SWRPC, 1991).

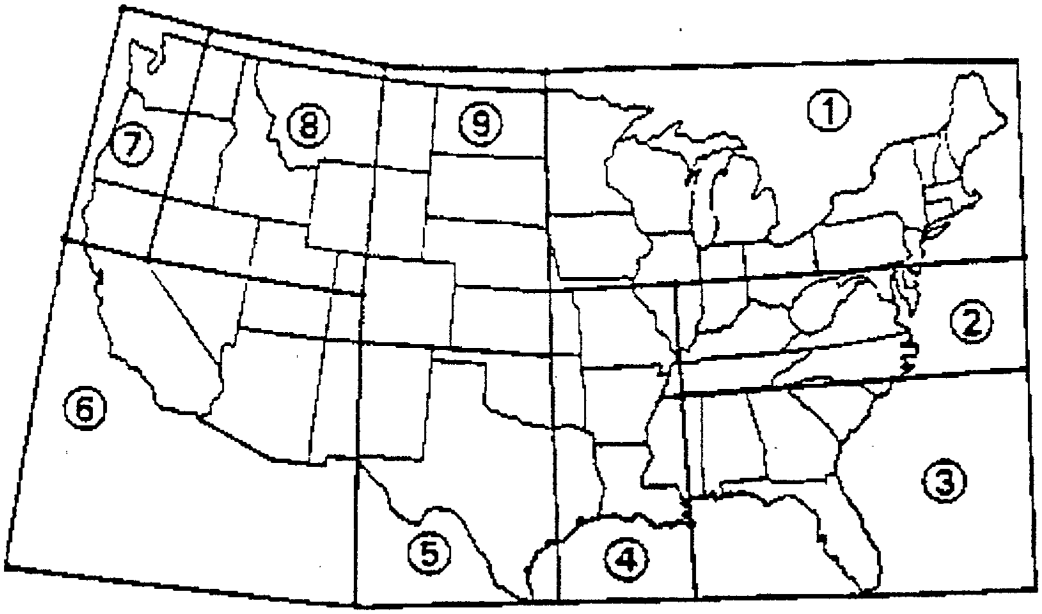
Any costs reported in the literature need to be adjusted for inflation and regional differences. All costs reported in this report assume a 3 percent annual inflation rate. In addition, studies are adjusted to the "twenty cities average" construction cost index, to adjust for regional biases, based on a methodology followed by the American Public Works Association (APWA, 1992). Using EPA's rainfall zones (see Figure 6-1), a cost adjustment factor is assigned to each zone (Table 6-3). For example, rainfall region 1 has a factor of 1.12. Thus, all studies in the Northeastern United States are divided by 1.12 in order to adjust for this bias.

Table 6-3. Regional Cost Adjustment Factors

Rainfall Zone	1	2	3	4	5	6	7	8	9
Adjustment Factor	1.12	0.90	0.67	0.92	0.67	1.24	1.04	1.04	0.76

Source: Modified from APWA, 1992

Figure 6-1. Rainfall Zones of the United States



Not shown: Alaska (Zone 7); Hawaii (Zone 7); Northern Mariana Islands (Zone 7); Guam (Zone 7); American Samoa (Zone 7); Trust Territory of the Pacific Islands (Zone 7); Puerto Rico (Zone 3) Virgin Islands (Zone 3).
Source: NPDES Phase I regulations, 40 CFR Part 122, Appendix E (US EPA, 1990)

6.1.1.1 Retention/Detention Basins and Constructed Wetlands

The total volume of the basin is generally a strong predictor of cost (Table 6-4). There are some economies of scale associated with constructing these systems, as evidenced by the slope of the volume equations derived. This is largely because of the costs of inlet and outlet design, and mobilization of heavy equipment that are relatively similar regardless of basin size.

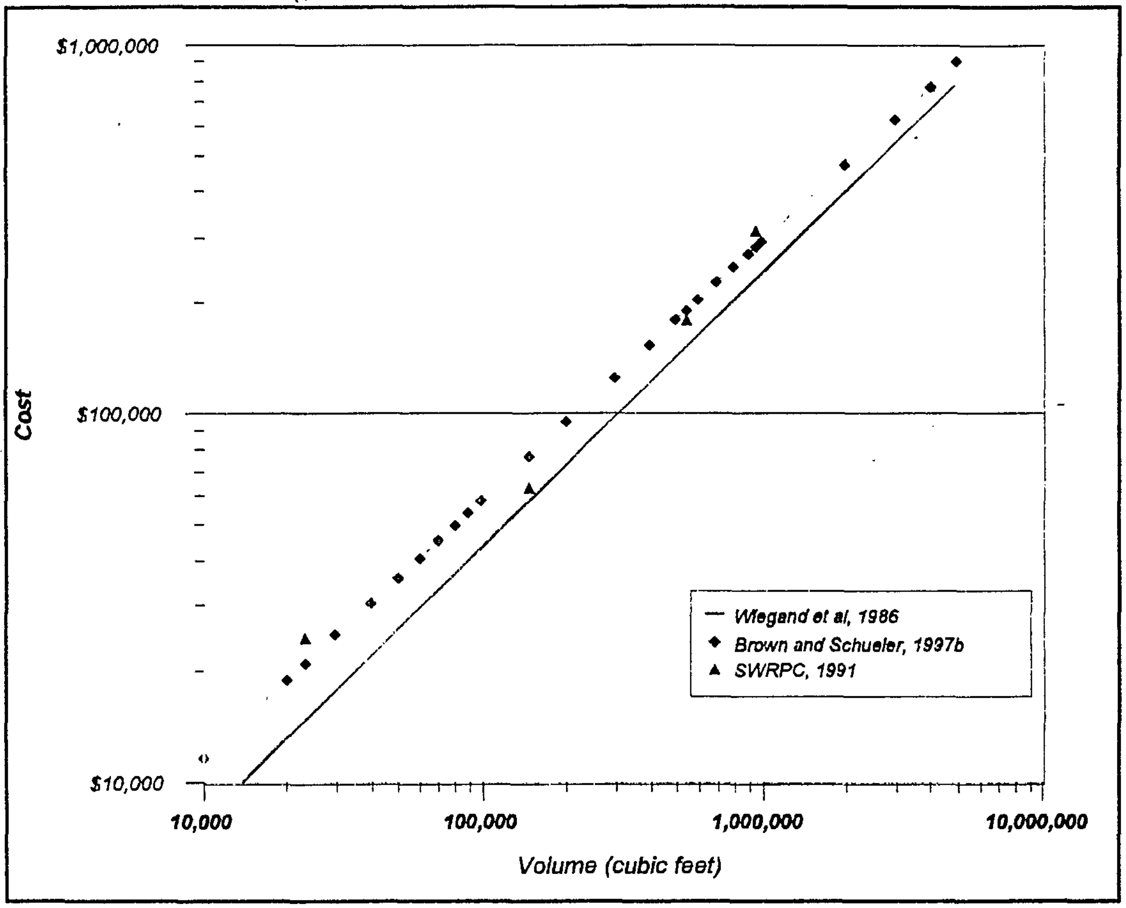
Erosion and sediment control represents only about 5 percent of the construction cost of basins and wetlands (Brown and Schueler, 1997b). Thus, the construction cost estimates presented in Table 6-2 are comparable. The cost of building storm water retention and detention systems has increased since 1986 (Figure 6-2), even after adjusting for inflation. Part of the reason for this increase is thought to be attributable to the improved design of these systems to enhance water quality driven by a more complex regulatory and review environment (Brown and Schueler, 1997b). The cost estimations made by SWRPC (1991) were generally a mid-range between the earlier and more recent studies.

Table 6-4. Base Capital Costs for Storm Water Ponds and Wetlands

BMP Type	Cost Equation or Estimate	Costs Included		Source
		Construction	E&S Control	
Retention Basins and Wetlands	$7.75V^{0.75}$	✔	✔	Wiegand et al, 1986
	$18.5V^{0.70}$	✔		Brown and Schueler, 1997b
Detention Basins	$7.47V^{0.78}$	✔	✔	Brown and Schueler, 1997b
Retention Basins	1.06V: 0.25 acre retention basin (23,300 cubic feet)	✔		SWRPC, 1991
	0.43V: 1.0 acre retention basin (148,000 cubic feet)			
	0.33V: 3.0 acre retention basin (547,000 cubic feet)			
	0.31V: 5.0 acre retention basin (952,000 cubic feet)			

Notes
V refers to the total basin volume in cubic feet
Costs presented from SWRPC (1991) are "moderate" costs reported in that study.

Figure 6-2. Retention Basin Construction Cost



6.1.1.2 Infiltration Practices

Costs for infiltration BMPs are highly variable from site to site, depending on soils and other geotechnical information. Perhaps because of this variability, cost estimates for infiltration trenches have been widely different (Table 6-5; Figure 6-3). Brown and Schueler (1997b) concluded that the Wiegand (1986) equation underestimated cost, partially because of the lack of pretreatment in earlier designs, although they were unable to develop a consistent equation due to a small sample size.

It is difficult to estimate the cost of infiltration basins, mainly due to a lack of recent cost data. The costs estimates for SWRPC are dramatically higher than those estimated by Schueler, 1987 (Figure 6-4). This is largely because the SWRPC document assumes that 50 percent additional volume is excavated for the spillway, while Schueler uses a retention basin cost equation.

Table 6-5. Base Capital Costs for Infiltration Practices

BMP Type	Cost Equation or Estimate[4]	Costs Included		Source
		Construction	E&S Control	
Infiltration Trenches[1]	$33.7V^{0.63}$	✔		Wiegand et al, 1986
	2V to 4V; average of 2.5V	✔		Brown and Schueler, 1997b
	$4,400: 3-foot deep, 4-foot wide, 100-foot long trench	✔		SWRPC, 1991
	$10,400: 6-foot deep, 10-foot wide, 100-foot long trench			
	3.9V+2,900: 3-foot deep, 100-foot long trench	✔		Modified from SWRPC, 1991
Infiltration Basins[2]	$13.2V^{0.69}$	✔	✔	Schueler, 1987; Modified from Wiegand et al, 1986
	1.3V: 0.25-acre infiltration basin (15,000 cubic feet)	✔		SWRPC, 1991
	0.8V: 1.0-acre infiltration basin (76,300 cubic feet)			
Porous Pavement[3]	50,000A	✔		SWRPC, 1991
	80,000A	✔		Schueler, 1987

1. V for infiltration trenches refers to the treatment volume (cubic feet) within the trench, assuming a porosity of 32%.
2. V for infiltration basins refers to the total basin volume (cubic feet).
3. A is the surface area in acres of porous pavement.
4. Costs presented from SWRPC (1991) are "moderate" costs reported in that study.

Figure 6-3. Infiltration Trench Cost

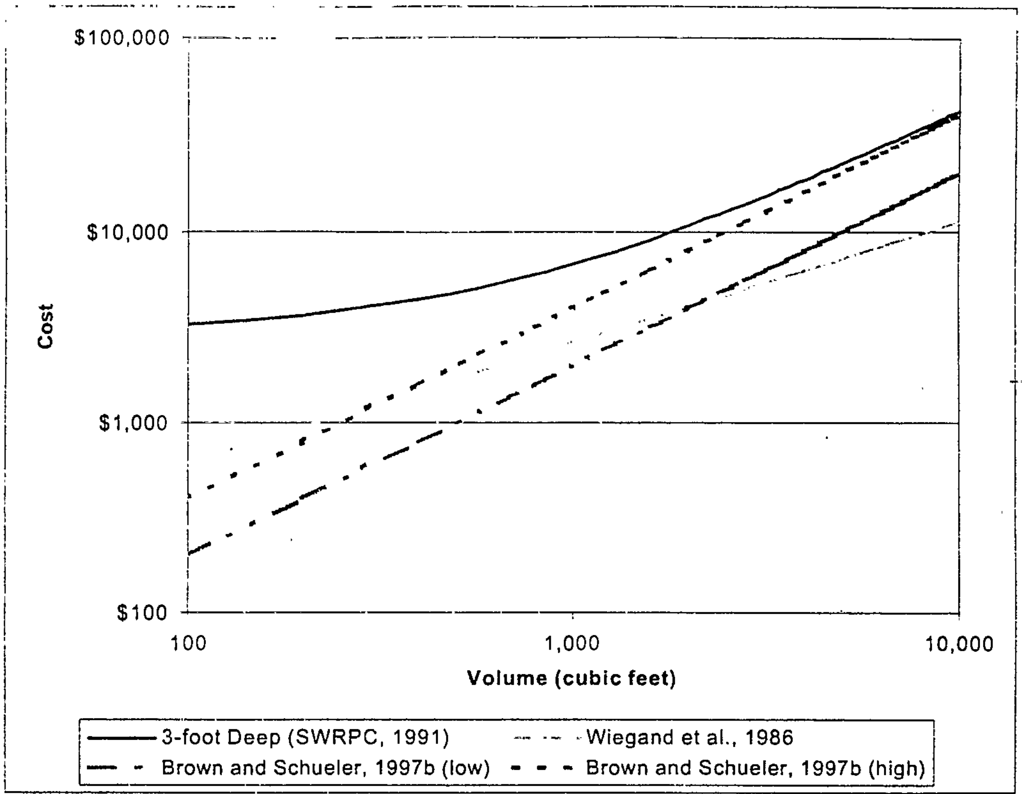


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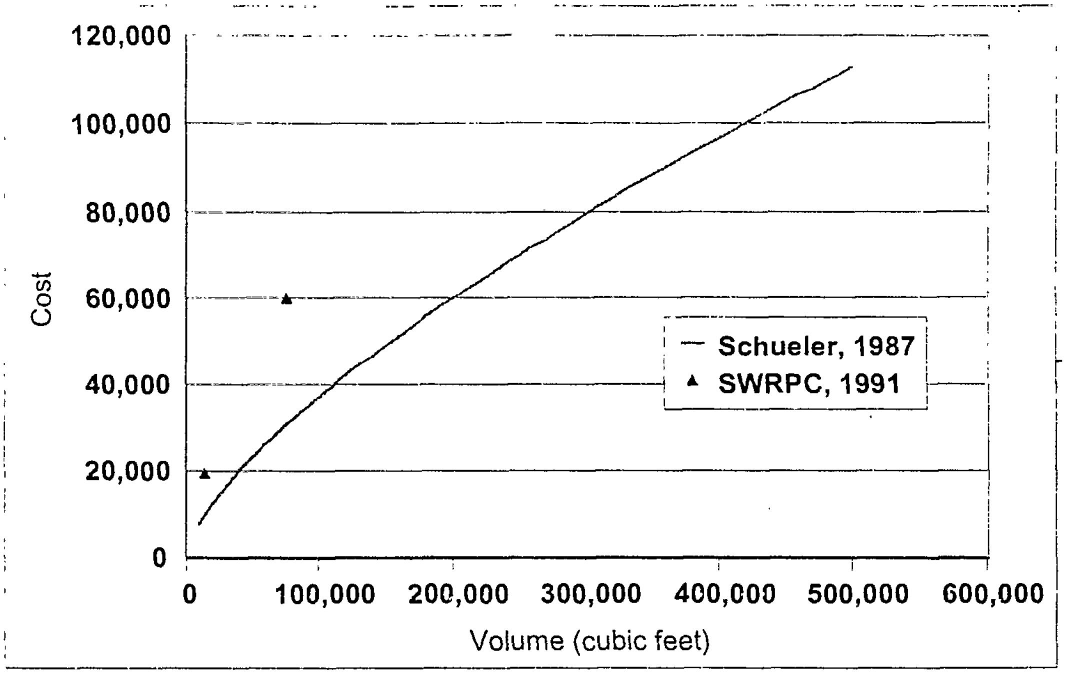
Figure 6-4. Infiltration Basin Construction Cost



6.1.1.3 Sand Filters

Since sand filters have not been used as long as other BMPs, less information is available on their cost than on most BMPs. In addition, the costs of sand filters vary significantly due to the wide range of design criteria for sand filters (Table 6-6). Brown and Schueler (1997b) were unable to derive a valid relationship between sand filter cost and water quality volume, with costs ranging between $2 and $6 per cubic foot of water quality volume, with a mean cost of $2.50 per cubic foot. The water quality volume includes the pore space in the sand filter, plus additional storage in the pretreatment basin.

Because of the lack of cost data, no equation referencing the economies of scale has been developed. However, it appears that economies of scale do exist. For example, data from Austin indicates that the cost per acre decreased by over 80 percent for a design of a 20-acre drainage area, when compared with a 1-acre drainage area. (Schueler, 1994a).

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Table 6-6. **Construction Costs for Various Sand Filters**

Region (Design)	Cost/Impervious Acre
Delaware	$10,000
Alexandria, VA (Delaware)	$23,500
Austin, TX (< 2 acres)	$16,000
Austin, TX (> 5 acres)	$3,400
Washington, DC (underground)	$14,000
Denver, CO	$30,000-$50,000

Source: Schueler, 1994a

6.1.1.4 Bioretention

Little information is available on the costs of bioretention because it is a relatively new practice. Brown and Schueler (1997b) found consistent construction costs of approximately $5.30 per cubic foot of water quality volume for the construction cost. The water quality volume includes 9 inches above the surface area of the bioretention structure.

6.1.1.5 Vegetative BMPs

The two major types of vegetative BMPs include filter strips and grassed swales (also called "biofilters"). The costs for these BMPs vary, and largely depend on the method used to establish vegetation (Table 6-7).

Table 6-7. Base Capital Costs of Vegetative BMPs

BMP Type	Cost Equation or Estimate[1]	Costs Included		Source
		Construction	E&S Control	
Filter Strips	Existing Vegetation: 0	✔		SWRPC, 1991
	Seed: $13,800/acre			
	Sod: $29,000/acre			
Grassed Channels	25¢ per square foot	✔		SWRPC, 1991

1. Costs presented from SWRPC (1991) are "moderate" costs reported in that study.

6.1.2 Design, Contingency and Permitting Costs

Most BMP cost studies assess only part of the cost of constructing a BMP, usually excluding permitting fees, engineering design and contingency or unexpected costs. In general, these costs are expressed as a fraction of the construction cost (Table 6-8). These costs are generally only estimates, based on the experience of designers.

Table 6-8. Design, Contingency and Permitting Costs

Additional Costs Estimate (Fraction of base construction costs)	Source	Comments
25%	Wiegand et al, 1986	Includes design, contingencies and permitting fees
32%	Brown and Schueler, 1997b	Includes design, contingencies, permitting process and erosion and sediment control

6.1.3 Land Costs

The cost of land is extremely variable both regionally and by surrounding land use. For example, many suburban jurisdictions require open space allocations within the developed site, reducing the effective cost of land for BMPs to zero (Schueler, 1987). On the other hand, the cost of land may far outweigh construction and design costs in ultra-urban settings. For this reason, some underground BMPs that are relatively expensive to construct may be attractive in this "ultra-urban" setting if sub-surface conditions are suitable (Lundgren, 1996). The land consumed per treatment volume depends largely on how much of the BMP's treatment is underground, and varies considerably (Table 6-9).

Table 6-9. Relative Land Consumption of Storm Water BMPs

BMP Type	Land consumption (% of Impervious Area)
Retention Basin	2-3%
Constructed Wetland	3-5%
Infiltration Trench	2-3%
Infiltration Basin	2-3%
Porous Pavement	0%
Sand Filters	0%-3%
Bioretention	5%
Swales	10%-20%
Filter Strips	100%

Note: Represents the amount of land needed as a percent of the impervious area that drains to the practice to achieve effective treatment.
Source: Claytor and Schueler, 1996

6.1.4 Operation and Maintenance Costs

Maintenance can be broken down into two primary categories: aesthetic/nuisance maintenance and functional maintenance. Functional maintenance is important for performance and safety reasons, while aesthetic maintenance is important primarily for public acceptance of BMPs, and because it may also reduce needed functional maintenance. Aesthetic maintenance is obviously more important for BMPs that are [illegible]sible, such as ponds and biofiltration facilities.

In most studies, operation and maintenance (O&M) costs have been estimated as a percentage of base construction costs (Table [illegible]). While some BMPs require infrequent, costly maintenance, others need more frequent but less costly maintenance.[5] Accordingly, selection of appropriate structural BMPs must factor in maintenance cost (and a responsible party to carry out maintenance) to ensure the necessary long-term performance. Typical maintenance activities are included in Table 5-3.

Table 6-10. Annual Maintenance Costs

BMP	Annual Maintenance Cost (% of Construction Cost)	Source(s)
Retention Basins and Constructed Wetlands	3%-6%	Wiegand et al, 1986 Schueler, 1987 SWRPC, 1991
Detention Basins[1]	<1%	Livingston et al, 1997; Brown and Schueler, 1997b
Constructed Wetlands[1]	2%	Livingston et al, 1997; Brown and Schueler, 1997b
Infiltration Trench	5%-20%	Schueler, 1987 SWRPC, 1991
Infiltration Basin[1]	1%-3%	Livingston et al, 1997; SWRPC, 1991
	5%-10%	Wiegand et al, 1986; Schueler, 1987; SWRPC, 1991
Sand Filters[1]	11%-13%	Livingston et al, 1997; Brown and Schueler, 1997b
Swales	5%-7%	SWRPC, 1991
Bioretention	5%-7%	(Assumes the same as swales)
Filter strips	$320/acre (maintained)	SWRPC, 1991

1. Livingston et al (1997) reported maintenance costs from the maintenance budgets of several cities, and percentages were derived from costs in other studies

[5] Maintenance costs can also vary significantly based on a variety of site- and region-specific parameters, therefore the maintenance costs presented in Table 6-10 should be considered only as general guidelines.

6.1.5 Long-Term BMP Costs: Two Scenarios

In order to compare various BMP options, costs were calculated for a 5-acre commercial site and a 38-acre residential site.[6] Construction costs were evaluated using the following steps:

1. *Calculate the water quality volume* (WQ_v).[7]
Using a water quality volume based on a 1-inch storm, the volume is equal to:

$$WQ_v = (.05 + .9I)\, A/12$$

where:
WQ_v = Water Quality Volume (Acre-Feet)
I = Impervious Fraction in the Watershed
A = Watershed Area (Acres)

2. *Calculate the detention storage volume.*
Total detention storage was determined using standard peak flow methods (USDA/NRCS, 1986). Detention storage was calculated for a 5-inch storm.

3. *Calculate total volume.*
Many BMPs do not require any detention storage, but for BMPs that do provide flood storage, the total volume is the sum of the water quality and detention volumes calculated in steps 1 and 2.

4. *Determine the construction cost.*
The construction cost for each BMP is determined based on equations described in Section 6.1.1.

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[6] Although these evaluations are useful for comparing potential costs of various structural BMPs, they should not be applied for use in all areas of the country. In addition, the BMPs, selected in these examples and the sizing criteria that the costs were based on should not be considered as recommendations for actual BMP selection and design. They are presented solely for illustrative purposes.

[7] "Water quality volume" refers to the volume of water that the BMP is designed to treat. For example, a BMP may be designed to capture the first inch of runoff from the drainage area. Any volume of rainfall over the first inch would bypass the BMP. Therefore water quality volume for this BMP would be one watershed inch.

6.1.5.1 5-Acre Commercial Development

The following data were used as the basis for the 5-acre commercial development.

Table 6-11. Data for the Commercial Site Scenario

Area (A)	5 acres
Impervious Cover (I)	65%
Water Quality Volume P · Rv · A/12 P = 1" of rainfall Rv = 0.5 + 0.9 (I) A = Drainage Area	0.26 ac-ft
Total Detention Storage (using TR-55 model)	0.74 ac-ft
Total Storage	1.00 ac-ft

These data were then used to compare various BMP options (Table 6-12). Grassed swales and filter strips were not included in this analysis because, although they do improve water quality, they are typically used only in combination with other BMPs in a new development area. Again, it is important to note that the cost of land is not included in this calculation. Although retention basins are the least expensive option on an annual basis, the cost of land may drive designs to less space-consumptive BMPs, such as sand filters or bioretention systems.

Table 6-12. BMP Costs for a Five Acre Commercial Development

BMP Type	Construction Cost Equation	Construction Cost	Typical Design, Contingency & Other Capital Costs (30% of Construction Costs)	Annual Maintenance Costs (% of Construction, $)	Notes	Sources
Retention Basin	$18.5V_t^{0.70}$	$32,700	$9,810	5%; $1,640	Much of the cost associated with this BMP is the extra storage to provide flood control and channel protection. Ponds are very reliable.	a, b, c, d, e
Infiltration Trench	$3.9WQ_v$ +2,900	$47,100	$14,100	12%; $5,650	Although infiltration trenches are designed to last a long time, they need to be inspected and rebuilt if they become clogged.	c, d, e
Infiltration Basin	$1.3WQ_v$	$14,700	$4,410	8%; $1,180	Infiltration basins require careful siting and design to perform effectively..	b, c d, e
Sand Filter	$4WQ_v$	$45,200	$13,600	12%; $5,420	Sand filters require frequent maintenance in order to function long-term.	a, e, f
Bioretention	$5.30WQ_v$	$60,000	$18,000	6%; $3,600	Bioretention is a relatively new BMP. Little is known about its long-term performance.	a, d

1. WQv = Water Quality Volume, cu. ft. 2. V_t = Total Volume, cu. ft.
3. Sand filter volume was estimated at 4WQv, which is slightly high, to account for the relatively small drainage area.

a. Brown and Schueler, 1997b b. Wiegand et al, 1986 c. Schueler, 1987 d. SWRPC, 1991 e. US EPA, 1993a f. Livingston et al, 1997

6.1.5.2 38-Acre Residential Development

The following data were used as the basis for the 38-acre residential development.

Table 6-13. Data for the Residential Site Scenario

Area (A)	38 acres
Impervious Cover (I)	36%
Water Quality Volume	1.1 ac-ft
Total Detention Storage (using TR-55 model)	2.8 ac-ft
Total Storage	3.9 ac-ft

The same analysis conducted for the commercial site was repeated for the larger site (Table 6-14). Bioretention and infiltration systems were not included in this analysis, because these BMPs are best applied on smaller sites. The costs of swales and filter strips were also not included, although they could be effectively used in combination with retention systems to provide pretreatment.

6.1.6 Adjusting Costs Regionally

The cost data in these examples can be adjusted to specific zones of the country using the regional cost adjustment factors in Table 6-3. For example, if costs for Rainfall Zone 1 were needed, the data in Tables 6-12 or 6-14 would be multiplied by 1.12.

In addition, design variations in different regions of the country may cause prices to be changed. For example, wetland and wet ponds may be restricted in arid regions of the country. Furthermore, while retention basins are used in semi-arid regions, they usually incorporate design variations to improve their performance (Saunders and Gilroy, 1997). In cold regions, BMPs may need to be adapted to account for snowmelt treatment, deep freezes and road salt application (Oberts, 1994; Caraco and Claytor, 1997), which will cause additional changes in BMP costs.

Table 6-14. BMP Costs for a Thirty-Eight Acre Residential Development

BMP Type	Construction Cost Equation	Construction Cost	Design, Contingency and other Capital Costs (30% of Construction)	Annual Maintenance Costs (% of Construction; $)	Notes	Sources
Retention Basin	$18.5V_t^{0.70}$	$84,800	$25,400	5%; $4,240	Pond systems are relatively easy to apply to large sites.	a, b, c, d, e
Sand Filter	$2WQ_v$	$95,800	$28,700	12%; $11,500	Although the sand filter is used in this example, some evidence suggests that sand filters may be subject to clogging if used on a site that drains a relatively pervious drainage area such as this one.	a, e, f

1. WQv = Water Quality Volume, cu. ft. 2. Vt = Total Volume, cu. ft.
3. Sand filter volume was estimated at 2V, which is slightly low, to account for the relatively large drainage area

a. Brown and Schueler, 1997b b. Wiegand et al, 1986 c. Schueler, 1987 d. SWRPC, 1991 e. US EPA, 1993a f. Livingston et al, 1997

6.2 Non-Structural BMP Costs

Non-structural BMPs are management measures that prevent degradation of water resources by preventing pollution at the source, rather than treating polluted runoff. Non-structural practices include a variety of site-specific and regional practices, including: street sweeping, illicit connection identification and elimination, public education and outreach, land use modifications to minimize the amount of impervious surface area, waste collection and proper materials storage. While non-structural practices play an invaluable role in protecting surface waters, their costs are generally not as easily quantified as for structural BMPs. This is primarily because there are no "design standards" for these practices. For example, the cost of a public education program may vary due to staff size. However, it is possible to identify costs associated with specific components of these programs based on past experience.

6.2.1 Street Sweeping

The costs of street sweeping include the capital costs of purchasing the equipment, plus the maintenance and operational costs to operate the sweepers. as well as costs of disposing the materials that are removed. Both equipment and operating costs vary depending on the type of sweeper selected. There are several different options for sweepers, but the two basic choices are mechanical sweepers versus vacuum-assisted sweepers. Mechanical sweepers use brushes to remove particles from streets. Vacuum-assisted dry sweepers, on the other hand, use a specialized brush and vacuum system in order to remove finer particles. While the equipment costs of mechanical sweepers are significantly higher, the total operation and maintenance costs of vacuum sweepers can be lower (Table 6-15).

Table 6-15. Street Sweeper Cost Data

Sweeper Type	Life (Years)	Purchase Price ($)	Operation and Maintenance Costs ($/curb mile)	Sources
Mechanical	5	75,000	30	Finley, 1996; SWRPC, 1991
Vacuum-assisted	8	150,000	15	Satterfield, 1996; SWRPC, 1991

Using these data, the cost of operating street sweepers per curb mile were developed, assuming various sweeping frequencies (Table 6-16). The following assumptions were made to conduct this analysis:

- One sweeper serves 8,160 curb miles during a year (SWRPC, 1991).

- The annual interest rate is 8 percent.

Table 6-16. Annualized Sweeper Costs ($/curb mile/year)

Sweeper Type	Sweeping Frequency					
	Weekly	Bi-weekly	Monthly	Four times per year	Twice per year	Annual
Mechanical	1,680	840	388	129	65	32
Vacuum-Assisted	946	473	218	73	36	18

Modified from Finley, 1996; SWRPC, 1991; and Satterfield, 1996

6.2.2 Illicit Connection Identification and Elimination

One source of pollutants is direct connections or infiltration to the storm drain system of wastewaters other than storm water, such as industrial wastes. These pollutants are then discharged through the storm drain system directly to streams without receiving treatment. These illicit connections can be identified using visual inspection during dry weather or through the use of smoke or dye tests. Using visual inspection techniques, illicit connections can be identified for between $1,250 and $1,750 per square mile (Center for Watershed Protection, 1996).

6.2.3 Public Education and Outreach

Public education programs encompass many other more specific programs, such as fertilizer and pesticide management, public involvement in stream restoration and monitoring projects, storm drain stenciling, and overall awareness of aquatic resources. All public education programs seek to reduce pollutant loads by changing people's behavior. They also make the public aware of and gain support for programs in place to protect water resources. Most municipalities have at least some educational component as a part of their program. A recent survey found that 30 of the 32 municipal storm water programs surveyed (94 percent) incorporate an education element and 11 programs (34 percent) mandated this element in law or regulation (Livingston et al, 1997).

The City of Seattle, with a population of approximately 535,000, has a relatively aggressive education program, including classroom and field involvement programs. The 1997 budget for some aspects of the program is included in Table 6-17. Although this does not necessarily reflect typical effort or expenditures, it does provide information on some educational expenditures. These data represent only a portion of the entire annual budget.

Table 6-17. Public Education Costs in Seattle, Washington

Item	Description	1997 Budget
Supplies for Volunteers	Covers supplies for the Stewardship Through Environmental Partnership Program	$17,500
Communications	Communications strategy highlighting a newly formed program within the city	$18,000
Environmental Education	Transportation costs from schools to field visits (105 schools with four trips each)	$46,500
Education Services / Field Trips	Fees for student visits to various sites	$55,000
Teacher Training	Covers the cost of training classroom teachers for the environmental education program	$3,400
Equipment	Equipment for classroom education, including displays, handouts, etc.	$38,800
Water Interpretive Specialist: Staff	Staff to provide public information at two creeks	$79,300
Water Interpretive Specialist: Equipment	Materials and equipment to support interpretive specialist program	$12,100
Youth Conservation Corps	Supports clean-up activities in creeks	$210,900

Source: Washington DOE, 1997

Some unit costs for educational program components (based on two different programs) are included in Table 6-18.

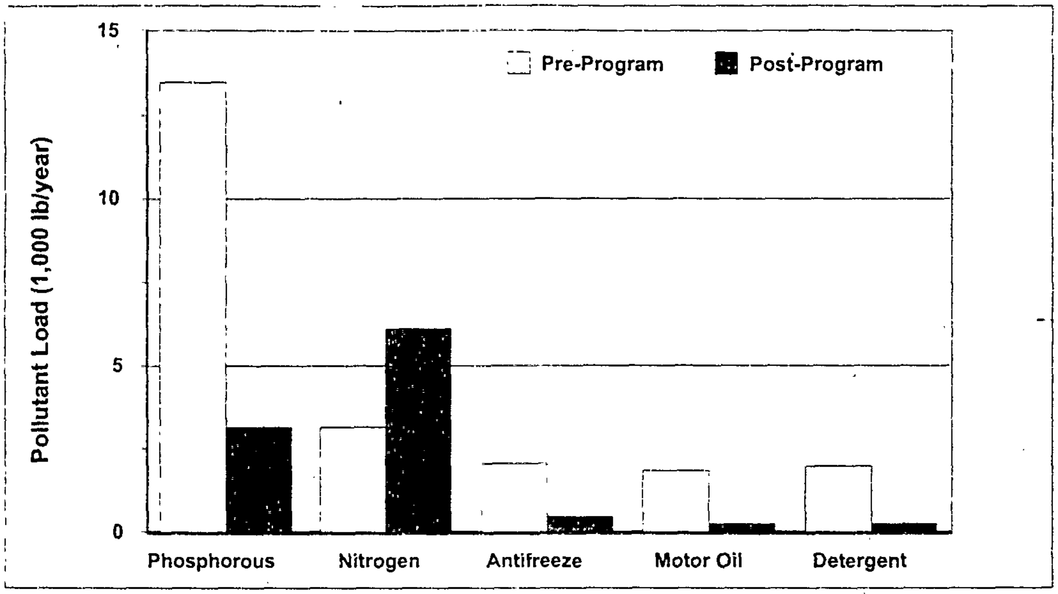
Table 6-18. Unit Program Costs for Public Education Programs

Item	Cost	Source
Public Attitude Survey	$1,250-$1,750 per 1,000 households	Center for Watershed Protection, 1996
Flyers	10-25¢/ flyer	Ferguson et al, 1997
Soil Test Kit*	$10	Ferguson et al, 1997
Paint	25-30¢/SD Stencil	Ferguson et al, 1997
Safety Vests for Volunteers	$2	Ferguson et al, 1997

* Includes cost of testing, but not sampling.

Although public education has the intended benefit of raising public awareness, and therefore creating support of environmental programs, it is difficult to quantify actual pollutant reductions associated with education efforts. Public attitudes can be used as a gauge of how these programs perform, however. In Prince George's County, Maryland a public survey was used in combination with modeling to estimate pollutant load reductions associated with public education (Smith et al, 1994; Claytor, 1996; Figure 6-5). An initial study was conducted to estimate pollution from field application of fertilizers, and use of detergents, oil and antifreeze. Pollutant reductions were then completed assuming that 70 percent of the population complied with recommendations of the public education program. A follow-up survey was used to assess the effectiveness of the program. Although insufficient data were available to support a second model run, a follow-up survey indicated that educational programs influenced many citizen behaviors, such as recycling. They were unsuccessful, however, at changing the rate at which citizens apply lawn fertilizers.

Figure 6-5. Changes in Pollutant Load Associated with a Public Education Program Based on a Public Survey



Source: Claytor, 1996

6.2.4 Land Use Modifications

One of the most effective tools to reduce the impacts of urbanization on water resources is to modify the way growth and development occurs across the landscape. At the jurisdictional or regional level, growth can be managed to minimize the outward extension of development. Jurisdictions can direct growth away from environmentally sensitive areas using such techniques as open space preservation, re-zoning or the transfer of development rights. At the site level, the nature of development can be modified to reduce the impacts of impervious cover at individual development projects through techniques such as reduced street widths, clustered housing, smaller parking lots, and incorporation of vegetative BMPs into site design. While there are legal fees associated with changing both local and regional zoning codes, data suggest that concentrating development and minimizing impervious cover at the site level can actually reduce construction costs to both developers and local governments.

By concentrating development near urban areas, the capital costs of development can be lowered substantially due to existing infrastructure and other public services. With conventional development patterns, the cost of servicing residential developments exceeds the tax revenues from these developments by approximately [illegible] percent (Pelley, 1997). By encouraging growth to occur in a compact region, rather than over a large area, these capital costs can be reduced substantially (Table 6-19).

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Table 6-19. Comparison of Capital Costs of Municipal Infrastructure for a Single Dwelling Unit

Development Pattern	Capital Costs[1] (1987 Dollars)
Compact Growth[2]	$18,000
Low-Density Growth (3 units/acre)	$35,000
Low-Density Growth, 10 Miles from Existing Development[3]	$48,000

Notes
1. Costs include streets (full curb and gutter), central sewers and water supply, storm drainage and school construction.
2. Assumes housing mix of 30% single family units and townhouses; 70% apartments.
3. Assumes housing is located 10 miles from major concentration of employment, drinking water plant and sewage treatment plant.

Source: Frank, 1989

Savings can also be realized at the site level by reducing the costs of clearing and grading, paving and drainage infrastructure. A recent study compared conventional development plans with alternative options designed to reduce the impacts of development on the quality of water resources. The cost savings realized through these alternative options are summarized in Table 6-20. In all site designs, the road width was reduced from 28 feet to 20 feet, lot sizes were reduced or reconfigured to consume less open space, and on-site storm water treatment was provided.

Table 6-20. Impervious Cover Reduction and Cost Savings of Conservation Development

Location	Techniques Used	Impervious Cover Reduction	Cost Savings
Sussex County, DE	1. Reduced street widths 2. Smaller lots 3. Cluster development	38%	52%
New Castle County, DE	4.Houses clustered into attached units around courtyards	6%	63%
Kent County, DE	5. Reduced road and driveway widths 6. Minimum disturbance boundary	24%	39%

Source: Delaware DNREC, 1997

6.2.5 Oil and Hazardous Waste Collection

Providing a central location for the disposal of oil or hazardous wastes protects water quality by offering citizens an alternative to disposing of these materials in the storm drain. Disposal costs vary considerably depending on the size of the program, and what types of wastes are collected. One study estimated the capital costs at approximately $30,000, with about $12,000 maintenance for a used oil collection recycling program in a typical MS4 (US EPA, 1998b). This estimate was based on data from the Galveston Bay National Estuary Program. Data from the City of Livonia, Michigan indicates that the cost of hazardous waste disposal averages about $12 per gallon (Ferguson et al, 1997).

6.2.6 Proper Storage of Materials

Proper storage of materials can prevent accidental spills or runoff into the storm drain. The design of storage structures varies depending on the needs of the facility. There are also training costs associated with the proper storage of materials. Typical cost estimates, based on standard construction data, are $6 to $11 per square foot for pre-engineered buildings and $3.40 to $5 per square foot for a 6-inch thick concrete slab (Ferguson et al, 1997).

6.3 Benefits of Storm Water BMPs

Although it is possible to estimate the economic benefits of water quality improvement (US EPA, 1983a), it is difficult to create a "balance sheet" of economic costs and benefits for individual BMPs. Ideally, benefits analysis would specify and quantify a chain of events: pollutant loading reductions achieved by the BMP; the physical-chemical properties of receiving streams and consequent linkages to biologic/ecologic responses in the aquatic environment; and human responses and values associated with these changes. However, the necessary data to conduct such an analysis does not currently exist. Instead, the benefits can be outlined in terms of: 1) effectiveness at reducing pollutant loads; 2) direct water quality impacts; and 3) economic benefits or costs.

6.3.1 Storm Water Pollutant Reduction

A primary function of storm water BMPs is to prevent pollutants from reaching streams and rivers. While all BMPs achieve this function to some extent, there is considerable variability between different types of BMPs. The extent of benefits from non-structural BMPs may be more speculative, partly because their ability to influence human behavior is difficult to predict.

A detailed discussion of pollution removal efficiencies for individual structural BMPs is provided in Section 5.5 of this report, so only non-structural BMPs will be reviewed in this section. Unlike structural BMPs, it is generally not possible to associate specific pollutant removal rates with non-structural BMPs, with the exception of street sweeping (Satterfield, 1996). However, some non-structural BMPs are targeted at specific pollutants. Table 6-21 outlines non-structural BMPs believed by designers to be the most effective for removing specific types of pollutants.

Table 6-21. Non-Structural BMPs Suited to Controlling Various Pollutants

Pollutant	Appropriate BMPs	
Solids	Street Sweeping	Land Use Modifications
Oxygen-Demanding Substances	Street Sweeping Education: Storm Drain Stenciling Land Use Modifications	Education: Pet Scoop Ordinance Illicit Connections Eliminated
Nitrogen and Phosphorus	Street Sweeping Education: Pet Scoop Ordinance Land Use Modifications Proper Materials Handling	Illicit Connections Eliminated Education: Lawn Care Materials Storage and Recycling
Pathogens	Illicit Connections Eliminated Land Use Modifications	Education: Pet Scoop Ordinance
Petroleum Hydrocarbons	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling	Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Metals	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling	Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Synthetic Organics	Illicit Connections Eliminated Education: Storm Drain Stenciling Proper Materials Handling	Education: Lawn Care Materials Storage and Recycling Land Use Modifications
Temperature	Land Use Modifications	
pH	Illicit Connections Eliminated Proper Materials Handling	Materials Storage and Recycling Land Use Modifications

6.3.1.1 Solids

Both highway runoff and soil erosion can be sources of solids in urban runoff. Street sweeping can reduce solids in urban runoff by removing solids from roadways and parking lots before they can be detached and transported by runoff. The benefits associated with street sweeping depend largely on the climate. In arid regions, airborne pollutants are a serious concern, and there is a long time between storms for pollutants to accumulate[8]. In humid regions, on the other hand, frequent rainfall makes the use of sweepers between storms less practical. In colder

[8] Therefore, regular sweeping programs in these areas can potentially remove large amounts of solids from roadways.

regions, sweeping is recommended twice per year: once in the fall after leaves fall and once in the spring in anticipation of the spring snowmelt (MPCA, 1989).

Modifying land use to preserve open space and to limit the impervious cover can also reduce solids loads. By preserving open space and maintaining vegetative cover, the amount of land cleared is limited, thus reducing the erosion potential during construction. Natural vegetated cover has less than one percent of the erosion potential of bare soil (Wischmeier and Smith, 1978).

6.3.1.2 Oxygen-Demanding Substances

Since the primary oxygen-demanding substances are organic materials (such as leaves and yard waste), BMPs that target these substances are best suited to reducing the oxygen demand in storm water. BMPs that reduce sediment loads often also reduce the loads of the organic material associated with that sediment. Pet waste is also a significant source of organic pollutants, and its control can reduce the loads of oxygen demanding substances in urban runoff. Finally, programs geared at reducing illegal dumping and eliminating illicit connections and accidental spills of materials can reduce the oxygen demand associated with these sources.

6.3.1.3 Nitrogen and Phosphorus

Nitrogen and phosphorus are prevalent in urban and suburban storm water. Nitrogen and phosphorus are natural components of soil, and can enter runoff from storm-induced erosion. Additional sources include the use of fertilizer on urban lawns and airborne deposition. Street sweeping can reduce nutrient loads by removing deposited nutrients from the street surface. Programs that focus on lawn chemical handling or replacing turf with natural vegetation also act to reduce nutrient loading. Finally, programs that educate the public or industry about illegal dumping to storm drains can result in reducing the nutrient loads associated with dumping chemicals that have high nutrient content. Energy conservation and reduced automobile use can reduce airborne nitrogen deposition.

6.3.1.4 Pathogens

Pathogens, including protozoa, viruses and bacteria, are prevalent in urban runoff. Bacteria can be found naturally in soil, and the urban landscape can produce large loads of bacteria that can be carried by runoff. Dogs in particular can be a significant source of pathogens. Thus, pet scoop ordinances and associated education are effective tools at reducing bacteria in urban runoff. Illicit connections of sewage may also be a source of pathogens, therefore eliminating these sources can effectively reduce pathogens in runoff.

6.3.1.5 Petroleum Hydrocarbons

Petroleum hydrocarbons are present in many chemicals used in the urban environment, from gasoline to cleaning solvents. Since roadways are a major source of petroleum pollution, scheduled street sweeping can be used to remove hydrocarbon build-up prior to storm water runoff. Programs geared at preventing spills of chemicals to the storm drain, either through deliberate or accidental dumping, are effective at reducing hydrocarbon loads. Modifying the way land is developed can reduce hydrocarbon loads on both a site and a regional level by reducing the use of the automobile and replacing impervious surfaces with natural vegetation.

6.3.1.6 Metals

Metals sources in urban runoff include automobiles and household chemicals, which can contain trace metals. Street sweeping can reduce metals loads deposited on the road surface. In addition, programs that focus on reducing dumping and proper material storage can reduce accidental or purposeful spills of chemicals with trace metals to the storm drain system. Finally, modifying land use can reduce metals loads by reducing impervious cover, thus reducing total runoff containing metals, and reducing the roadway length, which is often a source of runoff containing metals.

6.3.1.7 Synthetic Organics

Much of the source of synthetic organics in the urban landscape is household cleaners and pesticides. Thus, education programs geared at reducing chemical and pesticide use, and proper storage and handling of these chemicals, can reduce their concentrations in urban runoff. In addition, land use modifications that replace turf with natural vegetation will reduce pesticide use.

6.3.1.8 Temperature

Most non-structural BMPs are not able to prevent the increase in temperature associated with urban development. One exception is the use of site designs that more closely mimic the natural hydrograph by reducing impervious cover and encouraging infiltration.

6.3.1.9 pH

The primary source of low pH in urban runoff is acid rain, and most non-structural BMPs are not used to treat this problem. BMPs that focus on proper materials handling and disposal can prevent dumping of chemicals with extremely high or low pH, but this is generally not a major problem in urban watersheds.

6.3.2 Hydrological and Habitat Benefits

As reviewed in Chapter 4, one major impact of urbanization is induced through the conversion of farmland, forests, wetlands, and meadows to rooftops, roads, and lawns. This process of urbanization has a profound influence on surface water hydrology, morphology, water quality, and ecology (Horner et al, 1994). In this section, the hydrologic and related habitat impacts are briefly discussed as well as the potential benefits that can be achieved by managing storm water runoff using structural and non-structural BMPs.

Many of these impacts can be directly or indirectly related to the change in the hydrologic cycle from a natural system to the urban system. Figure 4-1 illustrates the fundamental effects that occur along with the development process. In the natural setting, very little annual rainfall is converted to runoff and about half is infiltrated into the underlying soils and water table. This water is filtered by the soils, supplies deep water aquifers, and helps support adjacent surface waters with clean water during dry periods. In the urbanizing conditions, less and less annual rainfall is infiltrated and more and more volume is converted to runoff. Not only is this runoff volume greater, it also occurs more frequently and at higher magnitudes. The result is that less water is available to streams and waterways during dry periods and more flow is occurring during storms. A recent study in the Pacific Northwest found that the ratio of the two-year storm to the baseflow discharge increased more than 20 percent in developed sub-watersheds (impervious cover approximately 50 percent) versus undeveloped sub-watersheds (May et al, 1997).

As a result of urbanization, runoff from storm events increases and accelerates flows, increases stream channel erosion, and causes accelerated channel widening and down cutting (Booth, 1990). This accelerated erosion is a significant source of sediment delivery to receiving waters and also can have a smothering effect on stream channel substrates, thereby eliminating aquatic species habitat. As a result, aquatic habitat is often degraded or eliminated in many urban streams. The results are that aquatic biological communities are among the first to be impacted and/or simplified by land conversion and resulting stream channel modifications. Subsurface drainage systems which frequently serve urbanized areas also contribute to the problem, by bypassing any attenuation achieved through surface flows over vegetated areas.

A unifying theme in stream degradation is this direct link with impervious cover. Impervious cover, or imperviousness, is defined as the sum of roads, parking lots, sidewalks, rooftops, and other impermeable surfaces in the urban landscape. This unifying theme can be used to guide the efforts of the many participants in watershed protection. Figure 6-6 visually illustrates this trend in degradation for a series of small headwater streams in the Mid-Atlantic Piedmont. Here, four stream segments, each with approximately the same drainage area, and subjected to the same physiographic conditions, respond to the effects of increased impervious cover. Similar results have been observed in the Southern United States with studies in Virginia, North Carolina and Georgia evidencing this same decline in fish and macroinvertebrate populations with increasing impervious cover (Crawford and Lenant, 1989; Weaver and Garman, 1994; Couch et al, 1996)

Figure 6-6. Effects of Impervious Cover on Stream Quality

Sensitive Stream →
(Impervious Cover $\leq$10%)
- *Stable Channel*
- *Excellent Biodiversity*
- *Excellent Water Quality*

← Impacted Stream
(Impervious Cover 10-20%)
- *Channel Becoming Unstable*
- *Fair to Good Biodiversity*
- *Fair to Good Water Quality*

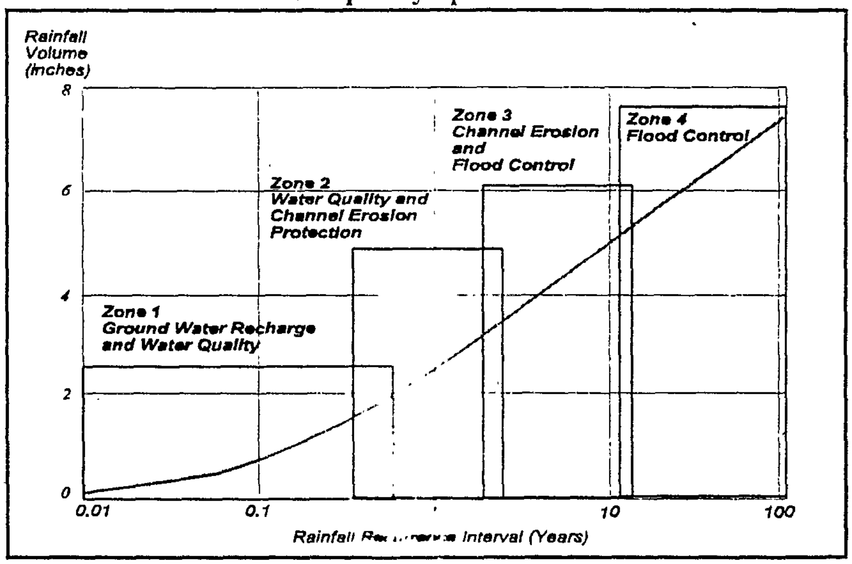
Restorable Stream →
(Impervious Cover $\approx$40%)
- *Highly Unstable Channel*
- *Poor Biodiversity*
- *Poor to Fair Water Quality*

Non-Supporting Stream →
(Impervious Cover $\approx$65%)
- *Poor to No Biodiversity*
- *Poor Water Quality*

To mitigate this impact, many local and state governments have required the installation of storm water management detention basins to attenuate this increased runoff volume. It is important to recognize that the change in hydrology caused by urbanization affects more than just a single storm return interval (e.g., the two-year event). Urbanization shifts the entire "rainfall frequency spectrum" (RFS) to a higher magnitude. As illustrated in Figure 6-7, the most significant change is to the smallest, most frequent storms that occur several times per year. In the undeveloped condition, most of the rainfall from these events is infiltrated into the underlying soil. In the developed condition, much of this rainfall is runoff. As the storm return interval increases, the difference between the undeveloped and developed condition narrows. Many jurisdictions only require management of specific storms, usually the two, ten and sometimes, the one hundred year events. The two-year storm is probably the most frequently used control point along this frequency spectrum. Hence, while BMPs may do a fairly good job of managing these specific control points, there have been very few locations across the country that have specific criteria in place to manage storm water over a wide range of runoff events. Claytor and Schueler (1996) describe the RFS as:

> ...classes of frequencies often broken down by return interval, such as the two year storm return interval. Four principal classes are typically targeted for control by stormwater management practices. The two smallest, most frequent classes [Zones 1 and 2] are often referred to as water quality storms, where the control objectives are groundwater recharge, pollutant load reduction, and to some extent control of channel erosion producing events. The two larger classes [Zones 3 and 4] are typically referred to as quantity storms, where the control objectives are channel erosion control, overbank control, and flood control.

Figure 6-7. Stormwater Control Points Along the Rainfall Frequency Spectrum



Source: Claytor and Schueler, 1996

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One recent study by MacRae (1997) concluded that stream channels below storm water detention basins designed to manage the two year storm experienced accelerated erosion at three times the pre-developed rate. His findings went on to suggest that the streams were eroding at much the same rate as if no storm water controls existed.

Other jurisdictions have employed an additional level of detention storage above and beyond that required for the two year storm. This concept is often called "extended detention" (ED). McCuen and Moglen (1988) conducted a theoretical analysis of this design criteria based on sediment transport capacity of the pre-developed channel versus that with ED control. This study found ED could produce an 85 percent reduction in the pre-developed peak flow of the two-year storm. What it did not analyze, however, was the erosion potential over a wide range of storms. MacRae (1993) suggested a different storm water control criterion called "distributed runoff control" (DRC). Here, channel erosion is minimized if the erosion potential along a channel's perimeter is maintained constant with pre-developed levels. This is accomplished by providing a non-uniform distribution of the storage-discharge relationship within a BMP, where multiple control points are provided along the runoff frequency spectrum.

6.3.2.1 Benefits of BMPs to Control Hydrologic Impacts

Numerous prior studies have documented the degradation of aquatic ecosystems of urban and suburban headwater streams. As stated above, in general, the studies point to a decrease in stream quality with increasing urbanization. Unfortunately, the benefits of BMPs to protect streams from hydrologic impacts have only recently been investigated and only for a few studies.

Maxted and Shaver (1997), Jones et al (1997), and Horner et al (1997) attempted to isolate the potential beneficial influence of local storm water best management practices on the impervious cover/stream quality relationship. Horner examined the possible influence of stream-side management on stream quality as a function of urbanization. Coffman et al (1998) recently presented data on the potential hydrologic benefits of alternative land development techniques. Called the "Low Impact Development Approach," this methodology attempts to mimic pre-developed hydrology by infiltrating more rainfall at the source, increasing the flow path and time of concentration of the remaining runoff, and providing more detention storage throughout the drainage network, as opposed to a one location at the end of the pipe.

The preliminary findings of Maxted and Shaver, and Jones et al, suggest that, for the BMPs examined, stream quality (as measured by a limited group of environmental indicators) cannot be sustained when compared to reference stream conditions. Jones assessed several BMPs by conducting biomonitoring (fish and macroinvertebrate sampling) above and below BMPs and comparing them to a reference watershed. He found that the biological community tended to be degraded immediately below BMPs as compared to the reference watersheds. One major flaw in the study was the lack of analysis in developed watersheds without BMPs. This would have compared the influence of BMPs on the aquatic community as compared to no BMPs.

Maxted and Shaver examined eight sub-watersheds with and without BMPs. Their study also concluded that BMPs did not adequately mitigate the impacts of urbanization once watershed impervious reached 20 percent cover. While this study was useful in defining the cumulative impacts of BMPs on watersheds, several critical questions remain. First, since no sub-watersheds with less than 22 percent impervious cover were analyzed, little is known about BMP ability to protect the most sensitive species seen in less developed watersheds. Data for sub-watersheds with BMPs was collected approximately three years after data for the sub-watersheds without BMPs, so climatic/seasonal constraints may have affected the outcome as much, or more than the BMPs themselves.

Horner et al (1997) evaluated several sub-watersheds, with varying levels of impervious cover, but only tangentially related the effectiveness of BMPs to protecting stream quality. Horner found that at relatively low levels of urbanization (approximately 4 percent impervious area) the most sensitive aquatic biological communities (e.g., salmonids) were adversely affected, and stream quality degradation (as measured by a several indicators) continued at a relatively continuous rate with increasing impervious area. Horner's study demonstrates a link between urbanization and stream quality in the Puget Sound region, but since the effects of BMPs were not directly assessed, the question of whether BMPs could "raise" these thresholds could not be answered.

Horner did find a positive relationship between stream quality and riparian buffer width and quality. Here, the otherwise direct relationship of degrading stream quality with increasing impervious cover was positively altered where good riparian cover existed. In other words, increasing the buffer width and condition tended to keep the stream systems healthier.

Coffman demonstrated techniques for maintaining pre-developed hydrologic parameters by replicating the curve number and time of concentration. The analysis indicated the amount of storage required on-site to accommodate the change in site imperviousness. The benefits of this type of development, while not yet fully monitored in a field study, are likely to include increased groundwater recharge, reduced channel erosion potential, and decreased flood potential.

One major hydrologic benefit of storm water management structures is the ability to mitigate for the potential flooding associated with medium to larger storms. Storm water detention and retention facilities have been applied in many parts of the country since about 1970 (Ferguson and Debo, 1990). These facilities include wet and dry basins, as well as rooftop and parking lot detention and underground storage vaults. These *storage facilities* attempt to reduce flooding downstream from developments by reducing the rate of flow out of the particular structure being used. Although the rate of flow is reduced, the volume of flow is generally not reduced. Instead, this volume is delivered downstream at a slower rate, and stretched out over a longer time. With the exception of properly design wet ponds, these structures do not provide any water quality benefit beyond the hydrologic modifications. This technique has proved to be a successful method of suppressing flood peaks when properly applied on a watershed-wide basis.

6.3.3 Human Health Benefits

Storm water can impact human health through direct contact from swimming or through contamination of seafood. Most human health problems are caused by pathogens, but metals and synthetic organics may cause increased cancer risks if contaminated seafood are consumed. Mercury, PCBs, and some pesticides have been linked to human birth defects, cancer, neurological disorders and kidney ailments. The risks may be greater to sensitive populations such as children or the elderly. BMPs that reduce pathogens, metals and synthetic organics will help to limit these health risks.

Economic benefits of avoiding human health problems can include swimming and recreation costs, as well as saved medical costs. One study in Saginaw, Michigan estimated that the swimming and beach recreation benefits associated with a CSO retention project exceeded seven million dollars (US EPA, 1998c). As another example, EPA initially estimated that proposed Phase II storm water controls would reduce the cost of shellfish-related illnesses by between $73,000 and $300,000 per year (US EPA, 1997d).

6.3.4 Additional and Aesthetic Benefits

Storm water BMPs can be perceived as assets or detriments to a community, depending on their design. Some examples of benefits include: increased wildlife habitat, increased property values, recreational opportunities, and supplemental uses. Detriments include: mosquito breeding, reduced property values, less developable land and safety concerns. These detriments can be mitigated through careful design.

6.3.4.1 Property Values and Public Perception

The impacts of BMPs on property values are site-specific. The presence of a structural BMP can affect property values in one of three ways: increase the value, decrease the value, or have no impact. BMPs that are visually aesthetic and safe for children can lead to increased property values. A practice becoming more prevalent is to situate developments around man-made ponds, lakes, or wetlands created to control flooding and reduce the impacts of urban runoff. Buffer zones and open areas that control runoff also provide land for outdoor recreation such as walking or hiking and for wildlife habitat. In many cases, developers are able to realize additional profits and quicker sales from units that are adjacent to such areas. A survey of residents in an Illinois subdivision indicates that residents are willing to pay between 5 percent and 25 percent more to be located next to a wet pond, but that being located next to a poorly-designed dry detention basin can reduce home values (Emmerling-Dinovo, 1995).

Safety is also a concern among the public. A childless adult may perceive a wet pond as an amenity, but a family might view it as a potential hazard to children. These concerns can be alleviated using such design features as gently sloping edges, a safety "bench" (a flat area surrounding a pond) and the use of dense vegetation surrounding ponds and infiltration basins to act as a barrier.

Aesthetic maintenance is also important when considering long term impacts on property values. Poorly-maintained wet ponds or constructed wetlands may be unsightly due to excess algal growth or public littering. Wet ponds and constructed wetlands can also become mosquito breeding grounds. However, mosquito problems can usually be reduced or eliminated through proper design and/or organic controls such as mosquito-eating fish. Successful designs avoid shallow or stagnant water, and reduce large areas of periodic drying, as occur in a dry detention basin (McLean, 1995). All BMPs need to have trash and debris removed periodically to prevent odor and preserve aesthetic values.

6.3.4.2 Dual-Use Systems

Since BMPs can consume a large amount of space, communities may opt to use these facilities for other purposes in addition to storm water management. Two examples are "water reuse" ponds and dual use infiltration or detention basins. In one study, a storm water pond was used to irrigate a golf course in Florida, decreasing the cost of irrigation by approximately 85 percent (Schueler, 1994b). In the southwestern United States, BMPs are often completely dry in between rain events. In these regions, it is very common to design infiltration basins or detention basins as parks that are maintained as a public open space (Livingston et al, 1997).

6.4 Review of Economic Analysis of the NPDES Phase II Storm Water Rule

The proposed storm water Phase II rule specifies that Phase II municipalities and operators of construction sites disturbing between one and five acres of land must apply for and receive a storm water permit. To meet this requirement, municipalities must develop a storm water pollution prevention plan that addresses six minimum measures[9]. Operators of construction sites are required to incorporate soil and erosion controls into their construction sites and implement a water pollution prevention plan. The analysis presented here is a summary of the most recent benefit-cost analysis prepared for the proposed Phase II storm water rule (Preliminary draft number 3). In order to address the issues raised in the public comments and during internal review, EPA gathered additional data and information to refine the analysis of potential benefits and costs conducted for the proposed Phase II rule. These data, analyses, and results are described in detail in the Preliminary Draft of the Economic Analysis of the Final Phase II Storm

[9] The six minimum measures are:
- Public Education and Outreach on Storm Water Impacts
- Public Involvement/Participation
- Illicit Discharge Detection and Elimination
- Construction Site Storm Water Runoff Control
- Post-Construction Storm Water Management in New Development and Redevelopment
- Pollution Prevention/Good Housekeeping for Municipal Operations (US EPA, 1998c).

Water Rule ("EA"), and are summarized in the sections that follow. All cost and benefit estimates are presented in 1998 dollars.

The reader should note that the Agency continues to revise the analysis based on internal review and new data and information. EPA envisions completing the economic analysis in conjunction with the Storm Water Phase II Final Rule. Hence, all estimates are subject to future refinement.

6.4.1 Analyses of Potential Costs

This section provides an overview of the methodology used to estimate costs and pollutant loading reductions for both municipalities and construction sites subject to the final Phase II rulemaking. The specific components of the analysis are discussed in detail in the Draft Final EA. Current Agency estimates of national compliance costs, which are subject to change, are also provided.

6.4.1.1 Municipal Costs

EPA estimated annual per household program cost for automatically designated municipalities (MS4s) using actual expenditures reported by 35 Phase I municipalities. Based on census data, EPA estimated the Phase II municipal universe to be 5,040 MS4s with a total population of 85 million people and 32.5 million households. An average annual per household administrative cost was estimated to address application, record keeping, and reporting requirements, which was added to the program per household cost to derive a total average per household cost. To obtain the national estimate of compliance costs, the Agency multiplied the estimated total per household compliance cost ($9.09) by the expected number of households in Phase II communities. EPA estimates the national Phase II municipal compliance costs to be approximately $295 million (see Section 4.2.1.3 in the draft EA)[10].

6.4.1.2 Construction Costs

In estimating incremental costs attributable to the final Phase II rule, EPA estimated a per site cost for construction sites of one, three, and five acres and multiplied the cost by the total number of Phase II construction starts in these size categories to obtain a national estimate of compliance costs. The Agency used construction start data from eleven municipalities that record construction start information to estimate the number of construction starts disturbing between one and five acres of land (see Section 4.2.2.1 in the Draft Final EA).

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[10] Estimated annual per household cost of compliance ranged from $0.63 to $60.44. See Section 4.2.1.2 in the Draft Final EA for a discussion of how EPA chose the mean value of $9.09 per household. Note that the estimated per household cost does not include municipal expenditures for post-construction storm water controls.

In estimating construction BMP costs, EPA used standard cost estimates from R.S. Means (R.S. Means, 1997a and 1997b) and created 27 model sites of typical site conditions in the United States. The model sites considered three different site sizes (1, 3, and 5 acres), three slope variations (3, 7, and 12 percent), and three soil erosivity conditions (low, medium, and high). The Agency used a database compiled by the Water Environment Federation (1992) to develop and apply BMP combinations appropriate to the model site conditions. For example, sites with shallow slopes and a low erosivity require few BMPs, while larger, steeper, and more erosive sites required more BMPs. Detailed site plans, assumptions, and BMPs that could be used are found in Appendix B-3 of the Draft Final EA. Based on the assumption that any combination of site factors are equally likely to occur on a given site, EPA averaged the matrix of estimated costs to develop an average cost for one, three, and five acre starts for all soil erodibilities and slopes. The average BMP cost was estimated to be $1,206 for a one-acre site, $4,598 for a three-acre site, and $8,709 for a five-acre site.

Administrative costs for the following elements were estimated per construction site and added to each BMP cost: submittal of a notice of intent (NOI) for permit coverage ($74); notification to municipalities ($17); development of a storm water pollution prevention plan ($1,219); record retention ($2); and submittal of a notice of termination ($17) for a total cost of $1,329 per site. From this analysis, EPA estimated total average compliance costs (BMP plus administrative) for a Phase II construction site of $2,535 for sites disturbing between one and two acres of land, $5,927 for sites disturbing between two and four acres, and $10,038 for sites disturbing between four and five acres of land.

The total per site costs were then multiplied by the total number of Phase II construction sites within each of those size categories to obtain the national compliance cost estimate. EPA estimated construction costs for 15 climatic zones to reflect regional variations in rainfall intensity and amount. Once the Phase II storm water rule is fully implemented, the total annual compliance cost is expected to be approximately $512 million (assuming 109,652 construction starts in 1998).

6.4.1.3 Pollutant Loading Reductions

To estimate municipal pollutant loading reductions for the final Phase II rulemaking, EPA used the results from a 1997 EPA draft report that calculated national municipal loading reductions for TSS based on the NURP study (US EPA, 1997d). To estimate pollutant loading reductions from Phase II construction starts, the U.S. Army Corps of Engineers developed a model based on EPA's 27 models sites to estimate sediment loads from construction starts with and without Phase II controls (US ACE, 1998). Estimating the pollutant loading reduction for TSS does not capture the full extent of potential loading reductions that result from implementing storm water controls, but provides a minimum estimate of the reductions that may result from the

Phase II rule[11]. EPA also anticipates that the rule will result in reductions in oil and grease, nitrogen, phosphorus, pathogens, lead, copper, zinc and other metals. Estimated annual TSS loading reductions range from 639,115 to approximately 4 million tons for municipalities and 2 million to 8 million tons for construction sites assuming BMP effectiveness of 20 to 80 percent.

6.4.2 Assessment of Potential Benefits

A number of potential problems are associated with assessing the benefits from the Phase II rule, including identifying the regulated municipalities as sources of current impairment to waters and determining the likely effectiveness of various measures; difficulties in water quality modeling; difficulties in modeling construction site BMP effectiveness; and most importantly, the inability to monetize some categories of benefits with currently available data.

The national benefits of Phase II controls will depend on a number of factors, including the number, intensity, and duration of wet weather events; the success of municipal programs; the effectiveness of the selected construction site BMPs; the site-specific water quality and physical conditions of receiving waters; the current and potential use of receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Because these factors will vary substantially from site to site, data are not available with which to develop estimates of benefits for each site and aggregate to obtain a national estimate. As a result, the Agency developed national level estimates of benefits based largely on a benefits transfer approach. This approach allows estimates of value developed for one site and level of environmental change to be applied in the analysis of similar sites and environmental changes.

6.4.2.1 Anticipated Benefits of Municipal Measures

As part of an effort to quantify the value of the United States' waters impaired by storm water discharges, EPA applied adjusted Carson and Mitchell (1993) estimates of willingness to pay (WTP) for incremental water quality improvements to estimates of waters impaired by storm water discharges as reported by states in their biennial Water Quality Inventory reports[12]. Potential Phase II benefits are assumed to equal the WTP for the different water quality levels multiplied by the water quality impairment associated with Phase II municipalities multiplied by the relevant number of households (WTP x percent impaired x number of households).

The Carson and Mitchell estimates apply to all fresh water, however it is not clear how these values would be apportioned among rivers, lakes and the Great Lakes. Lakes are the water

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[11] To date, there are no national studies that estimate pollutant loading reductions due to the implementation of municipal storm water controls for the other pollutants found in storm water runoff and discharges.

[12]EPA adjusted the WTP amounts to account for inflation growth in real per capita income, inflation, and a 30 percent increase in attitudes towards pollution control.

bodies most impaired by urban runoff and discharges, followed closely by the Great Lakes and then rivers. Hence, EPA applied the WTP values to the categories separately and assumed that the higher resulting value for lakes represents the high end of the range and the lower resulting value for rivers represents the low end of a value range for all fresh waters (i.e. high end assumes that lake impairment is more indicative of national fresh water impairment while low end assumes that river impairment is more indicative).

The extent to which impairment will be eliminated by the municipal measures is uncertain; hence, estimates are adjusted for a range of potential effectiveness of municipal measures. EPA expects that municipal programs will achieve at least 80% effectiveness, resulting in estimated annual benefits from fresh water use and passive use in the range of $67.2 to $241.2 million. The potential value of improvements in marine waters and human health benefits have not been quantified at this time.

6.4.2.2 Anticipated Benefits of Construction Site Controls

EPA estimates the benefits of construction site controls using a benefits transfer approach applying WTP estimates for an erosion and sediment control plan from Paterson et al (1993) contingent valuation (CV) survey of North Carolina residents. The adjusted WTP estimates are intended to reflect potential benefits of erosion and sediment control programs that protect all lakes, rivers, and streams. In order to transfer adjusted WTP results to estimate the potential benefits of the Phase II rule, EPA calculated the percentage of Phase II construction starts that are not covered by a state program or CZARA for each state. This percentage is multiplied by the number of households in the state and the adjusted mean WTP of $25. The results were then summed across all states and indicate that WTP for the erosion and sediment controls of the Phase II rule may be as high as $624.2 million per year.

6.4.3 Comparison of Benefits and Costs

EPA estimates the total compliance costs of the rule to be $807.2 million. The largest portion of the total cost, $512 million, is associated with erosion and sediment controls at construction sites. EPA was able to develop a partial monetary estimate of expected benefits of both the six minimum municipal measures and the construction components of the rule. The sum of these benefits ranges from $700 to $865 million annually [assuming 80 percent effectiveness of municipal programs and using the mean WTP ($25) from Paterson]. The largest portion of benefits, $624 million, are associated with erosion and sediment controls for construction sites.

6.5 Financial Issues

Effective storm water programs require both the existence of well-performing, cost-effective BMPs and sufficient funding. Financing issues are discussed extensively in other Agency reports and only briefly reviewed below.[13] Section 6.5.1 focuses on financing options for municipal storm water programs but does not discuss regulatory impacts on municipalities.

6.5.1 Municipal Financing of Storm Water Programs

Around the nation, local government general tax funds are the most commonly used source of funding for storm water programs. However, this may be the least suitable source of storm water program or maintenance funding. General tax revenues originate at a number of sources and are used to finance an equally diverse number of public programs, including education, police and fire protection, civil and criminal courts, and social and economic support programs. Storm water programs and maintenance must compete against a large number of other vital public programs for a very limited number of tax dollars. This problem has been compounded in recent years by tax caps and the public's general opposition to new or higher taxes.

The unreliability of general tax funds has led many communities around the country to develop storm water utilities. Storm water utilities rely on dedicated user charges related to the level of service provided. Charges are typically paid by property owners and managed in a separate enterprise fund. A variety of methods are used to determine charges, but are usually based on some estimate of the amount of storm water runoff contributed by the property, such as the total impervious surface or a ratio of impervious surface to total property area. Generally a flat rate is charged for residential properties.

There are several advantages of using utility fees to finance storm water programs. Unlike general tax revenues, utility charges are a dedicated, stable, and predictable source of funds and are not subject to state "tax cap" limitations. Also, because charges are based on the user's contribution to storm water runoff, it is often seen as more equitable or fair. Finally, utility fees provide a mechanism to incorporate economic incentives for implementation of on-site storm water management through reduced charges. For example, credits or discounts are often provided for on-site retention of storm water by nonresidential property owners. Providing such incentives creates greater flexibility by allowing each user to choose the cheaper option - paying the utility charge or implementing on-site controls. Storm water utilities are now well established as an effective financing option. As of 1991, over 100 communities across the country had instituted storm water utilities (US EPA, 1994a).

Similar to utility fees, the use of inspection or permit fees to help publicly finance storm water programs represents a relatively new application of an established component of government revenues. Often, these fees are associated with the issuance of a permit, such as a

[13] EPA has prepared publications to assist local governments in planning for program funding (US EPA, 1994b). More recently the Agency has established an internet site with current information, the "Environmental Finance Information Network." The website address is http://www.epa.gov/efinpage/efin.htm .

building permit, clearing permit, storm water permit, or sewer connection permit. A permit program based upon fees for annual inspections, such as a storm water discharge or storm water operating permit, can provide a continuing source of funds. However, many permit or inspection fees are a one time charge, typically when the facility is first constructed. These are generally not a good funding source for continuing storm water system maintenance.

Finally, the use of dedicated contributions from land developers may be used to finance public maintenance of storm water systems. Under this program, the local government assumes the operation and maintenance of a storm water system constructed as part of a private development. All or a portion of the estimated required funding for the O&M is obtained through a one-time contribution by the land developer to a dedicated account which is controlled by the local government. Often the developer is responsible for O&M during a "warranty period," frequently the first two years. Dedicated contributions provide a secure, dedicated funding source that is not subject to state tax cap limits. A disadvantage is that dedicated contributions are only applicable to new storm water systems.

6.6 Summary

The use of BMPs to control storm water runoff and discharges where none previously existed will ultimately result in a change in pollutant loadings, and there are indications that in the aggregate BMPs will improve water quality. The actual manner in which the loadings reductions are achieved will depend on the BMPs selected, which will determine the associated costs. The physical-chemical properties of receiving streams and consequent linkages to biologic/ecologic responses in the aquatic environment, and human responses and values associated with these changes will determine the benefits.

COST ANALYSIS

Washington Department of Ecology Year 2001 Minimum Requirements for Stormwater Management 2001

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Preface

This document contains information on the cost of implementing the new minimum stormwater control requirements for new developments and redevelopments as set forth by the Washington Department of Ecology (Ecology) in its *Stormwater Management Manual for Western Washington* (Ecology 2001). The minimum requirements include provisions for controlling erosion and sediment transport during construction, as well as permanent facilities for treating and controlling peak runoff flows from developed sites. This cost analysis considers only the stormwater system components required for erosion and sediment control, stormwater treatment, and stormwater detention and/or infiltration that go beyond conventional stormwater systems. Thus, the costs of installing stormwater system components such as catch basins and conveyance pipes that are independent of the Ecology requirements are not addressed in this cost analysis.

The cost estimates for satisfying Ecology's new minimum requirements that are provided in this report should be considered as approximate, and should be viewed in the context of the hypothetical sites for which they were developed. Individual site conditions, selected components of stormwater control plans, costs of land, costs of engineering and construction services, and many other factors can vary considerably throughout western Washington and from project to project. Some projects will be faced with costs associated with construction of stormwater management facilities that are not captured in this analysis, such as traffic control costs, additional property costs, and mitigation costs for sensitive areas that are impacted by placement of stormwater management facilities. Therefore, for a particular development or redevelopment of comparable size to the hypothetical sites discussed in this report, the costs of satisfying Ecology's minimum requirements may differ from the costs given in this analysis. This analysis does not address the costs that stormwater design engineers, site designers, developers, and development reviewers may incur in learning the updated requirements and preparing the resultant technical documentation that will likely require greater detail.

1. Introduction

This report provides information on costs of stormwater control measures required for new single-family residential and commercial developments in western Washington based on the minimum requirements set forth by the Washington Department of Ecology (Ecology) in the *Stormwater Management Manual for Western Washington*, referred to hereafter as "the manual" (Ecology 2001, final version pending as of the date this report was completed). The manual describes the stormwater management requirements applicable to various development and redevelopment scenarios, including many types of development other than single-family residential and commercial land use. There are a multitude of development scenarios that could potentially be evaluated for stormwater management implementation costs but doing so would require extensive amounts of time and effort. This report discusses the range of stormwater management costs that could be expected for some representative examples, and the reader must necessarily use the information as a general guide to understand the cost implications for a specific project of interest.

Development Examples

This report addresses three hypothetical development examples and presents the associated costs for compliance with Ecology's new minimum requirements. These three hypothetical development sites include the following: a 10-acre single-family residential development (site 1), a 1-acre commercial development (site 2), and a 10-acre commercial development (site 3). These examples assume that new development is occurring on the hypothetical sites, that there is no existing development on the sites, that greater than 2,000 square feet of impervious surface is added, and that greater than 7,000 square feet of land area is cleared. Therefore, all of the minimum requirements set forth in the manual are applicable to these examples. Because the decisions regarding how to manage stormwater for a particular site are often directly tied to soil characteristics, this report addresses a range of control measures that may be used in differing soil conditions. For each of the three example sites, the costs to implement the minimum requirements were analyzed for two different soil conditions (soils that would promote infiltration of runoff [type A soils] and soils that are not suitable for infiltration [type C soils]).

This report may be viewed as an update to a similar report prepared in 1993 entitled *Cost Analysis, Minimum Requirements for Stormwater Management in New Developments and Redevelopments* (Herrera 1993), which contained an analysis based on requirements set forth in the *Stormwater Management Manual for the Puget Sound Basin* (Ecology 1992). The analysis in this report repeats the hypothetical development examples from the 1993 report, and the analysis is based on the minimum requirements, design guidelines, and stormwater facility sizing procedures in the updated 2001 Ecology manual. Where applicable, this report refers to the 1993 cost analysis report to enable comparison of the differences in stormwater management costs between the older and newer requirements for the same site conditions.

Soil type is an important difference between the 1993 report and this report. The 1993 report used type B soils for the examples where infiltration was assumed feasible, whereas the present analysis assumed type A soils (i.e., glacial outwash or alluvial deposits that are more permeable than type B soils) for the examples where infiltration is assumed feasible. This distinction is important because it affects the selection and configuration of the permanent stormwater facilities. Specifically, the 1993 report assumed infiltration treatment would occur in type B soils, with overflow to a detention facility in higher storms. This analysis assumes pretreatment followed by flow disposal in the highly permeable type A soils. The decision to switch to Type A soils was based on the type of soil input data that the pending Ecology hydrologic model will allow, and a desire to have the case study examples match the model input options as directly as possible. To enable a fair cost comparison of 1992 requirements versus 2001 requirements for the examples where infiltration is feasible, the soil type must be consistent. Therefore, the permanent stormwater management system quantities and costs associated with type B soils in the 1993 report were disregarded, and new costs were developed for those examples assuming type A soils. As discussed in Appendix C of this report, quantities and costs were re-analyzed for the three sites assuming pretreatment and discharge of all runoff to an infiltration basin, using the 1992 design requirements to derive the sizes of those facilities. Thus, the comparison of permanent stormwater management costs associated with the previous requirements and the new requirements, presented at the end of this report, is based on updates to the 1993 cost figures for the non-infiltration examples and new cost figures for the infiltration examples.

Ecology's Minimum Requirements

Ecology's stormwater management requirements have changed substantially since 1992. In order to demonstrate compliance with Ecology's minimum requirements, preparation of a construction stormwater pollution prevention plan (SWPPP) and a permanent stormwater site plan is required for all new development sites that will create more than 2,000 square feet of impervious surface or clear more than 7,000 square feet of land area. The updated minimum requirements, which are discussed in detail in the manual (Ecology 2001), are summarized below with the changes highlighted:

1. **Preparation of Stormwater Site Plans** – All projects shall prepare a stormwater site plan for local government review.

   Significant Change: Demonstration of compliance with the 1992 manual required preparation of a Stormwater Site Plan. However, such plan preparation was not specifically identified as a minimum requirement. The updated manual specifically identifies the preparation of such plans as a minimum requirement. This is not a change that increases project costs.

2. **Construction Stormwater Pollution Prevention (SWPP)** – All new development and redevelopment shall comply with the 12 construction SWPP elements found in the manual.

Significant Changes: A new element to "Manage the Project" has been added. This includes phasing of construction activities, seasonal work limitations, coordination with utilities, inspection and monitoring of BMPs, retention of a certified professional in erosion and sediment control, and maintenance of a Stormwater Pollution Prevention Plan (SWPPP). Significant BMP additions that need to be considered in SWPPPs include chemical treatment, land application of polyacrylimide for soil stabilization, wheel washing, concrete handling, and sawcutting and surfacing.

3. **Source control of pollution** – All known, available and reasonable source control best management practices (BMPs) shall be applied to all projects.

   Significant Changes: There are 18 new source control BMPs described in the 2001 manual.

4. **Preservation of natural drainage systems and outfalls** – Natural drainage patterns shall be maintained, and discharges from the site shall occur at the natural location, to the maximum extent practicable.

5. **Onsite stormwater management** – Projects shall employ onsite stormwater BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent practicable without causing flooding or erosion impacts.

   Significant Change: This new requirement specifies use of flow dispersion or infiltration BMPs for concentrated runoff from impervious surfaces at residential sites, and for all areas not covered by impervious surfaces, the retention or enhancement of the soil moisture holding capacity of the original undisturbed soil native to the site. Specifically, the requirements include provision of a topsoil layer with a minimum organic matter content of ten percent dry weight and a pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil.

6. **Runoff treatment** – Projects that meet specific thresholds are required to construct stormwater treatment facilities that are sized to treat runoff from the water quality design storm (the 24-hour rainfall amount with a 6-month return frequency).

   Significant Changes: Treatment is required for pollution-generating pervious surfaces (PGPS), such as managed turfgrass, in addition to pollution-generating impervious surfaces (PGIS). The Water Quality Design Storm Event is still a 6-month, 24-hour storm, but the generic estimate for precipitation depth in such a storm event is increased from 64% to 72% of the 2-year, 24-hour storm precipitation depth.

7. **Flow control** – Projects that meet specific thresholds must provide flow control to reduce the impacts of increased stormwater runoff from new impervious surfaces and land cover conversions.

   Significant Changes: A flow duration standard is now the default requirement. The flow control standard in the 1992 manual was primarily targeted at matching pre-developed peak flow rates. The newer standard still requires matching of pre-developed peak flow rates but also requires matching of pre-developed flow durations to prevent prolonged discharges of the peak flows. In addition, the pre-developed site condition for runoff modeling purposes must be assumed forested unless reliable information establishes the pre-settlement conditions as pasture or prairie. The 1992 manual allowed use of the "existing site condition," as defined in the glossary, as the pre-developed condition to which peak flows of the developed condition are compared.

8. **Wetlands protection** – Discharges to wetlands shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses unless an assessment is completed consistent with specific criteria referenced in the manual.

9. **Basin/watershed planning** – Projects may be subject to equivalent or more stringent minimum requirements for erosion control, source control, treatment, wetlands protection, and operation and maintenance, and alternative requirements for flow control as identified in basin/watershed plans.

10. **Operation and maintenance** – An operation and maintenance manual that is consistent with the local government standards shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified.

The Stormwater Pollution Prevention Plan

The SWPPP must incorporate sufficient best management practices (BMPs) to prevent adverse offsite impacts during construction through a variety of measures as specified in minimum requirement number two. Twelve distinct elements of effective construction site pollution prevention must be included in the SWPPP to the extent they pertain to the site.

The Permanent Stormwater Site Plan

The permanent stormwater site plan must include the following elements to comply with the minimum requirements:

- Minimum requirement three: additional BMPs for prevention of runoff pollution, or source control

- Minimum requirement five: This important new requirement relates to implementation of onsite stormwater management measures to minimize the hydrologic changes that occur on the site (i.e., to minimize the increase in runoff that is inherent with development). The cost analyses discussed in this report incorporate this requirement. The effects of new onsite runoff reduction measures on the size and cost of permanent runoff treatment and flow control facilities are discussed for each development example.

- Minimum requirement six: treatment of onsite runoff to protect downstream water quality

- Minimum requirement seven: control of peak runoff flows that may otherwise cause damage to natural resources and constructed facilities downstream

- Minimum requirement ten: long-term operation and maintenance commitments for permanent stormwater management systems

Thoughtful selection and proper implementation of BMPs are critical to satisfying Ecology's minimum requirements for stormwater management for new development or redevelopment. In this analysis, the rationale for selection of particular BMPs is provided for each of the hypothetical development plans to illustrate the process by which BMPs were chosen.

Organization of the Cost Analysis

The remaining portion of section 1 outlines the assumptions used in creating hypothetical development site layouts. Also discussed are the assumptions and calculation methods used in analyzing minimum requirements for stormwater control and for sizing and selecting stormwater management BMPs.

Section 2 describes the hypothetical site characteristics and associated SWPPP and stormwater site plan details developed for the purpose of estimating costs to satisfy the minimum requirements. The estimated costs for planning, designing, constructing, and maintaining the chosen BMPs for each site are also provided in Section 2. Section 3 presents a summary of the construction and maintenance cost estimates for satisfaction of the minimum requirements, and discusses comparisons to the costs presented in the 1993 report associated with the previous minimum requirements. Appendix A contains itemized costs for planning, design, construction, and maintenance of the BMPs for each of the development sites, as well as assumptions and references used in developing the cost estimates. The technical assumptions, runoff modeling parameters, and design parameters used in the analysis of stormwater BMPs for each of the sites are outlined in Appendix B.

The SWPPP and stormwater site plan developed for each of the hypothetical sites are intended to be representative in their coverage of BMP concerns, but they do not include all of the information required of actual SWPPPs and stormwater site plans. Because this analysis focuses primarily on costs, details regarding site features such as setback requirements, existing vegetation to be retained, rights-of-way, and storm sewers, among other issues, are limited.

General Assumptions Used in Creating Hypothetical Site Layouts, Analyzing Minimum Requirements, and Selecting and Sizing Stormwater Management Facilities

The hypothetical development site layouts and associated stormwater facilities are based upon the assumptions outlined below:

- Each site is serviced by separate sanitary sewer and storm drainage systems. The cost of installing ditches or storm sewers beyond the site boundaries is a separate concern; this analysis addresses only the additional storm drainage facilities needed for treatment, infiltration and/or detention of runoff on the example site.
- Ground slopes on all of the sites are less than 5 percent.
- The land uses adjacent to the sites on all sides are unknown.
- Stormwater runoff on all of the sites eventually drains to a fish-bearing stream. For the commercial site examples (sites 2 and 3) this means that "enhanced treatment" of runoff is required.
- Phosphorus control is not required at any of the sites.
- Other more stringent local stormwater management requirements do not apply, and a jurisdictional basin plan does not exist for any of the site areas.

Costs for complying with the minimum requirements at each of the development sites are based on two scenarios: the first scenario assumes the site has outwash soils that are suitable for infiltration of all, or nearly all, of the stormwater runoff; the second scenario assumes till soils that are unsuitable for infiltration. Two separate cost estimates are provided for implementation of the minimum stormwater management requirements at each site, reflecting the two types of soils assumed at each site. Other than differences in the soil type present, the site characteristics are identical for the two scenarios evaluated at each site.

Calculation Methods

A combination of hydrologic modeling methods was used to perform conceptual sizing of stormwater management facilities for this analysis, including some modeling methods that are not described in the manual. The hydrologic model that eventually will be used for analysis and design of stormwater management systems in accordance with the manual's design criteria was in the developmental stage at the time this report was prepared; therefore, alternative methods were necessary. The 6-month recurrence interval water quality design storm hydrographs for the case study development examples were derived using StormShed™ computer software (Engenious Systems 2000), which incorporates the Santa Barbara Urban Hydrograph (SBUH) method. The model inputs are summarized in Appendix B. The performance of detention systems, including matching of pre-developed flow durations, was modeled using the King County Runoff Time Series (KCRTS) program. The KCRTS program offers a calculation method for evaluating flow durations that are central to the detention requirements set forth in the manual. Sand filter sizes were also evaluated using KCRTS. The KCRTS hydrographs corresponding to the 2-year recurrence interval peak flow discharged from detention facilities were routed through the KCRTS infiltration basin sizing routine, with vertical permeabilities corresponding to sand as opposed to soil, to determine the sand filter bed area needed to effectively treat those design flows. Infiltration facilities were sized using a spreadsheet based on Darcy's Law and the 100-year SBUH storm event hydrographs. The spreadsheet enabled confirmation of the time limits required for water level drawdown following design storm events.

2. Sample Sites and Associated Construction SWPPPs and Permanent Stormwater Site Plans

This section describes the three hypothetical development sites and provides details of corresponding construction SWPPPs and permanent stormwater site plans. Plan elements were chosen to provide examples of elements that satisfy the minimum requirements outlined in the manual. Also provided are implementation costs to satisfy the minimum requirements and operation and maintenance requirements and costs.

Site 1—Single-Family Residential Development

Site 1 is a 10-acre single-family residential development with 5.5 dwelling units per acre. Figure 1 shows the layout of the site as planned for development without stormwater control facilities to satisfy the minimum requirements. There is one entrance to the development. The topography of the site in its undeveloped state causes runoff to flow to the lower left-hand corner via a few defined drainage courses, the largest of which is indicated near the bottom of the plan view shown in Figure 1. These drainage courses are not streams and provide negligible ecological benefits. Because the development plan does not include extensive regrading of the slopes on the site, drainage would proceed in the same general direction after development. It is assumed that after development, any treated runoff (see below for treatment plans) from the site that does not infiltrate into the soil would be conveyed downstream of the site to a stream. An important distinction between this site and the other two sites analyzed in this report is that surface runoff discharged from a single-family residential development to a fish-bearing stream does not require "enhanced treatment" according to the manual requirements.

The topographic layout of site 1 is conducive to stormwater runon from adjacent land and through-flow in the main drainage course. It is assumed that a decision would be made to minimize the size (and cost) of temporary erosion and sediment control facilities and of permanent stormwater management facilities by separating the offsite runon from the onsite drainage. For the purposes of this analysis it is assumed that one or more culverts and/or intercepting ditches (or similarly effective diversion/conveyance facilities) would be provided to convey those flows around the site. Because these provisions are necessary due to hypothetical site conditions, costs are not included for them.

Site 1 Construction Stormwater Pollution Prevention Plan

For all new development and redevelopment projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet, such as site 1, the manual requires preparation of a SWPPP (minimum requirement two) to guide selection and implementation of a variety of BMPs during construction. The minimum requirements for stormwater pollution prevention during construction include the following 12 elements:

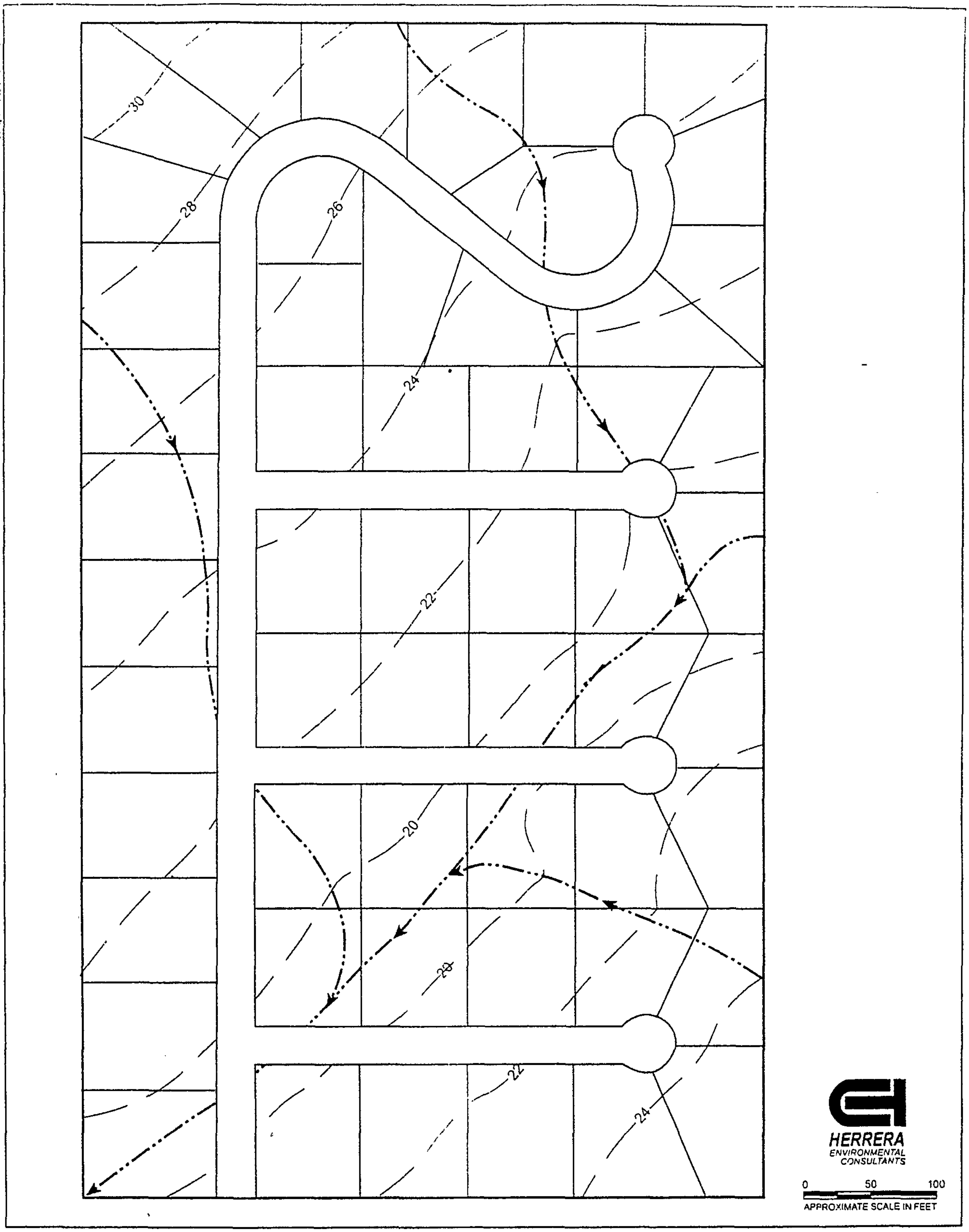

Figure 1. **Ten-acre residential development plan, without stormwater facilities, superimposed on natural (pre-development) topography and drainage features.**

1. Mark clearing limits
2. Establish construction access
3. Control flow rates
4. Install sediment controls
5. Stabilize soils
6. Protect slopes
7. Protect drain inlets
8. Stabilize channels and outlets
9. Control pollutants
10. Control de-watering
11. Maintain BMPs
12. Manage the project

It is assumed that construction would require 12 months of site work to complete. Two versions of a SWPPP were evaluated for the condition with type C soils on this site, one accounting for a stoppage of site grading activities from November through March (i.e., assuming that the project would be managed to greatly minimize potential for water quality problems in the wet season) and the other assuming that construction would proceed through the winter months. Thus, the total duration of construction for one SWPPP scenario is 17 months, and for the other SWPPP scenario is 12 months. For both cases it was assumed that the contractor would build the entire 10-acre residential development (houses included), rather than grading the site, providing basic infrastructure and utilities, and leaving individual building sites for future contractors. The comparison of SWPPP costs with and without a winter shutdown is made only for the site condition with type C soils. Type A soils are often associated with construction site erosion problems, and concerns for seasonal clearing and grading restrictions, but type C soils are typically more conducive to turbidity problems. This analysis reflects the likelihood that seasonal clearing and grading restrictions would be more common in type C soils. Of the 12 elements listed above, the only one that would not incur measurable costs in the context of this cost analysis is element 9. The potential opportunity cost to the developer of managing the project to avoid grading activity in the winter was not assessed for this study.

To control transport of sediments off the site and to protect downstream properties and waterways during construction, a combination of BMPs would be used including fenced clearing limits, stabilized site roads, equipment parking areas, storm drain inlet protection on the adjacent street, temporary ground cover in disturbed areas, stabilized conveyance ditches, a large sediment pond, and silt fencing. To satisfy the minimum requirements, these BMPs would be in place prior to beginning construction activities. It is assumed that de-watering would be required at this site, and that those flows could be managed effectively with a filtration device such as a dewatering filter bag or pipe filter sock and then discharged from the site. Therefore, the sizing of sedimentation facilities did not account for de-watering discharges.

Figure 2 shows the locations of the erosion and sediment control BMPs selected for the residential development site. The BMPs are the same for outwash (type A) soils (suitable for infiltration) and till (type C) soils (unsuitable for infiltration). However, the size of the temporary sediment pond differs because of the effect soil type has on runoff peak flows and volumes. The manual specifies that sediment ponds be designed based on the 2-year, 24-hour storm peak runoff flow rate. The 2-year post-developed peak runoff rate used for sediment pond sizing is estimated to be 0.48 cubic feet per second (cfs) with outwash soils (i.e., Type A soils) on the site, and 0.62 cfs with till soils on the site (i.e., type C soils). Figure 2 indicates the sediment pond size corresponding to type C soils. Silt fencing would be used as a divider within the temporary sediment pond to enhance the removal of suspended sediments.

Temporary interceptor swales and conveyance channels lined with suitable geotextiles or organic blankets, or stabilized with seed and mulch, would be used to convey all site runoff to the sediment pond. Silt fencing would be used on downslope edges of the site boundary to prevent sediment discharge. The site entrance would be stabilized with quarry spalls (large rocks), and construction roads on the site and one main parking/staging area would be stabilized with crushed rock. Mulch would be applied extensively to areas of exposed soil during staged construction.

Other BMPs such as vehicle tire washing, occasional street sweeping, and spraying of dusty areas would be implemented during construction. For the scenario where grading work is stopped for the period of November through March it is assumed that greater attention to soil stabilization (such as application of polyacrylamides on a large area) would be needed to prevent erosion on disturbed ground for several months, particularly in Type C soils. For the scenario where grading work occurs through the winter months it is assumed that greater attention to sediment pond maintenance, street sweeping, vehicle tire washing, and replacement of storm drain inlet protection devices would be needed. Following construction of homes on the site, grassed lawns would be planted, and sidewalks and streets would be paved to permanently stabilize disturbed areas.

Maintenance of the erosion and sediment control BMPs is a key component of the construction SWPPP. It is assumed that routine BMP maintenance checks would be performed once weekly and after runoff-producing storm events during the dry season, and daily during the wet season to ensure that BMPs continue to function effectively. The sediment pond must be checked periodically for sediment buildup, especially following storms. Excess sediment accumulation must be removed from the pond and disposed of off the site or spread in a controlled location on the site. Silt fencing must be checked periodically, especially following storms, to determine if repairs or replacement fabric sections are needed. Mulch used to cover stripped site areas would be relocated and replaced as needed, as portions of the site are permanently stabilized. If sediment is tracked offsite onto neighboring streets, it must be swept and collected as necessary.

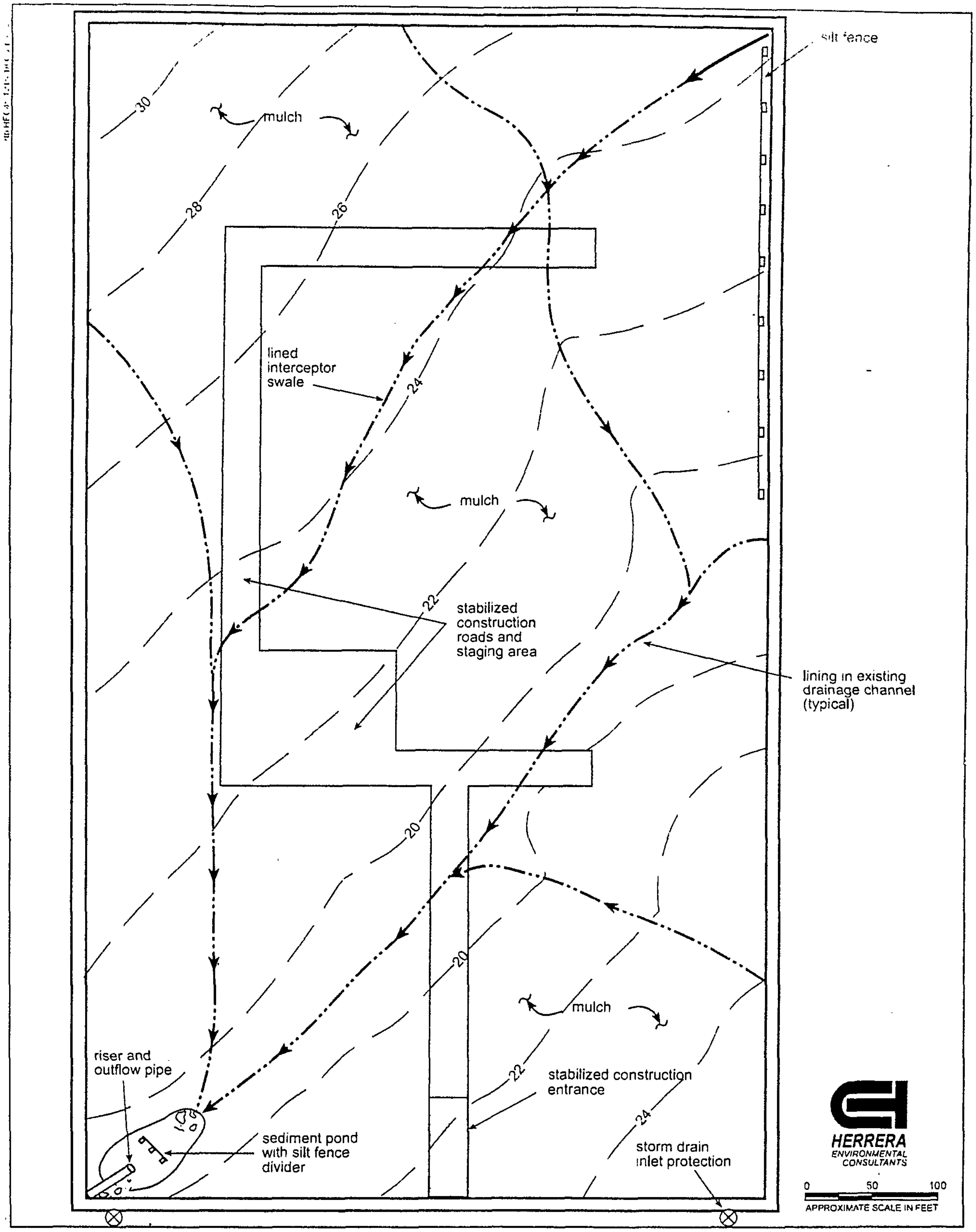

Figure 2. Erosion and sediment control BMPs for 10-acre residential development.

Costs for Construction Stormwater Pollution Prevention Plan

Without Wet Season Shutdown

For the scenario where it is assumed that grading activity continues on the site through the winter, the construction cost for the SWPPP BMPs is estimated at approximately $40,000 for type A soils and $49,000 for type C soils. Tables 1 and 4 in Appendix A, respectively, show itemized costs for the various BMP components and their associated construction procedures and materials. These costs do not include engineering planning and design fees, permit fees, performance bonding (or other appropriate financial instruments to ensure compliance with the approved SWPPP), and contingencies for unforeseen difficulties. Maintenance of the erosion and sediment control BMPs (included in the SWPPP BMP costs noted above) over the course of the 12-month construction period is estimated to cost approximately $8,400 for type A soils and $14,500 for type C soils (see Tables 3 and 7, respectively, in Appendix A). Appendix A provides further details on assumptions used to develop these costs.

With Wet Season Shutdown

For the scenario where it is assumed that the site is managed to avoid grading activity from November through March, the construction cost for the SWPPP BMPs is estimated at approximately $41,000 for type C soils. Table 5 in Appendix A shows itemized costs for the various BMP components and their associated construction procedures and materials. These costs do not include engineering planning and design fees, permit fees, performance bonding (or other appropriate financial instruments to ensure compliance with the approved SWPPP), and contingencies for unforeseen difficulties. As discussed below, the construction SWPPP costs are rolled into the permanent stormwater site plan costs to create a total implementation cost, and those estimates include engineering, permitting, and contingency costs. Maintenance of the erosion and sediment control BMPs over the course of the 17-month construction period (included in the SWPPP BMP cost noted above) is estimated to cost approximately $9,100 (see Table 8 in Appendix A). Appendix A provides further details on assumptions used to develop these costs.

Effects of Wet Season Site Work on SWPPP Cost

The total SWPPP implementation and maintenance cost varies slightly depending on whether clearing and grading activity occurs in the wet winter months. For the scenario where the site is stabilized for the period of November through March, it is estimated that the total SWPPP cost would be $7,400 less compared to the scenario where site activities continue through the winter. Avoidance of grading activities in the wet season is assumed to result in reduced costs for street sweeping, BMP inspections following storms, and catch basin cleaning, but increased cost for soil stabilization during the winter. Most of the SWPPP costs are independent of work scheduling in the wet season for this site. For example, the sedimentation pond size, the need for temporary lined conveyance ditches, and the need for stabilization of construction roads and construction staging areas are the same regardless of wet season work scheduling.

Site 1 Permanent Stormwater Site Plan

The stormwater site plan must include provisions for maintaining natural drainage patterns, using source control BMPs to prevent pollutants from entering stormwater runoff, reducing hydrologic changes through onsite stormwater management techniques, treating runoff from smaller storm events, detaining runoff from larger storm events to prevent stream bank erosion due to high flows, and maintaining the BMPs that are chosen and implemented. Minimum requirement eight, pertaining to wetlands, and minimum requirement nine, pertaining to basin planning, are assumed to be not applicable to this hypothetical site and this analysis. In accordance with the manual, two preliminary considerations guided BMP selection for site 1. Oil control and special phosphorus control measures must be considered; they are not required for this site. The standard western Washington peak flow control to match pre-development flow peaks and durations must be considered and is required because the site discharge is conveyed to a small stream (if site discharge is conveyed directly to a major water body, the standard does not apply).

Pollution Source Control BMPs

Pollution source control BMPs are important components of a stormwater site plan for site 1 to satisfy minimum requirement three. Several of the source control BMPs outlined in the manual are applicable to this development. However, only a few of the source control BMPs that should be applied to this development incur direct, calculable costs. Source controls such as environmentally sensitive vegetation management and protection of storage areas housing containers for chemicals, garbage, and other wastes are important and should be emphasized to homeowners. However, they are difficult to quantify in terms of costs. Moreover, some of these source controls are not required for residences. An actual stormwater site plan for this type of residential development site should mention these items; however, the cost estimates given herein do not include costs to implement source control BMPs that are educational in nature, as opposed to physical actions. The cost estimates for this site include only two source control BMPs from the manual: maintenance of storm drainage facilities (BMP S2.00) and street sweeping (BMP S2.20).

Onsite Stormwater Management Measures

In addition to pollution source control BMPs, onsite stormwater management measures must also be implemented to infiltrate, disperse, and retain stormwater runoff onsite where practicable (minimum requirement number 5). Some examples of onsite stormwater management BMPs applicable to this residential development include roof downspout infiltration and dispersion, use of permeable/porous pavements, and vegetated rooftops. For this site, the use of "alternative" roof downspout infiltration trenches was assumed with infiltratable soils on site (type A). These infiltration systems are suitable for coarse soils, and have a simpler design than downspout infiltration systems in soils with fine particles. Permanent stormwater facilities were sized, and the associated cost estimate developed, with roof downspout infiltration included. The contributing drainage area for the permanent pond facilities is considerably reduced as a result.

For the scenario with noninfiltratable type C soils, it was assumed that roof downspout dispersion systems would be provided for half of the total rooftop areas. The sizing of permanent stormwater treatment and flow control facilities accounted for 50 percent of the rooftop runoff, assuming that 50 percent could be dispersed through sufficient grassy areas and that the other 50 percent of the rooftop runoff would drain relatively quickly to conveyance systems carrying flow to the stormwater pond facilities. If all rooftop runoff could pass through grassy areas greater than 50 feet in length, the modeling of site runoff could assume that all of the rooftops are equivalent to grass and the size of the stormwater pond facilities would be reduced accordingly. The cost estimate for rooftop drainage dispersion systems assumes simple splashblocks that disperse flow across a long grassy area as opposed to rock-filled trenches with notched grade boards. Although it was assumed that porous pavements could be used for individual driveways, the sizing of the permanent stormwater treatment and flow control facilities conservatively assumed that all driveway runoff would reach the ponds relatively quickly. Thus, the cost estimate for this scenario is representative of a worst-case for the amount of flow to be managed. If earth-filled concrete paver blocks or similar materials were used for driveways, the modeling of site runoff could assume that 50 percent of the driveway areas are equivalent to grass and the size of the stormwater pond facilities would be reduced accordingly.

Permanent Stormwater Control Facilities by Soil Type

The permanent stormwater control facilities selected for the residential site to satisfy the minimum requirements are dependent on soil type.

Type A Soils – With Infiltration

Infiltration is the preferred method of stormwater treatment and surface flow reduction, but infiltration requires suitable soils. For the scenario with type A soils, an infiltration basin preceded by a wetpond provides stormwater treatment and flow control. Figure 3 shows the layout of the site with the permanent stormwater control facilities for this condition.

While type A soils are suitable for discharging the site runoff to ground water, they are too porous to accomplish water quality treatment. The design includes a wetpond that performs water quality treatment and serves as a presettling facility in front of the infiltration basin. The wetpond is designed to treat all runoff from the 6-month, 24-hour storm event and is divided into two separate cells. Both wetpond cells would be excavated approximately 6 feet below grade, with an additional foot of depth in the first cell for sediment storage.

The infiltration basin, which would also be excavated 6 feet below grade, was sized to completely infiltrate all runoff up to the 100-year, 24-hour storm event, even though in pre-developed conditions there would be slight runoff from the site in extreme storm events. The wetpond overflows to the infiltration basin, and the infiltration basin has an overflow structure for safe conveyance of extreme high flows.

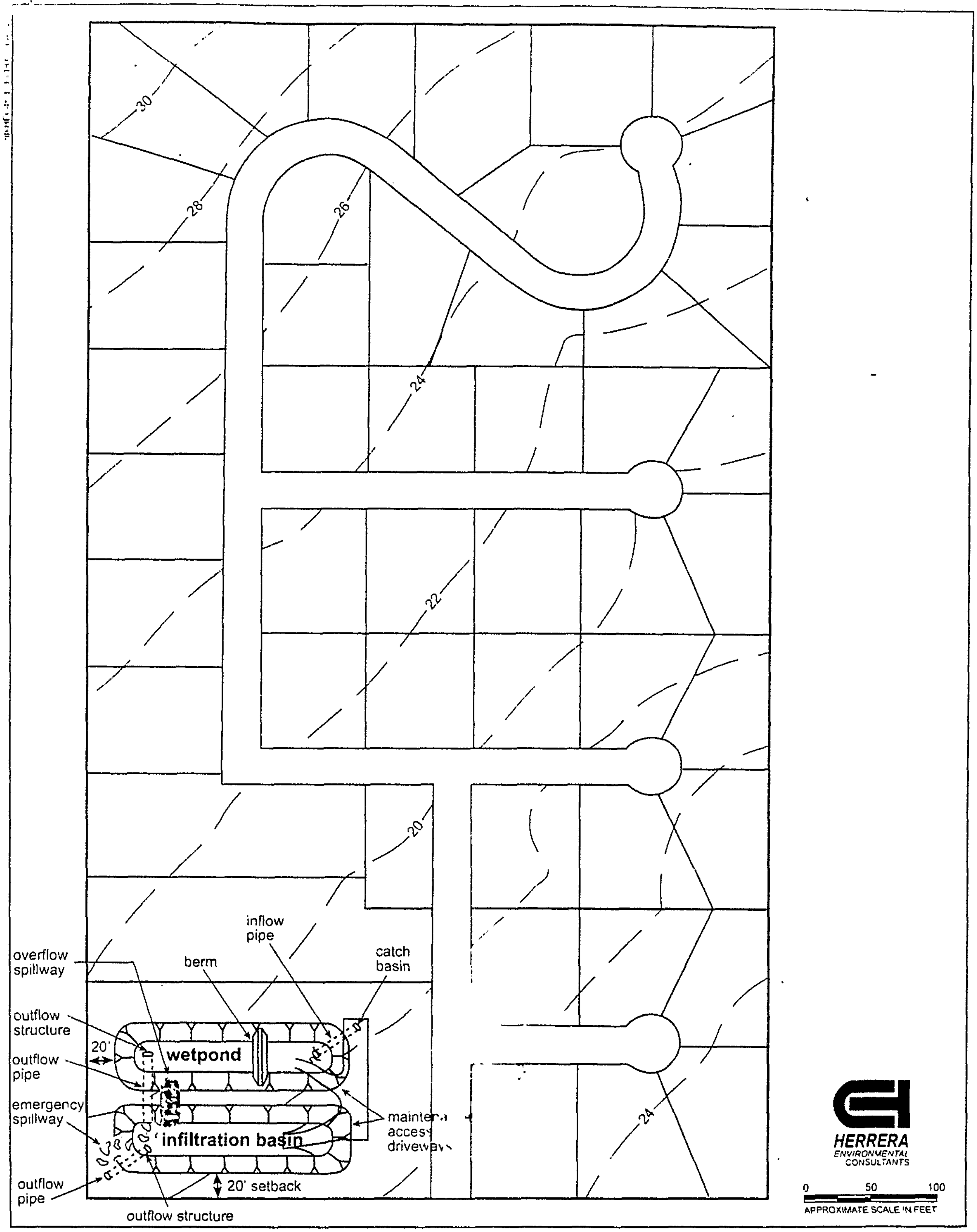

Figure 3. Permanent stormwater site plan BMPs for 10-acre residential development with infiltration.

Type C Soils– Without Infiltration

The scenario without infiltration (type C soils) contains a combined wet/detention pond with a permanent pool for water quality treatment and excess storage capacity for peak flow control. Figure 4 shows the layout of the site with the permanent stormwater control facilities for this condition. The pond does not require special design features for enhanced phosphorus removal.

The center of the pond is a permanent treatment pool with two cells separated by an earthen berm. The first cell is excavated approximately 10 feet below existing grade, and the second cell is excavated nine feet below grade. Each cell provides four feet of water depth to create a permanent pool (during the wet months) for water quality treatment. The first cell has an additional one foot of sediment storage capacity in the bottom. An additional four feet of storage space on top of the permanent pool provides detention capacity for the 100-year runoff event. The extra foot of freeboard allows for an emergency overflow spillway. The outer portion of the pond, which surrounds the permanent pool, provides detention storage. Because the detention storage volume needed is large in relation to the water quality treatment volume needed, the pond footprint area expands significantly in the upper detention zone. The pond has a multiple-orifice outflow restrictor above the permanent pool level to maintain predevelopment site discharge rates and flow durations.

The permanent BMP facilities, both with infiltration and without infiltration, are located so that they receive runoff from the entire development and maintain the natural drainage pattern of the site. The excavation for the temporary sediment pond is expanded for the permanent stormwater control facilities. A catch basin is provided at the site discharge location; it is assumed that the catch basin outflow is piped into the storm drainage system adjacent to the site.

Site 1 Implementation Costs to Satisfy the Minimum Requirements

Costs With Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plans for the scenario with infiltration is estimated at approximately $240,000, including engineering design and permitting costs, contingencies (25 percent of the total construction cost), and tax on the total cost with contingencies. The total cost for the scenario with the infiltration basin also includes the cost of performing a hydrogeologic evaluation to confirm infiltration suitability and/or determine the site-specific infiltration rate. The cost of the permanent stormwater facilities in the stormwater site plan is approximately 64 percent of the total implementation cost.

Costs Without Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plans for the scenario without infiltration is estimated at approximately $230,000. The cost of the permanent stormwater facilities in the stormwater site plan under this scenario is approximately 60 percent of the total implementation cost.

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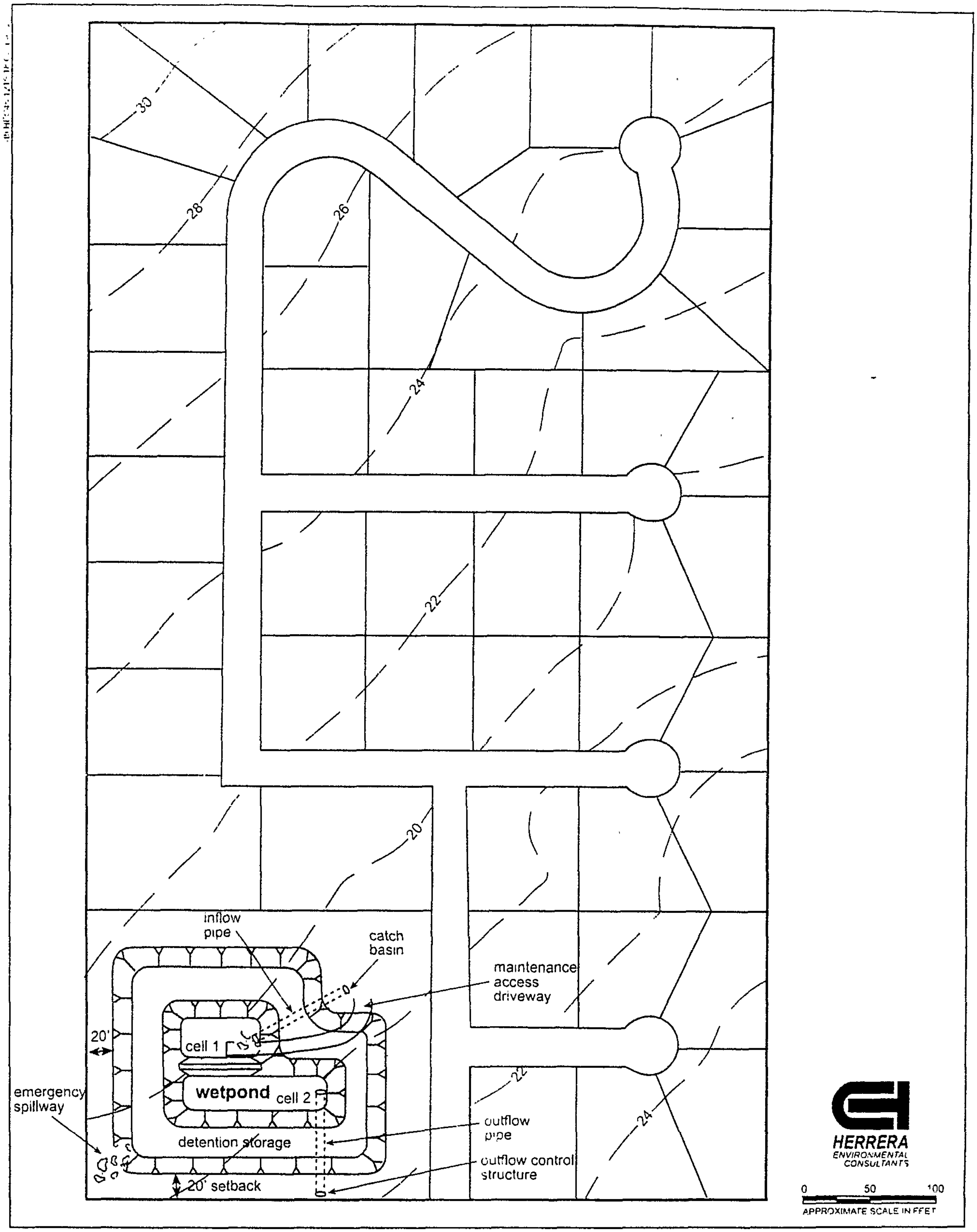

Figure 4. Permanent stormwater site plan BMPs for 10-acre residential development without infiltration.

Itemized costs for the components of the stormwater site plan are given for the two scenarios in Tables 2 and 6 of Appendix A. Appendix A also provides further details on assumptions used to estimate costs.

Comparison of Pond Storage Volumes to 1993 Estimates

For the scenario where infiltration is feasible in type A soils and a wetpond is used for treatment of the runoff prior to infiltration, both the wetpond and the infiltration basin are now smaller in comparison to the sizes under the 1992 requirements. This is due to the requirement for onsite stormwater management (roof downspout infiltration). The volume of runoff assumed to reach the wetpond and infiltration basin is significantly less in comparison to the calculations associated with the 1992 requirements. The wet/detention pond in type C soils analyzed in this case study is larger in size compared to the same type of facility analyzed for this same site scenario in the 1993 report (Herrera 1993). This is because the wetpond storage volume has increased as a result of the design criteria for the 6-month storm precipitation depth and the detention storage volume has increased considerably as a result of the requirement to match flow durations in addition to controlling peak flow rates.

The comparison of pond storage volumes in type A soils is as follows:

- 1993 analysis (re-analyzed as discussed in Appendix C) -- wetpond treatment pool volume = 23,950 cubic feet; infiltration basin storage volume = 60,900 cubic feet
- Present analysis -- wetpond treatment pool volume = 13,700 cubic feet; infiltration basin storage volume = 41,900 cubic feet;

The comparison of these storage volumes in type C soils is as follows:

- 1993 analysis -- wetpond treatment pool volume = 25,700 cubic feet; detention storage volume = 50,300 cubic feet; total pond storage volume = 76,000 cubic feet
- Present analysis -- wetpond treatment pool volume = 28,600 cubic feet; detention storage volume = 98,000 cubic feet; total pond storage volume = 127,000 cubic feet

Site 1 Operation and Maintenance Requirements and Costs

Operation and Maintenance Assumptions

Routine maintenance of the permanent stormwater facilities includes such tasks as conducting annual inspections; mowing the grass in the infiltration basin and wetpond, or combined wet/detention pond, at least twice per year; removing accumulations of debris and floating materials once per year; removing accumulated sediments in the wetpond once the sediment storage depth in the bottom is full (assumed to be once every 5 years); tilling the infiltration basin soil or otherwise re-establishing maximum infiltration capacity as needed (assumed to be once every 2 years); seeding of grassed areas that turn bare at least once per year; adding quarry spalls and/or gravel to overflow spillways and access driveways as needed; replacing miscellaneous parts and materials as needed; and cleaning out connecting pipes. In addition, streets within the development should be swept frequently to limit the amount of sediment that enters the permanent stormwater control facilities, enabling them to function more effectively. All catch basins and storm drains in the development should be cleaned frequently to prevent clogging and to remove some of the pollutants that otherwise could be flushed into the treatment and detention facilities during large storm events.

Operation and Maintenance Costs, With and Without Infiltration

The annual cost of routine maintenance procedures for the scenario with the infiltration basin and wetpond is estimated at $7,200 (see Table 3 in Appendix A). The annual maintenance cost for the scenario with a combined wet/detention pond (without infiltration) is estimated at $9,000 (see Tables 7 and 8 in Appendix A). Most of the annual operation and maintenance costs are associated with street sweeping and conveyance system cleaning rather than pond maintenance.

Further details on assumptions used to estimate operation and maintenance costs are given in Appendix A.

Site 2—Small Commercial Development

Site 2 is a 1-acre commercial development assumed to be a typical restaurant. Figure 5 shows the layout of the site as planned for development, without stormwater control facilities to satisfy the minimum requirements. The site has 90 percent impervious cover. There is one main site entrance for construction access (see Figure 6). This relatively flat site drains from the upper left to the lower right (as shown in Figure 5) in its undeveloped state, with the potential for stormwater runon from adjacent land. Because the site would not be graded extensively, after development drainage would flow in the same direction.

It is assumed that the developed site would have underground storm sewer pipes to convey runoff to the permanent stormwater control facilities. It is assumed that some mechanism is provided to divert offsite runoff around the site (such as that mentioned for the residential site), the costs of which are not included in this analysis. It is also assumed that developed site runoff that is not infiltrated is discharged to an offsite storm sewer, eventually reaching a stream.

Site 2 Construction Stormwater Pollution Prevention Plan

For all new development and redevelopment projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet, such as site 2, the manual requires preparation of a SWPPP to guide selection and implementation of a variety of BMPs during construction. The 12 minimum requirements for stormwater pollution prevention during construction are listed above for site 1. It is assumed that construction would take 2 months to complete.

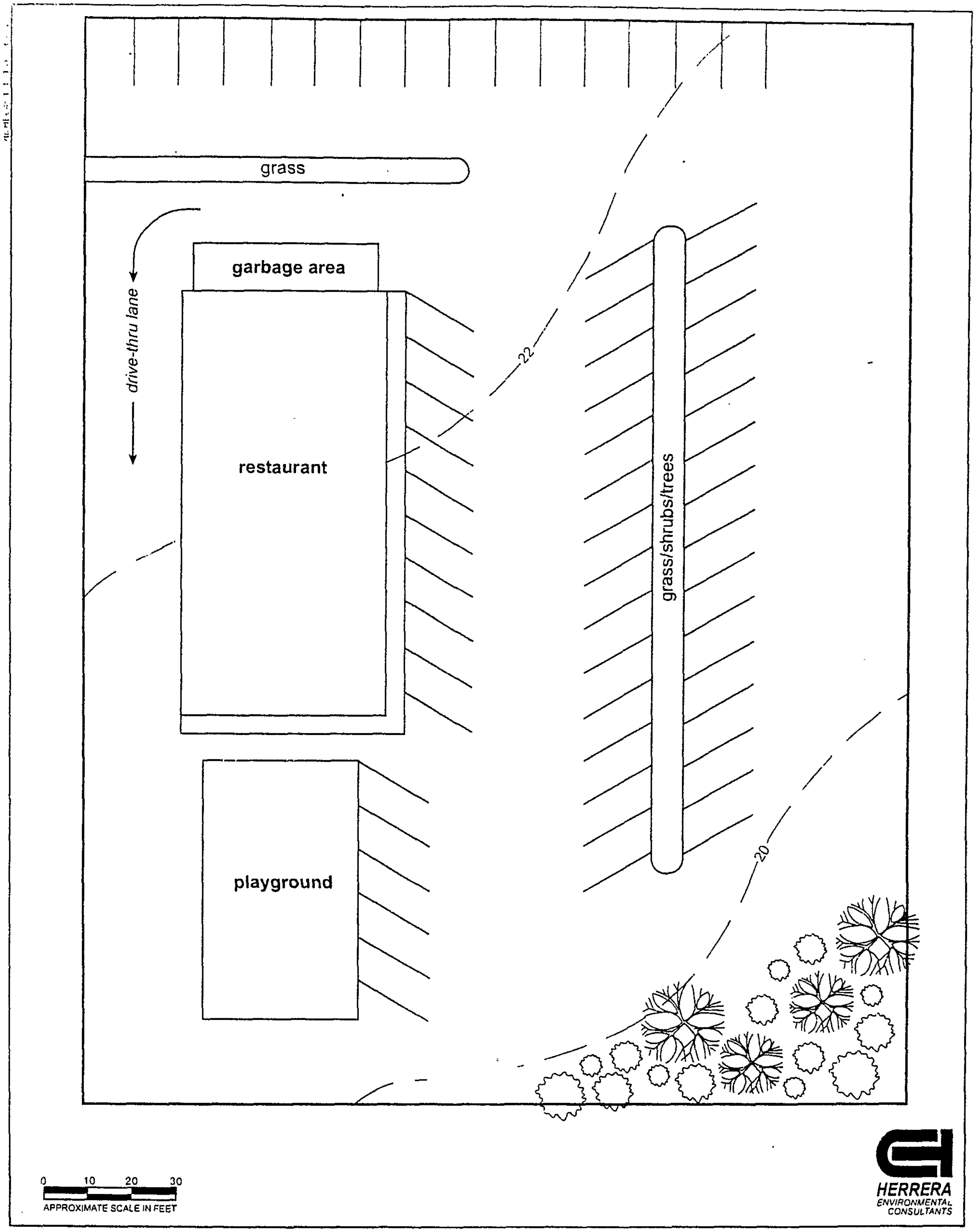

Figure 5. One-acre commerical development plan, without stormwater facilities, superimposed on natural (pre-development) topography and drainage features.

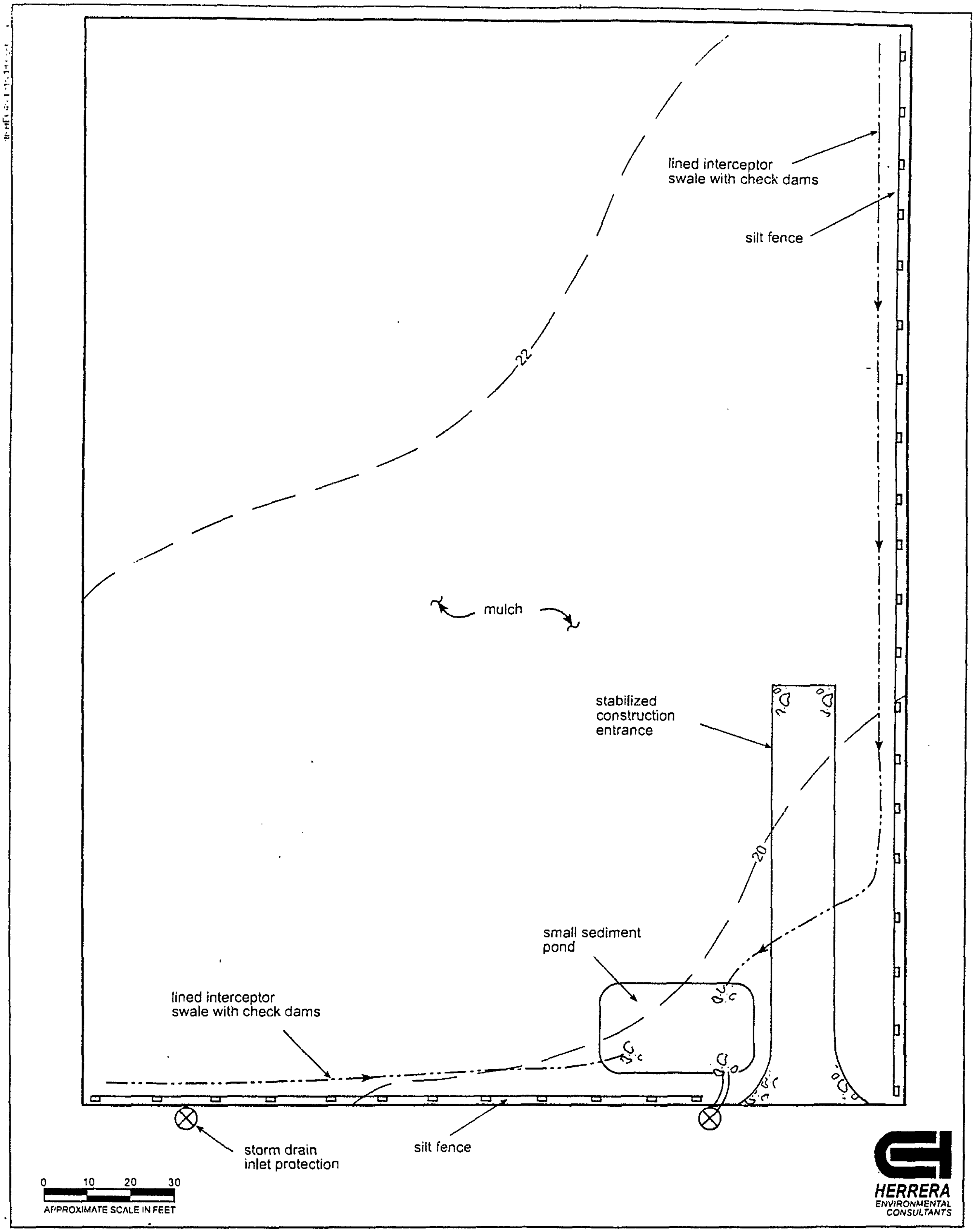

Figure 6. Erosion and sediment control BMPs for 1-acre commercial development.

Several BMPs are necessary to control site runoff and erosion during the construction phase of site 2. A combination of intercepting swales with check dams, a small sediment pond, a stabilized site entrance and equipment parking area, mulch application to bare areas, storm drain inlet protection on the adjacent street, and silt fencing on the downslope perimeter would be used to control transport of sediments off the site and to protect downstream properties and waterways during construction. These BMPs would be in place prior to construction activities to satisfy the minimum requirements.

Figure 6 shows the locations of the erosion and sediment control BMPs selected for the small commercial development site. The BMPs are almost all the same for type A soils (suitable for infiltration) and type C soils (unsuitable for infiltration). The size of the temporary sediment pond differs for the two soil types because of the effect soil type has on runoff peak flows and volumes. Figure 6 indicates the sediment pond size corresponding to type C soils, which is larger than the pond for type A soils.

It is assumed that interceptor swales for runoff collection would not be needed in type A soils. The intercepting swales along the edges of the site would be used to convey almost all of the construction site runoff to the sediment pond (in type C soils). The sediment pond would contain a silt fence divider to enhance trapping of suspended sediments. Silt fencing would be used to contain sediments on the site periphery that may be present in runoff that does not reach the interceptor swales. The site entrance would be stabilized with quarry spalls. Mulch would be applied as needed to areas of exposed soil during construction.

It is assumed that two catch basins on the adjacent street would require inlet protection. Due to the relatively short time frame for construction, it is assumed that cleaning of the catch basins on the adjacent street would not be necessary following construction, and that the small sediment pond would not require sediment cleanout prior to its removal. Other BMPs such as vehicle tire washing and spraying of dusty areas would be implemented during construction as needed.

Maintenance of the erosion and sediment control BMPs is a key component of the construction SWPPP. It is assumed that routine BMP maintenance checks would be performed once weekly and after runoff-producing storm events during the dry season, or daily during the wet season to ensure that BMPs continue to function effectively. Silt fencing must be checked periodically, especially following storms, to determine if repairs or replacement fabric sections are needed. Mulch used to cover stripped site areas would be relocated and replaced as needed, as portions of the site are permanently stabilized. If sediment is tracked offsite onto neighboring streets, it must be swept and collected as necessary.

Costs for Construction Stormwater Pollution Prevention Plan

The construction cost for these SWPPP BMPs is estimated at approximately $6,900 for type A soils and $8,600 for type C soils. Tables 9 and 12 in Appendix A show itemized costs for the various BMP components and their associated construction procedures and materials. These costs do not include engineering planning and design fees, permit fees, performance bonding (or other appropriate financial instruments to ensure compliance with the approved SWPPP), and contingencies for unforeseen difficulties. Maintenance of the erosion and sediment control BMPs over the course of the 2-month construction period (included in the SWPPP BMP costs noted above) is estimated to cost approximately $1,300 for type A soils and $1,900 for type C soils (see Tables 11 and 14 in Appendix A, respectively). Appendix A provides further details on assumptions used to develop these costs.

Site 2 Permanent Stormwater Site Plan

The stormwater site plan must include provisions for maintaining natural drainage patterns, using source control BMPs to prevent pollutants from entering stormwater runoff, reducing hydrologic changes through onsite stormwater management techniques, treating runoff from smaller storm events, detaining runoff from larger storm events to prevent stream bank erosion due to high flows, and maintaining the BMPs that are chosen and implemented. Minimum requirement eight, pertaining to wetlands and minimum requirement nine, pertaining to basin planning are assumed to be not applicable to this hypothetical site and this analysis.

In accordance with the manual, two preliminary considerations guided BMP selection for site 2. Oil control is assumed to be required for this site due to high vehicle turnover rates that meet the high use site definition. Phosphorous control is not required. The standard western Washington peak flow control to match pre-development flow peaks and durations is required because the site discharge is conveyed to a small stream (if site discharge is conveyed directly to a major water body, the standard does not apply).

Pollution Source Control BMPs

Pollution source control BMPs are important components of the stormwater site plan for site 2 to satisfy minimum requirement three. Several of the source control BMPs outlined in the manual are applicable to this development. The area designated for garbage containers adjacent to the restaurant should be covered or contained to prevent precipitation from contacting waste containers and to prevent the runoff from entering the nearby storm drainage system. The interior of this area must drain to the sanitary sewer if possible (BMP S1.50). Other materials and wastes that may introduce pollutants to stormwater should also be placed in the protected area. Cooking equipment such as vents and filters must not be cleaned outdoors unless a sanitary sewer drain is provided. In addition, storm drainage facilities must be maintained (BMP S2.00), and the parking lot should be swept frequently to collect and properly dispose of accumulated sediments and other materials that may contain pollutants (BMP S1.22).

Onsite Stormwater Management Measures

In addition to pollution source control BMPs, onsite stormwater management measures must also be implemented to infiltrate, disperse, and retain stormwater runoff onsite where practicable (minimum requirement five). Some examples of onsite stormwater management BMPs applicable to this commercial development include roof downspout infiltration, use of permeable/porous pavements in low traffic areas, and vegetated rooftops. For this site, the use of "typical" roof downspout infiltration trenches (with inlet catch basins and perforated pipe) was assumed with infiltratable soils on site (type A). The simpler ("alternative") infiltration trench design that is allowed in coarse soils, as assumed for Site 1, would require a wide strip of grass between the building and the trenches, and this type of site would not likely have available space for such a grass strip. Permanent stormwater facilities were sized, and the associated cost estimate developed, with roof downspout infiltration included.

For the scenario with type C soils, it was assumed that roof downspout dispersion systems would not be feasible due to limited area of grass or other open space. The sizing of permanent stormwater treatment and flow control facilities accounted for all rooftop runoff because it was assumed that this runoff would reach the stormwater control vaults quickly. Although it was assumed that porous pavements could be used for low traffic areas of the site, the sizing of the permanent stormwater treatment and flow control facilities conservatively assumed that all driveway and parking lot runoff would reach the vaults quickly.

Permanent Stormwater Control Facilities by Soil Type

The permanent stormwater control facilities selected for the small commercial development site to satisfy the minimum requirements are dependent on soil type. Regardless of soil type, it is assumed that the stormwater facilities would be placed underground to maximize surface area for vehicle parking. This is a departure from the assumption in the 1993 cost analysis report (Herrera 1993) that all stormwater management facilities would be placed above ground, regardless of the implications for available parking area, and results in significant cost differences. The oil control requirement also applies regardless of soil type. It is assumed that catch basin filter inserts would be used for this oil control.

Type A Soils – With Infiltration

Infiltration is the preferred method of stormwater treatment and flow control, but infiltration requires suitable soils. For the scenario with type A soils (suitable for infiltration), underground infiltration tanks preceded by a wet vault provides stormwater treatment and flow disposal. Figure 7 shows the layout of the site with the permanent stormwater control facilities for this condition. For cost estimating purposes, it was assumed that two sections of 8-foot diameter asphalt-treated steel pipe would be used to construct the wet vault, and that 5-foot diameter aluminized steel pipe with perforations would be used for the infiltration tanks. These structures would support traffic loads from above provided there is approximately 2 feet of cover beneath the parking lot pavement. The infiltration tanks and associated inflow piping are assumed to store and dispose of all runoff up to the 100-year event even though slight flows occur in the pre-development condition. Steel pipe was assumed for this analysis as a cost saving measure. In many cases concrete vaults may be necessary, and that would lead to increased costs.

Type A soils are not suitable for water quality treatment via infiltration; therefore, a wet vault (discussed below) provides pretreatment for ground water protection. The wet vault also provides protection for the infiltration system by significantly reducing the sediment loading that could potentially clog the infiltration media. With infiltration of all runoff, enhanced treatment is

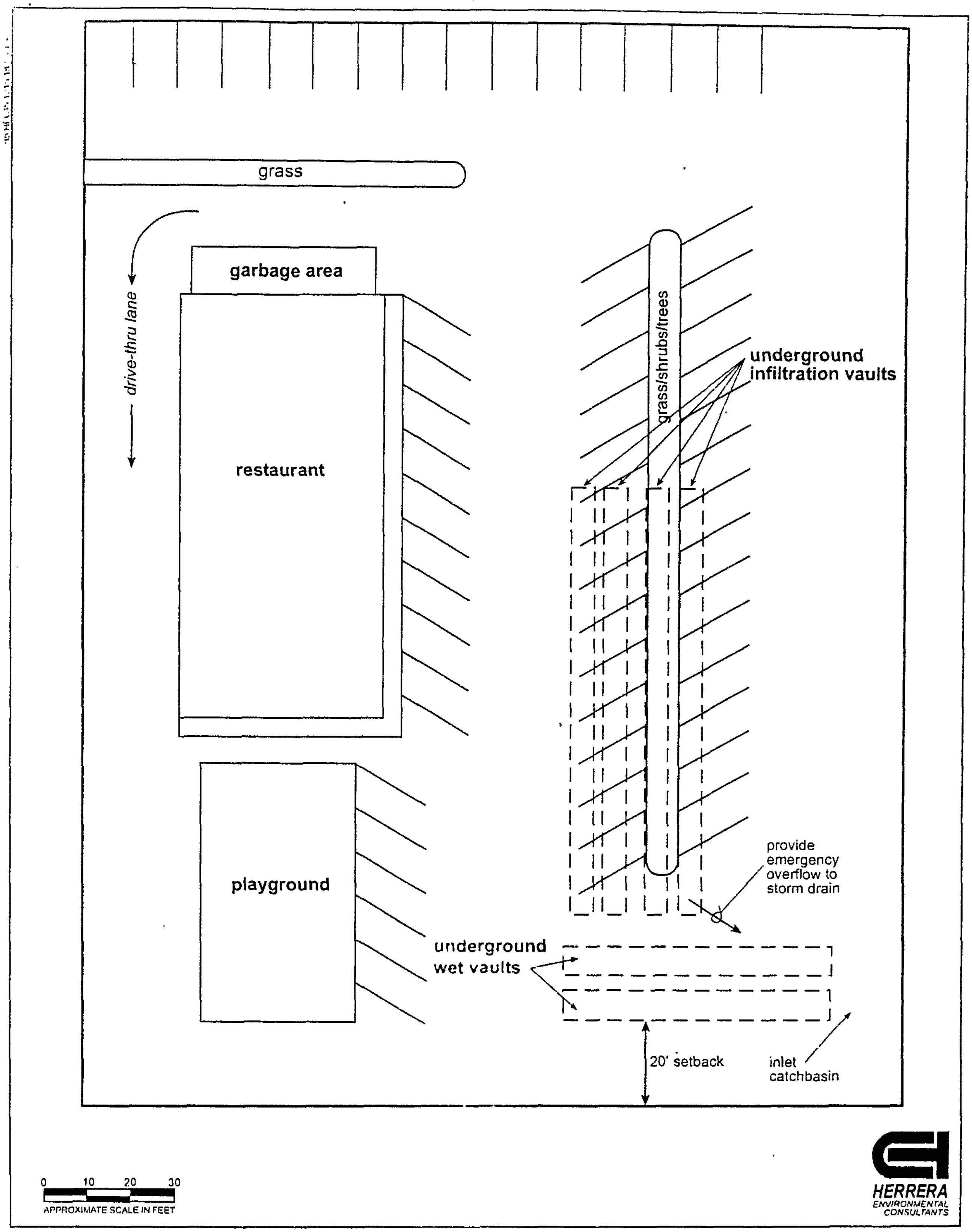

Figure 7. Permanent stormwater quality control BMPs for 1-acre commercial development with infiltration.

not required. It is assumed that downspout infiltration trenches (shown conceptually on Figure 7) would be provided in this scenario. Therefore, the rooftop runoff does not reach the wet vault or infiltration vaults and their sizes are reduced accordingly (by approximately 20 percent).

The wet vault is sized with a treatment pool volume equivalent to the site runoff volume (excluding rooftop area) of the 6-month, 24-hour storm event. This vault overflows to the buried infiltration tanks. Under extreme storm conditions (but less than the 100-year event), flows can back up through the infiltration tanks and wet vault and can be stored in the conveyance piping. The depth of the wet vault treatment pool is assumed to be 6 feet (with 1 foot of sediment storage on the bottom and 1 foot of freeboard on top), and the maximum depth of ponding inside the infiltration tanks is assumed to be 3 feet.

Type C Soils – Without Infiltration

For the scenario without infiltration, a wet vault with a permanent pool performs water quality treatment and adjacent detention pipes provide storage capacity for flow control. An additional sand filter vault provides the enhanced treatment required with a surface discharge to fish-bearing waters. Figure 8 shows the layout of the site with a wet vault, detention pipes, and separate sand filter vault in place. The treatment pool in the wet vault and the sand filter constitute a two-facility treatment train to perform the enhanced water treatment that is required. The wet vault does not require special design features for phosphorus removal. Because the detention storage volume needed is relatively large in comparison to the treatment volume, it is assumed that separate pipes of different diameter provide a detention function only. It is assumed that the wet vault would be built with 8-foot diameter asphalt-treated steel pipe and that the detention storage would be provided by four sections of 5-foot diameter aluminized steel pipe and a connecting manifold system. The detention pipes are of smaller diameter because the bottom elevation of the detention storage is set above the adjacent sand filter bed elevation, and a deeper detention storage outlet would result in a deeper sand filter vault. If the sand filter vault were excessively deep it would probably not be able to drain into the nearby storm sewer system. The detention pipe system is connected to a catch basin with a multiple-orifice outflow restrictor to maintain predevelopment site discharge rates and flow durations. The outlet control structure discharges to the sand filter vault. The sand filter is assumed to be housed in a concrete vault structure comprised of precast sections 20 feet in width and laid parallel, with pipes connecting the parallel vault sections. The sand filter bed is sized to treat the peak 2-year storm flow discharged from the detention system, with a perforated pipe underdrain system to collect treated flows, and flows above the 2-year detained peak would be discharged directly to the nearby storm sewer system via an overflow pipe.

By placing the stormwater management facilities in underground pipes, significantly more parking spaces are available in comparison to the design assumed in the comparable 1993 case study (Herrera 1993). If the facilities were placed above ground there would be insufficient parking area available to justify the development.

The permanent BMP facilities, both with infiltration and without infiltration, are located so that they receive runoff from the entire site and maintain the natural drainage pattern of the site. The

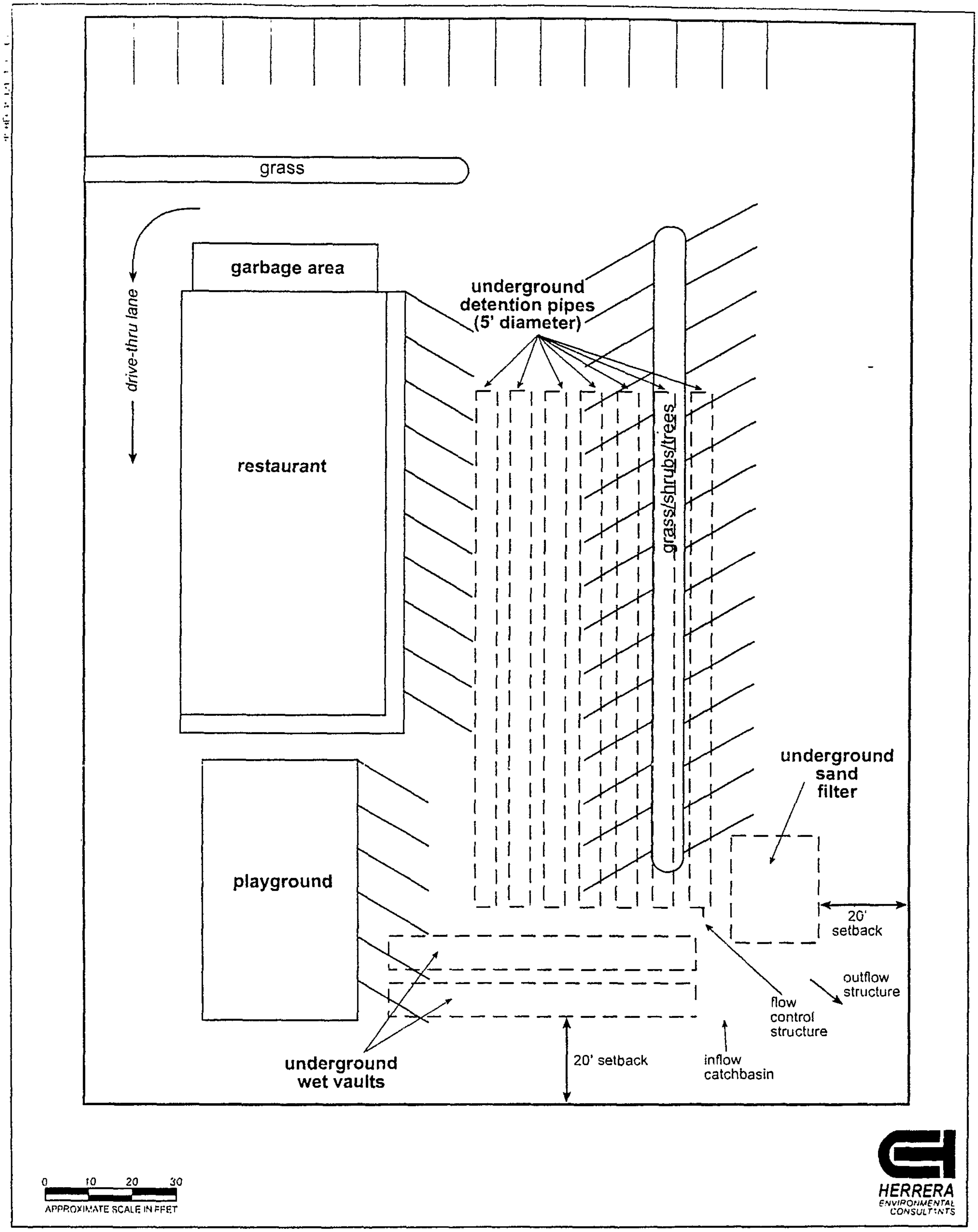

Figure 8. Permanent stormwater quality control BMPs for 1-acre commercial development without infiltration.

excavation site for the temporary sediment pond is partially used for burial of the permanent stormwater control vaults. Emergency overflow facilities are provided for each of the underground vaults. A catch basin is provided at the site discharge location; it is assumed that the catch basin outflow is piped into the storm sewer system adjacent to the site.

Site 2 Implementation Costs to Satisfy the Minimum Requirements

Costs With Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plans for the scenario with infiltration is estimated at approximately $280,000, including taxes and contingencies for unforeseen difficulties. The total cost for the scenario with the infiltration vaults also includes the cost of performing a hydrogeologic evaluation to confirm infiltration suitability and/or determine the site-specific infiltration rate. The cost of the permanent facilities in the stormwater site plan is approximately 95 percent of the total implementation cost.

Costs Without Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plans for the scenario without infiltration is estimated at approximately $570,000. The cost of the permanent stormwater facilities in the stormwater site plan under this scenario is approximately 97 percent of the total implementation cost.

Itemized costs for the components of the stormwater site plan are given for the two scenarios in Tables 10 and 13 of Appendix A. Appendix A also provides further details on assumptions used to estimate costs.

Comparison of Treatment and Detention Storage Volumes to 1993 Estimates

For the scenario where infiltration is feasible in type A soils and a wet vault is used for treatment of the runoff prior to infiltration, the storage volumes in both the wet vault and the infiltration tanks are now smaller in comparison to the sizes under the 1992 requirements. This is due to the requirement for onsite stormwater management (roof downspout infiltration). The volume of runoff assumed to reach the wet vault and infiltration tanks is significantly less in comparison to the calculations associated with the 1992 requirements. The storage volumes in the wet vault and detention pipes in type C soils analyzed in this case study are larger in size compared to the volumes estimated for this same site scenario in the 1993 report (Herrera 1993). This is because the wetpool storage volume has increased as a result of the design criteria for the 6-month storm precipitation depth and the detention storage volume has increased considerably as a result of the requirement to match flow durations in addition to controlling peak flow rates.

The comparison of these storage volumes in type A soils is as follows:

- 1993 analysis (re-analyzed as discussed in Appendix C) – wet vault treatment pool volume = 3,590 cubic feet: infiltration tank storage volume = 9,000 cubic feet

- Present analysis – wet vault treatment pool volume = 3,270 cubic feet; infiltration tank storage volume = 4,780 cubic feet

The comparison of these storage volumes in type C soils is as follows:

- 1993 analysis -- wetpond treatment pool volume = 3,660 cubic feet; detention storage volume = 7,200 cubic feet; total storage volume = 10,800 cubic feet

- Present analysis – wet vault treatment pool volume = 4,150 cubic feet; detention storage volume = 16,300 cubic feet; total storage volume = 20,500 cubic feet

The combination of greater storage volumes, the need for a sand filter to provide enhanced treatment, and placement of the facilities underground results in much greater stormwater management costs in the present analysis compared to the 1993 analysis.

Site 2 Operation and Maintenance Requirements and Costs

Operation and Maintenance Assumptions

Routine maintenance of the permanent stormwater facilities includes such tasks as annual inspections; frequent replacement of the catch basin inserts (assumed to be four times per year for each of four catch basins in the parking lot); tilling the bottom of the infiltration vaults periodically to restore maximum infiltration capacity (assumed to be once every two years); raking the sand filtration surface once the depth of accumulated silt and debris on the surface exceeds ¼ inch (assumed to be once every two years); removing accumulated sediments in the wet vault when the depth exceeds the sediment storage depth (assumed to be once every five years); replacing miscellaneous parts and materials as needed; and cleaning out connecting pipes. In addition, the parking lot should be swept frequently to limit the amount of sediments that enter the permanent stormwater control facilities, enabling them to function more effectively.

Operation and Maintenance Costs, With and Without Infiltration

The annual cost of routine operation and maintenance procedures for the scenario with the wet vault and infiltration tanks is estimated at approximately $4,000. The annual operation and maintenance cost for the scenario with a wet vault, detention pipes, and sand filter vault (without infiltration) is also estimated at approximately $4,000.

Further details on assumptions used to estimate maintenance costs are given in Appendix A. Tables 11 and 14 of Appendix A provide itemized costs of the individual maintenance tasks for each of the scenarios.

Site 3—Large Commercial Development

Site 3 is a 10-acre commercial development consisting of a retail shopping center and parking lot. Figure 9 shows the layout of the site as planned for development, without stormwater control facilities to satisfy the minimum requirements. The site has 85 percent impervious cover. The topography of this site in its undeveloped condition causes drainage to flow from the upper left to the lower right (as shown in Figure 9); there are several defined drainage courses that are not classified as streams or sensitive areas. This site would be graded extensively to construct the large building and parking lot. Stormwater runon and through-flow in the drainage courses would occur unless diversions are provided. It is assumed that the site would be ringed with diversion trenches on the upslope sides to convey runon and through-flow around the site to the downstream conveyance system.

The costs of providing diversion trenches and constructing retaining walls or similarly effective slope stabilization measures near the site border are not included in this analysis because their necessity is an arbitrary result of the hypothetical site layout.

Site 3 Construction Stormwater Pollution Prevention Plan

For all new development and redevelopment projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet, such as site 3, the manual requires preparation of a SWPPP to guide selection and implementation of a variety of BMPs during construction. The 12 minimum requirements for stormwater pollution prevention during construction are listed above for site 1. It is assumed that construction would take one year to complete, and that clearing and grading activities would continue through the wet season.

Several BMPs are necessary to control site runoff and erosion during the construction phase. A combination of intercepting swales, a temporary sediment pond, a stabilized construction entrance and equipment parking areas, mulch application to bare areas, stabilization of disturbed slopes, storm drain inlet protection on surrounding streets, and silt fencing would be used to control transport of sediments off the site and protect downstream properties and waterways during construction. Figure 10 shows the locations of the erosion and sediment control BMPs selected for the large commercial development site. It is assumed that the large commercial building would also require excavation that results in a relatively steep slope, where erosion control blankets are needed for soil stabilization. These BMPs would be in place prior to construction activities to satisfy the minimum requirements.

The BMPs are almost all the same for type A soils (suitable for infiltration) and type C soils (unsuitable for infiltration). The differences assumed for BMP applications with type A soils include reduced size of the temporary sediment pond, reduced extent of street sweeping, reduced

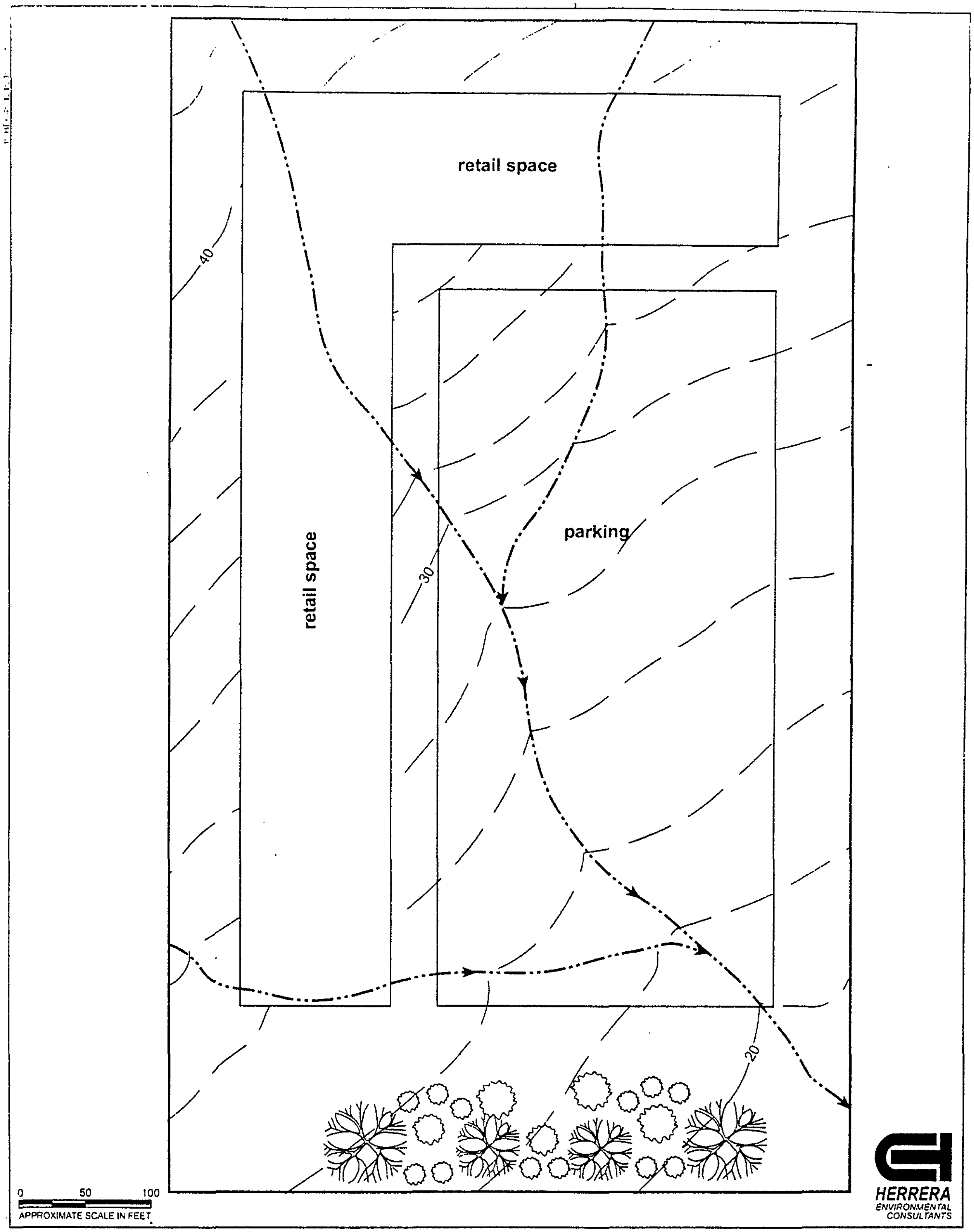

Figure 9. **Ten-acre commercial development plan, without stormwater facilities, superimposed on natural (pre-development) topography and drainage features.**

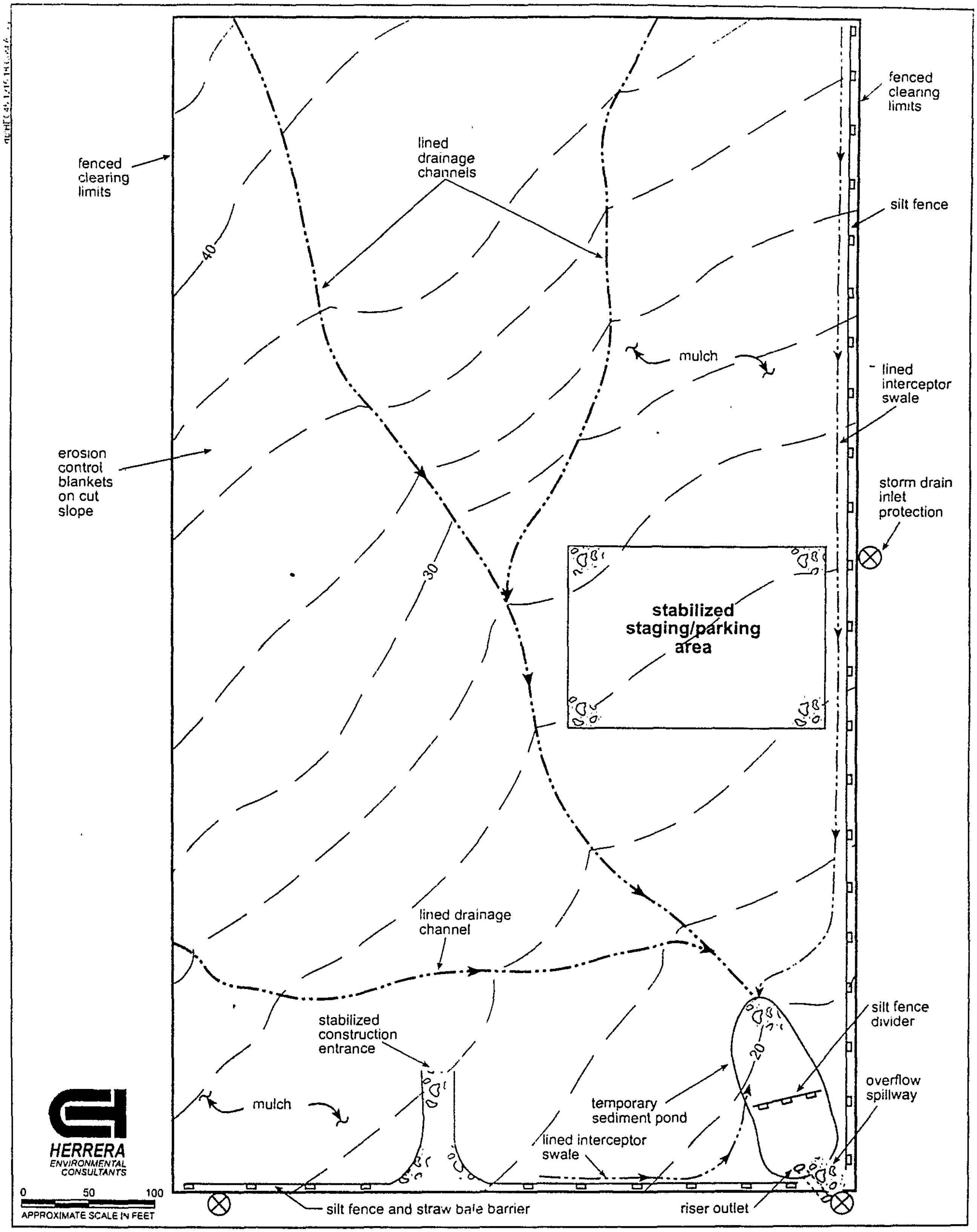

Figure 10. Erosion and sediment control BMPs for 10-acre commercial development.

extent of offsite catch basin cleaning, and elimination of a straw bale barrier along the lower left corner of the site as shown on Figure 10. Therefore, the cost estimate for the construction SWPPP associated with type A soils reflects slightly reduced BMP applications.

The intercepting swales would be used to convey site runoff to the sediment pond. These swales would be lined with suitable geotextiles or organic blankets, or stabilized with seed and mulch, to prevent erosion within the swale. Silt fencing would be used on downslope edges of the site boundary to prevent sediment discharge.

The manual specifies that sediment ponds be designed based on the 2-year, 24-hour storm peak runoff flow rate. The sediment pond size indicated on figure 10 is based on the 2-year peak runoff flow from the developed site with till soils (i.e., the larger sediment pond scenario for type C soils). Silt fencing would be used as a divider within the temporary sediment pond to enhance the removal of suspended sediments. The site entrance would be stabilized with quarry spalls, and all construction roads on the site and one main parking area would be stabilized with crushed rock. Mulch would be applied extensively to areas of exposed soil during staged construction. Silt fencing would be used to contain sediments on the site periphery that may be present in runoff that does not reach the interceptor swales. It is assumed that three catch basins on the adjacent street would require inlet protection. Other BMPs such as vehicle tire washing and spraying of dusty areas would be implemented during construction as needed.

Maintenance of the erosion and sediment control BMPs is a key component of the construction SWPPP. It is assumed that routine BMP maintenance checks would be performed once weekly and after runoff-producing storm events during the dry season, and daily during the wet season to ensure that BMPs continue to function effectively. Excess sediment accumulation must be removed from the pond and disposed of off the site or spread in a controlled location on the site. Silt fencing must be checked periodically, especially following storms, to determine if repairs or replacement fabric sections are needed. Mulch used to cover stripped site areas would be relocated and replaced as needed, as portions of the site are permanently stabilized. If sediment is tracked offsite onto neighboring streets, it must be swept and collected as necessary.

Costs for Construction Stormwater Pollution Prevention Plan

The construction cost for these SWPPP BMPs is estimated at approximately $54,000 for type A soils and $63,000 for type C soils. Tables 15 and 18 in Appendix A show itemized costs for the various BMP components and their associated construction procedures and materials. These costs do not include engineering planning and design fees, permit fees, performance bonding (or other appropriate financial instruments to ensure compliance with the approved SWPPP), and contingencies for unforeseen difficulties. Maintenance of the erosion control BMPs over the course of the 1-year construction period (included in the SWPPP BMP costs noted above) is estimated to cost approximately $10,000 for type A soils and $16,000 for type C soils (see Tables 17 and 21 in Appendix A, respectively). Appendix A provides further details on assumptions used to develop these costs.

Site 3 Permanent Stormwater Site Plan

The stormwater site plan must include provisions for maintaining natural drainage patterns, using source control BMPs to prevent pollutants from entering stormwater runoff, reducing hydrologic changes through onsite stormwater management techniques, treating runoff from smaller storm events, detaining runoff from larger storm events to prevent stream bank erosion due to high flows, and maintaining the BMPs that are chosen and implemented. Minimum requirement eight, pertaining to wetlands and minimum requirement nine, pertaining to basin planning, are assumed not to be applicable to this hypothetical site and this analysis.

In accordance with the manual, two preliminary considerations guided BMP selection for site 3. Oil control and special phosphorus control measures are not required for this site. The oil control requirement is assumed not applicable due to the traffic volume falling below the high use threshold. The standard western Washington peak flow control to match pre-development peak flow rates and durations is required because the site discharge is conveyed to a small stream (if site discharge is conveyed directly to a major water body, the standard does not apply).

Pollution Source Control BMPs

Pollution source control BMPs are important components of the stormwater site plan for this site to satisfy minimum requirement three. Several of the source control BMPs outlined in the manual are applicable to this development. The areas designated for garbage containers adjacent to the building should be covered or contained to prevent precipitation from contacting waste containers and to prevent the runoff from entering the nearby storm drainage system. The interior of this area must drain to the sanitary sewer if possible (BMP S1.50). Other materials and wastes that may introduce pollutants to stormwater should also be placed in the protected area. Cooking equipment such as vents and filters must not be cleaned outdoors unless a sanitary sewer drain is provided. In addition, storm drainage facilities must be maintained (BMP S2.00), and the parking lot should be swept frequently to collect and properly dispose of accumulated sediments and other materials that may contain pollutants (BMP S1.22).

Onsite Stormwater Management Measures

In addition to pollution source control BMPs, onsite stormwater management measures must also be implemented to infiltrate, disperse, and retain stormwater runoff onsite where practicable (minimum requirement five). Some examples of onsite stormwater management BMPs applicable to this commercial development include roof downspout infiltration, use of permeable/porous pavements in low traffic areas, and vegetated rooftops. For this site, the use of "typical" roof downspout infiltration trenches was assumed with infiltratable soils on site (type A). As with Site 2, the "alternative" infiltration design that is allowable in coarse soils was not assumed for this site because it is not likely that a grass strip would be provided between the building and the infiltration trenches in this type of development. Permanent stormwater facilities were sized, and the associated cost estimate developed, with roof downspout infiltration included. The contributing drainage area for the wetpond and infiltration basin is considerably reduced as a result (by approximately 25 percent).

For the scenario with type C soils, it was assumed that roof downspout dispersion systems would not be provided due to insufficient area for grass or other open space. The sizing of permanent stormwater treatment and flow control facilities accounted for all rooftop runoff because it was assumed that this runoff would reach the stormwater management pond quickly. Although it was assumed that porous pavements could be used for low traffic areas of the site, the sizing of the permanent stormwater treatment and flow control facilities conservatively assumed that all driveway and parking lot runoff would reach the pond quickly.

Permanent Stormwater Control Facilities by Soil Type

The permanent stormwater control facilities selected for the large commercial development site to satisfy the minimum requirements are dependent on soil type.

Type A Soils – With Infiltration

Infiltration is the preferred method of stormwater treatment and flow control, but infiltration requires suitable soils. For the scenario with type A soils, an infiltration basin preceded by a wetpond provides stormwater treatment. Figure 11 shows the layout of the site with the permanent stormwater control facilities for this condition. The infiltration basin would dispose of most runoff flows, but would have sufficient live storage capacity to detain and slowly release high flows to the nearby storm drainage system in this situation. Type A soils are suitable for infiltration disposal of runoff but are too porous to enable effective treatment of large volumes of water cost-effectively. Therefore, a wetpond (or other comparable treatment facility) is needed for pretreatment. The wetpond can also serve as a presettling facility to protect the infiltration soil surface from clogging.

The wetpond is designed to treat all runoff from the 6-month, 24-hour storm event and is divided into two separate cells. Both wetpond cells would be excavated approximately 4 feet deep, with an additional foot of depth in the first cell for sediment storage. The wetpond would overflow to the infiltration basin via a spillway. The infiltration basin would be excavated 4 feet below grade and is large enough to enable infiltration of most flow up to the 100-year event. An outlet control structure in the infiltration basin would enable limited flow to discharge to the nearby storm sewer system in extreme events, matching pre-developed site discharge rates and flow durations (the pre-developed site peak flows and volumes are very small in type A soils).

Type C Soils – Without Infiltration

For the scenario without infiltration, a combined wet detention pond with a permanent pool provides water quality treatment and excess storage capacity for peak flow control, and a sand filter provides enhanced treatment. Two options were evaluated for this sand filter. One option considered placement of the sand filter in an underground concrete vault. It was assumed that relatively frequent maintenance access requirements for the sand filter would lead to selection of a rectangular concrete vault structure as opposed to a large diameter pipe structure with less head room in the interior. The other option considered placement of the sand filter bed in an open-air configuration with steep (1H:1V) side slopes surrounded by safety fencing. A maintenance access roadway to the bottom of the sand filter bed would be required with this option. The

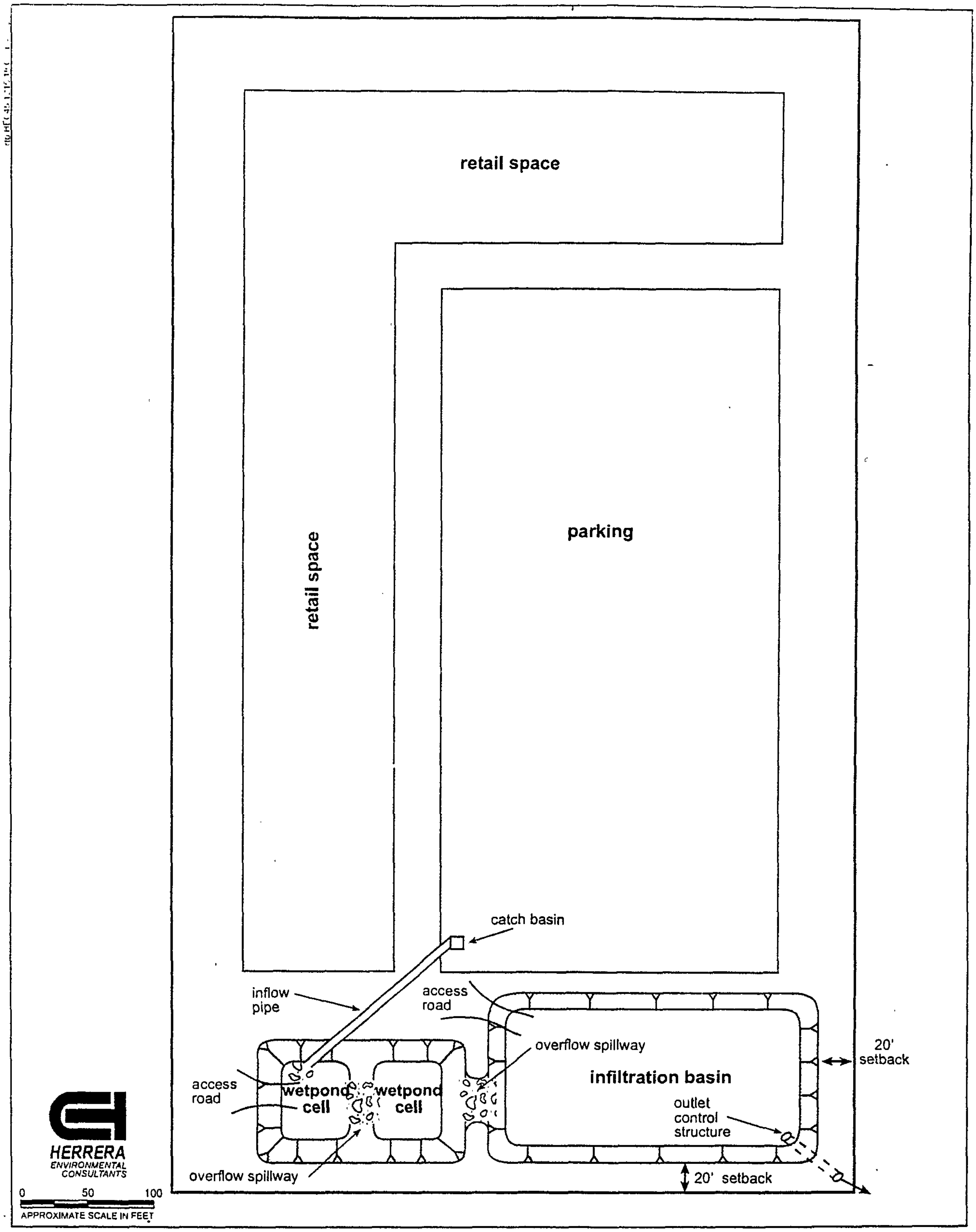

Figure 11. Permanent stormwater quality control BMPs for 10-acre commercial development with infiltration.

open-air configuration would reduce costs but would consume parking or roadway areas that may be valuable for the developer. Figure 12 shows the layout of the site with a combined wet/detention pond and the underground sand filter vault option. The treatment pool in the wet/detention pond and the subsequent sand filter constitute a two facility treatment train to perform the enhanced treatment that is required. The wetpond does not require special design features for enhanced phosphorus removal.

The wetpond has two cells separated by an earthen berm. The first cell is excavated approximately nine feet below existing grade, and the second cell is excavated eight feet below grade. Each cell provides four feet of water depth to create a permanent pool (during the wet months) for water quality treatment. The first cell has an additional foot of sediment storage capacity in the bottom. An additional 4 feet of storage space on top of the permanent pool provides detention capacity for the 100-year runoff event, including one foot of freeboard. This extra foot of storage allows for an emergency overflow spillway.

Because the detention storage volume needed is large in relation to the water quality treatment volume needed, the pond footprint area expands significantly in the upper detention zone. The pond has a multiple-orifice outflow restrictor above the permanent (treatment) pool level to maintain predevelopment site discharge rates. The detention outflow control structure directs flows into the sand filter. The bottom of the sand filter bed, whether in a vault or in an open-air configuration, is set approximately 8 feet below ground surface. The sand filter bed area was sized to treat the peak 2-year storm flow discharged from the detention outlet control structure, with a perforated pipe underdrain system to collect treated flows, and flows above the 2-year detained peak would be discharged directly to the nearby storm sewer system via an overflow pipe.

The permanent BMP facilities, both with infiltration and without infiltration, are located so that they receive runoff from the entire development and maintain the natural drainage pattern of the site. The excavation for the temporary sediment pond is expanded for the permanent stormwater control facilities. A catch basin is provided at the site discharge location; it is assumed that the catch basin outflow is piped into the storm drainage system adjacent to the site.

Site 3 Implementation Costs to Satisfy the Minimum Requirements

Costs With Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plan for the scenario with infiltration is estimated at approximately $320,000, including taxes and contingencies (see Table 16 in Appendix A). This total cost is higher than the cost estimated for the comparable 10-acre residential site. The size and cost of the wetpond and infiltration basin on site 3 would be significantly greater due to the greater amount of runoff generated on more impervious surfaces within the 10-acre development. The total cost for the scenario with the infiltration basin also includes the cost of performing a hydrogeologic evaluation to confirm infiltration suitability and/or determine the site-specific infiltration rate. The cost of the permanent stormwater facilities in the stormwater site plan is approximately 68 percent of the total implementation cost.

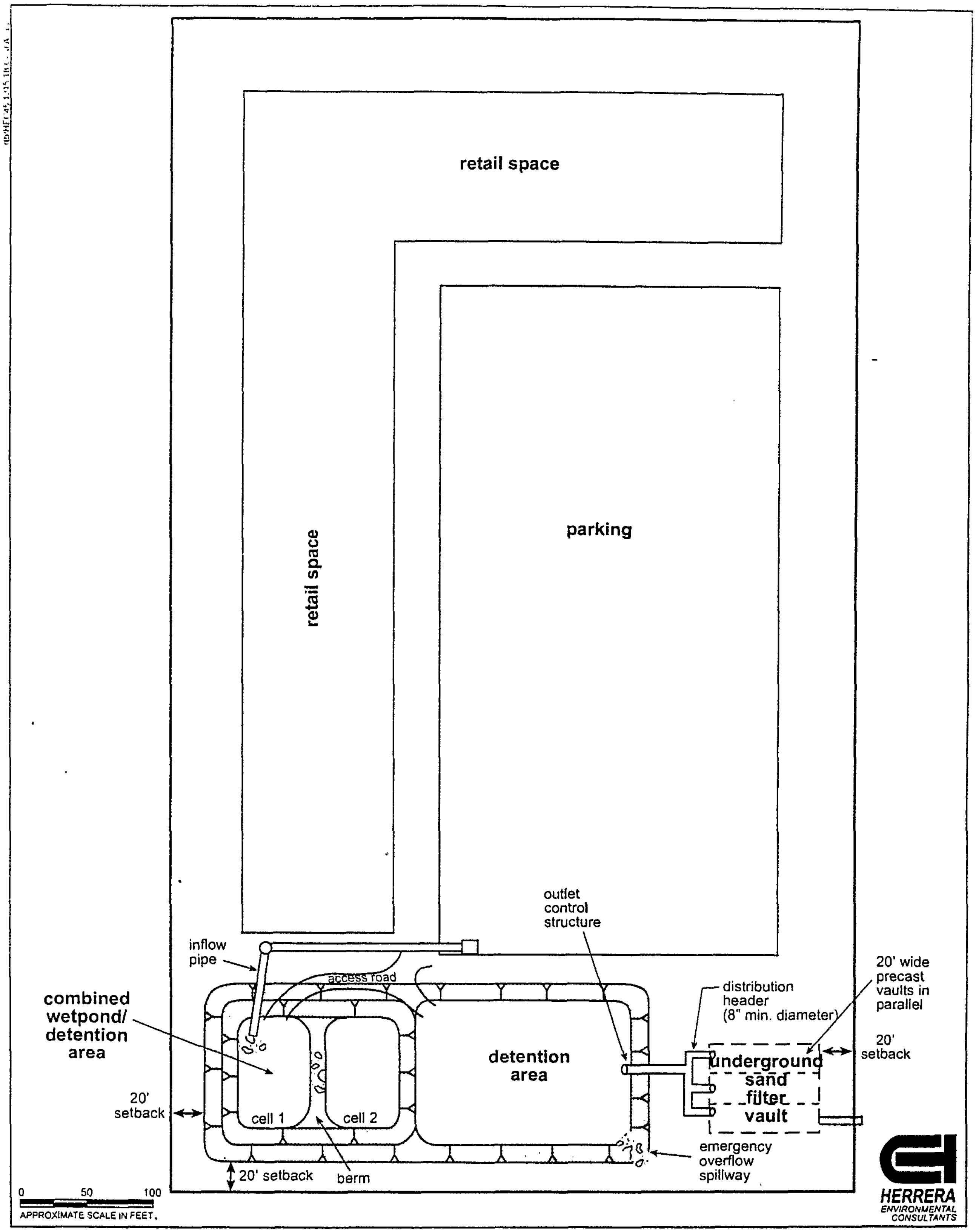

Figure 12. **Permanent stormwater quality control BMPs for 10-acre commercial development without infiltration.**

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Costs Without Infiltration

The total cost of planning, designing, and constructing the BMPs in the construction SWPPP and permanent stormwater site plan for the scenario without infiltration and with the underground sand filter vault option is estimated at approximately $860,000. The cost for this scenario is high because of the large size of the sand filter vault, and the assumed use of precast concrete to create the sand filter vault. If large diameter pipe or other creative means were used to construct the underground sand filter, the cost could be reduced considerably. The cost of this same scenario with the open-air sand filter option is estimated at approximately $490,000. While the open-air sand filter would reduce costs by $370,000 compared to placement of the sand filter in a buried vault, it would mean that approximately 0.25 acres of parking lot is unavailable for other use. The cost of the permanent stormwater facilities in the stormwater site plan with the underground sand filter vault option in this scenario is approximately 88 percent of the total implementation cost. That percentage is reduced if the sand filter is placed in an open-air configuration.

Itemized costs for the components of the stormwater site plan are given for the three scenarios in Tables 16, 19, and 20 in Appendix A. Appendix A also provides further details on assumptions used to estimate costs.

Comparison of Treatment and Detention Storage Volumes to 1993 Estimates

For the scenario where infiltration is feasible in type A soils and a wetpond is used for treatment of the runoff prior to infiltration, the storage volumes in both the wetpond and the infiltration basin are now smaller in comparison to the sizes under the 1992 requirements. This is due to the requirement for onsite stormwater management (roof downspout infiltration). The volume of runoff assumed to reach the wetpond and infiltration basin is significantly less in comparison to the calculations associated with the 1992 requirements. The storage volumes in the wet/detention pond in type C soils analyzed in this case study are larger in size compared to the volumes estimated for this same site scenario in the 1993 report (Herrera 1993). This is because the wetpond treatment storage volume has increased as a result of the design criteria for the 6-month storm precipitation depth and the detention storage volume has increased considerably as a result of the requirement to match flow durations in addition to controlling peak flow rates.

The comparison of these storage volumes in type A soils is as follows:

- 1993 analysis (re-analyzed as discussed in Appendix C) -- wetpond treatment volume = 34,600 cubic feet; infiltration basin storage volume = 69,300 cubic feet

- Present analysis – wetpond treatment volume = 27,700 cubic feet; infiltration basin storage volume = 56,200 cubic feet

The comparison of these storage volumes in type C soils is as follows:

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- 1993 analysis -- wetpond treatment volume = 35,600 cubic feet; detention storage volume = 69,400 cubic feet; total storage volume = 105,000 cubic feet

- Present analysis -- wetpond treatment volume = 40,000 cubic feet; detention storage volume = 162,000 cubic feet; total storage volume = 202,000 cubic feet

The combination of greater storage volumes, the need for a sand filter to provide enhanced treatment, and potential placement of the sand filter underground results in much greater stormwater management costs in the present analysis compared to the 1993 analysis.

Site 3 Operation and Maintenance Requirements and Costs

Operation and Maintenance Assumptions

Routine maintenance of the permanent stormwater facilities includes such tasks as conducting annual inspections; mowing the grass in the infiltration basin and wetpond, or combined wet/detention pond, at least twice per year; removing accumulations of debris and floating materials once per year; removing accumulated sediments in the wetpond once the sediment storage depth in the bottom is full (assumed to be once every five years); tilling the infiltration basin soil or otherwise re-establishing maximum infiltration capacity as needed (assumed to be once every two years); raking the sand filtration surface once the depth of accumulated silt and debris on the surface exceeds ¼ inch (assumed to be once every two years); seeding of grassed areas that turn bare at least once per year; adding gravel to overflow spillways and access driveways as needed; replacing miscellaneous parts and materials as needed; and cleaning out connecting pipes. In addition, the large parking lot should be swept frequently to limit the amount of sediments that enter the permanent stormwater control facilities, enabling them to function more effectively. All catch basins and storm drains in the development should be cleaned frequently to prevent clogging and to remove some of the pollutants that otherwise could be flushed into the treatment and detention facilities during large storm events.

Operation and Maintenance Costs, With and Without Infiltration

The annual cost of routine maintenance procedures is estimated at approximately $6,400 for the scenario with the wetpond and infiltration/detention basin. The annual maintenance cost for the scenario with a combined wet/detention pond and sand filter (without infiltration) is estimated at approximately $6,200. Much of the annual operation and maintenance cost is associated with conveyance system cleaning and street sweeping as opposed to pond and vault maintenance.

Further details on assumptions used to estimate maintenance costs are provided in Appendix A. Tables 17 and 21 in Appendix A provide itemized costs of the individual maintenance tasks for each of the scenarios.

3. Summary of Stormwater Site Plan Costs

This section presents a summary of the estimated costs for the three hypothetical development sites. The stormwater site plan features that greatly affect the total cost of satisfying the minimum requirements for stormwater controls in new developments are discussed. This section presents comparisons to the cost estimates developed in 1993 for the same case study development examples, based upon the minimum requirements in the 1992 *Stormwater Management Manual for the Puget Sound Basin*. The intent of this comparison is to illustrate the differences in costs between the 1992 and the 2001 requirements. Land costs are not included in the present analysis because there is considerable variability in land costs across western Washington that unnecessarily complicates this comparison. While land costs are not included in this analysis, they are an extremely important variable to be considered in accommodating the stormwater management requirements. Many project sites, for example those along transportation corridors, impose constraints on the ability to provide stormwater management facilities within the available space and therefore additional land must be purchased for those facilities. In many of the urban areas of western Washington that land can be very expensive.

Design Issues Affecting Cost

The permanent stormwater facilities for the three hypothetical development sites are sized according to what appears to be reasonable for the site conditions, but without a detailed assessment to optimize costs. Specifically, the 1-acre commercial development example has all of its stormwater management facilities underground because ground surface area is typically valuable at these types of sites, whereas the stormwater management facilities are mostly aboveground at the residential and large-scale commercial sites. The surface area of aboveground pond facilities could be minimized through the use of retaining walls or other steep slope stabilization techniques. However, the conceptual designs of wetponds and infiltration basins produced for this analysis assumed enough space is available to allow for more gradual side slopes. Surface ponds ideally have very gradual side slopes that consume greater area, and this analysis assumed 3H:1V side slopes, the maximum (steepest) allowed by the manual, to minimize cost. These assumptions affect the amount of land devoted to stormwater control facilities, which in turn affects total implementation cost.

For underground facilities, the assumptions regarding depth of water in the vault have a direct influence on cost. For instance, if a sand filter vault is assumed to have two feet of ponding depth above the sand bed rather than four feet, then the area of the filter bed is larger, resulting in vault excavation and material costs that are greater in comparison to a deeper vault with a smaller footprint area.

As illustrated for the 10-acre commercial development example (site 3) and type C soils where infiltration is not possible, placement of the sand filter in an underground vault results in far greater cost than if the sand filter is placed in an open-air configuration. The tradeoff of additional parking and driveway areas versus higher stormwater management costs on this site would constitute an important site planning decision.

Stormwater Control Components Having Greatest Cost Impact

The relatively expensive items in the construction SWPPP cost estimates are stabilization of construction site entrances, construction roads, equipment parking areas, and stripped areas on the sites with rock and mulch; excavation of temporary sediment ponds and interceptor swales; routine maintenance checks and upkeep of erosion and sediment control BMPs; and cleaning sediments off of streets adjacent to the sites. These BMPs are likely to be necessary on every developed site, so their cost cannot be avoided. The quarry spalls and crushed rock used for road stabilization may be used later in final site paving, so the cost of these materials cannot necessarily be categorized as strictly a construction SWPPP cost. The necessity of frequent street sweeping outside site entrances is uncertain and varies with site conditions.

The relatively expensive cost items for the permanent stormwater control BMPs are excavation of treatment and detention basins; liners for prevention of seepage in wetponds in porous type A soils (including topsoil backfill over the liner); inflow pipes, outflow pipes, and flow control structures; and downspout infiltration trenches. For the commercial site examples where it is assumed that some or all of the stormwater management facilities would be placed in underground vaults or tanks, the construction of those vaults and tanks is very expensive.

Additional costs that are not included in this analysis that may be incurred include compliance with local government requirements, such as fencing around permanent BMPs. Landscaping costs, which may be necessary to satisfy other local government requirements, may be reduced if the permanent BMPs can be incorporated into landscaping designs.

Total Stormwater Control Costs to Satisfy Minimum Requirements

The total estimated costs of compliance with the minimum requirements, not including land costs or foregone land use opportunity costs, are summarized on a per-acre basis in Table 1. A range of costs for each site is provided that incorporates the potential variation in soil condition, engineering planning and design costs, and construction costs. The range of costs per acre of site size are applicable only to the hypothetical sites discussed in this analysis. The cost to comply with the minimum requirements on other sites of various sizes and development plans can be estimated based on this information, with the understanding that each site has unique characteristics and development concerns that affect the actual cost of developing and implementing a stormwater site plan. Therefore, these cost figures should be considered only approximate indicators of the actual cost to be expected for a particular new residential or commercial development of comparable size. The costs listed in Table 1 include construction-phase SWPPP costs as well as permanent BMP costs.

Table 1. Summary of Costs to Comply with the Minimum Requirements for New Development

Type of Development	Low Cost Per Acre of Development	High Cost Per Acre of Development
10-acre single-family residential (5.5 dwelling units per acre)	$23,000	$24,000
1-acre commercial	$280,000	$570,000
10-acre commercial	$32,000	$86,000

Comparisons to Costs Associated With the Former Minimum Requirements

A similar cost analysis was performed for the 1992 *Stormwater Management Manual for the Puget Sound Basin.* Although the cost estimates for the current analysis include some items that were not incorporated in the 1993 analysis, those previous cost estimates provide a basis for a general evaluation of the effects of the updated stormwater management requirements on total implementation costs. The cost totals for the site examples with type C soils (i.e., no infiltration) in the 1993 report were updated to the year 2001 by using the same unit prices, as well as the same assumptions for engineering and permitting costs (30 percent) and taxes (8.8 percent), as applied in the present analysis. Thus, the 1993 cost analysis material quantities were used in combination with cost assumptions that parallel the present analysis as much as possible. Several minor cost items from the 1993 analysis were not incorporated in the cost tables for this report, and therefore a different approach was used to update those items to the year 2001. An adjustment factor of 30 percent was used to update these miscellaneous cost items, based on construction cost inflation observed in the Puget Sound area through the year 2000 and extrapolation to this year (ENR 2000).

The cost totals for the site examples with type B soils from the 1993 report were disregarded in the present analysis. Instead, new quantity and cost estimates were prepared for those site examples assuming type A soils, assuming the same types of permanent stormwater site plan BMPs as assumed in the present analysis, and incorporating the year 1992 design requirements to determine wetpond and infiltration basin sizes under the older requirements. The revised stormwater facility quantity estimates were then coupled with the year 2001 unit prices used for the present analysis to estimate comparable costs based on the previous design manual requirements. Appendix C presents a brief overview of the re-analysis performed for the 1993 cost examples with infiltration.

The updated cost totals for the 1993 examples, excluding land costs, are shown in Table 2 below in comparison to the cost totals from the present analysis.

This comparison illustrates some important points. If most or all of the site runoff can be infiltrated, and underground facilities are not needed in that process, the costs of managing stormwater are comparable or slightly lower in the present analysis. That is mostly due to the effect that rooftop downspout infiltration has on reduction of wetpond and infiltration basin sizes.

Table 2. Comparison of Implementation Costs Under the Year 1992 and Year 2001 Stormwater Management Requirements.

Development Scenario	Total Implementation Costs Based on 1992 Standards	Total Implementation Costs Based on 2001 Standards	Difference in Cost
10-acre residential with infiltration	$280,000	$240,000	- 14%
10-acre residential without infiltration	$214,000	$230,000	+ 7%
1-acre commercial with infiltration	$84,000[a]	$280,000	+ 233%
1-acre commercial without infiltration	$41,000[a]	$570,000	+ 1290%
10-acre commercial with infiltration	$340,000	$320,000	- 6%
10-acre commercial without infiltration	$260,000	$490,000[b]	+ 88%

[a] The 1993 study assumed that the stormwater management facilities would be placed above ground rather than in vaults, and that greatly affects implementation cost.

[b] Cost associated with open-air sand filter rather than more expensive option with buried sand filter vault

The new requirements for enhanced treatment of runoff (sites 2 and 3) and flow control to match pre-developed flow durations as well as peak rates (for the scenarios with type C soils on all three sites) result in significantly greater storage volumes in the stormwater management ponds and vaults compared to the 1992 requirements. If a site cannot use an infiltration system for flow disposal, the cost of managing the stormwater rises significantly because of the required detention volume and the required enhanced treatment system (at non-residential sites). The detention storage volumes needed to satisfy the new flow duration control requirements, in particular, are much higher, on the order of twice the detention volumes previously needed for peak flow control only. In addition, the wetpool treatment storage volumes needed have increased slightly compared to the 1992 requirements because of a greater design storm precipitation depth. The increase in storage volumes needed on all of the example sites has a direct effect on compliance costs. When these facilities are placed in buried vaults, that cost increase becomes more pronounced.

The new requirements for onsite stormwater management using downspout infiltration systems and flow dispersion systems (among other techniques) also have an effect on overall costs. In the 10-acre residential development example with type A soils these facilities are relatively inexpensive due to the ability to use the "alternative" infiltration trench design. However, in the 1- and 10-acre commercial site examples with type A soils these systems are relatively expensive due to the need for inlet catch basins, perforated pipe, and soil backfill. Even with the greater relative cost for downspout infiltration at the commercial sites, the savings in cost that result from smaller pretreatment systems and infiltration systems (roughly 20 percent lower cost) is well worth the investment in downspout infiltration. In type C soils it was assumed that downspout infiltration systems would not be provided at any of the sites (inexpensive downspout dispersion systems were assumed), resulting in a greater volume of runoff flowing to the stormwater treatment and detention facilities. This analysis did not attempt to incorporate creative design elements such as vegetated rooftops, porous pavements in selected areas, landscaping to promote infiltration and dispersion of runoff at the commercial sites, and other onsite runoff management techniques that can potentially result in significant cost savings due to smaller stormwater control ponds and vaults.

The overall trend that can be expected in stormwater management costs for sites where infiltration cannot be accomplished is a significant increase relative to the costs associated with satisfaction of the 1992 requirements. If infiltration can be accomplished, the overall stormwater management costs may be similar, and possibly lower, in comparison to the costs associated with the 1992 requirements. Some cost components, such as the costs for temporary erosion and sediment control, may not change significantly.

COST ANALYSIS

Washington Department of Ecology
Year 2001 Minimum Requirements
for Stormwater Management
in Western Washington

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Washington State
Department of Transportation

August 2001

R0010830

Note:
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Tables

Figures

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Preface

This document contains information on the cost of implementing the new minimum stormwater control requirements for new developments and redevelopments as set forth by the Washington Department of Ecology (Ecology) in its *Stormwater Management Manual for Western Washington* (Ecology 2001). The minimum requirements include provisions for controlling erosion and sediment transport during construction, as well as permanent facilities for treating and controlling peak runoff flows from developed sites. This cost analysis considers only the stormwater system components required for erosion and sediment control, stormwater treatment, and stormwater detention and/or infiltration that go beyond conventional stormwater systems. Thus, the costs of installing stormwater system components such as catch basins and conveyance pipes that are independent of the Ecology requirements are not addressed in this cost analysis.

The cost estimates for satisfying Ecology's new minimum requirements that are provided in this report should be considered as approximate, and should be viewed in the context of the hypothetical sites for which they were developed. Individual site conditions, selected components of stormwater control plans, costs of land, costs of engineering and construction services, and many other factors can vary considerably throughout western Washington and from project to project. Some projects will be faced with costs associated with construction of stormwater management facilities that are not captured in this analysis, such as traffic control costs, additional property costs, and mitigation costs for sensitive areas that are impacted by placement of stormwater management facilities. Therefore, for a particular development or redevelopment of comparable size to the hypothetical sites discussed in this report, the costs of satisfying Ecology's minimum requirements may differ from the costs given in this analysis. This analysis does not address the costs that stormwater design engineers, site designers, developers, and development reviewers may incur in learning the updated requirements and preparing the resultant technical documentation that will likely require greater detail.

1. Introduction

This report provides information on costs of stormwater control measures required for new single-family residential and commercial developments in western Washington based on the minimum requirements set forth by the Washington Department of Ecology (Ecology) in the *Stormwater Management Manual for Western Washington*, referred to hereafter as "the manual" (Ecology 2001, final version pending as of the date this report was completed). The manual describes the stormwater management requirements applicable to various development and redevelopment scenarios, including many types of development other than single-family residential and commercial land use. There are a multitude of development scenarios that could potentially be evaluated for stormwater management implementation costs but doing so would require extensive amounts of time and effort. This report discusses the range of stormwater management costs that could be expected for some representative examples, and the reader must necessarily use the information as a general guide to understand the cost implications for a specific project of interest.

Development Examples

This report addresses three hypothetical development examples and presents the associated costs for compliance with Ecology's new minimum requirements. These three hypothetical development sites include the following: a 10-acre single-family residential development (site 1), a 1-acre commercial development (site 2), and a 10-acre commercial development (site 3). These examples assume that new development is occurring on the hypothetical sites, that there is no existing development on the sites, that greater than 2,000 square feet of impervious surface is added, and that greater than 7,000 square feet of land area is cleared. Therefore, all of the minimum requirements set forth in the manual are applicable to these examples. Because the decisions regarding how to manage stormwater for a particular site are often directly tied to soil characteristics, this report addresses a range of control measures that may be used in differing soil conditions. For each of the three example sites, the costs to implement the minimum requirements were analyzed for two different soil conditions (soils that would promote infiltration of runoff [type A soils] and soils that are not suitable for infiltration [type C soils]).

This report may be viewed as an update to a similar report prepared in 1993 entitled *Cost Analysis, Minimum Requirements for Stormwater Management in New Developments and Redevelopments* (Herrera 1993), which contained an analysis based on requirements set forth in the *Stormwater Management Manual for the Puget Sound Basin* (Ecology 1992). The analysis in this report repeats the hypothetical development examples from the 1993 report, and the analysis is based on the minimum requirements, design guidelines, and stormwater facility sizing procedures in the updated 2001 Ecology manual. Where applicable, this report refers to the 1993 cost analysis report to enable comparison of the differences in stormwater management costs between the older and newer requirements for the same site conditions.

APPENDIX A

Cost Estimates and Related Assumptions

Cost Estimate Assumptions and Itemized Cost Estimates

This appendix provides detailed information on assumptions and references used in developing the cost estimates for implementing stormwater site plans at the three hypothetical development sites described in Section 2. Itemized cost tabulations are included at the end of the appendix for all of the BMPs associated with the construction SWPPP and permanent stormwater site plan for the three sites.

Costs of equipment, labor, materials, engineering services, and permitting fees are included in the estimates. Unit prices are derived from estimates on other stormwater projects, from the *Site Work and Landscape Cost Data* guide (Means 2000), from the Washington State Department of Transportation's "unit bid analysis" information posted on their web site, and from educated estimates on items for which cost information is not published. An additional 10 percent is added to the subtotal construction cost to cover mobilization and demobilization of equipment for construction and maintenance of BMPs. A contingency of 25 percent is subsequently added to cover unforeseen difficulties during construction and other miscellaneous items. Contingencies are necessary in planning level engineering cost estimates; the 25 percent used here is typical for the limited amount of site information available. An additional cost is listed for investigation of soil suitability for infiltration in the scenarios where infiltration is used for stormwater treatment. Tax (at 8.8 percent) is included on the total construction costs. Engineering services and permitting fees are added at a rate of 30 percent on the total construction cost for most of the development scenarios to obtain the total BMP implementation cost for each site. The assumed percentage of cost for engineering and permitting services was reduced to 15 percent for the 10-acre commercial site with buried sand filter vault because the capital construction costs are disproportionately high due to underground facilities.

The total BMP implementation costs listed in Tables 2, 6, 10, 13, 16, 19, and 20 are relatively conservative estimates. However, site conditions may dictate higher costs if steep slopes and erosive soils are present, or if extensive landscaping is used to make the BMPs aesthetically pleasing. The total implementation cost could also be considerably lower for some sites of comparable size. The total cost estimates should be considered as indicative of approximate average implementation costs. All costs listed in this analysis are in 2001 dollars.

Assumptions Used to Estimate Construction Costs

Assumptions used in developing construction costs for procedures and materials common to all three hypothetical development sites and many BMPs are outlined below. Assumptions used in developing construction costs for procedures and materials unique to either construction SWPPP BMPs or permanent stormwater site plan BMPs are briefly outlined separately in subsequent sections of this appendix.

References

Ecology. 2001. Stormwater management manual for western Washington (final version pending as of the date this report was completed). Washington State Department of Ecology, Lacey, Washington.

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Means, R.S. 1999. Site work and landscape cost data, 19th annual edition, 2000. R.S. Means Company, Inc., Kingston, MA.

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Construction SWPPP Assumptions

- The cost of excavation for all three sites and all stormwater facilities assumes a short hauling distance of 150 feet (implying onsite relocation and reuse of excavated material). Grading of excavated areas is also included in the unit price of excavation, as shown in the itemized cost tables. The unit price includes equipment and labor.

- The cost of seeding for bare areas assumes hydroseeding with a common utility mix and includes equipment and labor.

- The cost of straw mulch assumes it is mechanically blown on the site rather than hand-cast.

- The cost of street sweeping assumes it is done for one hour, once per week for 6 months adjacent to the 10-acre development sites with type A soils; three times per week adjacent to the 10-acre development sites with type C soils; five times during the course of construction at the 1-acre commercial development site with type A soils; and 10 times during the course of construction at the 1-acre commercial development site with type C soils.

- Approximately 10 percent of the total silt fence length would need to be repaired at the 10-acre development sites with type A soils, and approximately 20 percent of the total silt fence length would need to be repaired at the 10-acre development sites with type C soils.

Permanent Stormwater Site Plan Assumptions

- Bottom liners were assumed necessary for wetponds in type A soils. The unit cost of the bottom liners is based on recent experience with a variety of lining systems at the Cedar Hills Landfill and recent contractor bids for a stormwater pond liner at a park-and-ride site in Puyallup. The backfill over basin liners is assumed to be compacted topsoil or sand, 18 inches thick.

- Access driveways and maintenance pads for all pond-type BMPs were assumed to be 15 feet wide, and the driveway portion extending into the pond bottom was assumed to be common borrow soil underlying a crushed gravel surfacing.

- Pond-type BMPs were assumed to be hydroseeded upon completion of grading rather than via hand-spread seeding.

- For downspout infiltration systems at Site 1 (residential, type A soils), it was assumed that each house (48 total) would have all of its downspouts draining into simple rock-filled trench systems without need for inlet catch basins and perforated pipe.

- It was assumed that the 1-acre commercial development building would have two separate downspout infiltration trench systems, and that the 10-acre commercial development building would have six separate trench systems. These systems would require inlet catch basins and perforated pipe. It was assumed that the catch basins used with these commercial downspout infiltration systems would be made of high density polyethylene rather than concrete to save on cost.

- Underground wet vaults were assumed to consist of 8-foot diameter corrugated steel pipe treated with asphalt coating.

- Underground infiltration tanks were assumed to consist of 5-foot diameter corrugated steel pipe with perforations in the bottom half of the barrel, laid on the drain rock.

- Underground detention systems were assumed to consist of 5-foot diameter corrugated aluminized steel pipe with prefabricated manifold connections, end caps and access risers.

- Underground sand filter vaults were assumed to consist of pre-cast concrete vault sections 20 feet in width, with lateral connecting pipes.

Operation and Maintenance Cost Assumptions

Operation and maintenance (O&M) costs are estimated for the temporary erosion and sediment control and permanent stormwater site plan BMPs. The total duration of construction for Sites 1 and 3 is assumed to be 12 months. The total duration of construction for Site 2 is assumed to be 2 months. The estimates of O&M costs for the construction SWPPPs are applicable only during the construction phase, that is, they are one-time costs. These O&M costs for construction SWPPP measures are factored into the total SWPPP costs listed in Tables 2, 6, 10, 13, 16, 19 and 20. The estimates of O&M costs for permanent stormwater control facilities are applicable as annual requirements. These O&M cost estimates are approximate. A contingency of 20 percent is added to all O&M cost estimates to account for miscellaneous maintenance requirements and variable site conditions. The following discussion details the assumptions used to develop the O&M cost estimates, which are found in Tables 3, 7, 8,11, 14, 17, and 21.

Erosion and Sediment Control BMP Maintenance

- It is assumed that erosion and sediment control BMPs are checked daily in the wet season, and once per week for the remainder of the year. In the dry season it was assumed that several other checks would be needed following infrequent storm events.

- Sediment accumulations in temporary sediment ponds would be cleaned out once during construction on the 10-acre sites with type A soils, and twice during construction on the 10-acre sites with type C soils.

- Offsite catch basins adjacent to the site would be cleaned out for the 10-acre sites with type C soils, but such cleaning would not be needed on the 1-acre commercial site due to the short duration of construction, nor on the 10-acre sites with type A soils because offsite sediment transport would not be problematic in outwash soils.

- Laborers involved in all aspects of operation and maintenance of BMPs are paid at a rate of $30 per hour.

Permanent Stormwater Control BMP Maintenance

Permanent stormwater facilities must be routinely maintained on a scheduled basis for the life of the facilities. Assumptions used to develop O&M costs for permanent stormwater facilities are as follows:

- Infiltration and detention basins, which are normally dry, must be mowed twice per year to promote thick grass cover that enhances sediment settling and infiltration It is assumed that 4 hours of labor would be required to mow the infiltration basins at Sites 1 and 3, twice per year.

- The bottom and side slopes of infiltration basins and the bottoms of the infiltration tanks should be tilled periodically to loosen sediments that may clog the soil surface. It is assumed that tilling is conducted once every 2 years, requiring two laborers for one 8-hour work day on the 10-acre sites (Sites 1 and 3) and two laborers for 4 hours on the 1-acre site (Site 2). In addition to the labor cost, it is assumed that a lump cost of $300 covers mobilization, equipment, and sediment disposal (if necessary) associated with this activity.

- It is assumed that tilling, conditioning, and/or removal of sediment accumulations is conducted once every 2 years in the sand filters for Sites 2 and 3, requiring two laborers for 4 hours on the 1-acre site (Site 2) and two laborers for 8 hours on the 10-acre site (Site 3). In addition to the labor cost, it is assumed that a lump cost of $300 covers mobilization, equipment, and sediment disposal (if necessary) associated with this activity.

- It is assumed that sediment deposits are cleaned out once every 5 years in wetponds and wet vaults. The wetponds at Sites 1 and 3 take approximately 16 hours to clean with a crew of two laborers, and the wet vault at Site 2 takes approximately 12 hours to clean with a crew of two laborers. It is assumed that mobilization, equipment, and sediment disposal associated with this activity costs $500 for Sites 1 and 3, and $300 for Site 2, in addition to the above labor costs.

- Catch basins and storm drains must also be cleaned out periodically to remove accumulated sediments and debris. It is assumed that some of the catch basins in the residential development are cleaned every year, that half of the catch basins in the parking lot at the 1-acre commercial site are cleaned once per year, and that roughly half of the catch basins in the parking lot for the 10-acre commercial site are cleaned each year. It is assumed that the cost is $200 per catch basin or storm drain segment.

- It is assumed that the catch basin inserts in each of four catch basins in the parking lot at Site 2 are replaced four times per year, for a total of 16 inserts per year.

- It is assumed that street or parking lot sweeping will be conducted at each of the sites. At the residential site (Site 1) it is assumed that a sweeper will operate 4 hours per month, for each of 7 months during the year. At the 1-acre commercial site (Site 2), it is assumed that a sweeper will operate 1 hour per month, for each of 7 months during the year. At the 10-acre commercial site (Site 3), it is assumed that a sweeper will operate 3 hours per month for a total of 7 months during the year.

Table 1. Cost estimate for construction stormwater pollution prevention plan -- 10-acre residential development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Stabilized staging/parking area - crushed gravel	CY	700	$20	$14,000
Tire wash	LS	1	$500	$500
Interceptor swale excavation	CY	90	$15	$1,350
Interceptor swale seeding	AC	0.6	$1,000	$600
Interceptor swale bonded fiber matrix	AC	0.6	$200	$120
Check dams - quarry spalls	CY	10	$35	$350
Dewatering bag	EA	1	$300	$300
Storm drain inlet protection	EA	2	$200	$400
Straw mulch	AC	9	$800	$7,200
Silt fence	LF	340	$5	$1,700
Water spray for dust control	LS	1	$300	$300
Temporary sediment pond excavation	CY	160	$10	$1,600
Quarry spalls for spillway, inlet dissipation	CY	7	$35	$245
Compacted earth fill berm	CY	55	$4	$220
8" CMP riser pipe for outflow (incl. conc. base)	EA	1	$400	$400
Corrugated polyethylene dewatering device	EA	1	$200	$200
Subtotal				$31,800
Maintenance of erosion and sediment control BMPs (see Table 3 for details)				$8,400
Total SWPPP cost				$ 40,200

Table 2. Cost estimate for permanent stormwater site plan -- 10-acre residential development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Onsite stormwater management measures				
Downspout infiltration trench excavation	CY	430	$10	$4,300
Downspout infiltration trench drain rock	CY	320	$30	$9,600
Geotextile for material separation	SY	1,600	$1.25	$2,000
Wet pond				
Excavation	CY	1,300	$10	$13,000
Bottom liner	SY	720	$10	$7,200
Liner backfill (soil or sand)	CY	270	$15	$4,050
Common borrow and gravel for access driveways	CY	40	$20	$800
Outflow structure (catch basin with debris barrier)	EA	1	$3,000	$3,000
Discharge pipe, 12" diam.	LF	50	$40	$2,000
Infiltration basin				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Basin excavation	CY	2,600	$10	$26,000
Basin liner - nonwoven geotextile	SY	1,870	$1.25	$2,338
Quarry spalls for overflow spillway	CY	7	$35	$245
Seeding	AC	0.39	$1,000	$390
Gravel for access driveway, maintenance pad	CY	41	$20	$820
Observation wells	EA	2	$200	$400
Subtotal				$86,100
Construction SWPPP cost (see Table 1 for detailed TESC costs)				$40,200
Subtotal construction cost				$126,300
Mobilization and demobilization (10%)				$12,630
Subtotal stormwater control BMP cost				$138,930
Contingencies (25%)				$34,733
Total construction cost				$173,700
Taxes (8.8%)				$15,300
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$52,100
Total cost for stormwater BMP construction				$240,000

Table 3. **Cost estimate for stormwater BMP operation and maintenance -- 10-acre residential development with infiltration.**

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	190	$20	$3,800
Clean out sediment buildup in pond	EA	1	$300	$300
Repair damaged sections of silt fencing	LF	30	$5	$150
Sediment removal in offsite catch basins	EA	0	$200	$0
Street sweeping	HR	26	$100	$2,600
Removal of BMPs at conclusion of construction	LS	1	$1,500	$1,500
Total SWPPP O&M cost (for 1 year only)				$8,400
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wetpond	EA	0.2	$1,460	$292
Mow infiltration basin	EA	2	$120	$240
Till/remove sediments from infiltration basin	EA	0.5	$780	$390
Spot seeding/repair of bare areas	LS	1	$100	$100
Clean catch basins and storm drains	EA	10	$200	$2,000
Street sweeping	HR	28	$100	$2,800
Subtotal permanent stormwater BMP annual O&M cost				$6,000
Contingencies (20%)				$1,200
Total annual O&M cost				$7,200

Table 4. Cost estimate for construction stormwater pollution prevention plan -- 10-acre residential development without infiltration and without wet season shutdown

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Stabilized staging/parking area - crushed gravel	CY	700	$20	$14,000
Tire wash	LS	1	$500	$500
Interceptor swale excavation	CY	90	$15	$1,350
Interceptor swale seeding	AC	0.6	$1,000	$600
Interceptor swale bonded fiber matrix	AC	0.6	$200	$120
Check dams - quarry spalls	CY	10	$35	$350
Dewatering bag	EA	1	$300	$300
Storm drain inlet protection	EA	8	$200	$1,600
Straw mulch	AC	9	$800	$7,200
Silt fence	LF	340	$5	$1,700
Water spray for dust control	LS	1	$300	$300
Temporary sediment pond excavation	CY	290	$10	$2,900
Quarry spalls for spillway, inlet dissipation	CY	7	$35	$245
Compacted earth fill berm	CY	65	$4	$260
8" CMP riser pipe for outflow (incl. conc. base)	EA	1	$400	$400
Corrugated polyethylene dewatering device	EA	1	$200	$200
Subtotal				$34,300
Maintenance of erosion and sediment control BMPs (see Table 7 for details)				$14,500
Total SWPPP cost				$48,800

Table 5. **Cost estimate for construction stormwater pollution prevention plan -- 10-acre residential development without infiltration and with wet season shutdown**

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Stabilized staging/parking area - crushed gravel	CY	700	$20	$14,000
Tire wash	LS	1	$500	$500
Interceptor swale excavation	CY	90	$15	$1,350
Interceptor swale seeding	AC	0.6	$1,000	$600
Interceptor swale bonded fiber matrix	AC	0.6	$200	$120
Check dams - quarry spalls	CY	10	$35	$350
Dewatering bag	EA	1	$300	$300
Storm drain inlet protection	EA	4	$200	$800
Straw mulch	AC	5	$800	$4,000
Soil stabilization with polyacrylamide for winter	AC	9	$200	$1,800
Silt fence	LF	340	$5	$1,700
Water spray for dust control	LS	1	$500	$500
Temporary sediment pond excavation	CY	290	$10	$2,900
Quarry spalls for spillway, inlet dissipation	CY	7	$35	$245
Compacted earth fill berm	CY	65	$4	$260
8" CMP riser pipe for outflow (incl. conc. base)	EA	1	$400	$400
Corrugated polyethylene dewatering device	EA	1	$200	$200
Subtotal				$32,300
Maintenance of erosion and sediment control BMPs (see Table 8 for details)				$9,100
Total SWPPP cost				$41,400

Table 6. Cost estimate for permanent stormwater site plan -- 10-acre residential development without infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Onsite stormwater management measures				
Downspout dispersion splash blocks	EA	96	$20	$1,920
Wet/detention pond				
Excavation	CY	6,200	$10	$62,000
Common borrow and gravel for access driveways	CY	65	$20	$1,300
Quarry spalls for inlet dissipation, overflow spillway	CY	7	$35	$245
Seeding	AC	0.45	$1,000	$450
Outlet piping	LF	60	$40	$2,400
Outlet control structure	EA	1	$3,500	$3,500
Subtotal				$71,800
Construction SWPPP cost (see Table 4 for detailed TESC costs)				$48,800
Subtotal construction cost				$120,600
Mobilization and demobilization (10%)				$12,100
Subtotal stormwater control BMP cost				$132,700
Contingencies (25%)				$33,200
Total construction cost				$165,900
Taxes (8.8%)				$14,600
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$49,800
Total cost for stormwater BMP construction				$230,000

Table 7. Cost estimate for stormwater BMP operation and maintenance -- 10-acre residential development without infiltration and without wet season shutdown.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	190	$20	$3,800
Clean out sediment buildup in pond	EA	2	$300	$600
Repair damaged sections of silt fencing	LF	70	$5	$350
Sediment removal in offsite catch basins	EA	2	$200	$400
Street sweeping	HR	78	$100	$7,800
Removal of BMPs at conclusion of construction	LS	1	$1,500	$1,500
Total SWPPP O&M cost (for 1 year only)				$14,500
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet pond	EA	0.2	$1,460	$292
Mow wet/detention pond slopes	EA	2	$120	$240
Spot seeding/repair of bare areas	LS	1	$50	$50
Clean catch basins and storm drains	EA	20	$200	$4,000
Street sweeping	HR	28	$100	$2,800
Subtotal permanent stormwater BMP annual O&M cost				$7,500
Contingencies (20%)				$1,500
Total annual O&M cost				$9,000

Table 8. Cost estimate for stormwater BMP operation and maintenance --
10-acre residential development without infiltration and with wet season shutdown.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	60	$20	$1,200
Clean out sediment buildup in pond	EA	2	$300	$600
Repair damaged sections of silt fencing	LF	70	$5	$350
Sediment removal in offsite catch basins	EA	1	$200	$200
Street sweeping	HR	52	$100	$5,200
Removal of BMPs at conclusion of construction	LS	1	$1,500	$1,500
Total SWPPP O&M cost (for 1 year only)				$9,100
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet pond	EA	0.2	$1,460	$292
Mow wet/detention pond slopes	EA	2	$120	$240
Spot seeding/repair of bare areas	LS	1	$50	$50
Clean catch basins and storm drains	EA	20	$200	$4,000
Street sweeping	HR	28	$100	$2,800
Subtotal permanent stormwater BMP annual O&M cost				$7,500
Contingencies (20%)				$1,500
Total annual O&M cost				$9,000

Table 9. **Cost estimate for construction stormwater pollution prevention plan -- 1-acre commercial development with infiltration.**

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Storm drain inlet protection	EA	2	$200	$400
Straw mulch	AC	0.8	$800	$640
Silt fence	LF	390	$5	$1,950
Temporary sediment pond excavation	CY	17	$10	$170
Quarry spalls for spillway, inlet dissipation	CY	2	$35	$70
Rock and washed gravel spillway	CY	2	$40	$80
Subtotal				$5,600
Maintenance of erosion and sediment control BMPs (see Table 11 for details)				$1,300
Total SWPPP cost				$6,900

Table 10. Cost estimate for permanent stormwater site plan -- 1-acre commercial development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Onsite stormwater management measures				
Downspout infiltration trench excavation	CY	40	$10	$400
Downspout infiltration trench drain rock	CY	30	$30	$900
Compacted backfill	CY	10	$4	$40
Geotextile for material separation	SY	200	$1.25	$250
Type 1 catch basin with sump	EA	2	$400	$800
4" perforated drain pipe	LF	250	$2	$500
Extension of downspouts into trenches	LF	25	$2	$50
Wet vaults				
Excavation	CY	540	$15	$8,100
Vault structures (8' diameter steel pipe)	LF	110	$95	$10,450
Vault installation and connections	LF	110	$80	$8,800
Pipe bedding gravel	CY	100	$20	$2,000
Vault backfill	CY	235	$4	$940
Hauling and disposal of excess material	CY	305	$20	$6,100
Discharge pipe, 12" diam.	LF	40	$40	$1,600
Infiltration tanks				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Tank excavation	CY	1,000	$15	$15,000
Tank structures (5' diameter perforated steel pipe)	LF	405	$80	$32,400
Tank installation and connections	LF	405	$50	$20,250
Pipe bedding gravel	CY	260	$20	$5,200
Tank backfill	CY	460	$4	$1,840
Hauling and disposal of excess material	CY	540	$20	$10,800
Observation wells	EA	4	$200	$800
Catch basin inserts	EA	4	$100	$400
Subtotal				$137,600
Construction SWPPP cost (see Table 9 for detailed TESC costs)				$6,900
Subtotal construction cost				$144,500
Mobilization and demobilization (10%)				$14,450
Subtotal stormwater control BMP cost				$158,950
Contingencies (25%)				$39,700
Total construction cost				$198,700
Taxes (8.8%)				$17,500
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$59,600
Total cost for stormwater BMP construction				$280,000

Table 11. Cost estimate for stormwater BMP operation and maintenance -- 1-acre commercial development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	10	$20	$200
Water spray for dust suppression	LS	1	$100	$100
Repair damaged sections of silt fencing	LF	20	$5	$100
Street sweeping	HR	5	$100	$500
Removal of BMPs at conclusion of construction	LS	1	$400	$400
Total SWPPP O&M cost (for 2 months only)				$1,300
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet vault	EA	0.2	$1,020	$204
Till/remove sediments from infiltration tanks	EA	0.5	$540	$270
Replace catch basin inserts	EA	16	$100	$1,600
Clean catch basins and storm drains	EA	2	$200	$400
Parking lot sweeping	HR	7	$100	$700
Subtotal permanent stormwater BMP annual O&M cost				$3,300
Contingencies (20%)				$700
Total annual O&M cost				$4,000

Table 12. Cost estimate for construction stormwater pollution prevention plan -- 1-acre commercial development without infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Interceptor swale excavation	CY	36	$15	$540
Interceptor swale geosynthetic liner	SY	144	$2	$288
Check dams - quarry spalls	CY	2	$35	$70
Storm drain inlet protection	EA	2	$200	$400
Straw mulch	AC	0.8	$800	$640
Silt fence	LF	390	$5	$1,950
Temporary sediment pond excavation	CY	31	$10	$310
Quarry spalls for spillway, inlet dissipation	CY	2	$35	$70
Rock and washed gravel spillway	CY	2	$40	$80
Subtotal				$6,700
Maintenance of erosion and sediment control BMPs (see Table 14 for details)				$1,900
Total SWPPP cost				$8,600

Table 13. **Cost estimate for permanent stormwater site plan -- 1-acre commercial development without infiltration.**

Item	Unit	Quantity	Unit Cost	Cost
Wet vaults				
Excavation	CY	690	$15	$10,350
Vault structures (8' diameter steel pipe)	LF	140	$95	$13,300
Vault installation and connections	LF	140	$80	$11,200
Pipe bedding gravel	CY	130	$20	$2,600
Vault backfill	CY	300	$4	$1,200
Hauling and disposal of excess material	CY	390	$20	$7,800
Discharge pipe, 12" diam.	LF	40	$40	$1,600
Detention vaults				
Excavation	CY	2,400	$15	$36,000
Vault structures (5' diameter steel pipe)	LF	970	$75	$72,750
Vault installation and connections	LF	970	$50	$48,500
Pipe bedding gravel	CY	600	$20	$12,000
Vault backfill	CY	1,100	$4	$4,400
Hauling and disposal of excess material	CY	1,300	$20	$26,000
Discharge pipe, 12" diam.	LF	100	$40	$4,000
Outlet control structure	EA	1	$3,500	$3,500
Sand filter vault				
Excavation	CY	250	$15	$3,750
Vault structure (20' wide precast sections)	LF	25	$750	$18,750
Vault installation, connections, and backfill	LF	25	$350	$8,750
Sand	CY	40	$25	$1,000
Perforated pipe underdrains	LF	50	$2	$100
Drain rock	CY	20	$30	$600
Geotextile fabric for material separation	SY	60	$1.25	$75
Catch basin inserts	EA	4	$100	$400
Subtotal				$ 288,600
Construction SWPPP cost (see Table 12 for detailed TESC costs)				$8,600
Subtotal construction cost				$297,200
Mobilization and demobilization (10%)				$29,700
Subtotal stormwater control BMP cost				$326,900
Contingencies (25%)				$81,700
Total construction cost				$408,600
Taxes (8.8%)				$36,000
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$122,600
Total cost for stormwater BMP construction				$570,000

Table 14. Cost estimate for stormwater BMP operation and maintenance -- 1-acre commercial development without infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	10	$20	$200
Water spray for dust suppression	LS	1	$100	$100
Repair damaged sections of silt fencing	LF	20	$5	$100
Street sweeping	HR	10	$100	$1,000
Removal of BMPs at conclusion of construction	LS	1	$500	$500
Total SWPPP O&M cost (for 2 months only)				$1,900
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet vault	EA	0.2	$1,020	$204
Till surface of sand filter / replace sand	EA	0.5	$540	$270
Replace catch basin inserts	EA	16	$100	$1,600
Clean catch basins and storm drains	EA	2	$200	$400
Parking lot sweeping	HR	7	$100	$700
Subtotal permanent stormwater BMP annual O&M cost				$3,300
Contingencies (20%)				$700
Total annual O&M cost				$4,000

Table 15. **Cost estimate for construction stormwater pollution prevention plan -- 10-acre commercial development with infiltration.**

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Stabilized staging/parking area - crushed gravel	CY	500	$20	$10,000
Interceptor swale excavation	CY	150	$15	$2,250
Interceptor swale seeding	AC	0.14	$1,000	$140
Interceptor swale bonded fiber matrix	AC	0.14	$200	$28
Check dams - quarry spalls	CY	20	$35	$700
Storm drain inlet protection	EA	3	$200	$600
Straw mulch	AC	9	$800	$7,200
Silt fence	LF	1300	$5	$6,500
Erosion control blankets	SY	2200	$5	$11,000
Temporary sediment pond excavation	CY	220	$10	$2,200
Quarry spalls for spillway, inlet dissipation	CY	7	$35	$245
Compacted earth fill berm	CY	100	$4	$400
8" CMP riser pipe for outflow (incl. conc. base)	EA	1	$400	$400
Corrugated polyethylene dewatering device	EA	1	$200	$200
Subtotal				$44,200
Maintenance of erosion and sediment control BMPs (see Table 17 for details)				$10,000
Total SWPPP cost				$54,200

Table 16. Cost estimate for permanent stormwater site plan -- 10-acre commercial development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Onsite stormwater management measures				
Downspout infiltration trench excavation	CY	230	$10	$2,300
Downspout infiltration trench drain rock	CY	170	$30	$5,100
Compacted backfill	CY	60	$4	$240
Geotextile for material separation	SY	1,170	$1.25	$1,463
Type 1 catch basin with sump	EA	6	$800	$4,800
4" perforated drain pipe	LF	1,500	$2	$3,000
Extension of downspouts into trenches	LF	100	$2	$200
Wet pond				
Excavation	CY	1,350	$10	$13,500
Bottom liner	SY	1,160	$10	$11,600
Soil or sand backfill on bottom liner	CY	580	$15	$8,700
Common borrow and gravel for access driveways	CY	35	$20	$700
Outflow structure (catch basin with debris barrier)	EA	1	$3,000	$3,000
Discharge pipe, 12" diam.	LF	200	$40	$8,000
Infiltration basin				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Basin excavation	CY	3,400	$10	$34,000
Compacted earthen berm	CY	30	$4	$120
Basin liner - nonwoven geotextile	SY	2,600	$1.25	$3,250
Quarry spalls for overflow spillway	CY	35	$35	$1,225
Seeding	AC	0.57	$1,000	$570
Gravel for access driveway, maintenance pad	CY	35	$20	$700
Observation wells	EA	3	$200	$600
Subtotal				$113,100
Construction SWPPP cost (see Table 15 for detailed TESC costs)				$54,200
Subtotal construction cost				$167,300
Mobilization and demobilization (10%)				$16,730
Subtotal stormwater control BMP cost				$184,030
Contingencies (25%)				$46,000
Total construction cost				$230,000
Taxes (8.8%)				$20,200
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$69,000
Total cost for stormwater BMP construction				$320,000

Table 17. Cost estimate for stormwater BMP operation and maintenance -- 10-acre commercial development with infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	190	$20	$3,800
Water spray for dust suppression	LS	1	$500	$500
Clean out sediment buildup in pond	EA	1	$300	$300
Repair damaged sections of silt fencing	LF	130	$5	$650
Sediment removal in offsite catch basins	EA	3	$200	$600
Street sweeping	HR	26	$100	$2,600
Removal of BMPs at conclusion of construction	LS	1	$1,500	$1,500
Total SWPPP O&M cost (for 1 year only)				$10,000
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet pond	EA	0.2	$1,460	$292
Mow infiltration basin	EA	2	$120	$240
Till/remove sediments from infiltration basin	EA	0.5	$780	$390
Spot seeding/repair of bare areas	LS	1	$100	$100
Clean catch basins and storm drains	EA	10	$200	$2,000
Parking lot sweeping	HR	21	$100	$2,100
Subtotal permanent stormwater BMP annual O&M cost				$5,300
Contingencies (20%)				$1,100
Total annual O&M cost				$6,400

Table 18. Cost estimate for construction stormwater pollution prevention plan -- 10-acre commercial development without infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction entrance - quarry spalls	CY	60	$35	$2,100
Stabilized construction entrance - geotextile	SY	170	$1.25	$213
Stabilized staging/parking area - crushed gravel	CY	500	$20	$10,000
Interceptor swale excavation	CY	150	$15	$2,250
Interceptor swale seeding	AC	0.14	$1,000	$140
Interceptor swale bonded fiber matrix	AC	0.14	$200	$28
Check dams - quarry spalls	CY	20	$35	$700
Storm drain inlet protection	EA	3	$200	$600
Straw mulch	AC	9	$800	$7,200
Silt fence	LF	1300	$5	$6,500
Straw bale barrier	LF	160	$5	$800
Erosion control blankets	SY	2200	$5	$11,000
Temporary sediment pond excavation	CY	400	$10	$4,000
Quarry spalls for spillway, inlet dissipation	CY	7	$35	$245
Compacted earth fill berm	CY	100	$4	$400
8" CMP riser pipe for outflow (incl. conc. base)	EA	1	$400	$400
Corrugated polyethylene dewatering device	EA	1	$200	$200
Subtotal				$46,800
Maintenance of erosion and sediment control BMPs (see Table 21 for details)				$16,100
Total SWPPP cost				$62,900

Table 19. Cost estimate for permanent stormwater site plan -- 10-acre commercial development without infiltration and with buried sand filter.

Item	Unit	Quantity	Unit Cost	Cost
Wet/detention pond				
Excavation	CY	10,400	$10	$104,000
Common borrow and gravel for access driveways	CY	125	$20	$2,500
Quarry spalls for inlet dissipation, overflow spillway	CY	35	$35	$1,225
Seeding	AC	1.33	$1,000	$1,330
Outlet piping	LF	300	$40	$12,000
Outlet control structure	EA	1	$3,500	$3,500
Sand filter vault				
Excavation	CY	2,450	$15	$36,750
Shoring	SY	400	$10	$4,000
Vault structure (20' wide precast sections)	LF	240	$750	$180,000
Vault construction/installation	LF	240	$350	$84,000
Sand	CY	260	$25	$6,500
Perforated pipe underdrains	LF	240	$2	$480
Drain rock	CY	175	$30	$5,250
Geotextile fabric for material separation	SY	520	$1.25	$650
Subtotal				$442,200
Construction SWPPP cost (see Table 18 for detailed TESC costs)				$62,900
Subtotal construction cost				$505,100
Mobilization and demobilization (10%)				$50,500
Subtotal stormwater control BMP cost				$555,600
Contingencies (25%)				$138,900
Total construction cost				$694,500
Taxes (8.8%)				$61,100
Engineering and permitting fees for stormwater facilities (15%) (excluding basic site drainage infrastructure)				$104,180
Total cost for stormwater BMP construction				$860,000

Table 20. Cost estimate for permanent stormwater site plan --
10-acre commercial development without infiltration and with open air sand filter.

Item	Unit	Quantity	Unit Cost	Cost
Wet/detention pond				
Excavation	CY	10,400	$10	$104,000
Common borrow and gravel for access driveways	CY	125	$20	$2,500
Quarry spalls for inlet dissipation, overflow spillway	CY	35	$35	$1,225
Seeding	AC	1.33	$1,000	$1,330
Outlet piping	LF	300	$40	$12,000
Outlet control structure	EA	1	$3,500	$3,500
Sand filter				
Excavation	CY	3,050	$15	$45,750
Drain rock	CY	170	$30	$5,100
Sand	CY	260	$25	$6,500
Access driveway crushed gravel surfacing	CY	40	$20	$800
Access driveway containment wall blocks	LS	1	$5,000	$5,000
Perforated pipe underdrains	LF	240	$2	$480
Geotextile fabric for material separation	SY	520	$1.25	$650
Seeding on side slopes	LS	1	$400	$400
Perimeter fencing	LF	410	$15	$6,150
Subtotal				$195,400
Construction SWPPP cost (see Table 21 for detailed TESC costs)				$62,900
Subtotal construction cost				$258,300
Mobilization and demobilization (10%)				$25,800
Subtotal stormwater control BMP cost				$284,100
Contingencies (25%)				$71,000
Total construction cost				$355,100
Taxes (8.8%)				$31,200
Engineering and permitting fees for stormwater facilities (30%) (excluding basic site drainage infrastructure)				$106,530
Total cost for stormwater BMP construction				$490,000

Table 21. Cost estimate for stormwater BMP operation and maintenance -- 10-acre commercial development without infiltration.

Item	Unit	Quantity	Unit Cost	Cost
Construction SWPPP BMPs				
Regular maintenance checks on BMPs	EA	190	$20	$3,800
Water spray for dust suppression	LS	1	$500	$500
Clean out sediment buildup in pond	EA	2	$300	$600
Repair damaged sections of silt fencing	LF	260	$5	$1,300
Sediment removal in offsite catch basins	EA	3	$200	$600
Street sweeping	HR	78	$100	$7,800
Removal of BMPs at conclusion of construction	LS	1	$1,500	$1,500
Total SWPPP O&M cost (for 1 year only)				$16,100
Permanent stormwater site plan BMPs				
Annual inspection	EA	1	$100	$100
Misc. cleanup	EA	1	$50	$50
Drain and remove sediments from wet pond	EA	0.2	$1,460	$292
Mow wet/detention pond slopes	EA	2	$120	$240
Spot seeding/repair of bare areas	LS	1	$50	$50
Till surface of sand filter / replace sand	LS	0.5	$780	$390
Clean catch basins and storm drains	EA	10	$200	$2,000
Parking lot sweeping	HR	21	$100	$2,100
Subtotal permanent stormwater BMP annual O&M cost				$5,200
Contingencies (20%)				$1,000
Total annual O&M cost				$6,200

APPENDIX B

Technical Assumptions Used in Analysis of Stormwater Best Management Practices

Technical Assumptions Used in Analysis of Stormwater Best Management Practices

The technical assumptions, runoff modeling methods, and design parameters used in the analysis of stormwater BMPs for each of the three hypothetical development sites are outlined below.

Two methods were used to estimate runoff from the sites and size stormwater facilities. StormShed, which employs the Santa Barbara Urban Hydrograph (SBUH) method, was used to determine water quality treatment volumes for permanent pretreatment and water quality treatment ponds. The King County Run Time Series (KCRTS) model was used to estimate runoff peak flows for pre- and post-developed conditions, and to determine the size of stormwater detention facilities. KCRTS is a continuous simulation model that functions similarly to the Ecology Hydrologic Model, which, when released, will be WSDOE's preferred tool for stormwater analysis. The water quality sand filtration systems were sized based on treatment of the post-detention 2-year peak flow derived with KCRTS.

Rainfall data used in StormShed for analyzing stormwater runoff volumes are from SeaTac Airport (estimated from isopluvial maps). The 6-month, 24-hour precipitation depth was used to calculate water quality treatment volume, and was estimated to be 1.44 inches, or 72 percent of the 2-year precipitation depth at SeaTac Airport (2.0 inches). The cost analyses for these same site examples for the 1992 storm water manual requirements (Herrera 1993) assumed 1.28 inches for the 6-month storm depth.

The SCS curve numbers (CN) used in the StormShed runoff modeling are:

- Type A soil, residential site, pervious areas in the post-development condition CN = 80 ("good" grass cover)
- Type A soil, commercial sites, pervious areas in the post-development condition CN = 85 ("fair" grass cover)
- Type C soil, residential site, pervious areas in the post-development condition CN = 86 ("good" grass cover)
- Type C soil, commercial sites, pervious areas in the post-development condition CN = 90 ("fair" grass cover)
- Impervious surfaces on all sites CN = 98.

Curve number values listed above for Type A soils are slightly conservative. This resulted in more conservative runoff volume estimates for water quality treatment, pretreatment and infiltration pond designs.

The infiltration rate assumed for the sites with suitable soils is 1 inch per hour.

Depth to ground water is assumed to be 20 feet (below the bottom of an infiltration basin) for all sites.

Rainfall data from the SeaTac rain gauge was used in the KCRTS runoff modeling with a 1.0 scaling factor. The predevelopment ground cover for all of the sites is assumed to be 100 percent forest.

The land use categories and areas used in the KCRTS runoff modeling are:

- Type A soil, 10-acre residential site, predeveloped condition – 10-acres outwash forest.
- Type A soil, 1-acre commercial site, predeveloped condition – 1-acre outwash forest.
- Type A soil, 10-acre commercial site, predeveloped condition – 10-acres outwash forest.
- Type A soil, 10-acre residential site, during construction – 90 percent (9.0 acres) outwash grass, 10 percent (1.0 acre) impervious
- Type A soil, 10-acre residential site, developed condition with on-site storm water management BMPs – 3.3–acres drain to downspout infiltration systems, 2.1-acres impervious, 4.6-acres outwash grass.
- Type A soil, 1-acre commercial site, developed condition with on-site storm water management BMPs – 0.2-acres drain to downspout infiltration systems, 0.1-acres outwash grass, 0.7-acres impervious.
- Type A soil, 10-acre commercial site, developed condition with on-site storm water management BMPs – 2.5-acres drain to downspout infiltration systems, 6.0-acres impervious, 1.5-acres outwash grass.
- Type C soil, 10-acre residential site, predeveloped condition – 10-acres till forest.
- Type C soil, 1-acre commercial site, predeveloped condition – 1-acre till forest.
- Type C soil, 10-acre commercial site, predeveloped condition – 10-acres till forest.

- Type C soil, 10-acre residential site, during construction – 90 percent (9.0 acres) till grass, 10 percent (1.0 acre) impervious
- Type C soil, 10-acre residential site, developed condition – 1.65-acres till grass (rooftops to downspout dispersion), 1.65-acres rooftop impervious, 2.1-acres other impervious, 4.6-acres till grass (lawns).
- Type C soil, 1-acre commercial site, developed condition – 0.9-acres impervious, 0.1-acres till grass.
- Type C soil, 10-acre commercial site, developed condition – 8.5-acres impervious, 1.5-acres till grass.

Re-Analysis of 1993 Cost Examples with Infiltration Systems

This appendix provides information on the methods and results of a re-analysis of stormwater management costs for the site examples from the 1993 cost analysis report (Herrera 1993) that included runoff infiltration. That report assumed type B soils for the infiltration scenarios, whereas the present report assumes type A soils for the infiltration scenarios. To make the cost estimates as comparable as possible, the soil type must be consistent. Therefore, a decision was made to re-analyze the 1993 infiltration examples assuming type A soils. The 1992 design requirements set forth in the *Stormwater Management Manual for the Puget Sound Basin* (Ecology 1992) were applied to the three case study sites with type A soils.

This re-analysis essentially maintains consistency with all aspects of the 2001 cost analysis examples for type A soils, except the sizing of the treatment and flow control facilities is based on the 1992 requirements. The 1993 cost analysis examples for type C soils were not included in this re-analysis, as there was no need to revise the sizes and types of stormwater facilities for those examples to enable a fair cost comparison. The methods used to adjust the cost estimates for those examples to year 2001 dollars are described in the main body of this report.

Permanent Stormwater Site Plan Assumptions

It was assumed that a wetpond and infiltration basin would be used in combination to accomplish treatment and flow disposal at each of the three case study sites for the scenario with type A soils. As discussed in the present report, type A soils enable disposal of large quantities of runoff but pretreatment must be provided. The 1992 Ecology manual required full 6-month design storm treatment prior to discharge to an infiltration system using one of several options, among them a wetpond. Wetponds were assumed for all three sites to closely match the assumptions used in the 2001 cost analysis examples.

As was done in the 1993 report, it was assumed that the stormwater control facilities for the 1-acre commercial development site (Site 2) would be placed aboveground. Likewise, the wetpond and infiltration basin for each of the 10-acre site examples were assumed to be aboveground. The wetponds were sized based on the runoff volume associated with 64 percent of the 2-year 24-hour storm rainfall depth.

The infiltration basins were sized to infiltrate all site runoff up to the 100-year event, with drawdown criteria as stipulated in the 1992 manual (these criteria have not changed in the 2001 manual). The native soil infiltration rate for each of these examples was assumed to be 4 inches per hour, which is on the low end of what is typically observed in type A soils. The 1992 manual required application of a factor of safety of 2, and therefore the design infiltration rate applied in this re-analysis was 2 inches per hour for each infiltration basin. As described in Appendix B, the 2001 analyses of the infiltration examples assumed a design infiltration rate of 1 inch per hour, incorporating a factor of safety of 4 (as if the native soil infiltration rate were measured as 4 inches per hour).

Whereas the 2001 case study examples assumed that rooftop runoff would be disposed of via infiltration trenches, the re-analysis of the 1993 infiltration examples assumed that rooftop runoff would reach the wetponds and infiltration basins.

Results of the Re-analysis of Costs for Sites with Infiltration Capacity Under the 1992 Requirements

Tables C-1 through C-9 present the cost estimates for the permanent stormwater control facilities, temporary erosion and sediment control facilities, and operations and maintenance of temporary and permanent facilities for each of the three case studies in type A soils. These cost tables incorporate unit prices, contingencies, taxes, and engineering and permitting fees that are consistent with the tables for the 2001 cost analysis examples (see Tables 1 through 21 in Appendix A). Thus, the cost estimates presented in Tables C-1 through C-9 are in year 2001 dollars.

Table C-1. Cost estimate for permanent stormwater quality control facilities -- 10-acre residential development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Wet pond				
Excavation	CY	2,000	$10	$20,000
Bottom liner	SY	1,400	$10	$14,000
Liner backfill (soil or sand)	CY	470	$15	$7,050
Common borrow and gravel for access driveways	CY	40	$20	$800
Outflow structure (catch basin with debris barrier)	EA	1	$3,000	$3,000
Discharge pipe, 12" diam.	LF	50	$40	$2,000
Infiltration basin				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Basin excavation	CY	3,400	$10	$34,000
Basin liner - nonwoven geotextile	SY	2,150	$1.25	$2,688
Quarry spalls for overflow spillway	CY	7	$35	$245
Seeding	AC	0.44	$1,000	$440
Gravel for access driveway, maintenance pad	CY	41	$20	$820
Observation wells	EA	2	$200	$400
Subtotal				$95,400
ESC plan cost (see Table C-2 for detailed ESC costs)				$46,810
Subtotal construction cost				$142,210
Mobilization and demobilization (10%)				$14,221
Subtotal stormwater control BMP cost				$156,431
Contingencies (25%)				$39,108
Total construction cost				$195,540
Soils investigation for infiltration suitability (cost range $6,200 to $7,900)				$6,200
Taxes (8.8%)				$17,750
Additional engineering and permitting fees (30%)				$58,660
Total cost for stormwater BMP implementation (see Table C-3 for annual operation and maintenance costs)				$280,000

Table C-2. Cost estimate for erosion and sediment control measures -- 10-acre residential development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction roads and entrances				
4"-8" quarry spalls	CY	90	$35.00	$3,150
2"-4" crushed rock	CY	790	$20.00	$15,800
Interceptor swales				
Excavation	CY	450	$15.00	$6,750
Temporary seeding	AC	0.29	$1,000.00	$290
Check dams (pea gravel filled sandbags)	CY	1	$35.00	$35
Sediment trap				
Excavation	CY	300	$10.00	$3,000
2"-4" gravel fill for outflow weir	CY	6.5	$35.00	$228
3/4"-1.5" gravel fill for outflow weir	CY	15	$35.00	$525
4" gravel outflow protection	CY	5	$35.00	$175
Filter fabric fencing	LF	30	$5.00	$150
Sediment pond				
Excavation	CY	340	$10.00	$3,400
2"-4" gravel fill for inlet protection	CY	2	$35.00	$70
Compacted earth fill berm	CY	80	$4.00	$320
12" riser pipe for outflow (incl. conc. base)	EA	1	$400.00	$400
2" perforated drain pipe on bottom	LF	25	$1.00	$25
0.5" gravel backfill for drain pipe	CY	0.5	$30.00	$15
Filter fabric wrapping around drain pipe	SY	8	$1.25	$10
12" outflow pipe	LF	45	$10.00	$450
4" gravel outflow protection	CY	11	$35.00	$385
Filter fabric fencing	LF	50	$5.00	$250
Miscellaneous				
Mulch for bare site areas	AC	2	$800.00	$1,600
4" gravel protection for offsite diversion	CY	2	$35.00	$70
Removal of sediment BMPs	LS	1	$1,500.00	$1,500
Subtotal				$38,598
Maintenance of erosion and sediment control BMPs (see Table C-3 for details)				$8,210
Total ESC plan cost				$46,810

Table C-3. Cost estimate for stormwater BMP annual operation and maintenance -- 10-acre residential development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Erosion and sediment control plan BMPs				
Regular maintenance checks on BMPs (2/week)	EA	104	$20.00	$2,080
Rotate mulch cover on areas exposed	AC	2	$800.00	$1,600
Clean out sediment buildup in traps and ponds	EA	6	$60.00	$360
Repair damaged sections of filter fabric fencing	LF	40	$5.00	$200
Collect and dispose of sediments tracked offsite	LS	1	$2,600.00	$2,600
Subtotal erosion and sediment control BMP maintenance cost				$6,840
Contingencies (20%)				$1,368
Total ESC O&M cost (for 1 year only)				$8,210
Permanent stormwater quality control BMPs				
Mow infiltration, presettling, and detention basins	EA	2	$120.00	$240
Rake infiltration and presettling basins	EA	0.5	$780.00	$390
Clean out sediment buildup in presettling basin	EA	1	$225.00	$225
Periodically replace materials and equipment	LS	1	$250.00	$250
Clean catch basins and storm drains	EA	10	$200.00	$2,000
Street sweeping	LS	1	$2,800.00	$2,800
			subtotal	*$1,105*
Subtotal permanent stormwater control annual O&M cost				$5,905
Contingencies (20%)				$1,181
Total annual O&M cost				$7,090

Table C-4. Cost estimate for permanent stormwater quality control facilities -- 1-acre commercial development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Wet pond				
Excavation	CY	450	$10	$4,500
Bottom liner	SY	380	$10	$3,800
Liner backfill (soil or sand)	CY	130	$15	$1,950
Common borrow and gravel for access drivewa:	CY	20	$20	$400
Outflow structure (catch basin with debris barrie	EA	1	$3,000	$3,000
Discharge pipe, 12" diam.	LF	50	$40	$2,000
Infiltration basin				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Basin excavation	CY	580	$10	$5,800
Basin liner - nonwoven geotextile	SY	250	$1.25	$313
Quarry spalls for overflow spillway	CY	7	$35	$245
Seeding	AC	0.10	$1,000	$100
Gravel for access driveway, maintenance pad	CY	20	$20	$400
Observation wells	EA	2	$200	$400
Subtotal				$32,900
ESC plan cost (see Table C-5 for detailed ESC costs)				$9,020
Subtotal construction cost				$41,920
Mobilization and demobilization (10%)				$4,192
Subtotal stormwater control BMP cost				$46,112
Contingencies (25%)				$11,528
Total construction cost				$57,640
Soils investigation for infiltration suitability (cost range $3,300 to $4,500)				$3,300
Taxes (8.8%)				$5,360
Additional engineering and permitting fees (30%)				$17,290
Total cost for stormwater BMP implementation (see Table C-6 for annual operation and maintenance costs)				$84,000

Table C-5. Cost estimate for erosion and sediment control measures -- 1-acre commercial development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction roads and entrances				
4"-8" quarry spalls	CY	50	$35.00	$1,750
2"-4" crushed rock	CY	50	$20.00	$1,000
Interceptor swales				
Excavation	CY	105	$15.00	$1,575
Temporary seeding	AC	0.07	$1,000.00	$70
Sediment trap				
Excavation	CY	115	$10.00	$1,150
2"-4" gravel fill for outflow weir	CY	4	$35.00	$140
3/4"-1.5" gravel fill for outflow weir	CY	10	$35.00	$350
Baffles (4'x8'x1/2" plywood, 6' posts 8' o.c.)	LS	1	$270.00	$270
4" gravel outflow protection	CY	5	$35.00	$175
Filter fabric fencing	LF	20	$5.00	$100
Miscellaneous				
Mulch for bare site areas	AC	0.4	$800.00	$320
Removal of sediment BMPs	LS	1	$400.00	$400
Subtotal				$7,300
Maintenance of erosion and sediment control BMPs (see Table C-6 for details)				$1,720
Total ESC plan cost				$9,020

Table C-6. Cost estimate for stormwater BMP annual operation and maintenance -- 1-acre commercial development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Erosion and sediment control plan BMPs				
Regular maintenance checks on BMPs (2/week)	EA	18	$20.00	$360
Rotate mulch cover on areas exposed	AC	0.5	$800.00	$400
Clean out sediment buildup in traps and ponds	EA	2	$60.00	$120
Repair damaged sections of filter fabric fencing	LF	10	$5.00	$50
Collect and dispose of sediments tracked offsite	LS	1	$500.00	$500
Subtotal erosion and sediment control BMP maintenance cost				$1,430
Contingencies (20%)				$286
Total ESC O&M cost (for 1 year only)				$1,720
Permanent stormwater quality control BMPs				
Mow infiltration, presettling, and detention basins	EA	2	$60.00	$120
Rake infiltration and presettling basins	EA	0.5	$400.00	$200
Clean out sediment buildup in presettling basin	EA	1	$100.00	$100
Periodically replace materials and equipment	LS	1	$150.00	$150
Clean catch basin	EA	2	$200.00	$400
Parking lot sweeping	LS	1	$700.00	$700
			subtotal	*$570*
Subtotal permanent stormwater control annual O&M cost				$1,670
Contingencies (20%)				$334
Total annual O&M cost				$2,000

Table C-7. Cost estimate for permanent stormwater quality control facilities -- 10-acre commercial development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Wet pond				
Excavation	CY	2,700	$10	$27,000
Bottom liner	SY	1,740	$10	$17,400
Soil or sand backfill on bottom liner	CY	580	$15	$8,700
Common borrow and gravel for access driveways	CY	41	$20	$820
Outflow structure (catch basin with debris barrier)	EA	1	$3,000	$3,000
Discharge pipe, 12" diam.	LF	50	$40	$2,000
Infiltration basin				
Hydrogeologic evaluation for soil suitability	LS	1	$10,000	$10,000
Basin excavation	CY	4,050	$10	$40,500
Basin liner - nonwoven geotextile	SY	2,540	$1.25	$3,175
Quarry spalls for overflow spillway	CY	7	$35	$245
Seeding	AC	0.51	$1,000	$510
Gravel for access driveway, maintenance pad	CY	41	$20	$820
Observation wells	EA	3	$200	$600
Subtotal				$114,800
ESC plan cost (see Table C-8 for detailed ESC costs)				$57,450
Subtotal construction cost				$172,250
Mobilization and demobilization (10%)				$17,225
Subtotal stormwater control BMP cost				$189,475
Contingencies (25%)				$47,369
Total construction cost				$236,840
Soils investigation for infiltration suitability (cost range $6,800 to $8,500)				$6,800
Taxes (8.8%)				$21,440
Additional engineering and permitting fees (30%)				$71,050
Total cost for stormwater BMP implementation (see Table C-9 for annual operation and maintenance costs)				$340,000

Table C-8. Cost estimate for erosion and sediment control measures -- 10-acre commercial development with infiltration (1992 design standards).

Item	Unit	Quantity	Unit Cost	Cost
Stabilized construction roads and entrances				
4"-8" quarry spalls	CY	180	$35.00	$6,300
2"-4" crushed rock	CY	900	$20.00	$18,000
Interceptor swales				
Excavation	CY	830	$15.00	$12,450
Temporary seeding	AC	0.55	$1,000.00	$550
Check dams (pea gravel filled sandbags)	CY	4.2	$35.00	$147
Sediment pond				
Excavation	CY	350	$10.00	$3,500
2"-4" gravel fill for inlet protection	CY	3	$35.00	$105
Compacted earth fill berm	CY	575	$4.00	$2,300
Baffles (4'x8'x1/2" plywood, 6' posts 8' o.c.)	LS	1	$360.00	$360
12" riser pipe for outflow (incl. conc. base)	EA	1	$400.00	$400
2" perforated drain pipe on bottom	LF	35	$1.00	$35
0.5" gravel backfill for drain pipe	CY	0.6	$30.00	$18
Filter fabric wrapping around drain pipe	SY	11	$1.25	$14
12" outflow pipe	LF	45	$10.00	$450
4" gravel outflow protection	CY	11	$35.00	$385
Filter fabric fencing	LF	50	$5.00	$250
Miscellaneous				
Mulch for bare site areas	AC	2	$800.00	$1,600
4" gravel protection for offsite diversions	CY	7	$35.00	$245
Removal of sediment BMPs	LS	1	$1,500.00	$1,500
Subtotal				$48,609
Maintenance of erosion and sediment control BMPs (see Table C-9 for details)				$8,840
Total ESC plan cost				$57,450

Table C-9. Cost estimate for stormwater BMP annual operation and maintenance -- 10-acre commercial development with infiltration (1992 design standards).

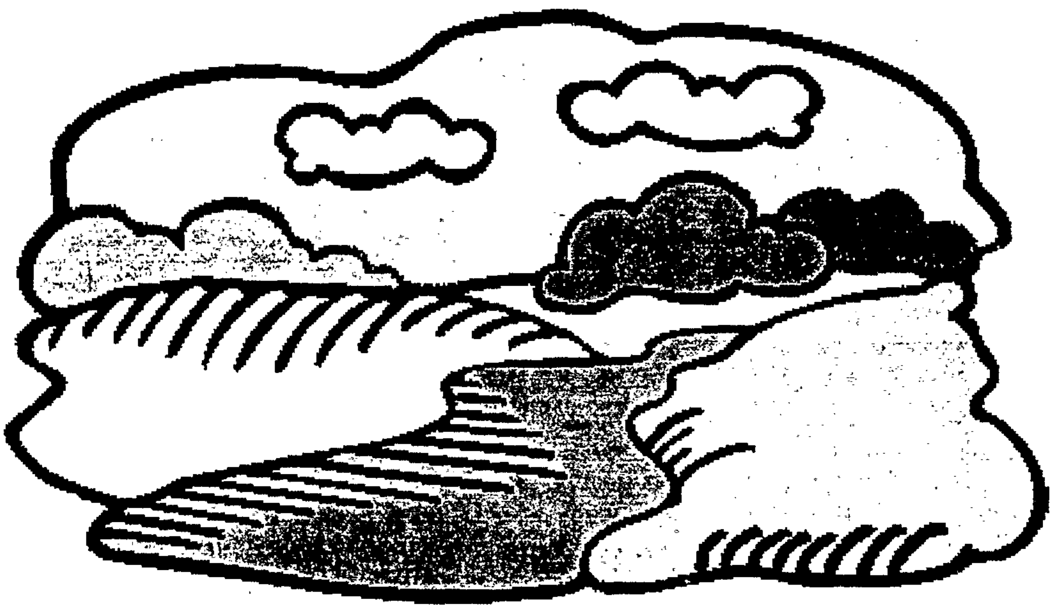
Item	Unit	Quantity	Unit Cost	Cost
Erosion and sediment control plan BMPs				
Regular maintenance checks on BMPs (2/week)	EA	104	$20.00	$2,080
Rotate mulch cover on areas exposed	AC	2	$800.00	$1,600
Clean out sediment buildup in traps and ponds	EA	6	$60.00	$360
Repair damaged sections of filter fabric fencing	LF	25	$5.00	$125
Collect and dispose of sediments tracked offsite	LS	1	$3,200.00	$3,200
Subtotal erosion and sediment control BMP maintenance cost				$7,365
Contingencies (20%)				$1,473
Total ESC O&M cost (for 1 year only)				$8,840
Permanent stormwater quality control BMPs				
Mow infiltration and presettling basins	EA	2	$120.00	$240
Rake infiltration and presettling basins	EA	0.5	$780.00	$390
Clean out sediment buildup in presettling basin	EA	1	$300.00	$300
Periodically replace materials and equipment	LS	1	$250.00	$250
Clean catch basins and storm drains	EA	10	$200.00	$2,000
Parking lot sweeping	LS	1	$2,100.00	$2,100
			subtotal	*$1,180*
Subtotal permanent stormwater control annual O&M cost				$5,280
Contingencies (20%)				$1,056
Total annual O&M cost				$6,340

APPENDIX C

Re-Analysis of 1993 Cost Examples with Infiltration Systems

The Economic Benefits of Protecting Virginia's Streams, Lakes, and Wetlands

October 2001



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R0010880

The Economic Benefits of Protecting Virginia's Streams, Lakes, and Wetlands

and

The Economic Benefits of Better Site Design in Virginia

December 2001

Prepared for:

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Technical Paper:

The Economic Benefits of Protecting Virginia's Streams, Lakes, and Wetlands

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CENTER FOR WATERSHED PROTECTION

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1.0 Introduction

In 1989, the economic importance of the Chesapeake Bay was estimated to be $678 billion per year to the economies of Virginia and Maryland through commercial fishing, marine trade, tourism, port activities, and land values (MDEED, 1989). While it is often difficult to calculate the "true" value of a waterbody or watershed, the above statistic shows that society often measures the value of these resources in terms of factors such as income from water-related activities, property values, and construction costs.

The irony of placing an economic value on water and other natural resources is that, for the most part, the services of these resources are freely available to those who wish to use it. However, human activity that has a negative impact on water resources such as dumping of toxic waste into rivers and streams, or sediment pollution downstream due to extensive land clearing upstream, also has a negative economic impact on the value of these water resources to others who wish to use them. In this case, the person creating the negative impact is transferring the cost of carrying out these activities responsibly to the general public, who will end up paying the consequences. To illustrate this externality, EPA estimated that because of urban runoff pollution, hundreds of millions of dollars are lost each year through added government expenditures, illness, or loss of economic output (USEPA, 1998). The intent of this report is to document these economic costs related to poor environmental regulation or lack thereof, as well as to document the economic benefits of implementing environmental regulations.

The Center for Watershed Protection has conducted a literature search and synthesis of potential economic benefits associated with environmental protection regulations such as stream buffer establishment, wetland protection, erosion and sediment control, floodplain protection, zoning restrictions, stormwater management (quantity and quality), forest conservation, and source water protection. This study identifies sources that illustrate land value and other benefits associated with environmental protection programs as well as possible negative economic consequences of ineffective or non-existent programs. This research is provided in support of Virginia's coastal nonpoint source stormwater management program. Therefore, sources that reference Virginia economic considerations were given preference over others. A list of references is included with this report.

2.0 Economic Benefits of Watershed Protection

The Center for Watershed Protection previously developed an approach to watershed protection that applies eight tools to protect or restore aquatic resources. These eight tools of watershed protection are: watershed planning, land conservation, aquatic buffers, better site design, erosion and sediment control, stormwater treatment practices, non-stormwater discharges, and watershed stewardship programs (see Figure 1). This report reviews the economic benefits of environmental regulations within the framework of these eight tools.

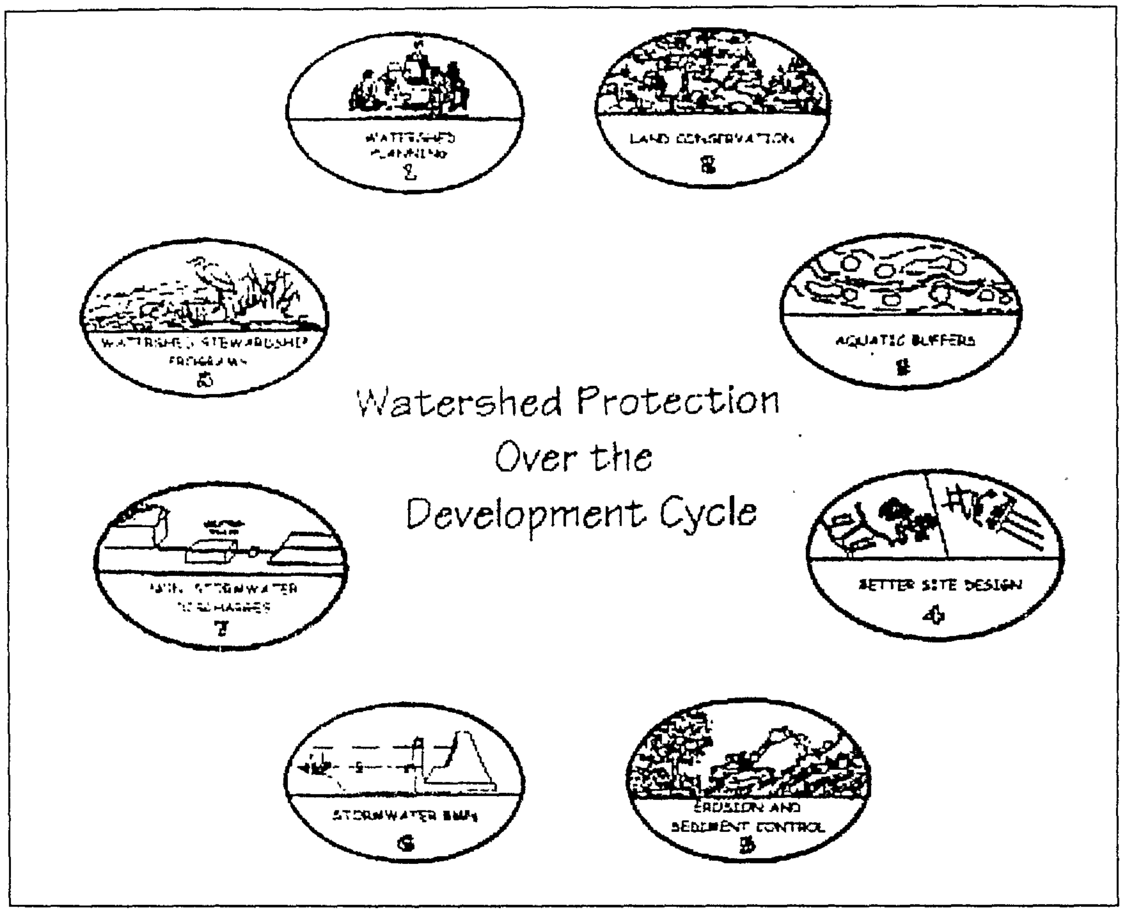


Figure 1 - The Eight Tools of Watershed Protection

The eight tools correspond roughly to the stages of the development cycle from land use planning, site design, construction and ownership. Communities can apply these tools to guide where and how new development occurs, and to design development to have the smallest possible impact on streams, lakes, wetlands and estuaries. While economic research on some of the tools is rather sparse, much of the evidence indicates that these tools can have a positive or at least neutral economic effect, when applied properly. Each tool is described in more detail in this report.

There are two types of economic benefits of implementing environmental protection regulations: income generated by economic activities which rely on water or other natural resources, and a reduction in or avoidance of costs which may result from environmental degradation and consumption of natural resources. These benefits are listed in Table 1 by the eight watershed protection tools. Environmental regulations that correspond to the watershed protection tools are listed next to each tool.

Table 1 – The Economic Benefits of Watershed Protection

Watershed Protection Tool	Economic Benefit
Watershed Planning – zoning tools, urban growth boundaries, source water protection	• Income from fisheries, agriculture, industry, and recreation and tourism • Reduction of drinking water treatment costs, health care costs, and restoration costs
Land Conservation – forest conservation, wetland protection, preservation of parks and open space	• Income from recreation and tourism and increased property values • Reduction of energy costs, health care costs, flood control and stormwater quality and quantity treatment costs
Aquatic Buffers – resource protection areas, stream buffers	• Income from fishing and increased property values • Reduction of flood control and stormwater quality and quantity treatment costs, and restoration costs
Better Site Design – cluster development, impervious cover limits	• Income from increased property values • Reduction of construction, maintenance, and infrastructure costs, as well as stormwater and flood control costs
Erosion and Sediment Control – channel protection, clearing and grading, construction site erosion and sediment control	• Income from marine and port activities and increased property values • Reduction of drinking water treatment costs, construction costs, restoration costs, and dredging costs
Stormwater Treatment Practices – **stormwater regulations, floodplain protection**	• Income from increased property values • Reduction of flood damage costs, reduction of cost of structural stormwater and flood controls
Non-Stormwater Discharges – ***point source controls, septic system regulations***	• Reduction of pollution-related health costs and restoration costs
Watershed Stewardship Programs – ***watershed education and management, monitoring, and residential, industrial and commercial pollution prevention programs***	• Income from stewardship programs • Reduction of restoration costs

The benefits listed above may be direct benefits, indirect benefits, or diversionary benefits. Direct benefits of water quality improvement include enhanced recreational water activities and reduced exposure to contaminants (USEPA, 1999). Indirect benefits include enhancement of near-stream recreational activities, or the quality of residing, working, or traveling near water (USEPA, 1999). Diversionary benefits include avoided water storage replacement costs and water treatment costs (USEPA, 1999). The remainder of this report provides a more comprehensive review of each of the above benefits and cost reductions associated with environmental regulations within the framework of the eight tools of watershed protection.

2.1 Watershed Planning

Watershed planning is perhaps the most important watershed protection tool because it involves decisions on the amount and location of development and impervious cover, and choices about appropriate land use management techniques. Land use planning techniques include overlay zoning, urban growth boundaries, down zoning, transfer of development rights, and many others. The benefit of these tools is improved water quality due to a reduced pollutant load; however, there are often costs associated with many of these land use planning techniques, such as reduced tax revenue and less economic activity. Down zoning in particular can be costly to developers, landowners, and the community because a reduction in density deprives landowners of the potential value of development. Transfer of development rights may help to offset these costs by transferring development potential from sensitive watershed areas to areas designated for growth without taking away the benefits of potential development value. The benefits of watershed planning are difficult to quantify, but are usually measured in terms of the economic benefits of improved water quality.

Stream quality is directly related to land use and consequently impervious cover. Because many land use planning elements also fall under at least one of the other watershed protection tools, this section will focus on the economic benefits of watershed planning regulations that specifically protect water quality. Good water quality has important economic benefits because it is essential for productive fisheries and water-related recreation. Improvements in water quality can also reduce drinking water treatment costs, dredging costs, pollution-related medical costs (e.g., water-bourne illness), and stream and lake restoration costs.

The U.S. economy also depends on clean water. Water used for irrigating crops and raising livestock helps American farmers produce and sell $197 billion worth of food and fiber (USEPA, 2000c). Water is equally important to industry. Manufacturers use about nine trillion gallons of fresh water every year (USEPA, 2000c). The soft drink manufacturing industry alone uses more than 12 billion gallons of water annually to produce products valued at almost $58 billion (USEPA, 2000c).

The fisheries industry is important in the U.S., and especially in the Chesapeake Bay region. The total economic value of commercial fishing in the Chesapeake Bay was estimated to be $520 million per year in 1987 dollars (MDEED, 1989). In 1999, 460 million lbs of fish valued at $108 million were landed in Virginia (NMFS, 2001). Particularly important in Virginia are oysters and blue crabs. In 1999, blue crabs brought in $21 million while the eastern oyster generated $967,000 (NMFS, 2001).

This income from fisheries can quickly decline when water quality declines. Pollutants can contaminate or suffocate fish, as well as degrade fish habitat. The EPA estimated that stormwater runoff costs the commercial fish and shellfish industries approximately $17 million to $31 million per year (USEPA, 1999). Nitrogen and phosphorus are often associated with stormwater runoff, and high levels of these nutrients have been linked to fish kills caused by the toxic dinoflagellete *pfiesteria piscicda*. According to Douglas W. Lipton, coordinator of the Maryland Sea Grant Extension Program, *pfiesteria* cost the Chesapeake Bay seafood industry $43 million in 1997, and the recreational fishing industry $4.3 million.

Water quality is just as important for recreational fishing and other water-related recreational activities such as rafting, swimming, and boating. The average estimated value of freshwater for recreational fishing and wildlife habitat in the U.S. was $48 per acre foot (Frederick, et al., *1996), while freshwater wetlands were valued at $200 per acre for recreational use (Thibodeau and Ostro, 1981). The following statistics illustrate the contribution of recreational fishing and water-related recreation to the economy.*

- A third of all Americans visit coastal areas each year, making a total of 901 million trips while spending about $44 billion (USEPA, 2000c).

- In 1996, total expenditures related to recreational salt and freshwater fishing in Virginia were $821,318 (USFWS, 1997).

- On North Carolina's Nantahala River, raft trip participants increased 700% between 1972 and 1981, and generated $1.8 million in expenditures in 1982 (Swain County Board of Commissioners, 1982).

- *A national survey determined that people were willing to pay more for a higher quality outdoor recreation opportunity (Walsh,* ét al., *1986).*

Medical costs associated with the treatment of illnesses related to water pollution may be reduced when water quality is improved. Pollution-related illness commonly occurs from direct contact with polluted water or from eating contaminated fish or seafood. The USEPA (1994) estimated the economic benefits of the Clean Water Act related to human health effects to be $40 million to $320 million in 1993 dollars. Pollution-related illness can also occur from drinking contaminated water. Currently, EPA estimates that at least half a million cases of illness annually can be attributed to microbial contamination in drinking water (USEPA, 2000c).

The costs associated with source water protection are relatively small when compared to the costs of installing a drinking water treatment plant, locating new drinking water sources, constructing new systems, and cleaning up contamination sites. Other potential costs that go along with cleaning up after a contamination incident include decreased property values, loss of tax base, loss of citizens confidence in their drinking water, public utilities, and community leaders (USEPA, 2001).

Examples of capital costs for drinking water treatment plants are $660 million for the Croton reservoir in New York and $150 million for Portland-Bull Run (cost information was obtained from the respective treatment plants). Operation and maintenance costs for these reservoirs are $11 million and $4 million per year, respectively. These reservoirs are currently unfiltered, therefore treatment costs are lower than for filtered water supplies. The estimated cost of the proposed filtration of New York City's Catskill/Delaware water supply is $4.57 billion (Aponte Clarke and Stoner, 2001).

On average, protecting water quality is less costly than restoring or treating water after it has been polluted. The average annual federal cost of reducing nonpoint source inputs of nitrogen, phosphorus, and sediment to Highland Silver Lake in southwest Illinois was estimated to be $3,000 to $9,000 per percentage point reduction in pollutant loading for non-structural practices. Compare this to the cost for structural treatment practices such as impoundments, which can be greater than $59,000 per percentage point (Setia and Magelby, 1988). Lake restoration costs can be even greater than the water quality protection practices, and will vary depending on the technique used as well as the characteristics of the lake. For example, alum addition can cost $14,000 per 100 tons, shading and sediment covers can range from $1,375 to $65,475 per acre, and plant harvesting costs on average $140 to $310 per acre (USEPA, 1990). Often, more than one technique is used to restore a body of water, which may raise these costs significantly.

2.2 Land Conservation

The second tool, land conservation, involves choices about the types of land that should be conserved to protect a watershed. Conserving forests and open space, and protecting sensitive areas such as wetlands can be accomplished through techniques such as land acquisition and conservation easements, and has an important economic value. While land conservation regulations may have associated costs related to the loss of marketable land, the benefits can greatly outweigh these costs. The conservation of trees has value for keeping energy costs down and reducing air pollution, while wetland protection can reduce flood damage and stormwater management costs. Forest and open space that is preserved as park or greenbelt can also be used for multiple types of recreation.

Properties located near these natural areas have higher real estate values, may appreciate at a faster rate, or have higher than normal resident retention rates. Studies show that people are often willing to pay more to live or work near parks or open space, and lots with trees or near a park tend to sell at a faster rate than typical lots. On average, property values have been found to increase by 5 to 33% when located near a park or greenbelt. The following studies document these findings.

- *The results of a Maryland survey show almost half the respondents said they would be inclined to move if existing open space in their commun[illegible] lost (CBP, 1998).*
- *According to a Bank of America survey, [illegible] agents say that homes with treed lots are 20% more saleable (CBP, 1998).*
- *A land developer donated a 50 foot wide [illegible] easement to provide a critical link for the Big Blue Trail in Front Royal, Virginia. Th[illegible] along the perimeter of a subdivision, and the developer advertised that the trail would [illegible] parcels, all of which sold within four months (American Hiking Society, 1990).*

- *1294-acre Pennypack Park in Philadelphia was found to account for 33% of the land value of properties located 40 feet from the park, compared to 9% of properties located 1000 feet away (CBF, 1996b; Hammer,* et al., *1974).*

- *In Boulder, Colorado, the average value of property adjacent to a greenbelt was 32% greater than properties 3200 feet away (Correll,* et al., *1978).*

- *In Salem, Oregon, urban land adjacent to a greenbelt was worth $1200 more per acre than urban land 1000 feet away (Nelson, 1986).*

- *An analysis of property surrounding four parks in Worcester, Massachusetts found that homes located 20 feet away sold for $2,675 more than similar homes located 2000 feet away from the park. This study also found that if residents were willing to pay $1 per visit to the park, the annual income of $425,000 would be greater than the annual cost to maintain the park of $125,000 (More,* et al., *1982).*

- *In the Whetstone Park area of Columbus, Ohio, a nearby park and river accounted for 7.5% of the selling prices of residential homes (Kimmel, 1985).*

- *Two regional economic surveys document that conserving forests on residential and commercial sites can enhance property values by an average of 6 to 15% and increases the rate at which units are sold or leased (Morales, 1980; Weyerhaeuser, 1989).*

Because many of these conservation areas are preserved as parks, there may be a significant amount of income generated through recreation activities such as biking, hiking, wildlife-viewing, and hunting. The following statistics illustrate the contribution of these activities to local economies.

- *The economic value of tourist activities in the Chesapeake Bay region was estimated to be $8.4 billion per year in 1987 dollars (MDEED, 1989).*

- *In 1996, total expenditures related to wildlife-watching in Virginia were $698,245 (USFWS, 1997).*

- *In 1996, total expenditures related to hunting in Virginia were $518,891 (USFWS, 1997).*

- *A survey by the U.S. Fish and Wildlife Service found that 60% of suburban residents actively engage in wildlife watching, and are willing to pay premiums for locations in settings that attract wildlife (USFWS, 1993).*

- *A national survey determined that people were willing to pay more for higher quality outdoor recreation opportunities (Walsh,* et al., *1986).*

Recreation activities involving exercise can also reduce health care costs. People who exercise regularly have 14 percent lower claims against their medical insurance, spend 30 percent fewer days in the hospital, and have 41 percent fewer claims greater than $5,000. These figures were taken from a Corporate Wellness Study for the city of San Jose, Department of Recreation in 1988 (cited in NPS, 1995). The creation of greenways and trails also reduces employees commuting costs because they provide the opportunity to commute by foot or bicycle (NPS, 1995). People are also more likely to exercise if they have convenient access to a park or greenway with trails or other type of recreation area.

Another type of cost savings that can result from tree conservation and forest preservation is reduced home heating and cooling costs. Energy savings of 10% can result by adding as little as 10% tree cover to buffers near buildings (CBP, 1998). This is because a single mature tree releases about 100 gallons of clean water per day into the atmosphere, and provides the cooling equivalent of nine room air conditioners operating at 8000 btus per hour for twelve hours a day (CBP, 1998). Studies by the American Forest Association have shown that homes and businesses that retain trees save 20% to 25% in their energy bills for heating and cooling. In some cases, trees can reduce winter heating costs by up to 40% (Newsweek, 1979).

Wetland and forest preservation is important not only to protect the diversity of wildlife and habitat there, but also because of the capacity of wetlands and forests to hold floodwaters and filter sediment and nutrients, as well as other toxicants. The cost of preserving or protecting a wetland is therefore less than the benefits gained when taking into account the cost of floodwater storage and water treatment that would otherwise be necessary if the wetland were lost. Forested areas also store floodwaters and filter sediment and nutrients, because the vegetation slows down runoff and promotes infiltration. The following studies document the economic value of wetlands and forest for flood control and water treatment.

- *The Minnesota DNR computed the average cost to replace an acre-foot of floodwater storage to be $300. Therefore, if development eliminates 1 acre of wetland that naturally stores 1 foot of water during a storm, the public replacement cost is $300. The cost to replace 5000 acres of wetlands lost annually in Minnesota would be $1.5 million (FMA, 1994)*

- The wetlands of Congaree Bottom Swamp in South Carolina provide sediment, toxicant, and excess nutrient removal. The least cost substitute for comparable water quality services provided would be a $5 million water treatment plant (FMA, 1994).

- American Forests found that from 1972 to 1996, areas with high vegetation and tree canopy coverage declined by 37% in the Puget Sound area. It is estimated that replacing this lost stormwater retention capacity with reservoirs and other engineering structures would cost $2.4 billion or $2 per cubic foot (American Forests, 1998).

- In Atlanta, Georgia, it was found that a 20% loss in trees and other vegetation in the metropolitan region provided a 4.4 billion cubic foot increase in stormwater runoff; officials estimated that at least $2 billion would be required to build containment facilities capable of storing the excess water (American Forests, as cited in US Water News, 1997).

- The estimated value of freshwater wetlands for water treatment plant function is $10,578 per acre (Thibodeau and Ostro, 1981).

2.3 Aquatic Buffers

The third watershed protection tool, aquatic buffers, involves choices on how to maintain the integrity of streams, shorelines and wetlands, and provide protection from disturbance. Stream and shoreline buffers perform a variety of functions that promote infiltration, slow runoff, store floodwaters, stabilize stream banks, provide stream surface shading, provide habitat, and filter nutrients and sediment. Unfortunately, many development projects will clear right up to the stream edge and remove protective streamside vegetation. Buffer programs preserve existing buffers and create new ones along a stream at a designated distance from the stream edge. Economic benefits resulting from establishing aquatic buffers include: increased property values, reduced flood damage and restoration costs, improved fisheries, and reduced drinking water treatment costs. The following studies document these economic benefits by category.

Property Values

- The Maryland Conservation Act encourages conservation of trees and buffers. Developers in Maryland say they are receiving 10 to 15% premiums for lots adjacent to forest and buffers (CBP, 1998).

- In one Maine case study, increased water clarity (increased visibility depth of 3 feet) due to the addition of lake buffers increased property values by $11 to $200 more per foot of shoreline property (Michael, *et al.*, 1996).

- An economic study in California showed that home prices increased on average 17% because of trees and buffers (CBP, 1998).

- Homes near seven California stream restoration projects had 3 to 13% higher property values than homes on unrestored streams. Most of the perceived value was due to enhanced buffers, habitat, and recreation afforded by the restoration (Streiner and Loomis, 1996).

- Fawn Lake, a 200 acre golf course/lake community in Spotsylvania County, Virgina, received premiums of at least $10,000 per lot for property adjacent to buffer zones or open space compared to interior lots. The total preservation area of the development was 464 acres in buffer zones and open space and these areas were successfully incorporated into the marketing strategy (Melton, 1997).

Fish Habitat

- Land clearing for development can reduce stream surface shading. Studies have shown that when stream surface shade is reduced to 35%, trout populations can drop by as much as 85% (CBP, 1998; Galli, 1991). Stream and shoreline buffers also contribute to better water quality, which means better fish habitat and therefore more productive fisheries.

Flooding

- *Retaining forest area and buffers has reduced stormwater costs in Fairfax County, VA by $57 million (CBP, 1998).*

- Observations of flood damage after major flooding in Virginia in 1994-95 showed that where forest and trees were retained in the floodplain or along streams, the damage was less extensive than in grassy or farmed areas (CBP, 1998).

Water Quality

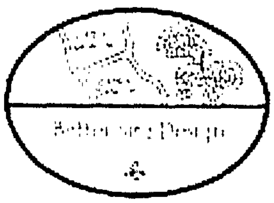
- Riparian forest buffers remove an estimated 21 lbs of nitrogen per acre per year for $0.30 per pound, compared to $3 to $5 per pound for Washington, D.C. area wastewater treatment facilities (CBP, 1998).

Stream Restoration

- *In Fairfax County, Virginia, a local bond issue provided nearly $1.5 million to restore two miles of degraded stream and riparian area (CBP, 1998). Retaining stream buffers is a much more cost-effective way to preserve the integrity of the stream and protect it from erosion and habitat degradation.*

- A summary of 15 stream restoration projects in Maryland and Illinois ranging from 500 feet to 13,200 feet in length showed costs ranging from $12,000 to $2.2 million per project (CWP, 2000b).

- Streambank restoration projects can cost up to $100,000 per linear foot for concrete channelization, compared to $100 per linear foot for vegetative methods such as reforesting the buffer area (Firehock and Doherty, 1995).



2.4 Better Site Design

Better site design is an alternative to conventional sprawl-like development that focuses on clustering development in order to preserve open space, treating stormwater for quantity and quality, and minimizing impervious cover in order to reduce impacts to local streams. Cluster developments, particularly those that permanently protect open space, are often more desirable to live in, and consequently have higher property values. Additionally, there are various cost savings associated with environmentally sensitive development, most of which are related to infrastructure, maintenance, and stormwater costs.

The proximity to a forested area, park or open space often increases property values and real estate premiums; therefore, it is to a developers' advantage to conserve trees and open space within a subdivision. Cluster developments, which use better site design techniques such as tree conservation, reduction of impervious cover, increased common open space, and minimal clearing and grading, typically keep 40 to 80% of a site in permanent community open space and yield lots that bring a higher selling price. In addition, urban forests boost property values by reducing irritating noise levels and screening adjacent land uses. These costs savings are documented with the following examples.

- Clustered homes with permanently protected open space in a development in Amherst, Massachusetts appreciated at an average annual rate of 22% compared with 19.5% for a conventional subdivision. This translated into an average difference in selling price of $17,100 in 1989, even though the conventional subdivision had larger lot sizes (Lacy, 1991).

- In Howard County, MD a cluster development with an average lot size of one acre had the same market value as a conventional subdivision with one to five acre lots (Legg Mason, 1990).

- *The Maryland Critical Areas Act and the New Jersey Pinelands land use regulations improved the tax base because the value of developed land increased by 5% to 17%, and the value of vacant land increased by 5% to 25% (Beaton, 1988; Beaton, 1991). Similar land use restrictions designed to protect the Chesapeake Bay increased property values by 14% to 27% (Fausold and Lillieholm, 1996).*

- *It was projected in 1970 that for a 760 square mile area in Maryland, uncontrolled development would yield $33.5 million in land sales and development profits by 1980. Open space development would yield $40.5 million, yielding $2300 more per acre (Caputo, 1979).*

What many developers do not realize is that using better site techniques can actually cost less than conventional design. However, in cases where the use of better site design techniques creates additional construction costs, these costs are usually offset by increased revenues and higher than normal resident retention rates (CBP, 1998). The following studies document the decrease in infrastructure and maintenance costs associated with better site design.

- *For a medium density residential site in Stafford County, Virginia, using better site design techniques saved $300,547 compared to a conventional design due to reduced infrastructure and stormwater costs (CWP, 1998).*

- *An assessment of better site design techniques in Virginia found that for three residential case studies, better site design cost from 14.5 to 49% less than conventional development, due to reduced infrastructure costs (CWP, 2000).*

- *A Prince William County, Virginia report in 1998 estimated that each new sprawl-designed home costs that locality $1600 more than is returned in taxes and other revenues (CBF, 2000).*

- *Suffolk, Virginia estimates that each new single-family home costs the increasingly spread-out city $7000 in capital for infrastructure and services (CBF, 2000).*

- *A 1986 American Farmland Trust study determined that school transportation costs for a 1,000 unit development at 1 dwelling unit per acre in Virginia's Loudon County would be over 5.5 times greater than the same number of units at 4.5 dwelling units per acre (American Farmland Trust, 1986).*

- *Case studies of developments in New York [illegible] and North Carolina showed that corporate land owners can save $270 to $640 per acre in [illegible] mowing and maintenance costs when open lands are managed as a natural buffer area rather [illegible] WHEC, 1992).*

- *The 1988 public costs for maintaining op[illegible] Boulder, Colorado were $2425 to $3125 less than maintaining developed land (Crain, 198[illegible]*

- *Tax revenue spent on county services in [illegible] County, Virginia in 1987 was 6.6 times greater for residential land uses than for industrial, commercial, farm, forest, or open lands. The same study showed that the average new residential unit in Culpeper County can be expected to produce a deficit* *in the county budget of $1242 (1988 dollars) because the public service costs exceed the revenue (Vance and Larson, 1988).*

- *A study by the Chesapeake Bay Foundation (1996a) derived cost estimates for two development scenarios for Remlick Farm Hall that result in equivalent yield to the developer. In the conventional scenario, the farm is subdivided into 84 large-lot units, whereas in the open space scenario, 52 higher-end units are located on smaller lots in three clusters. Over 85% of the site is retained in open space, as farmland, forest or wetland. The authors compute net development savings of over $600,000 for this 490-acre cluster development (50% lower than the conventional scenario). Most of the savings are attributed to lower infrastructure costs (CBF, 1996a).*

- *Cluster development can reduce the capital cost of subdivision development by 10 to 33%, primarily by reducing the length of the infrastructure needed to serve the development (NAHB, 1986; Maryland Office of Planning, 1989; Schueler, 1995).*

- *Better site design can also reduce the need to clear and grade 35% to 60% of total site area. Since the total cost to clear, grade, and install erosion control practices can range up to $5,000 per acre, reduced clearing can be a significant cost savings to builders (Schueler, 1995).*

Much of the reduction in capital costs can be attributed to a reduction in impervious cover. According to Schueler (1997), potential savings related to impervious cover reduction include:

- *$150 for each linear foot of road that is shortened*

- *$25 to $50 for each linear foot of roadway that is narrowed*

- *$10 for each linear foot of sidewalk that is eliminated*

- *$1,100 of construction cost per space that is eliminated in a commercial parking lot, with a lifetime savings in the range of $5,000 to $7,000 per space when future parking lot maintenance is considered*

Better site design can reduce site impervious cover from 10% to 50% (depending on the original lot size and layout), thereby also lowering the cost for both stormwater conveyance and treatment (Schueler, 1997). This cost savings can be considerable, as the cost to treat the quality and quantity of stormwater from a single impervious acre can range from $30,000 to $50,000 (CWP, 1997). Additionally, the use of non-structural methods of stormwater conveyance and treatment such as grass channels, swales, bioretention areas, and site grading, is typically less expensive than conventional stormwater techniques. Some examples are cited below:

- *Liptan and Brown (1996) documented two commercial/industrial case studies in Oregon where the use of bioretention and swales reduced the size and cost of conventional storm drains for stormwater requirements. Total savings per project ranged from $10,000 to $78,000 (Liptan and Brown, 1996).*

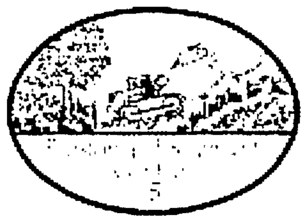
- *In the same study, Liptan and Brown (1996) found that the use of open space design techniques at a residential develoment in Davis, California provided an estimated infrastructure construction cost savings of $800 per home (Liptan and Davis, 1996).*

- *The Oregon Museum of Science and Industry in Portland saved $78,000 by using vegetated swales instead of conventional stormwater management to convey and treat runoff (Lehner,* et al., *1999).*

- *Developers of Prairie Crossing in Grayslake, Illinois saved $2.7 million by using swales, prairie, and wetlands for stormwater conveyance and treatment, and eliminating curb and gutter (Lehner,* et al., *1999).*

- *Curb and gutter costs $40 to $50 per running foot, which is 2-3 times more than an engineered swale (SMBIA, 1990; CWP, 1998).*

2.5 Erosion and Sediment Control



Erosion and sediment control deals primarily with the clearing and grading stage in the development cycle when runoff can carry high quantities of sediment into nearby waterways. Sediment is the most common pollutant affecting U.S. waters (USEPA, 2000b). Sediment pollution and deposition impacts navigable waterways and raises drinking water treatment costs, while shoreline and bank erosion can erode property and destroy fish habitat. Therefore, the control of erosion at its source through construction site erosion and sediment controls, channel protection, and clearing and grading restrictions can increase property values, as well as reduce drinking water treatment costs, stream and lake restoration costs, and dredging costs.

A 1998 analysis of the Phase II Stormwater Rule showed that the annual estimated gross federal benefits for construction site erosion and sediment controls as well as post-construction controls were comparable to the costs of these erosion and sediment controls (USEPA, 1999). However, the benefits to the developer may be even greater. For example, reducing the amount of clearing and grading on a site can save money (as well as trees) in the long run, since the cost to clear, grade, and install erosion control devices can range up to $5,000 per acre (DEDNREC, 1997).

Water resources are essential to the operation of the marine industry. Erosion and sediment control may ultimately decrease the amount of dredging needed to keep these waterways cleared for boat traffic. It costs $10 to $11.5 million annually to dredge and dispose sediments deposited into Baltimore Harbor to keep it navigable (CBP, 1998). Listed below are some facts documenting the economic benefits of marine and port activities on local economies:

- The economic impact of port activity in the Chesapeake Bay (from 3 major ports, Baltimore, Norfolk, and Newport News) was estimated to be $5.3 billion per year in 1987 (MDEED, 1989).

- The economic impact of the shipbuilding and repair industry in the Chesapeake Bay region was estimated to be $17.3 billion per year in 1987 dollars (MDEED, 1989).

- Frederick, *et al.* (1996) estimated the average value of freshwater for navigation to be $146 per acre foot for the entire U.S.

Dredging is necessary not only in navigable waterways, but also in drinking water reservoirs that lose capacity with excess sediment deposition. Because a major function of drinking water treatment plants is to remove sediment, it stands to reason that the more sediment in the intake water, the more effort will have to be expended to remove the sediment and ultimately dispose of it. Therefore erosion and sediment control regulations can prevent an increase in drinking water treatment costs.

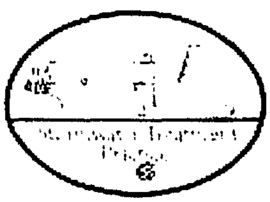
To illustrate the costs of sediment pollution, the following example computes the sediment loading to a downstream reservoir during one year from active construction on a 100 acre mixed use site. The Simple Method (Schueler, 1987) was used to calculate the sediment load in pounds per year from the construction site, assuming 40 inches of annual rainfall, 0.9 effective precipitation value, a runoff coefficient of 0.5 for the construction site, and an event mean concentration (EMC) of 15,000 mg/L (taken from Owens, *et al.*, 2000). Using 100 pounds per cubic foot as the dry density of the sediment, the volume of sediment entering the reservoir during one year was determined to be 2,267 cubic yards. Assuming a cost of $20 per cubic yard for dredging, transport, and disposal of the material, the annual cost would be $45,340 to remove the sediment generated from one source alone. When other sources of sediment to the reservoir are accounted for, this cost will rise significantly.

Shoreline and bank erosion eats away at property values as well as the shoreline. The economic benefits of erosion and sediment control are illustrated with the following studies.

- A study in the Lake Erie, Ohio area used the hedonic price method[1] to predict that an erosion control device lasting 8 years would raise property values by $5,500, and one lasting 20 years would raise property values $11,000 (Kreisel, *et al.*, 1993).

- Using hedonic price indices, Van deVerg and Lent determined that property values for Chesapeake Bay shoreline homes in Maryland would decline on average $3,474 per annual foot of erosion (Van deVerg and Lent, 1994).

2.6 Stormwater Treatment Practices



The sixth tool, stormwater treatment practices, involves choices about how, when, and where to provide stormwater management within a watershed, and which combination of management practices can best meet watershed objectives. Stormwater regulations that are designed to prevent flooding or reduce damages from flooding have measurable economic benefits. Not only are the costs of flood damage reduced or in some cases eliminated, but non-structural controls such as floodplain protection also reduce the need for structural stormwater controls of these larger storms. Effective stormwater management that reduces flood risk may also increase the property values of nearby homes. Stormwater treatment practices also improve water quality, and these benefits are discussed under the first watershed protection tool, watershed planning.

[1] The hedonic price index is a statistical method for determining the prices of the individual attributes of properties. .

Flood damages can be extensive, particularly in areas where there are no regulations regarding development in the floodplain. From 1990-1999, flooding was the most frequently reported disaster in the U.S., and according to FEMA more than $7.3 billion was committed by FEMA for flood damages (FEMA, 2001). Conversely, FEMA placed a value of $800 million on the amount communities are collectively saving on an annual basis through the National Flood Insurance Program by adopting and enforcing responsible floodplain management and regulating new development in flood hazard areas (FEMA, 1999). The following studies document the economic impacts of flooding and flood control.

- *The so-called 'Grandfather' of water resources management, Gilbert White estimated in 1958 that for every six dollars in potential damages reduced each year by new flood protection measures, at least five dollars in additional damage resulted from development in floodplains. Flooding accounts for larger annual property losses than any other single geophysical hazard (Riley, 1985).*

- *At a cost of $27 million, Baltimore County acquired 100 homes and cleared the 100 year floodplain in eight of its most critical watersheds, saving $85 million in local storm damage assistance costs over 5 years (Caputo, 1979).*

- *A national study of ten programs that diverted development away from flood-prone areas found that land next to protected floodplains increased in value by an average of $10,427 per acre (Burby, 1988).*

The total gross benefits of the Phase II Stormwater Rule were estimated to be between $671.5 million and $1.10 billion per year, compared to total annual costs of $847.6 million to 981.3 million (USEPA, 1999). The benefits included reduced damages from flooding, as well as increased property values. Property values can increase from reduced flood risk as well as residents desire to live near water features such as stormwater ponds. The following studies document residents' preference to live near urban runoff controls as well as the real estate premiums paid for this privilege.

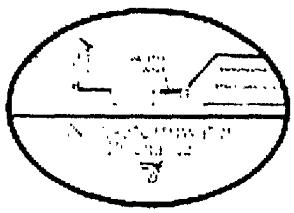
- *A survey of 143 residents in Champaign-Urbana, Illinois found 82.3% of residents were willing to pay a premium to be located next to a wet pond. Overall, the respondents believed lots adjacent to wet ponds were worth on average 21.9% more than non-adjacent lots in the same subdivision (Emmerling-DiNovo, 1995).*

- *In 1982 the National Institute for Urban Wildlife surveyed 600 homeowners in Columbia, Maryland. 75% of homeowners expressed a preference for lots near wet basins, and felt the pond presence increased property values. 73% of respondents were willing to pay more to live in an area with a detention basin designed to enhance fish and wildlife use. The same survey found that developments with wet ponds have higher initial costs, but these costs are recovered by a faster sales rate (Adams,* et al., *1986).*

- *An EPA study of several developments in Virginia showed that real estate premiums for property fronting urban runoff controls averaged up to $7,500 per unit for condominiums, up to $10,000 per unit for townhomes, up to $49,000 per unit for single family homes, up to $10 per month per apartment rental, and up to $1 per square foot for commercial rentals (USEPA, 1995).*

- *Chancery on the Lake, a condominium development in Alexandria, Virginia is a residential project with an attractive 14-acre urban runoff detention area. The wet pond is the focal point of the* *development, and is surrounded by a walking trail and will be used for fishing. Condominiums that front the lake are selling at a $7,500 premium (Harden, 1995).*

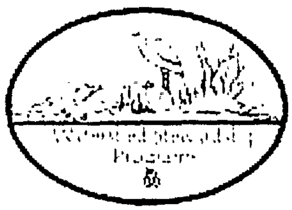
- *In Fairfax County, Virginia, the townhouse community of Pinewood Lakes has been selling waterfront townhomes at a premium for 23 years. The average sales price of a waterfront townhome is $6,117 more than a similar home without a view of the constructed pond (Wade, 1995).*
- *A townhouse community in Tysons Corner, Virginia called Evans Mills is built around an existing pond. In 1994, the waterfront homes sold for an average $17,467 premium above the average price of homes not facing the pond (Wade, 1995).*
- *Franklin Farms, a single family home residential neighborhood in northern Virginia has a 5-acre urban runoff detention area surrounded by a walking path. Waterfront homes in this development sold for 10 to 20 % more initially and again at resale than land with no water view (Downham, 1995).*



2.7 Non-Stormwater Discharges

The seventh tool, non-stormwater discharges, involves choices on how to control discharges from wastewater disposal systems, illicit connections to stormwater systems, discharges from failing septic systems, and reducing pollution from household and industrial products. The EPA estimated the annual benefits of current water quality levels relative to what they would have been without water pollution control programs, particularly the Clean Water Act. This benefit was estimated to be $11 billion annually (USEPA, 2000).

One type of non-stormwater discharge is septic system effluent. In areas outside water and sewer service areas, septic systems are used to treat wastewater. In order to be effective, septic systems must have appropriate drainage area and soils as well as be maintained regularly. There are costs associated with failing septic systems. A failed or failing septic system can decrease property values, delay the issuance of building permits, or hold up the purchase settlement (NSFC, 1995). In the event a septic system fails, homeowners can expect to pay from $3,000 to $10,000 for replacement (Schueler, 1997).



2.8 Watershed Stewardship

The final tool, watershed stewardship programs, involves careful choices about how to promote private and public stewardship to sustain watershed management. Many communities now invest in programs of watershed education, public participation in watershed management, monitoring, inspection of treatment systems, low input lawn care, household hazardous waste collection, or industrial and commercial pollution prevention programs. The common theme running through each program is education, and although this is somewhat difficult to put a price on, some examples are listed below.

- The Chesapeake Bay Restoration fund reports revenues of $341,811 in the year 2000 from donations, while sales of bay plates have climbed to $1 million per year.

- The Mattaponi and Pamunkey Rivers Association in Virginia reports they receive over 3,000 volunteer hours annually for water quality monitoring, trash cleanup, and community education. Assuming public works employees were paid $15/hour for the same work, this results in a savings of over $45,000 per year just from one organization's efforts. There are currently over 300 watershed organizations in the Chesapeake Bay watershed alone.

- The Alliance for the Chesapeake Bay reports they currently have 145 volunteers who perform weekly water quality monitoring, which allows the paid staff to address other critical issues.

- The Chesapeake Bay Foundation reports an estimated 300,000 volunteer hours per year bay-wide for projects such as bay restoration and cleanup. They estimate this benefit to be worth $3 million annually based on a rate of $10 per hour of work.

- Education about lawn care practices has an associated cost reduction. In 1981 the city of Plano, Texas, instituted a program that encouraged residents to leave clippings on home lawns to provide nutrients and moisture. Knopp and Whitney (1989) reported that the city saved $60,000 in disposal costs the first year, even though the number of households served increased 12% over the same period. Residents participating in the program saved $22,000 in leaf/lawn bag purchases (Knopp and Whitney, 1989).

- In Seattle, an education program encouraged urban citizens to compost yard and food wastes. About 5,300 tons of yard waste were removed from disposal annually, for a net savings of $378,000 (EPA, 1991).

- Raup and Smith (1986) reported that integrated pest management (IPM) reduced community pest management costs by 22%, even though more pests were controlled under the new program. The use of expensive chemicals to control weeds can also be substantially reduced.

- Conserving native vegetation results in significant costs savings for maintenance. Americans spend over $7.5 billion each year on lawn care products to maintain turf lawns (CWP, 1998). Native vegetation is usually low-maintenance and is better adapted to climatic changes and pests, therefore does not require the use of fertilizer or constant watering that is characteristic of the turf lawn (CWP, 1998).

3.0 Conclusions

Environmental regulations cost money to implement. However, the related benefits and savings can be equal to or greater than the costs. This report documents the economic benefits of specific environmental regulations including: floodplain, water quality, conservation area protection, buffers, erosion and sediment control, and zoning regulations. The numerous sources of references in this report identify several types of economic benefits resulting from these regulations. These benefits include increased property values, income from fisheries, recreation, tourism, and the marine industry, as well as savings or avoidance of costs related to flood damage, stormwater treatment, construction, infrastructure and maintenance, drinking water treatment, home heating and cooling, medical treatment, and stream/lake restoration. These economic benefits, combined with the other, immeasurable benefits of preserving forests, and protecting habitat, biodiversity and natural resources, makes the decision to establish environmental regulations a justifiable and responsible approach to protecting water resources and the environment in general.

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Technical Paper:

The Economic Benefits of Better Site Design in Virginia

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The Economic Benefits of Better Site Design In Virginia

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Many Virginia communities are currently struggling with the issue of balancing economic growth with protection of their natural resources and water quality. The rise in impervious cover associated with new development affects local water resources by reducing the infiltration of rainfall and increasing the volumes of stormwater runoff that eventually enter local waterbodies. One strategy for minimizing the effects of this additional runoff is through a variety of development strategies collectively known as "better site design".

Better site design is a process by which local governments review and modify their zoning codes and ordinances to permit new site development practices that preserve more pervious areas and lessen environmental impacts. These better site design practices allow communities to continue to realize the economic benefits of new development while improving their ability to protect the local environment . At the heart of the better site design process is a set of Model Development Principles that focus on the design of streets, parking lots, and site lots in new developments. Recently, 16 Model Development Principles were reviewed and endorsed by the Virginia Chesapeake Bay Local Assistance Department as conducive to addressing the general performance criteria of the Chesapeake Bay Preservation Act. Table 1 provides a summary of the sixteen principles applicable to the Chesapeake Bay Preservation Act.

The application of the better site design principles can help developers and local governments recognize increased economic benefits through reduced infrastructure requirements, decreased need for clearing and grading of sites, and less expenditure to meet stormwater management requirements due to reduced runoff volumes and nutrient export from a site. The following are examples of the economic benefits that Virginia communities can gain through the encouragement of better site design practices:

- For a 45 acre medium density residential site in Stafford County, Virginia, using better site design techniques would have saved $300,547 compared to a more conventional design due to reduced infrastructure and stormwater costs (CWP, 1998b).
- Studies have found that construction savings can be as much as 66% by using the open space designs encouraged by better site design (CWP, 1998a).
- Better site design can also reduce the need to clear and grade 35% to 60% of total site area. Since the total cost to clear, grade, and install erosion control practices can range up to $5,000 per acre, reduced clearing can be a significant cost savings to builders (Schueler, 1995).
- A summary of 40 years of fiscal impact studies showed that smart growth consumes 45% less land, costs 25% less for roads, 15% less for utilities 5% less for housing, and costs 2% less for other fiscal impacts than current trends of sprawl development. (Burchell and Listokin, 1995).

A 1990 study for the city of Virginia Beach compared the costs and benefits of conventional and smart growth development patterns. The study found that the smart growth pattern resulted in 45% more land preserved, 45% less in infrastructure costs to the city, and a 50% reduction in impervious surface due to roads (Siemon, Larsen and Purdy, et al., 1990).

Table 1. Virginia Model Development Principles

Conservation of Natural Areas

1. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas to promote natural vegetation.
2. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

Lot Development

3. Promote open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.
4. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.
5. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.
6. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

Residential Streets and Parking Lots

7. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.
8. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.
9. Residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.
10. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
11. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.
12. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.
13. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.
14. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in the spillover parking areas where possible.
15. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.
16. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

To illustrate the economic advantages of better site design, a comparison of four development projects in Virginia that have applied a number of the Model Development Principles was recently conducted. Table 2 provides a short summary of the environmental cost benefits realized for the four projects reviewed. For a more complete description of each case study, consult the publication "Better Site Design: An Assessment of the Better Site Design Principles for Communities Implementing the Chesapeake Bay Preservation Act" available from the Center for Watershed Protection or from the Virginia Chesapeake Bay Local Assistance Department.

The assessment of Model Development Principle application in Virginia found that for the three residential case studies, the use of better site design could save up to 49% in total infrastructure costs compared to conventional development (CWP, 2000). Estimated total infrastructure costs include the costs of roads, gutters, sidewalks, landscaping, and stormwater management best management practices. In all three cases, the designs incorporating the Model Development Principles saved the developers more than $200,000 in infrastructure costs, while producing the same number of housing units. In addition, other more intangible economic benefits that may be derived from the use of better site design practices are not included in the case studies. These may include reduced heating and cooling costs for homeowners from tree preservation, decreases in flooding incidence and associated damage, and improved pollutant removal from the filtering action of forest and stream buffer areas. For a more detailed summary, consult "The Economic Benefits of Protecting Virginia's Streams, Lakes, and Wetlands" prepared for the Virginia Department of Conservation and Recreation by the Center for Watershed Protection.

Table 2. Benefits of Better Site Design vs. Conventional Development - 4 Virginia Studies

Case Study	Percent of Natural Areas Conserved	Percent Reduction in Impervious Cover	Percent Reduction in Stormwater Impacts			Percent Reduction in Total Infrastructure Costs
			Runoff	N Load	P Load	
Fields at Cold Harbor Hanover County	80.4	25.3	12.2	6.4	6.4	47.2
Governor's Land, James City County	49.3	21.7	14.3	17.5	17.3	14.5
Rivergate, Alexandria	0*	32	30	25	28	49
The Arboretum III, Chesterfield County	5.1	12	19.7	36	37.1	N/C

* - Open space area is maintained as landscaped parkland.
N/C - Not Calculated.

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Conclusion

Better site design is an alternative to conventional development that focuses on preserving open space as natural areas and minimizing impervious cover in order to reduce the impacts of stormwater runoff on local streams. Studies have found that developments that permanently protect open space are often more desirable to live in, and consequently have higher property values (CWP, 1998a). Table 3 illustrates the cost savings for both local governments and developers associated with using better site design, most of which are related to infrastructure, maintenance, and stormwater costs.

As the case studies show, using better site design not only saves money, but provides significant reductions in nutrient export, especially at higher densities. Adoption of the Model Development Principles by Virginia communities will help protect local water quality while permitting the new development necessary for local governments to fund community services and protect watersheds.

Table 3. Burchell (1992-1997) Savings Due to Compact Growth Patterns

Area of Impact	Lexington, KY and Delaware Estuary	Michigan	South Carolina	New Jersey
Infrastructure Roads	14.8-19.7	12.4	12	26
Utilities	6.7-8.2	13.7	13	8
Developable Land Preservation	20.5-24.2	15.5	15	6
Agricultural Land Preservation	18-29	17.4	18	39

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U.S. Metro Economies

The Engines of America's Growth

PREPARED FOR:

The United States Conference of Mayors

PREPARED BY:

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THE UNITED STATES CONFERENCE OF MAYORS

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PRESS RELEASES

IMMEDIATE RELEASE
July 10, 2001

Conference of Mayors President Launches Nationwide "Competitive Cities Tour"

Releases New Report Showing Many U.S. Metro Areas Outpace States, Even Nations, in Economic Output

Washington, DC -- Today, delivering the keynote address at a National Press Club luncheon, Conference President and New Orleans Mayor Marc H. Morial announced a nationwide "Competitive Cities" tour dramatizing the renaissance of America's cities during the 1990s. To set the stage for the tour, Morial released data from a new report showing that America's cities drive the national economy, and outpace states, and even nations, in economic output.

Download the Full Transcript of the Speech

Download the Full Report and Charts

Metro Economies: A Decade of Prosperity

"The new data we are releasing today makes it clear that metropolitan economies are the engines of America's growth and driving America's economy," Morial said in releasing the report. "Metro regions are growing, producing more, and creating unprecedented levels of employment."

The data is part of the fourth annual report, entitled "U.S. Metro Economies: A Decade of Prosperity." Compiled by Standard & Poor's DRI, the report documents the Gross Metropolitan Product (GMP) of the nation's 319 largest metro areas, and shows improved economic vitality for the nation's metro regions. (Gross Metropolitan Product is a concept analogous to Gross Domestic Product, the commonly accepted measure nations use to calculate the total annual value of goods and services they have produced.)

This report describes the scope of metro areas, their vital contribution to the nation's economy, the level of income creation by metro areas, generation of new industries by metro areas, and the relationship between metro areas and the nation's overall economic growth. The report also ranks U. S. metro areas relative to themselves, states and national economies around the world. Among the key findings of the 2001 report:

International

- In 2000, U.S. Metro areas retained their leadership status in the world economy—if treated as nations, U.S. metro areas would comprise 47 of the world's largest economies.

- New York now ranks as the 14^{th} largest economy in the world, compared to last year's ranking of 16^{th}; Los Angles moved from 17^{th} to 16^{th}; and Chicago moved from 19^{th} to 18^{th} in world ranking; Boston moved from 24^{th} to 23^{rd}. The New York metro area had more economic output than Australia; Los Angeles more than the Netherlands; Chicago more than Taiwan, Argentina, Russia, or Switzerland; Boston more than Belgium, Sweden or Turkey; Philadelphia and Houston more than Hong Kong.

- If the five largest U.S. metro areas were treated as a single country, it would rank as the fourth largest economy in the world ($1.59 trillion), trailing only the U.S., Japan and Germany.

National

- The combined gross economic output of the top ten U.S. metro areas in 2000 was $2.43 trillion—an amount greater than the combined economic output of 31 states ($2.39 trillion).
- In 2000, U.S. metro areas contributed to the U.S. economy 84 percent of employment (111 million jobs); 85 percent of Gross Domestic Product ($8.476 trillion); and 88 percent of labor income ($4.22 trillion).
- Over the past decade, the majority of new jobs in the financial services and transportation and utilities sectors were created within cities: 88 percent, or 804,000 jobs in financial services, and 90 percent, or 1.116 million jobs in transportation and utilities.

The 1990s

- U.S. metro areas' contribution to Gross Domestic Product grew from 84.3 percent in 1990 to 84.7 percent in 2000 and is forecast to increase steadily over the next 25 years, reaching 86.9 percent in 2025.
- U.S. metro areas contributed an astounding 86 percent, or $3.66 trillion, of economic growth to the U.S. economy during the 1990s—an amount larger than the 2000 gross domestic product of Germany and the United Kingdom combined.
- Las Vegas (10.3%), Austin (9.8%), Boise (9.4%), Laredo (9.4%) and Phoenix (9.2%) had the fastest average annual growth rate for gross metropolitan product in the 1990s.

Mayors believe national and international economic policies must focus on the needs of the 319 economically potent metropolitan regions surveyed in the report. "We believe that the data we've seen sustain our call to the Congress and the Administration to support local and metropolitan economic growth by investing in transportation, distressed communities, and education and training," Morial said.

__Nationwide Competitive Cities Tour__

Mayor Morial also announced a nationwide "Competitive Cities Tour" to promote America's metro areas as competitive powerhouses in the national and international economic arenas.

The tour, scheduled to begin in September, will highlight the best practices and strategies employed by Mayors across the country to foster what Mayor Morial calls the *six keys to keeping cities competitive:*

- Safe streets and communities;
- A skilled workforce;
- The arts, as both a cultural/educational and economic force in communities;
- Strong infrastructure;
- Good, affordable housing; and
- Strong economies.

"America's cities are cultural destinations for people around the world," Morial said in his address. "Cities are economic powerhouses. You may not see it, but every day, in cities across the nation, Mayors are working to forge partnerships on the national and international economic stages. What does it mean when the City of Denver opens trade offices in London and China, or negotiates with airlines for international non-stop flights bringing tourism and business travel into the city? Or when the Mayor of Akron brokers an agreement which locates a German business in that city, bringing with it 70 new jobs and millions of dollars annually in economic output?

"It might mean, if you really think about it, that there are a number of Mayors in this country who are taking their rightful places as world economic leaders. Because of their economic clout, in the coming years you will see mayors leading trade delegations as much if not more so than governors. Institutions involved in promoting trade, such as the Commerce Department, will have to reinvent themselves to think metro economies, not states." Morial continued." If this nationwide tour of America's Competitive Cities accomplishes one goal, I hope that it's to secure our cities' rightful place in the dialogue on national and international economic issues and development."

Copies of the report, charts, graphs and accompanying data and information, as well as the full text of Mayor Morial's address, will be posted on the Conference's website, www.usmayors.org, as of 2:00pm EST on Tuesday, July 10.

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PRESS RELEASES HOMEPAGE

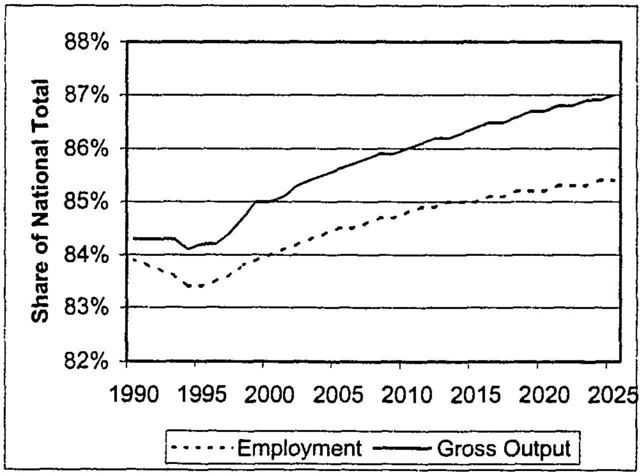
The Role of Metropolitan Areas in the National Economy

As the focal points of economic activity, metropolitan areas are vital to the nation's economic development. While states are defined by geographic and political boundaries, metro areas are shaped by economic activity, sometimes across state or national borders. The concentration of people and business in metro areas creates unique economic conditions that give rise to new industries, speed the diffusion of knowledge, spur technological innovation, and increase productivity. The economic dynamism and creativity found in metro areas enables American industries to thrive in global competition. Historically, most of the largest U.S. industries began in cities, where access to labor, capital, and customers fostered business development. Today, metro areas generate more than 80% of the nation's employment, income, and production of goods and services.

1 The Recent Performance of Metropolitan Area Economies

The contribution of metro areas to the national economy has increased over the last decade, a trend that is expected to continue over the next twenty-five years. Metro area employment increased from 92.1 million in 1990 to 110.8 million in 2000, growing at a 1.9% annual rate over the decade. In 2000, metro area employment posted a solid 2.6% gain. The share of employment in metro areas fell slightly in the first half of the 1990s before rebounding to a new high of 84.0% last year.

Figure 1 - The Contribution of Metro Areas to the National Economy Will Continue to Grow



Gross metropolitan product, the value of goods and services produced in metro areas, increased from $4.812 trillion in 1990 to $8.476 trillion in 2000, an average gain of 5.8%

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annually. After adjusting for inflation, this represented an annual growth rate of 3.5%. The share of the nation's output produced in metro areas advanced from 84.3% at the beginning of the decade to 84.7% in 2000. DRI-WEFA projects that the contribution of metro areas to U.S. gross domestic product will increase steadily over the next 25 years, reaching 86.9% by 2025.

Metro area economies now compare even more favorably with international economies than they did a decade ago. The ranking of New York City's gross metro product among international economies rose from 21st in 1990 to 14th last year; its economy is now ranked ahead of Australia's. The economy of the Washington, D.C. metro area ranks 27th, up from 35th in 1990, and ahead of Austria and Hong Kong; the gross product of the Dallas metro area surpassed Denmark, Saudi Arabia, and Thailand on its rise from 47th to 35th. Denver's ranking increased from 77th to 60th, as it's GDP grew to exceed those of Malaysia and the Philippines.

Many other key indicators of the contribution of metro areas to the national economy have also increased steadily. Metro area employment in the financial services and transportation, communications, and utilities sectors, which are two of the nation's highest value-added industries, grew 1.3% and 2.0% annually, respectively, from 1990 to 2000. Metro area business services payrolls rose 6.8% annually. Following the national pattern, high-tech employment in metro areas declined from 1990 to 1993 in response to defense spending reductions. In the second half of the 1990s, high-tech employment surged 5.4% annually, lifting its ten-year growth rate to 2.6%. Metro area per capita income increased by 4.4% over the last decade, a gain of over $3,100. After accounting for inflation, this represented a real gain of 2.1% annually.

2 The Contribution of Metropolitan Areas to the National Economy

2.1 The Scope of Metro Area Economies

The size of metro area economies illustrates their importance to the nation. If they were counted as a single country, the gross product of the five largest U.S. metropolitan areas ($1.59 trillion) would rank fourth among the world's economies, trailing only the U.S. ($9.96 trillion), Japan ($4.6 trillion) and Germany ($1.87 trillion). The importance of metro area economies can also be illustrated by their size relative to the output of U.S. states. The gross product of the 10 largest U.S. metro areas exceeds the combined output of the 31 smallest states. Last year, the five largest metro areas produced more goods and services than California; $1.59 trillion compared with $1.3 trillion.

Within a particular state, a single metropolitan area often dominates the state's economy. For example, the Atlanta metro area provides 55% of Georgia's employment and 56% of gross state product. In Minnesota, the Minneapolis-St. Paul metro area produces 66% of the state's output and employs 65% of the work force. In highly urbanized states, almost all economic activity occurs in metro areas. In Pennsylvania, 97% of employment and 98% of output is generated within metro areas.

2.2 Employment and Output

As previously noted, most of the economic activity in the United States occurs within metro area cities and counties. A total of 110.8 million workers were employed in metro areas in 2000, or 84.0% of national employment. The total value of goods and services produced in metro areas last year was $8.476 trillion, 85% of U.S. gross domestic product. Metro areas, though geographically smaller, contribute much more to the national economy than non-metro areas. The metro area percentages of national employment and gross domestic product both exceed metro area shares of population and land area, highlighting the geographic concentration of economic activity within urban and suburban areas.

This geographic concentration of companies and people is one of the main reasons metro areas are able to make a disproportionately large contribution to the national economy. Close proximity between producers and consumers reduces the costs of business operations, allowing more goods and services to be produced per person and per acre of land.

Table 1 - Most Economic Activity Occurs in Metro Areas

Shares of U.S. Economy (2000)		Metro Areas	Rest of United States	United States
Size	Population (Millions)	226	55	281
	Percentage	80%	20%	
	Land Area (Square Miles, 000s)	719	2,873	3,592
	Percentage	20%	80%	
Jobs & Output	Employment (Millions)	111	21	131
	Percentage	84%	16%	
	Gross Domestic Product (Billions)	$8,476	$1,501	$9,977
	Percentage	85%	15%	
High Value Added Employment Sectors	Financial Services (Thousands)	6,882	720	7,602
	Percentage	91%	9%	
	Transportation & Utilities (Thousands)	6,096	928	7,024
	Percentage	87%	13%	

The clustering of two of the nation's highest value added sectors in urban locations also magnifies the metro area contribution to the national economy. In 2000, 91% of financial services employment and 87% of transportation, communications, and utilities sector employment was located within metropolitan areas. The financial services sector had the highest level of output per employee last year, $257,000. Financial services companies choose to locate in metro areas for proximity to major securities and commodity markets and access to highly skilled workers. Companies maximize the efficiency of their transportation and communications networks by locating hubs and distribution centers in metro areas, taking advantage of extensive road, rail, shipping, and communications infrastructure.

From 1990 to 2000, most of the economic gains made in the United States were generated within cities and counties in metro areas. Of the 22.2 million jobs created in the U.S. over that period, 18.7 million, or 84%, were created in metropolitan areas. The contribution of metro areas to gross domestic product, meanwhile, increased by nearly $3.7 trillion in the last decade, representing 86% of the national gain.

Table 2 - Most Economic Gains Were Made in Metro Areas

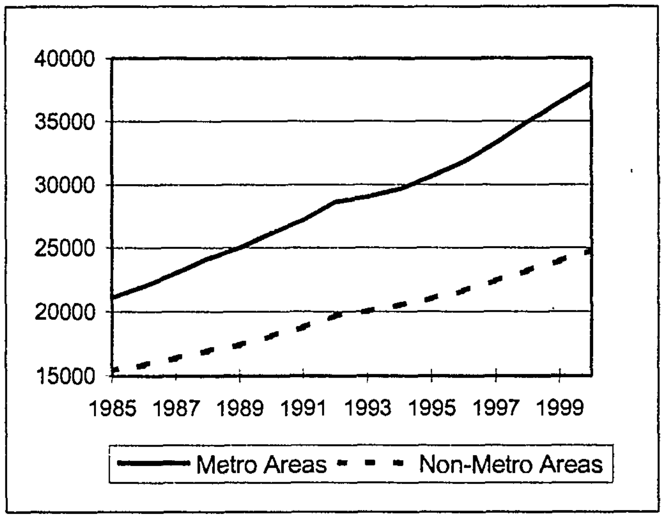
Additions to U.S. Economy (1990 to 2000)		Metro Areas	Rest of United States	United States
Size	Population (Millions)	28	5	33
	Percentage	84%	16%	
Jobs & Output	Employment (Millions)	18.7	3.5	22.2
	Percentage	84%	16%	
	Gross Domestic Product	$3,664	$606	$4,270
	Percentage	86%	14%	
High Value Added Employment Sectors	Financial Services (Thousands)	804	106	910
	Percentage	88%	12%	
	Transportation & Utilities (Thousands)	1,116	124	1,240
	Percentage	90%	10%	

2.3 Income Creation

Most of the nation's labor income is also generated by metro area economies. In 2000, metro area workers earned $4.22 trillion in wages and salaries, while non-metro area workers earned $554 billion. Metro area economies also create more income per person than non-metro areas. Last year, the average metro area worker collected $38,000 in wages and benefits, while the average non-metro area worker earned $24,800, a difference of $13,200 per worker. The gap between metro and non-metro area workers has grown consistently since 1985, when the difference between metro area and non-metro area earnings was only $4,600.

In most labor markets, earnings are directly related to labor productivity--workers that are more productive receive higher wages and benefits. Figure 2, therefore, provides an indirect measure of the higher labor productivity in cities and counties within metro areas. Metro area workers are able to produce more goods and services than non-metro area workers because of the clustering of specialized industries within urban areas, access to superior training and educational facilities, and a greater degree of knowledge-transfer and interaction between companies.

Figure 2 - Metro Area Workers Earn More Than Non-Metro Area Workers



2.4 Generating New Industries

With few exceptions[1], most major industries in the United States started in cities, including automobile manufacturing (Detroit), television broadcasting (New York), and personal computer manufacturing (San Jose). Metro areas provide new industries with crucial amenities--a diverse and ample supply of labor, financial and physical capital, access to national and international markets, a local base of technical knowledge--that are essential for their initial development and eventual success. As an industry matures, technological advances often allow companies within that industry to move to non-urban locations. As a consequence, newer, faster-growing industries tend to cluster within metro areas, while older, slower-growing industries are less tied to urban locations.

Table 3 shows that two of the fastest-growing segments of the U.S. economy, high-tech and business services, are almost entirely concentrated within metro areas. These two sectors of the economy contain some of the nation's newest and most innovative industries, including computer hardware, computer software, telecommunications equipment, optical instruments, Internet publishing, and management consulting. From

[1] The major exceptions are resource-extraction industries (e.g., forestry, coal mining, oil drilling) which are tied to the geographic location of a particular natural resource.

1990 to 2000, employment in high-tech industries grew 2.6% per year, while employment in the business services sector increased by a remarkable 6.8% per year.

Table 3 - Most High-Tech and Business Services Employment is Located in Metro Areas

Shares of U.S. Employment (2000)		Metro Areas	Rest of United States	United States
High Growth Employment Sectors	High-Tech (Thousands)	7,345	524	7,869
	Percentage	93%	7%	
	Business Services (Thousands)	9,140	642	9,783
	Percentage	93%	7%	

Over the past ten years, the majority of these new jobs in the high-tech and business services segments have been created in metro areas. Metro area business services employment increased by close to 4.4 million from 1990 to 2000, compared with an increase of only 312,000 outside of metro areas. Over the same period, almost 1.66 million jobs were created by high-tech companies in metro areas, while only 52,500 jobs were added outside of metro areas.

In the future, metro areas will play a larger and larger role in the national economy. The movement of people from rural to urban areas will continue unabated, providing a steady stream of labor, knowledge, and capital to the businesses located there.

Table 4 - Gross Product of Metro Areas

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
New York, NY	363.19	383.60	407.60	437.80	1
Los Angeles-L Beach, CA	303.09	321.03	339.45	363.70	2
Chicago, IL	283.03	299.81	314.30	332.80	3
Boston, MA	193.99	208.04	221.59	238.80	4
Washington, DC-MD-VA-WV	172.74	187.02	200.79	217.00	5
Philadelphia, PA-NJ	152.95	161.59	170.92	182.40	6
Houston, TX	139.74	148.86	159.13	177.50	7
Atlanta, GA	129.10	141.05	152.88	164.20	8
Dallas, TX	125.56	136.19	146.55	160.00	9
Detroit, MI	131.97	139.87	147.32	156.30	10
Orange Co, CA	101.15	110.82	119.67	130.00	11
Minneapolis-St. Paul, MN-WI	99.98	105.98	113.07	121.30	12
Seattle-Bellevue-Everett, WA	91.51	101.92	108.02	115.00	13
Phoenix-Mesa, AZ	87.93	96.33	104.45	114.20	14
San Francisco, CA	88.59	94.49	99.54	107.30	15
Nassau-Suffolk, NY	86.96	92.10	99.81	106.80	16
San Diego, CA	81.22	88.67	96.46	104.60	17
Newark, NJ	81.03	84.89	90.44	96.30	18
Baltimore, MD	80.89	85.15	90.38	96.20	19
Oakland, CA	74.44	78.95	84.67	92.10	20
Denver, CO	71.08	77.96	83.93	91.10	21
St. Louis, MO-IL	77.09	80.74	84.76	89.60	22
San Jose, CA	67.81	72.51	76.78	85.40	23
Riverside-San Bernardino, CA	64.14	69.16	76.41	84.10	24
Tampa-St Petersb-Clrwater, FL	64.93	70.19	75.57	82.20	25
Cleveland-Lorain-Elyria, OH	69.01	72.27	76.27	80.80	26
Pittsburgh, PA	68.08	71.62	75.81	80.70	27
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	63.83	67.50	71.87	76.80	28
Miami, FL	60.78	63.55	66.68	71.60	29
Portland-Vancouver, OR-WA	59.73	63.81	66.82	71.50	30
Kansas City, MO-KS	53.66	57.39	60.82	64.80	31
Hartford, CT	54.57	57.45	60.37	64.30	32
Middlesex-Somerset-Hunterdon, NJ	51.75	54.18	58.57	63.60	33
Sacramento, CA	49.23	53.97	58.94	63.10	34
Fort Worth-Arlington, TX	49.03	53.20	57.50	63.00	35
Charlotte-Gastonia-R Hill, NC-SC	47.73	51.81	56.39	61.30	36
Columbus, OH	50.30	53.51	57.04	60.70	37
Orlando, FL	46.77	51.12	55.82	59.50	38
Cincinnati, OH-KY-IN	50.39	53.22	55.99	59.40	39

Nominal Gross Product (Billions, $Current)					
Metro Area	1997	1998	1999	2000	Rank
Bergen-Passaic, NJ	50.55	53.60	56.50	59.30	40
Indianapolis, IN	47.38	50.59	53.81	57.70	41
Milwaukee-Waukesha, WI	46.86	49.29	51.95	54.80	42
Las Vegas, NV-AZ	41.05	44.69	49.45	54.60	43
San Antonio, TX	42.92	46.03	49.70	53.70	44
Norfolk-Va Beach-Newport News, VA-NC	42.75	46.16	48.66	51.70	45
Austin-San Marcos, TX	36.11	39.73	43.47	48.20	46
Buffalo-Niagara Falls, NY	40.85	42.63	45.21	47.80	47
Fort Lauderdale, FL	38.23	40.55	43.13	46.70	48
New Orleans, LA	40.79	41.08	42.66	46.50	49
Salt Lake City-Ogden, UT	38.12	40.65	43.22	46.40	50
Greensboro-W-Salem-High Point,NC	38.65	41.23	43.55	46.30	51
Rochester, NY	38.66	40.58	42.89	45.70	52
Richmond-Petersburg, VA	37.24	40.03	42.64	45.70	53
Nashville, TN	37.14	39.97	42.48	45.20	54
Raleigh-Durham-Chapel Hill, NC	35.17	38.23	41.16	44.30	55
Jacksonville, FL	34.82	37.13	39.62	43.00	56
Gr Rapids-Muskegon-Holland, MI	34.92	37.31	39.51	42.30	57
Memphis, TN-AR-MS	32.93	34.78	36.77	38.90	58
Louisville, KY-IN	31.55	33.62	35.63	38.70	59
Albany-Schenectady-Troy, NY	31.92	33.63	35.62	37.80	60
W Palm Beach-Boca Raton, FL	26.42	28.59	30.42	33.20	61
Honolulu, HI	29.68	30.27	31.24	33.00	62
Monmouth-Ocean, NJ	27.47	28.71	30.71	33.00	63
Providence-Warwick, RI	27.20	28.41	30.18	32.50	64
Oklahoma City, OK	26.88	28.08	29.88	32.30	65
Birmingham, AL	27.02	28.44	30.22	32.00	66
Wilmington-Newark, DE	25.24	27.43	29.30	31.40	67
Dayton-Springfield, OH	27.58	28.64	29.67	31.20	68
Manchester-Nashua, NH	23.85	25.94	27.88	30.20	69
Syracuse, NY	25.41	26.71	28.41	30.10	70
Greenville-Spartanburg-Anderson, SC	24.90	26.26	27.56	29.90	71
Jersey City, NJ	22.49	23.55	25.28	28.10	72
Harrisburg-Lebanon-Carlisle, PA	23.28	24.32	25.36	27.10	73
Fresno, CA	21.69	22.67	24.39	26.30	74
Omaha, NE-IA	21.95	23.11	24.64	26.20	75
Tulsa, OK	21.30	22.59	23.75	25.70	76
Albuquerque, NM	21.51	22.14	23.54	25.60	77
Ventura, CA	18.73	20.27	22.30	24.50	78
Tucson, AZ	18.02	19.24	20.80	22.90	79
Akron, OH	18.75	19.52	20.61	21.90	80
Knoxville, TN	17.98	19.13	20.24	21.50	81
Toledo, OH	18.14	18.97	20.06	21.20	82

Nominal Gross Product (Billions, $Current)					
Metro Area	1997	1998	1999	2000	Rank
Springfield, MA	17.33	18.38	19.53	20.90	83
Allentown-Bethlehem-Easton, PA	17.08	18.06	19.20	20.60	84
Scranton-Wilkes-Barre-Hazelton, PA	17.55	18.28	19.14	20.60	85
Santa Rosa, CA	15.30	17.14	18.27	20.50	86
Baton Rouge, LA	16.90	17.89	18.86	20.40	87
Des Moines, IA	15.69	16.90	18.18	19.10	88
Ann Arbor, MI	15.88	16.87	17.98	19.10	89
Columbia, SC	16.28	17.28	18.19	19.10	90
Tacoma, WA	15.63	16.99	17.92	19.00	91
Bakersfield, CA	15.18	15.74	16.93	18.90	92
Fort Wayne, IN	15.68	16.61	17.46	18.60	93
El Paso, TX	15.87	16.87	17.57	18.60	94
Trenton, NJ	15.51	16.18	17.42	18.50	95
Little Rock-N. L.Rock, AR	15.07	16.09	17.23	18.40	96
Madison, WI	15.73	16.50	17.40	18.40	97
Lafayette, LA	14.39	14.52	14.80	18.20	98
Lexington, KY	14.48	15.58	16.66	17.80	99
Colorado Springs, CO	13.85	15.10	16.27	17.60	100
Wichita, KS	15.16	16.18	16.70	17.50	101
Chattanooga, TN-GA	14.29	15.31	16.36	17.50	102
Santa Barbara-Santa Maria-Lompoc, CA	13.58	14.65	15.49	17.20	103
Sarasota-Bradenton, FL	13.51	14.25	15.50	16.90	104
Lancaster, PA	13.77	14.38	15.32	16.50	105
Stockton-Lodi, CA	14.58	14.99	15.57	16.20	106
Youngstown-Warren, OH	13.08	13.75	14.83	16.20	107
Gary, IN	14.06	14.67	15.28	16.10	108
Lansing-East Lansing, MI	14.31	15.10	15.61	16.10	109
Kalamazoo-Battle Creek, MI	14.26	14.38	14.97	15.70	110
Atlantic-Cape May, NJ	13.08	13.67	14.72	15.70	111
Spokane, WA	12.90	13.87	14.54	15.40	112
Modesto, CA	11.28	12.45	13.33	15.00	113
Augusta-Aiken, GA-SC	11.86	12.70	13.85	14.80	114
Reno, NV	11.58	12.51	13.45	14.70	115
Charleston-N Charleston, SC	11.82	12.63	13.49	14.70	116
Vallejo-Fairfield-Napa, CA	11.08	11.90	13.14	14.50	117
Boise City, ID	10.85	11.94	12.97	14.40	118
Rockford, IL	12.22	12.82	13.38	14.30	119
Jackson, MS	12.41	13.12	13.73	14.30	120
Mobile, AL	12.01	12.63	13.32	14.00	121
Johnson City-Kingspt-Bristol, TN-VA	12.09	12.43	13.07	13.90	122
Salinas, CA	10.85	11.68	12.42	13.80	123
Appleton-Oshkosh-Neenah, WI	11.13	11.72	12.53	13.50	124
Peoria-Pekin, IL	11.37	12.06	12.57	13.30	125

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Lakeland-Winter Haven, FL	10.97	11.37	12.08	13.00	126
Davenport-Moline-Rock Isld, IA-IL	10.29	11.25	12.04	13.00	127
Reading, PA	10.98	11.72	12.24	13.00	128
Anchorage, AK	11.02	11.64	12.21	12.80	129
Hickory-Morganton, NC	10.52	10.73	11.28	12.80	130
Saginaw-Bay City-Midland, MI	11.24	11.65	12.10	12.70	131
Canton-Massillon, OH	10.77	11.40	11.96	12.70	132
Corpus Christi, TX	10.24	11.09	11.80	12.60	133
Roanoke, VA	10.43	10.90	11.49	12.60	134
York, PA	10.56	10.90	11.57	12.50	135
Beaumont-Port Arthur, TX	10.39	11.00	11.54	12.40	136
Shreveport-Bossier City, LA	10.77	10.90	11.28	12.30	137
Odessa-Midland, TX	9.73	9.54	9.99	12.30	138
Boulder-Longmont, CO	9.70	10.43	11.14	12.00	139
Melbourne-Titusville-Palm Bay, FL	9.85	10.49	11.16	12.00	140
Macon, GA	9.39	10.32	11.08	12.00	141
Portland, ME	9.57	10.07	11.00	12.00	142
Utica-Rome, NY	9.81	10.47	11.19	11.90	143
Springfield, IL	9.71	10.40	10.88	11.40	144
Fort Myers-Cape Coral, FL	11.04	11.06	11.22	11.30	145
Flint, MI	8.93	9.78	10.53	11.30	146
Newburgh, NY-PA	8.82	9.53	10.23	10.90	147
Springfield, MO	8.71	9.33	9.90	10.80	148
McAllen-Edinburg-Mission, TX	9.12	9.62	10.17	10.80	149
Huntsville, AL	8.94	9.50	9.98	10.60	150
Visalia-Tulare-Porterville, CA	8.94	9.45	9.99	10.50	151
Pensacola, FL	8.57	9.11	9.75	10.50	152
Savannah, GA	8.68	9.22	9.81	10.50	153
Evansville-Henderson, IN-KY	8.22	8.92	9.46	10.50	154
Montgomery, AL	8.58	9.22	9.74	10.40	155
Daytona Beach, FL	8.70	9.34	9.83	10.40	156
Eugene-Springfield, OR	8.48	9.03	9.65	10.40	157
New London-Norwich, CT	8.76	9.14	9.73	10.30	158
Tallahassee, FL	8.53	9.08	9.59	10.20	159
S L Obispo-Atascadero-Paso Robles, CA	7.87	8.55	9.07	10.10	160
Green Bay, WI	8.10	8.68	9.29	10.00	161
Binghamton, NY	8.22	8.70	9.26	9.90	162
Salem, OR	8.18	8.67	9.24	9.90	163
Columbus, GA-AL	8.27	8.58	9.12	9.80	164
Erie, PA	7.94	8.62	9.13	9.80	165
Lincoln, NE	7.93	8.50	9.01	9.60	166
Santa Cruz-Watsonville, CA	7.35	8.09	8.56	9.50	167
Dutchess County, NY	7.79	8.24	8.86	9.50	168

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Biloxi-Gulfport-Pascagoula, MS	7.74	8.47	9.01	9.40	169
Fayetteville-Springdale-Rogers, AR	7.32	7.78	8.36	9.00	170
Yolo, CA	7.21	7.88	8.38	8.90	171
Elkhart-Goshen, IN	6.95	7.54	7.98	8.90	172
Houma, LA	7.09	7.62	8.03	8.60	173
Hamilton-Middletown, OH	6.97	6.95	7.09	8.60	174
South Bend, IN	6.89	7.19	7.53	8.50	175
Longview-Marshall, TX	7.24	7.77	8.18	8.50	176
Lubbock, TX	7.15	7.62	7.98	8.50	177
Lynchburg, VA	6.80	7.43	7.92	8.50	178
Charleston, WV	7.06	7.41	7.91	8.40	179
Fort Collins-Loveland, CO	6.45	7.12	7.68	8.30	180
Provo-Orem, UT	6.63	7.17	7.72	8.30	181
Bloomington-Normal, IL	6.44	7.39	7.76	8.20	182
Duluth-Superior, MN-WI	6.66	7.07	7.52	8.20	183
Sioux Falls, SD	6.10	6.57	7.35	8.00	184
Waco, TX	6.55	6.95	7.31	7.80	185
Gainesville, FL	6.25	6.78	7.21	7.70	186
Cedar Rapids, IA	6.37	6.92	7.27	7.70	187
Wilmington, NC	6.46	6.88	7.28	7.70	188
Huntington-Ashland, WV-KY-OH	6.63	6.82	7.16	7.60	189
Chico-Paradise, CA	6.24	6.61	6.96	7.50	190
Asheville, NC	6.32	6.75	7.09	7.50	191
Amarillo, TX	6.22	6.64	6.98	7.50	192
Brownsv-Harlingen-San Benito, TX	5.96	6.42	6.77	7.50	193
Killeen-Temple, TX	5.97	6.39	6.73	7.30	194
Galveston-Texas City, TX	5.93	6.32	6.67	7.20	195
Fayetteville, NC	5.98	6.45	6.73	7.10	196
Burlington, VT	5.75	6.05	6.50	7.00	197
Myrtle Beach, SC	5.30	5.79	6.33	6.90	198
Naples, FL	5.14	5.69	6.25	6.80	199
Barnstable-Yarmouth, MA	5.58	5.84	6.15	6.80	200
Tyler, TX	5.43	5.76	6.27	6.80	201
Fort Pierce-Port St. Lucie, FL	5.35	5.78	6.21	6.70	202
Johnstown, PA	5.66	5.83	6.18	6.70	203
Laredo, TX	5.36	5.49	5.81	6.60	204
Redding, CA	5.61	5.81	6.13	6.50	205
Topeka, KS	5.20	5.55	5.86	6.50	206
Olympia, WA	5.22	5.63	5.97	6.40	207
Fort Smith, AR-OK	5.00	5.45	5.86	6.30	208
Charlottesville, VA	5.27	5.51	5.84	6.30	209
Lake Charles, LA	5.43	5.54	5.72	6.20	210
Brazoria, TX	5.17	5.52	5.83	6.20	211

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Richland-Kennewick-Pasco, WA	5.30	5.48	5.76	6.20	212
Yakima, WA	5.09	5.29	5.57	6.20	213
Merced, CA	4.76	5.11	5.44	6.10	214
St. Cloud, MN	4.91	5.27	5.59	6.00	215
Ocala, FL	4.99	5.34	5.65	5.90	216
Lafayette, IN	4.62	5.10	5.49	5.90	217
Fargo-Moorhead, ND-MN	4.88	5.25	5.52	5.80	218
Champaign-Urbana, IL	4.91	5.17	5.41	5.70	219
Mansfield, OH	5.02	5.15	5.40	5.70	220
Vineland-Millville-Bridgeton, NJ	4.69	4.86	5.19	5.60	221
Joplin, MO	4.68	4.95	5.19	5.50	222
Bremerton, WA	4.60	4.83	5.12	5.50	223
Athens, GA	4.35	4.69	5.01	5.40	224
Lima, OH	4.62	4.83	5.06	5.40	225
Bellingham, WA	4.33	4.71	5.00	5.40	226
Benton Harbor, MI	4.25	4.64	4.90	5.30	227
Rochester, MN	4.26	4.69	5.00	5.30	228
Bryan-College Station, TX	4.72	4.84	5.03	5.30	229
Racine, WI	4.39	4.60	4.91	5.30	230
Greeley, CO	3.89	4.32	4.71	5.20	231
Fort Walton Beach, FL	4.23	4.52	4.82	5.10	232
Medford-Ashford, OR	4.17	4.46	4.74	5.10	233
Tuscaloosa, AL	4.21	4.46	4.72	5.00	234
Monroe, LA	4.28	4.48	4.67	5.00	235
Pittsfield, MA	4.12	4.39	4.66	5.00	236
Columbia, MO	4.22	4.43	4.71	5.00	237
Jamestown, NY	4.06	4.28	4.58	4.90	238
Wichita Falls, TX	4.11	4.22	4.42	4.90	239
Hagerstown, MD	4.19	4.48	4.73	4.80	240
Eau Claire, WI	3.96	4.19	4.47	4.80	241
Wausau, WI	3.94	4.21	4.49	4.80	242
Rocky Mount, NC	3.86	4.13	4.40	4.70	243
Florence, SC	4.04	4.25	4.43	4.70	244
Albany, GA	3.84	4.06	4.29	4.60	245
Abilene, TX	3.90	3.93	4.13	4.60	246
Panama City, FL	3.72	3.98	4.25	4.50	247
Decatur, IL	3.96	4.14	4.28	4.50	248
Santa Fe, NM	3.98	4.08	4.28	4.50	249
Glens Falls, NY	3.84	3.92	4.19	4.50	250
Clarksville-Hopkinsville, TN-KY	3.74	3.98	4.21	4.50	251
Parkersburg-Marietta, WV-OH	3.65	3.95	4.20	4.50	252
Janesville-Beloit, WI	3.88	4.07	4.28	4.50	253
La Crosse, WI-MN	3.69	3.90	4.18	4.50	254

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Waterloo-Cedar Falls, IA	3.87	4.03	4.20	4.40	255
Jackson, MI	3.71	3.85	4.10	4.40	256
State College, PA	3.80	3.99	4.16	4.40	257
Bangor, ME	3.53	3.74	4.00	4.30	258
Pueblo, CO	3.60	3.77	3.96	4.20	259
Terre Haute, IN	3.55	3.70	3.92	4.20	260
Greenville, NC	3.61	3.81	4.01	4.20	261
Altoona, PA	3.47	3.72	3.94	4.20	262
Wheeling, WV-OH	3.30	3.60	3.86	4.20	263
Dothan, AL	3.58	3.76	3.94	4.10	264
Sioux City, IA-NE	3.38	3.60	3.84	4.10	265
Williamsport, PA	3.43	3.58	3.80	4.10	266
Sheboygan, WI	3.55	3.67	3.86	4.10	267
Jackson, TN	3.34	3.55	3.78	4.00	268
Grand Junction, CO	3.17	3.40	3.60	3.80	269
Dover, DE	3.17	3.40	3.63	3.80	270
Bloomington, IN	3.26	3.41	3.60	3.80	271
Billings, MT	2.93	3.19	3.45	3.80	272
Decatur, AL	3.14	3.27	3.45	3.70	273
Flagstaff, AZ-UT	2.94	3.17	3.36	3.70	274
Yuba City, CA	3.05	3.26	3.40	3.70	275
Kokomo, IN	3.06	3.24	3.46	3.70	276
Elmira, NY	3.10	3.29	3.50	3.70	277
San Angelo, TX	3.12	3.34	3.49	3.70	278
Texarkana, AR-TX	3.00	3.18	3.34	3.60	279
Muncie, IN	3.06	3.26	3.43	3.60	280
Alexandria, LA	3.07	3.20	3.36	3.60	281
Las Cruces, NM	3.11	3.26	3.41	3.60	282
Sharon, PA	2.92	3.13	3.32	3.60	283
Sherman-Denison, TX	3.10	3.21	3.37	3.60	284
Danville, VA	3.03	3.22	3.35	3.60	285
Iowa City, IA	3.00	3.23	3.34	3.50	286
Steubenville-Weirton, OH-WV	2.92	3.15	3.33	3.50	287
Florence, AL	3.12	3.12	3.26	3.40	288
Victoria, TX	2.68	2.76	2.91	3.30	289
Kankakee, IL	2.81	2.92	3.05	3.20	290
Kenosha, WI	2.61	2.80	2.99	3.20	291
Dubuque, IA	2.74	2.83	2.96	3.10	292
Anniston, AL	2.44	2.59	2.77	3.00	293
Owensboro, KY	2.30	2.59	2.78	3.00	294
Lewiston-Auburn, ME	2.61	2.74	2.86	3.00	295
Hattiesburg, MS	2.51	2.62	2.80	3.00	296
St. Joseph, MO	2.59	2.70	2.83	3.00	297

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Rapid City, SD	2.45	2.60	2.76	3.00	298
Goldsboro, NC	2.53	2.68	2.79	2.90	299
Bismarck, ND	2.26	2.26	2.42	2.90	300
Casper, WY	2.36	2.54	2.69	2.90	301
Cumberland, MD-WV	2.30	2.45	2.61	2.80	302
Missoula, MT	2.49	2.62	2.75	2.80	303
Grand Forks, ND-MN	2.29	2.41	2.58	2.80	304
Sumter, SC	2.36	2.49	2.62	2.80	305
Yuma, AZ	2.32	2.44	2.57	2.70	306
Lawrence, KS	2.30	2.41	2.52	2.70	307
Corvallis, OR	2.15	2.30	2.42	2.70	308
Cheyenne, WY	2.20	2.35	2.47	2.60	309
Auburn-Opelika, AL	2.14	2.28	2.38	2.50	310
Gadsden, AL	2.18	2.24	2.36	2.50	311
Jacksonville, NC	2.12	2.22	2.33	2.50	312
Punta Gorda, FL	1.94	2.10	2.27	2.40	313
Lawton, OK	2.10	2.17	2.26	2.40	314
Jonesboro, AR	1.89	2.01	2.12	2.30	315
Pine Bluff, AR	1.79	1.86	1.95	2.10	316
Great Falls, MT	1.65	1.73	1.84	2.00	317
Pocatello, ID	1.58	1.66	1.78	1.90	318
Enid, OK	1.47	1.51	1.58	1.70	319

Table 5 – Gross Product of Countries and Metro Areas

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
1	United States	9963.00
2	Japan	4614.00
3	Germany	1873.00
4	United Kingdom	1410.00
5	France	1286.00
6	China	1104.00
7	Italy	1074.00
8	Canada	699.00
9	Brazil	665.00
10	Mexico	578.00
11	Spain	557.00
12	India	510.00
13	South Korea	480.00
14	***New York, NY***	437.80
15	Australia	428.00
16	***Los Angeles-Long Beach, CA***	363.70
17	Netherlands	360.00
18	***Chicago, IL***	332.80
19	Taiwan	323.00
20	Argentina	284.00
21	Russia	247.00
22	Switzerland	241.30
23	***Boston, MA***	238.80
24	Belgium	227.00
25	Sweden	224.10
26	Turkey	217.60
27	***Washington, DC-MD-VA-WV***	217.00
28	Austria	184.90
29	***Philadelphia, PA-NJ***	182.40
30	***Houston, TX***	177.50
31	Hong Kong	164.60
32	***Atlanta, GA***	164.20
33	Norway	164.00
34	Poland	163.00
35	***Dallas, TX***	160.00
36	Denmark	158.00
37	***Detroit, MI***	156.30
38	Indonesia	147.60
39	Saudi Arabia	145.30
40	South Africa	132.30
41	***Orange County, CA***	130.00
42	Thailand	128.20

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
43	***Minneapolis-St.Paul, MN-WI***	121.30
44	Finland	118.00
45	***Seattle-Bellevue-Everett, WA***	115.00
46	***Phoenix-Mesa, AZ***	114.20
47	Greece	110.90
48	Israel	108.00
49	***San Francisco, CA***	107.30
50	***Nassau-Suffolk, NY***	106.80
51	***San Diego, CA***	104.60
52	Venezuela	102.90
53	Portugal	100.50
54	***Newark, NJ***	96.30
55	***Baltimore, MD***	96.20
56	Ireland	95.10
57	Singapore	93.70
58	***Oakland, CA***	92.10
59	Egypt	91.50
60	***Denver, CO***	91.10
61	Colombia	90.00
62	***St. Louis, MO-IL***	89.60
63	Malaysia	88.80
64	***San Jose, CA***	85.40
65	***Riverside-San Bernardino, CA***	84.10
66	***Tampa-St Petersburg-Clearwater, FL***	82.20
67	***Cleveland-Lorain-Elyria, OH***	80.80
68	***Pittsburgh, PA***	80.70
69	Philippines	78.00
70	***New Haven, CT***	76.80
71	Chile	73.00
72	***Miami, FL***	71.60
73	***Portland-Vancouver, OR-WA***	71.50
74	Iran	67.10
75	Puerto Rico	65.30
76	***Kansas City, MO-KS***	64.80
77	***Hartford, CT***	64.30
78	***Middlesex-Somerset-Hunterdon, NJ***	63.60
79	***Sacramento, CA***	63.10
80	***Fort Worth-Arlington, TX***	63.00
81	Pakistan	62.70
82	Peru	62.70
83	***Charlotte-Gastonia-RHill, NC-SC***	61.30
84	***Columbus, OH***	60.70
85	United Arab	60.70

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
86	***Orlando, FL***	59.50
87	***Cincinnati, OH-KY-IN***	59.40
88	***Bergen-Passaic, NJ***	59.30
89	***Indianapolis, IN***	57.70
90	Nigeria	54.90
91	***Milwaukee-Waukesha, WI***	54.80
92	***Las Vegas,NV-AZ***	54.60
93	***San Antonio,TX***	53.70
94	Algeria	52.80
95	New B131Zealand	52.10
96	***Norfolk-Virginia Beach-Newport News,VA-NC***	51.70
97	Czech	50.80
98	***Austin-San Marcos,TX***	48.20
99	***Buffalo-Niagara Falls,NY***	47.80
100	Hungary	47.40
101	***Fort Lauderdale,FL***	46.70
102	***New Orleans,LA***	46.50
103	***Salt Lake City-Ogden,UT***	46.40
104	***Greensboro--Winston-Salem--HighPoint,NC***	46.30
105	***Rochester,NY***	45.70
106	***Richmond-Petersburg,VA***	45.70
107	***Nashville,TN***	45.20
108	***Raleigh-Durham-ChapelHill, NC***	44.30
109	***Jacksonville, FL***	43.00
110	***GrRapids-Muskegon-Holland, MI***	42.30
111	***Memphis, TN-AR-MS***	38.90
112	***Louisville, KY-IN***	38.70
113	Bangladesh	38.50
114	Kuwait	38.05
115	***Albany-Schenectady-Troy, NY***	37.80
116	Syria	35.53
117	Morocco	34.80
118	***WPalmBeach-BocaRaton, FL***	33.20
119	***Honolulu, HI***	33.00
120	***Monmouth-Ocean, NJ***	33.00
121	Romania	33.00
122	***Providence-Warwick, RI***	32.50
123	***OklahomaCity, OK***	32.30
124	***Birmingham, AL***	32.00
125	Ukraine	31.70
126	***Wilmington-Newark, DE***	31.40
127	***Dayton-Springfield, OH***	31.20
128	Vietnam	30.60

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
129	***Manchester-Nashua, NH***	30.20
130	***Syracuse, NY***	30.10
131	***Greenville-Spartanburg-Anderson, SC***	29.90
132	***Jersey City, NJ***	28.10
133	***Harrisburg-Lebanon-Carlisle, PA***	27.10
134	***Fresno, CA***	26.30
135	***Omaha, NE-IA***	26.20
136	***Tulsa, OK***	25.70
137	***Albuquerque, NM***	25.60
138	Iraq	25.50
139	***Ventura, CA***	24.50
140	***Tucson, AZ***	22.90
141	***Akron, OH***	21.90
142	***Knoxville, TN***	21.50
143	***Toledo, OH***	21.20
144	***Springfield, MA***	20.90
145	***Allentown-Bethlehem-Easton, PA***	20.60
146	***Scranton-Wilkes-Barre-Hazelton, PA***	20.60
147	***Santa Rosa, CA***	20.50
148	Uruguay	20.49
149	***Baton Rouge, LA***	20.40
150	Slovakia	20.20
151	Tunisia	19.96
152	Dominican Republic	19.67
153	***DesMoines, IA***	19.10
154	***AnnArbor, MI***	19.10
155	***Columbia, SC***	19.10
156	Guatemala	19.05
157	***Tacoma, WA***	19.00
158	Croatia(Hrvatska)	19.00
159	***Bakersfield, CA***	18.90
160	Oman	18.82
161	***FortWayne, IN***	18.60
162	***ElPaso, TX***	18.60
163	***Trenton, NJ***	18.50
164	Slovenia	18.47
165	***LittleRock-N.L.Rock, AR***	18.40
166	***Madison, WI***	18.40
167	***Lafayette, LA***	18.20
168	Kazakhstan	18.20
169	Luxembourg	18.10
170	***Lexington, KY***	17.80
171	***ColoradoSprings, CO***	17.60

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
172	***Wichita, KS***	17.50
173	***Chattanooga, TN-GA***	17.50
174	Lebanon	17.36
175	***SantaBarbara-SantaMaria-Lompoc, CA***	17.20
176	***Sarasota-Bradenton, FL***	16.90
177	***Lancaster, PA***	16.50
178	SriLanka	16.47
179	***Stockton-Lodi, CA***	16.20
180	***Youngstown-Warren, OH***	16.20
181	***Gary, IN***	16.10
182	***Lansing-EastLansing, MI***	16.10
183	CostaRica	16.02
184	***Kalamazoo-BattleCreek, MI***	15.70
185	***Atlantic-CapeMay, NJ***	15.70
186	***Spokane, WA***	15.40
187	***Modesto, CA***	15.00
188	***Augusta-Aiken, GA-SC***	14.80
189	***Reno, NV***	14.70
190	***Charleston-NCharleston, SC***	14.70
191	Qatar	14.58
192	***Vallejo-Fairfield-Napa, CA***	14.50
193	***BoiseCity, ID***	14.40
194	***Rockford, IL***	14.30
195	***Jackson, MS***	14.30
196	***Mobile, AL***	14.00
197	***JohnsonCity-Kingspt-Bristol, TN-VA***	13.90
198	***Salinas, CA***	13.80
199	***Appleton-Oshkosh-Neenah, WI***	13.50
200	***Peoria-Pekin, IL***	13.30
201	El Salvador	13.22
202	Ecuador	13.04
203	***Lakeland-WinterHaven, FL***	13.00
204	***Davenport-Moline-RockIsld, IA-IL***	13.00
205	***Reading, PA***	13.00
206	***Anchorage, AK***	12.80
207	***Hickory-Morganton, NC***	12.80
208	***Saginaw-BayCity-Midland, MI***	12.70
209	***Canton-Massillon, OH***	12.70
210	***CorpusChristi, TX***	12.60
211	***Roanoke, VA***	12.60
212	***York, PA***	12.50
213	***Beaumont-PortArthur, TX***	12.40
214	***Shreveport-BossierCity, LA***	12.30

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
215	***Odessa-Midland, TX***	12.30
216	Uzbekistan	12.30
217	Bulgaria	12.23
218	***Boulder-Longmont, CO***	12.00
219	***Melbourne-Titusville-PalmBay, FL***	12.00
220	***Macon, GA***	12.00
221	***Portland, ME***	12.00
222	***Utica-Rome, NY***	11.90
223	***Springfield, IL***	11.40
224	***FortMyers-CapeCoral, FL***	11.30
225	***Flint, MI***	11.30
226	Lithuania	11.23
227	Sudan	10.98
228	Coted'Ivoire	10.93
229	***Newburgh, NY-PA***	10.90
230	***Springfield, MO***	10.80
231	***McAllen-Edinburg-Mission, TX***	10.80
232	Belarus	10.78
233	***Huntsville, AL***	10.60
234	Kenya	10.60
235	***Visalia-Tulare-Porterville, CA***	10.50
236	***Pensacola, FL***	10.50
237	***Savannah, GA***	10.50
238	***Evansville-Henderson, IN-KY***	10.50
239	***Montgomery, AL***	10.40
240	***DaytonaBeach, FL***	10.40
241	***Eugene-Springfield, OR***	10.40
242	***NewLondon-Norwich, CT***	10.30
243	***Tallahassee, FL***	10.20
244	***SLObispo-Atascadero-PasoRobles, CA***	10.10
245	Cuba	10.10
246	***GreenBay, WI***	10.00
247	***Binghamton, NY***	9.90
248	***Salem, OR***	9.90
249	***Columbus, GA-AL***	9.80
250	***Erie, PA***	9.80
251	Cameroon	9.67
252	Myanmar	9.61
253	***Lincoln, NE***	9.60
254	***SantaCruz-Watsonville, CA***	9.50
255	***DutchessCounty, NY***	9.50
256	***Biloxi-Gulfport-Pascagoula, MS***	9.40
257	Tanzania	9.32

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
258	Iceland	9.17
259	***Fayetteville-Springdale-Rogers, AR***	9.00
260	Cyprus	8.94
261	***Yolo, CA***	8.90
262	***Elkhart-Goshen, IN***	8.90
263	***Houma, LA***	8.60
264	***Hamilton-Middletown, OH***	8.60
265	Bolivia	8.54
266	***SouthBend, IN***	8.50
267	***Longview-Marshall, TX***	8.50
268	***Lubbock, TX***	8.50
269	***Lynchburg, VA***	8.50
270	***Charleston, WV***	8.40
271	***FortCollins-Loveland, CO***	8.30
272	***Provo-Orem, UT***	8.30
273	***Bloomington-Normal, IL***	8.20
274	***Duluth-Superior, MN-WI***	8.20
275	***SiouxFalls, SD***	8.00
276	Yemen(Unified)	7.96
277	***Waco, TX***	7.80
278	Jordan	7.75
279	***Gainesville, FL***	7.70
280	***CedarRapids, IA***	7.70
281	***Wilmington, NC***	7.70
282	Zimbabwe	7.61
283	***Huntington-Ashland, WV-KY-OH***	7.60
284	***Chico-Paradise, CA***	7.50
285	***Asheville, NC***	7.50
286	***Amarillo, TX***	7.50
287	***Brownsv-Harlingen-SanBenito, TX***	7.50
288	Paraguay	7.49
289	Libyan Arab Jamahiriya	7.47
290	Panama	7.34
291	***Killeen-Temple, TX***	7.30
292	Federal Republic of Yugoslavia	7.30
293	Trinidad & Tobago	7.28
294	***Galveston-TexasCity, TX***	7.20
295	Jamaica	7.18
296	Latvia	7.15
297	Bahrain	7.11
298	***Fayetteville, NC***	7.10
299	***Burlington, VT***	7.00
300	***Myrtle Beach, SC***	6.90

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
301	***Naples, FL***	6.80
302	***Barnstable-Yarmouth, MA***	6.80
303	***Tyler, TX***	6.80
304	Ethiopia	6.80
305	***FortPierce-PortSt.Lucie, FL***	6.70
306	***Johnstown, PA***	6.70
307	***Laredo, TX***	6.60
308	***Redding, CA***	6.50
309	***Topeka, KS***	6.50
310	***Olympia, WA***	6.40
311	***FortSmith, AR-OK***	6.30
312	***Charlottesville, VA***	6.30
313	Ghana	6.30
314	***LakeCharles, LA***	6.20
315	***Brazoria, TX***	6.20
316	***Richland-Kennewick-Pasco, WA***	6.20
317	***Yakima, WA***	6.20
318	Uganda	6.20
319	***Merced, CA***	6.10
320	***St.Cloud, MN***	6.00
321	Honduras	5.93
322	***Ocala, FL***	5.90
323	***Lafayette, IN***	5.90
324	***Fargo-Moorhead, ND-MN***	5.80
325	***Champaign-Urbana, IL***	5.70
326	***Mansfield, OH***	5.70
327	***Vineland-Millville-Bridgeton, NJ***	5.60
328	***Joplin, MO***	5.50
329	***Bremerton, WA***	5.50
330	Nepal	5.42
331	***Athens, GA***	5.40
332	***Lima, OH***	5.40
333	***Bellingham, WA***	5.40
334	Botswana	5.36
335	***BentonHarbor, MI***	5.30
336	***Rochester, MN***	5.30
337	***Bryan-CollegeStation, TX***	5.30
338	***Racine, WI***	5.30
339	Brunei Darussalam	5.21
340	Gabon	5.21
341	***Greeley, CO***	5.20
342	***FortWaltonBeach, FL***	5.10
343	***Medford-Ashford, OR***	5.10

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
344	***Tuscaloosa, AL***	5.00
345	***Monroe, LA***	5.00
346	***Pittsfield, MA***	5.00
347	***Columbia, MO***	5.00
348	WestBank and Gaza	4.94
349	Estonia	4.92
350	***Jamestown, NY***	4.90
351	***WichitaFalls, TX***	4.90
352	Azerbaijan	4.90
353	***Hagerstown, MD***	4.80
354	***EauClaire, WI***	4.80
355	***Wausau, WI***	4.80
356	***RockyMount, NC***	4.70
357	***Florence, SC***	4.70
358	***Albany, GA***	4.60
359	***Abilene, TX***	4.60
360	Mauritius	4.60
361	Senegal	4.53
362	***PanamaCity, FL***	4.50
363	***Decatur, IL***	4.50
364	***Santa Fe, NM***	4.50
365	***Glens Falls, NY***	4.50
366	***Clarksville-Hopkinsville, TN-KY***	4.50
367	***Parkersburg-Marietta, WV-OH***	4.50
368	***Janesville-Beloit, WI***	4.50
369	***LaCrosse, WI-MN***	4.50
370	Angola	4.43
371	***Waterloo-CedarFalls, IA***	4.40
372	***Jackson, MI***	4.40
373	***StateCollege, PA***	4.40
374	Turkmenistan	4.40
375	***Bangor, ME***	4.30
376	***Pueblo, CO***	4.20
377	***TerreHaute, IN***	4.20
378	***Greenville, NC***	4.20
379	***Altoona, PA***	4.20
380	***Wheeling, WV-OH***	4.20
381	Bahamas	4.19
382	Mozambique	4.17
383	***Dothan, AL***	4.10
384	***Sioux City, IA-NE***	4.10
385	***Williamsport, PA***	4.10
386	***Sheboygan, WI***	4.10

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
387	***Jackson, TN***	4.00
388	Albania	3.89
389	***GrandJunction, CO***	3.80
390	***Dover, DE***	3.80
391	***Bloomington, IN***	3.80
392	***Billings, MT***	3.80
393	Madagascar	3.79
394	***Decatur, AL***	3.70
395	***Flagstaff, AZ-UT***	3.70
396	***YubaCity, CA***	3.70
397	***Kokomo, IN***	3.70
398	***Elmira, NY***	3.70
399	***San Angelo, TX***	3.70
400	PapuaNewGuinea	3.67
401	***Texarkana, AR-TX***	3.60
402	***Muncie, IN***	3.60
403	***Alexandria, LA***	3.60
404	***Las Cruces, NM***	3.60
405	***Sharon, PA***	3.60
406	***Sherman-Denison, TX***	3.60
407	***Danville, VA***	3.60
408	Malta	3.53
409	Namibia	3.51
410	***IowaCity, IA***	3.50
411	***Steubenville-Weirton, OH-WV***	3.50
412	Macedonia	3.41
413	***Florence, AL***	3.40
414	***Victoria, TX***	3.30
415	Congo, Dem.Repub.of	3.28
416	Guinea	3.21
417	***Kankakee, IL***	3.20
418	***Kenosha, WI***	3.20
419	Georgia	3.15
420	Cambodia	3.12
421	***Dubuque, IA***	3.10
422	Zambia	3.10
423	Haiti	3.09
424	***Anniston, AL***	3.00
425	***Owensboro, KY***	3.00
426	***Lewiston-Auburn, ME***	3.00
427	***Hattiesburg, MS***	3.00
428	***St.Joseph, MO***	3.00
429	***RapidCity, SD***	3.00

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Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
430	Congo	2.92
431	***Goldsboro, NC***	2.90
432	***Bismarck, ND***	2.90
433	***Casper, WY***	2.90
434	***Cumberland, MD-WV***	2.80
435	***Missoula, MT***	2.80
436	***GrandForks, ND-MN***	2.80
437	***Sumter, SC***	2.80
438	***Yuma, AZ***	2.70
439	***Lawrence, KS***	2.70
440	***Corvallis, OR***	2.70
441	Barbados	2.69
442	Bermuda	2.67
443	***Cheyenne, WY***	2.60
444	***Auburn-Opelika, AL***	2.50
445	***Gadsden, AL***	2.50
446	***Jacksonville, NC***	2.50
447	Nicaragua	2.50
448	BurkinaFaso	2.44
449	***PuntaGorda, FL***	2.40
450	***Lawton, OK***	2.40
451	Mali	2.40
452	***Jonesboro, AR***	2.30
453	Benin	2.27
454	Liechtenstein	2.25
455	***PineBluff, AR***	2.10
456	NetherlandsAntilles	2.06
457	***GreatFalls, MT***	2.00
458	Malawi	1.99
459	Fiji	1.97
460	Aruba	1.96
461	Rwanda	1.95
462	Armenia	1.92
463	***Pocatello, ID***	1.90
464	***Enid, OK***	1.70
465	Somalia	1.67
466	Niger	1.59
467	Cayman Islands	1.59
468	Chad	1.47
469	Kyrgyzstan	1.30
470	Moldova	1.30
471	Togo	1.29
472	Afghanistan	1.27

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
473	Swaziland	1.22
474	Laos	1.09
475	Mongolia	1.03
476	Equatorial Guinea	1.01
477	Tajikistan	1.01
478	Central African Republic	0.99
479	Lesotho	0.95
480	Mauritania	0.91
481	Burundi	0.77
482	Guyana	0.75
483	Eritrea	0.75
484	Belize	0.74
485	Saint Lucia	0.70
486	Antigua & Barbuda	0.69
487	Suriname	0.65
488	Seychelles	0.63
489	SierraLeone	0.59
490	Djibouti	0.56
491	CapeVerde	0.51
492	Bhutan	0.47
493	Gambia	0.45
494	Maldives	0.44
495	Grenada	0.42
496	Solomon Islands	0.39
497	Saint Kitts and Nevis	0.33
498	Saint Vincent and the Grenadines	0.33
499	Dominica	0.28
500	Guinea-Bissau	0.23
501	Vanuatu	0.23
502	Samoa	0.19
503	Comoros	0.18
504	Sao Tome and Principe	0.05

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Table 6

The Gross Product of the Top 10 Metro areas in 2000 exceeds the combined output of the following 31 States.

Total Gross Metro Product $2.43 trillion		Total Gross State Product $2.15 trillion
• New York, NY • Los Angeles-L Beach, CA • Chicago, IL • Boston, MA • Washington, DC-MD-VA-WV • Philadelphia, PA-NJ • Houston, TX • Atlanta, GA • Dallas, TX • Detroit, MI	Is greater than >	• Vermont • North Dakota • Montana • Wyoming • South Dakota • Alaska • Rhode Island • Idaho • Maine • Delaware • Hawaii • West Virginia • New Hampshire • New Mexico • Nebraska • D. C. • Utah • Mississippi • Arkansas • Nevada • Kansas • Oklahoma • Iowa • South Carolina • Oregon • Alabama • Kentucky • Louisiana • Arizona • Connecticut • Colorado

Table 7 – Gross Product of Metro Areas

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Las Vegas, NV-AZ	20.5	54.6	166.3	1
Austin-San Marcos, TX	18.8	48.2	156.4	2
Laredo, TX	2.7	6.6	144.4	3
Provo-Orem, UT	3.4	8.3	144.1	4
Boise City, ID	5.9	14.4	144.1	5
Phoenix-Mesa, AZ	47.3	114.2	141.4	6
Colorado Springs, CO	7.3	17.6	141.1	7
Myrtle Beach, SC	2.9	6.9	137.9	8
Fort Collins-Loveland, CO	3.5	8.3	137.1	9
Greeley, CO	2.2	5.2	136.4	10
Yolo, CA	3.9	8.9	128.2	11
Albuquerque, NM	11.3	25.6	126.5	12
Yuma, AZ	1.2	2.7	125.0	13
Corvallis, OR	1.2	2.7	125.0	14
Atlanta, GA	73.4	164.2	123.7	15
Grand Junction, CO	1.7	3.8	123.5	16
Sioux Falls, SD	3.6	8.0	122.2	17
Boulder-Longmont, CO	5.4	12.0	122.2	18
Salt Lake City-Ogden, UT	21.1	46.4	119.9	19
Fayetteville-Springdale-Rogers, AR	4.1	9.0	119.5	20
Denver, CO	41.8	91.1	117.9	21
Santa Rosa, CA	9.5	20.5	115.8	22
Raleigh-Durham-Chapel Hill, NC	20.7	44.3	114.0	23
Wilmington, NC	3.6	7.7	113.9	24
Green Bay, WI	4.7	10.0	112.8	25
Naples, FL	3.2	6.8	112.5	26
McAllen-Edinburg-Mission, TX	5.1	10.8	111.8	27
Orlando, FL	28.2	59.5	111.0	28
Jackson, TN	1.9	4.0	110.5	29
Pueblo, CO	2.0	4.2	110.0	30
Portland-Vancouver, OR-WA	34.1	71.5	109.7	31
Charlotte-Gastonia-R Hill, NC-SC	29.3	61.3	109.2	32
Killeen-Temple, TX	3.5	7.3	108.6	33
Tucson, AZ	11.0	22.9	108.2	34
San Antonio, TX	25.8	53.7	108.1	35
Nashville, TN	21.9	45.2	106.4	36
Dallas, TX	77.6	160.0	106.2	37
S L Obispo-Atascadero-Paso Robles, CA	4.9	10.1	106.1	38
Santa Fe, NM	2.2	4.5	104.5	39
Clarksville-Hopkinsville, TN-KY	2.2	4.5	104.5	40
Manchester-Nashua, NH	14.8	30.2	104.1	41
Medford-Ashford, OR	2.5	5.1	104.0	42

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Bryan-College Station, TX	2.6	5.3	103.8	43
Ocala, FL	2.9	5.9	103.4	44
Salem, OR	4.9	9.9	102.0	45
Fort Worth-Arlington, TX	31.4	63.0	100.6	46
Athens, GA	2.7	5.4	100.0	47
Bloomington-Normal, IL	4.1	8.2	100.0	48
Columbia, MO	2.5	5.0	100.0	49
Springfield, MO	5.4	10.8	100.0	50
Las Cruces, NM	1.8	3.6	100.0	51
Eugene-Springfield, OR	5.2	10.4	100.0	52
Rapid City, SD	1.5	3.0	100.0	53
Bellingham, WA	2.7	5.4	100.0	54
Reno, NV	7.4	14.7	98.6	55
Gr Rapids-Muskegon-Holland, MI	21.4	42.3	97.7	56
Brownsv-Harlingen-San Benito, TX	3.8	7.5	97.4	57
Tampa-St Petersb-Clrwater, FL	41.7	82.2	97.1	58
Merced, CA	3.1	6.1	96.8	59
Sarasota-Bradenton, FL	8.6	16.9	96.5	60
Joplin, MO	2.8	5.5	96.4	61
Jacksonville, FL	21.9	43.0	96.3	62
Fort Walton Beach, FL	2.6	5.1	96.2	63
Columbus, GA-AL	5.0	9.8	96.0	64
Biloxi-Gulfport-Pascagoula, MS	4.8	9.4	95.8	65
Waco, TX	4.0	7.8	95.0	66
Victoria, TX	1.7	3.3	94.1	67
Olympia, WA	3.3	6.4	93.9	68
Knoxville, TN	11.1	21.5	93.7	69
St. Cloud, MN	3.1	6.0	93.5	70
Houston, TX	91.8	177.5	93.4	71
W Palm Beach-Boca Raton, FL	17.2	33.2	93.0	72
Lawrence, KS	1.4	2.7	92.9	73
Spokane, WA	8.0	15.4	92.5	74
Chico-Paradise, CA	3.9	7.5	92.3	75
Modesto, CA	7.8	15.0	92.3	76
Amarillo, TX	3.9	7.5	92.3	77
Eau Claire, WI	2.5	4.8	92.0	78
Wausau, WI	2.5	4.8	92.0	79
Jonesboro, AR	1.2	2.3	91.7	80
Wilmington-Newark, DE	16.4	31.4	91.5	81
Houma, LA	4.5	8.6	91.1	82
Hamilton-Middletown, OH	4.5	8.6	91.1	83
Greenville, NC	2.2	4.2	90.9	84
Fort Lauderdale, FL	24.5	46.7	90.6	85

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Dover, DE	2.0	3.8	90.0	86
Pocatello, ID	1.0	1.9	90.0	87
Tacoma, WA	10.0	19.0	90.0	88
Lexington, KY	9.4	17.8	89.4	89
Riverside-San Bernardino, CA	44.5	84.1	89.0	90
Barnstable-Yarmouth, MA	3.6	6.8	88.9	91
Longview-Marshall, TX	4.5	8.5	88.9	92
Tyler, TX	3.6	6.8	88.9	93
Seattle-Bellevue-Everett, WA	60.9	115.0	88.8	94
Fort Myers-Cape Coral, FL	6.0	11.3	88.3	95
Kenosha, WI	1.7	3.2	88.2	96
Lincoln, NE	5.1	9.6	88.2	97
Memphis, TN-AR-MS	20.7	38.9	87.9	98
Fort Wayne, IN	9.9	18.6	87.9	99
Richland-Kennewick-Pasco, WA	3.3	6.2	87.9	100
Visalia-Tulare-Porterville, CA	5.6	10.5	87.5	101
Panama City, FL	2.4	4.5	87.5	102
Owensboro, KY	1.6	3.0	87.5	103
Hattiesburg, MS	1.6	3.0	87.5	104
Appleton-Oshkosh-Neenah, WI	7.2	13.5	87.5	105
La Crosse, WI-MN	2.4	4.5	87.5	106
Fargo-Moorhead, ND-MN	3.1	5.8	87.1	107
Middlesex-Somerset-Hunterdon, NJ	34.0	63.6	87.1	108
Minneapolis-St. Paul, MN-WI	64.9	121.3	86.9	109
Indianapolis, IN	30.9	57.7	86.7	110
Mobile, AL	7.5	14.0	86.7	111
Missoula, MT	1.5	2.8	86.7	112
Sumter, SC	1.5	2.8	86.7	113
Chattanooga, TN-GA	9.4	17.5	86.2	114
Jersey City, NJ	15.1	28.1	86.1	115
Omaha, NE-IA	14.1	26.2	85.8	116
Fort Smith, AR-OK	3.4	6.3	85.3	117
Greensboro-W-Salem-High Point,NC	25.0	46.3	85.2	118
Flagstaff, AZ-UT	2.0	3.7	85.0	119
San Angelo, TX	2.0	3.7	85.0	120
Macon, GA	6.5	12.0	84.6	121
Punta Gorda, FL	1.3	2.4	84.6	122
Iowa City, IA	1.9	3.5	84.2	123
El Paso, TX	10.1	18.6	84.2	124
Albany, GA	2.5	4.6	84.0	125
Madison, WI	10.0	18.4	84.0	126
Rochester, MN	2.9	5.3	82.8	127
Yakima, WA	3.4	6.2	82.4	128

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Fayetteville, NC	3.9	7.1	82.1	129
Sacramento, CA	34.7	63.1	81.8	130
Elkhart-Goshen, IN	4.9	8.9	81.6	131
Salinas, CA	7.6	13.8	81.6	132
Vallejo-Fairfield-Napa, CA	8.0	14.5	81.3	133
Bismarck, ND	1.6	2.9	81.3	134
Lubbock, TX	4.7	8.5	80.9	135
Lynchburg, VA	4.7	8.5	80.9	136
Louisville, KY-IN	21.4	38.7	80.8	137
Florence, SC	2.6	4.7	80.8	138
Redding, CA	3.6	6.5	80.6	139
Kansas City, MO-KS	35.9	64.8	80.5	140
Little Rock-N. L.Rock, AR	10.2	18.4	80.4	141
Lafayette, LA	10.1	18.2	80.2	142
Corpus Christi, TX	7.0	12.6	80.0	143
Galveston-Texas City, TX	4.0	7.2	80.0	144
Sherman-Denison, TX	2.0	3.6	80.0	145
Janesville-Beloit, WI	2.5	4.5	80.0	146
San Jose, CA	47.6	85.4	79.4	147
Lancaster, PA	9.2	16.5	79.3	148
Montgomery, AL	5.8	10.4	79.3	149
Santa Cruz-Watsonville, CA	5.3	9.5	79.2	150
Gainesville, FL	4.3	7.7	79.1	151
Cedar Rapids, IA	4.3	7.7	79.1	152
Columbus, OH	33.9	60.7	79.1	153
Tallahassee, FL	5.7	10.2	78.9	154
Lafayette, IN	3.3	5.9	78.8	155
Auburn-Opelika, AL	1.4	2.5	78.6	156
Tuscaloosa, AL	2.8	5.0	78.6	157
Jacksonville, NC	1.4	2.5	78.6	158
Asheville, NC	4.2	7.5	78.6	159
Savannah, GA	5.9	10.5	78.0	160
Richmond-Petersburg, VA	25.7	45.7	77.8	161
Chicago, IL	187.5	332.8	77.5	162
Abilene, TX	2.6	4.6	76.9	163
Des Moines, IA	10.8	19.1	76.9	164
Jackson, MS	8.1	14.3	76.5	165
Monmouth-Ocean, NJ	18.7	33.0	76.5	166
Portland, ME	6.8	12.0	76.5	167
Fort Pierce-Port St. Lucie, FL	3.8	6.7	76.3	168
Daytona Beach, FL	5.9	10.4	76.3	169
Decatur, AL	2.1	3.7	76.2	170
State College, PA	2.5	4.4	76.0	171

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Greenville-Spartanburg-Anderson, SC	17.0	29.9	75.9	172
Baton Rouge, LA	11.6	20.4	75.9	173
Birmingham, AL	18.2	32.0	75.8	174
Lakeland-Winter Haven, FL	7.4	13.0	75.7	175
Pensacola, FL	6.0	10.5	75.0	176
Harrisburg-Lebanon-Carlisle, PA	15.5	27.1	74.8	177
Norfolk-Va Beach-Newport News, VA-NC	29.7	51.7	74.1	178
San Diego, CA	60.2	104.6	73.8	179
Boston, MA	137.8	238.8	73.3	180
Odessa-Midland, TX	7.1	12.3	73.2	181
Washington, DC-MD-VA-WV	125.3	217.0	73.2	182
Peoria-Pekin, IL	7.7	13.3	72.7	183
Bloomington, IN	2.2	3.8	72.7	184
Billings, MT	2.2	3.8	72.7	185
Roanoke, VA	7.3	12.6	72.6	186
Beaumont-Port Arthur, TX	7.2	12.4	72.2	187
Evansville-Henderson, IN-KY	6.1	10.5	72.1	188
Ann Arbor, MI	11.1	19.1	72.1	189
Columbia, SC	11.1	19.1	72.1	190
Bremerton, WA	3.2	5.5	71.9	191
Johnson City-Kingspt-Bristol, TN-VA	8.1	13.9	71.6	192
Hagerstown, MD	2.8	4.8	71.4	193
Sharon, PA	2.1	3.6	71.4	194
Charleston, WV	4.9	8.4	71.4	195
Ventura, CA	14.3	24.5	71.3	196
Charleston-N Charleston, SC	8.6	14.7	70.9	197
Duluth-Superior, MN-WI	4.8	8.2	70.8	198
Sheboygan, WI	2.4	4.1	70.8	199
Orange Co, CA	76.2	130.0	70.6	200
Newburgh, NY-PA	6.4	10.9	70.3	201
Fresno, CA	15.5	26.3	69.7	202
Detroit, MI	92.3	156.3	69.3	203
Waterloo-Cedar Falls, IA	2.6	4.4	69.2	204
Erie, PA	5.8	9.8	69.0	205
Wichita Falls, TX	2.9	4.9	69.0	206
York, PA	7.4	12.5	68.9	207
New London-Norwich, CT	6.1	10.3	68.9	208
Allentown-Bethlehem-Easton, PA	12.2	20.6	68.9	209
Reading, PA	7.7	13.0	68.8	210
Stockton-Lodi, CA	9.6	16.2	68.8	211
Cincinnati, OH-KY-IN	35.2	59.4	68.8	212
Akron, OH	13.0	21.9	68.5	213
Hickory-Morganton, NC	7.6	12.8	68.4	214

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Yuba City, CA	2.2	3.7	68.2	215
Augusta-Aiken, GA-SC	8.8	14.8	68.2	216
Kokomo, IN	2.2	3.7	68.2	217
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	45.7	76.8	68.1	218
Altoona, PA	2.5	4.2	68.0	219
Cleveland-Lorain-Elyria, OH	48.1	80.8	68.0	220
Gadsden, AL	1.5	2.5	66.7	221
South Bend, IN	5.1	8.5	66.7	222
Great Falls, MT	1.2	2.0	66.7	223
Glens Falls, NY	2.7	4.5	66.7	224
Burlington, VT	4.2	7.0	66.7	225
Milwaukee-Waukesha, WI	32.9	54.8	66.6	226
Oakland, CA	55.4	92.1	66.2	227
Pittsburgh, PA	48.6	80.7	66.0	228
Racine, WI	3.2	5.3	65.6	229
St. Louis, MO-IL	54.1	89.6	65.6	230
Santa Barbara-Santa Maria-Lompoc, CA	10.4	17.2	65.4	231
Kalamazoo-Battle Creek, MI	9.5	15.7	65.3	232
Atlantic-Cape May, NJ	9.5	15.7	65.3	233
Nassau-Suffolk, NY	64.8	106.8	64.8	234
Grand Forks, ND-MN	1.7	2.8	64.7	235
Miami, FL	43.5	71.6	64.6	236
Melbourne-Titusville-Palm Bay, FL	7.3	12.0	64.4	237
Williamsport, PA	2.5	4.1	64.0	238
Oklahoma City, OK	19.7	32.3	64.0	239
Texarkana, AR-TX	2.2	3.6	63.6	240
Muncie, IN	2.2	3.6	63.6	241
Alexandria, LA	2.2	3.6	63.6	242
Scranton-Wilkes-Barre-Hazelton, PA	12.6	20.6	63.5	243
Brazoria, TX	3.8	6.2	63.2	244
Huntsville, AL	6.5	10.6	63.1	245
Utica-Rome, NY	7.3	11.9	63.0	246
Jackson, MI	2.7	4.4	63.0	247
Saginaw-Bay City-Midland, MI	7.8	12.7	62.8	248
Tulsa, OK	15.8	25.7	62.7	249
Lansing-East Lansing, MI	9.9	16.1	62.6	250
Providence-Warwick, RI	20.0	32.5	62.5	251
New York, NY	269.6	437.8	62.4	252
Trenton, NJ	11.4	18.5	62.3	253
Youngstown-Warren, OH	10.0	16.2	62.0	254
Florence, AL	2.1	3.4	61.9	255
Philadelphia, PA-NJ	112.9	182.4	61.6	256
Pine Bluff, AR	1.3	2.1	61.5	257

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Charlottesville, VA	3.9	6.3	61.5	258
Goldsboro, NC	1.8	2.9	61.1	259
Elmira, NY	2.3	3.7	60.9	260
Benton Harbor, MI	3.3	5.3	60.6	261
Toledo, OH	13.2	21.2	60.6	262
Kankakee, IL	2.0	3.2	60.0	263
Newark, NJ	60.2	96.3	60.0	264
San Francisco, CA	67.2	107.3	59.7	265
Johnstown, PA	4.2	6.7	59.5	266
Albany-Schenectady-Troy, NY	23.7	37.8	59.5	267
Wichita, KS	11.0	17.5	59.1	268
Topeka, KS	4.1	6.5	58.5	269
Springfield, IL	7.2	11.4	58.3	270
Jamestown, NY	3.1	4.9	58.1	271
Anniston, AL	1.9	3.0	57.9	272
Lewiston-Auburn, ME	1.9	3.0	57.9	273
St. Joseph, MO	1.9	3.0	57.9	274
Dothan, AL	2.6	4.1	57.7	275
Sioux City, IA-NE	2.6	4.1	57.7	276
Rochester, NY	29.0	45.7	57.6	277
Canton-Massillon, OH	8.1	12.7	56.8	278
Davenport-Moline-Rock Isld, IA-IL	8.3	13.0	56.6	279
Danville, VA	2.3	3.6	56.5	280
Bergen-Passaic, NJ	37.9	59.3	56.5	281
Monroe, LA	3.2	5.0	56.3	282
Pittsfield, MA	3.2	5.0	56.3	283
Bakersfield, CA	12.1	18.9	56.2	284
Terre Haute, IN	2.7	4.2	55.6	285
Cumberland, MD-WV	1.8	2.8	55.6	286
Vineland-Millville-Bridgeton, NJ	3.6	5.6	55.6	287
Parkersburg-Marietta, WV-OH	2.9	4.5	55.2	288
Baltimore, MD	62.0	96.2	55.2	289
Dubuque, IA	2.0	3.1	55.0	290
Lake Charles, LA	4.0	6.2	55.0	291
Gary, IN	10.4	16.1	54.8	292
Buffalo-Niagara Falls, NY	30.9	47.8	54.7	293
Enid, OK	1.1	1.7	54.5	294
Champaign-Urbana, IL	3.7	5.7	54.1	295
Hartford, CT	41.8	64.3	53.8	296
Springfield, MA	13.6	20.9	53.7	297
Bangor, ME	2.8	4.3	53.6	298
Dayton-Springfield, OH	20.4	31.2	52.9	299
Cheyenne, WY	1.7	2.6	52.9	300

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Casper, WY	1.9	2.9	52.6	301
Huntington-Ashland, WV-KY-OH	5.0	7.6	52.0	302
Rocky Mount, NC	3.1	4.7	51.6	303
Syracuse, NY	19.9	30.1	51.3	304
Rockford, IL	9.5	14.3	50.5	305
Lima, OH	3.6	5.4	50.0	306
Lawton, OK	1.6	2.4	50.0	307
Wheeling, WV-OH	2.8	4.2	50.0	308
Binghamton, NY	6.7	9.9	47.8	309
Mansfield, OH	3.9	5.7	46.2	310
New Orleans, LA	32.3	46.5	44.0	311
Flint, MI	7.9	11.3	43.0	312
Dutchess County, NY	6.7	9.5	41.8	313
Shreveport-Bossier City, LA	8.7	12.3	41.4	314
Decatur, IL	3.2	4.5	40.6	315
Los Angeles-L Beach, CA	261.7	363.7	39.0	316
Steubenville-Weirton, OH-WV	2.6	3.5	34.6	317
Honolulu, HI	25.1	33.0	31.5	318
Anchorage, AK	10.5	12.8	21.9	319

Table 8 –Gross Product Metro Areas

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Las Vegas, NV-AZ	20.5	54.6	10.3	1
Austin-San Marcos, TX	18.8	48.2	9.8	2
Boise City, ID	5.9	14.4	9.4	3
Laredo, TX	2.7	6.6	9.4	4
Phoenix-Mesa, AZ	47.3	114.2	9.2	5
Fort Collins-Loveland, CO	3.5	8.3	9.2	6
Provo-Orem, UT	3.4	8.3	9.2	7
Colorado Springs, CO	7.3	17.6	9.1	8
Greeley, CO	2.2	5.2	9.1	9
Myrtle Beach, SC	2.9	6.9	9.1	10
Yolo, CA	3.9	8.9	8.5	11
Grand Junction, CO	1.7	3.8	8.5	12
Albuquerque, NM	11.3	25.6	8.5	13
Atlanta, GA	73.4	164.2	8.4	14
Corvallis, OR	1.2	2.7	8.4	15
Boulder-Longmont, CO	5.4	12.0	8.3	16
Sioux Falls, SD	3.6	8.0	8.3	17
Salt Lake City-Ogden, UT	21.1	46.4	8.2	18
Fayetteville-Springdale-Rogers, AR	4.1	9.0	8.1	19
Denver, CO	41.8	91.1	8.1	20
Santa Rosa, CA	9.5	20.5	8.0	21
Yuma, AZ	1.2	2.7	7.9	22
Naples, FL	3.2	6.8	7.9	23
Raleigh-Durham-Chapel Hill, NC	20.7	44.3	7.9	24
Wilmington, NC	3.6	7.7	7.9	25
Orlando, FL	28.2	59.5	7.8	26
McAllen-Edinburg-Mission, TX	5.1	10.8	7.8	27
Green Bay, WI	4.7	10.0	7.8	28
Charlotte-Gastonia-R Hill, NC-SC	29.3	61.3	7.7	29
Portland-Vancouver, OR-WA	34.1	71.5	7.7	30
Jackson, TN	1.9	4.0	7.7	31
Tucson, AZ	11.0	22.9	7.6	32
San Antonio, TX	25.8	53.7	7.6	33
S L Obispo-Atascadero-Paso Robles, CA	4.9	10.1	7.5	34
Medford-Ashford, OR	2.5	5.1	7.5	35
Nashville, TN	21.9	45.2	7.5	36
Dallas, TX	77.6	160.0	7.5	37
Pueblo, CO	2.0	4.2	7.4	38
Manchester-Nashua, NH	14.8	30.2	7.4	39
Santa Fe, NM	2.2	4.5	7.4	40
Bryan-College Station, TX	2.6	5.3	7.4	41
Killeen-Temple, TX	3.5	7.3	7.4	42

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Ocala, FL	2.9	5.9	7.3	43
Salem, OR	4.9	9.9	7.3	44
Clarksville-Hopkinsville, TN-KY	2.2	4.5	7.3	45
Fort Walton Beach, FL	2.6	5.1	7.2	46
Eugene-Springfield, OR	5.2	10.4	7.2	47
Fort Worth-Arlington, TX	31.4	63.0	7.2	48
Athens, GA	2.7	5.4	7.1	49
Bloomington-Normal, IL	4.1	8.2	7.1	50
Gr Rapids-Muskegon-Holland, MI	21.4	42.3	7.1	51
Biloxi-Gulfport-Pascagoula, MS	4.8	9.4	7.1	52
Springfield, MO	5.4	10.8	7.1	53
Reno, NV	7.4	14.7	7.1	54
Brownsv-Harlingen-San Benito, TX	3.8	7.5	7.1	55
Jacksonville, FL	21.9	43.0	7.0	56
Sarasota-Bradenton, FL	8.6	16.9	7.0	57
Tampa-St Petersb-Clrwater, FL	41.7	82.2	7.0	58
Pocatello, ID	1.0	1.9	7.0	59
Las Cruces, NM	1.8	3.6	7.0	60
Merced, CA	3.1	6.1	6.9	61
Columbus, GA-AL	5.0	9.8	6.9	62
Columbia, MO	2.5	5.0	6.9	63
Joplin, MO	2.8	5.5	6.9	64
Rapid City, SD	1.5	3.0	6.9	65
Bellingham, WA	2.7	5.4	6.9	66
Olympia, WA	3.3	6.4	6.9	67
Modesto, CA	7.8	15.0	6.8	68
W Palm Beach-Boca Raton, FL	17.2	33.2	6.8	69
Knoxville, TN	11.1	21.5	6.8	70
Houston, TX	91.8	177.5	6.8	71
Victoria, TX	1.7	3.3	6.8	72
Waco, TX	4.0	7.8	6.8	73
Spokane, WA	8.0	15.4	6.8	74
Eau Claire, WI	2.5	4.8	6.8	75
Flagstaff, AZ-UT	2.0	3.7	6.7	76
Wilmington-Newark, DE	16.4	31.4	6.7	77
Fort Lauderdale, FL	24.5	46.7	6.7	78
Lawrence, KS	1.4	2.7	6.7	79
Houma, LA	4.5	8.6	6.7	80
Barnstable-Yarmouth, MA	3.6	6.8	6.7	81
St. Cloud, MN	3.1	6.0	6.7	82
Missoula, MT	1.5	2.8	6.7	83
Amarillo, TX	3.9	7.5	6.7	84
Longview-Marshall, TX	4.5	8.5	6.7	85

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Tyler, TX	3.6	6.8	6.7	86
Tacoma, WA	10.0	19.0	6.7	87
Wausau, WI	2.5	4.8	6.7	88
Chico-Paradise, CA	3.9	7.5	6.6	89
Riverside-San Bernardino, CA	44.5	84.1	6.6	90
Dover, DE	2.0	3.8	6.6	91
Lexington, KY	9.4	17.8	6.6	92
Lincoln, NE	5.1	9.6	6.6	93
Greenville, NC	2.2	4.2	6.6	94
Fargo-Moorhead, ND-MN	3.1	5.8	6.6	95
Hamilton-Middletown, OH	4.5	8.6	6.6	96
Seattle-Bellevue-Everett, WA	60.9	115.0	6.6	97
Fort Smith, AR-OK	3.4	6.3	6.5	98
Jonesboro, AR	1.2	2.3	6.5	99
Visalia-Tulare-Porterville, CA	5.6	10.5	6.5	100
Fort Myers-Cape Coral, FL	6.0	11.3	6.5	101
Fort Wayne, IN	9.9	18.6	6.5	102
Indianapolis, IN	30.9	57.7	6.5	103
Minneapolis-St. Paul, MN-WI	64.9	121.3	6.5	104
Middlesex-Somerset-Hunterdon, NJ	34.0	63.6	6.5	105
Memphis, TN-AR-MS	20.7	38.9	6.5	106
Richland-Kennewick-Pasco, WA	3.3	6.2	6.5	107
Kenosha, WI	1.7	3.2	6.5	108
La Crosse, WI-MN	2.4	4.5	6.5	109
Mobile, AL	7.5	14.0	6.4	110
Macon, GA	6.5	12.0	6.4	111
Iowa City, IA	1.9	3.5	6.4	112
Omaha, NE-IA	14.1	26.2	6.4	113
Jersey City, NJ	15.1	28.1	6.4	114
Greensboro-W-Salem-High Point,NC	25.0	46.3	6.4	115
Chattanooga, TN-GA	9.4	17.5	6.4	116
Appleton-Oshkosh-Neenah, WI	7.2	13.5	6.4	117
Panama City, FL	2.4	4.5	6.3	118
Rochester, MN	2.9	5.3	6.3	119
Hattiesburg, MS	1.6	3.0	6.3	120
Sumter, SC	1.5	2.8	6.3	121
El Paso, TX	10.1	18.6	6.3	122
Madison, WI	10.0	18.4	6.3	123
Sacramento, CA	34.7	63.1	6.2	124
Vallejo-Fairfield-Napa, CA	8.0	14.5	6.2	125
Punta Gorda, FL	1.3	2.4	6.2	126
Albany, GA	2.5	4.6	6.2	127
Fayetteville, NC	3.9	7.1	6.2	128

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Jacksonville, NC	1.4	2.5	6.2	129
Lubbock, TX	4.7	8.5	6.2	130
San Angelo, TX	2.0	3.7	6.2	131
Yakima, WA	3.4	6.2	6.2	132
Tuscaloosa, AL	2.8	5.0	6.1	133
Little Rock-N. L.Rock, AR	10.2	18.4	6.1	134
Salinas, CA	7.6	13.8	6.1	135
Louisville, KY-IN	21.4	38.7	6.1	136
Lafayette, LA	10.1	18.2	6.1	137
Kansas City, MO-KS	35.9	64.8	6.1	138
Asheville, NC	4.2	7.5	6.1	139
Bismarck, ND	1.6	2.9	6.1	140
Corpus Christi, TX	7.0	12.6	6.1	141
Galveston-Texas City, TX	4.0	7.2	6.1	142
Montgomery, AL	5.8	10.4	6.0	143
San Jose, CA	47.6	85.4	6.0	144
Santa Cruz-Watsonville, CA	5.3	9.5	6.0	145
Tallahassee, FL	5.7	10.2	6.0	146
Elkhart-Goshen, IN	4.9	8.9	6.0	147
Cedar Rapids, IA	4.3	7.7	6.0	148
Owensboro, KY	1.6	3.0	6.0	149
Columbus, OH	33.9	60.7	6.0	150
Lancaster, PA	9.2	16.5	6.0	151
Florence, SC	2.6	4.7	6.0	152
Lynchburg, VA	4.7	8.5	6.0	153
Janesville-Beloit, WI	2.5	4.5	6.0	154
Redding, CA	3.6	6.5	5.9	155
Gainesville, FL	4.3	7.7	5.9	156
Savannah, GA	5.9	10.5	5.9	157
Chicago, IL	187.5	332.8	5.9	158
Lafayette, IN	3.3	5.9	5.9	159
Des Moines, IA	10.8	19.1	5.9	160
Portland, ME	6.8	12.0	5.9	161
Jackson, MS	8.1	14.3	5.9	162
Abilene, TX	2.6	4.6	5.9	163
Sherman-Denison, TX	2.0	3.6	5.9	164
Richmond-Petersburg, VA	25.7	45.7	5.9	165
Birmingham, AL	18.2	32.0	5.8	166
Fort Pierce-Port St. Lucie, FL	3.8	6.7	5.8	167
Lakeland-Winter Haven, FL	7.4	13.0	5.8	168
Pensacola, FL	6.0	10.5	5.8	169
Baton Rouge, LA	11.6	20.4	5.8	170
Monmouth-Ocean, NJ	18.7	33.0	5.8	171

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Greenville-Spartanburg-Anderson, SC	17.0	29.9	5.8	172
Sheboygan, WI	2.4	4.1	5.8	173
San Diego, CA	60.2	104.6	5.7	174
Daytona Beach, FL	5.9	10.4	5.7	175
Peoria-Pekin, IL	7.7	13.3	5.7	176
Boston, MA	137.8	238.8	5.7	177
Billings, MT	2.2	3.8	5.7	178
Harrisburg-Lebanon-Carlisle, PA	15.5	27.1	5.7	179
State College, PA	2.5	4.4	5.7	180
Norfolk-Va Beach-Newport News, VA-NC	29.7	51.7	5.7	181
Roanoke, VA	7.3	12.6	5.7	182
Auburn-Opelika, AL	1.4	2.5	5.6	183
Washington, DC-MD-VA-WV	125.3	217.0	5.6	184
Bloomington, IN	2.2	3.8	5.6	185
Evansville-Henderson, IN-KY	6.1	10.5	5.6	186
Hagerstown, MD	2.8	4.8	5.6	187
Columbia, SC	11.1	19.1	5.6	188
Johnson City-Kingspt-Bristol, TN-VA	8.1	13.9	5.6	189
Beaumont-Port Arthur, TX	7.2	12.4	5.6	190
Odessa-Midland, TX	7.1	12.3	5.6	191
Decatur, AL	2.1	3.7	5.5	192
Orange County, CA	76.2	130.0	5.5	193
Ventura, CA	14.3	24.5	5.5	194
Yuba City, CA	2.2	3.7	5.5	195
New London-Norwich, CT	6.1	10.3	5.5	196
Waterloo-Cedar Falls, IA	2.6	4.4	5.5	197
Ann Arbor, MI	11.1	19.1	5.5	198
Duluth-Superior, MN-WI	4.8	8.2	5.5	199
Newburgh, NY-PA	6.4	10.9	5.5	200
Reading, PA	7.7	13.0	5.5	201
Sharon, PA	2.1	3.6	5.5	202
Charleston-N Charleston, SC	8.6	14.7	5.5	203
Bremerton, WA	3.2	5.5	5.5	204
Charleston, WV	4.9	8.4	5.5	205
Fresno, CA	15.5	26.3	5.4	206
Stockton-Lodi, CA	9.6	16.2	5.4	207
Detroit, MI	92.3	156.3	5.4	208
Cincinnati, OH-KY-IN	35.2	59.4	5.4	209
Allentown-Bethlehem-Easton, PA	12.2	20.6	5.4	210
Altoona, PA	2.5	4.2	5.4	211
Erie, PA	5.8	9.8	5.4	212
York, PA	7.4	12.5	5.4	213
Gadsden, AL	1.5	2.5	5.3	214

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	45.7	76.8	5.3	215
Augusta-Aiken, GA-SC	8.8	14.8	5.3	216
Kokomo, IN	2.2	3.7	5.3	217
Hickory-Morganton, NC	7.6	12.8	5.3	218
Akron, OH	13.0	21.9	5.3	219
Cleveland-Lorain-Elyria, OH	48.1	80.8	5.3	220
Oakland, CA	55.4	92.1	5.2	221
Santa Barbara-Santa Maria-Lompoc, CA	10.4	17.2	5.2	222
South Bend, IN	5.1	8.5	5.2	223
Kalamazoo-Battle Creek, MI	9.5	15.7	5.2	224
St. Louis, MO-IL	54.1	89.6	5.2	225
Atlantic-Cape May, NJ	9.5	15.7	5.2	226
Grand Forks, ND-MN	1.7	2.8	5.2	227
Pittsburgh, PA	48.6	80.7	5.2	228
Wichita Falls, TX	2.9	4.9	5.2	229
Burlington, VT	4.2	7.0	5.2	230
Milwaukee-Waukesha, WI	32.9	54.8	5.2	231
Huntsville, AL	6.5	10.6	5.1	232
Melbourne-Titusville-Palm Bay, FL	7.3	12.0	5.1	233
Miami, FL	43.5	71.6	5.1	234
Jackson, MI	2.7	4.4	5.1	235
Glens Falls, NY	2.7	4.5	5.1	236
Nassau-Suffolk, NY	64.8	106.8	5.1	237
Goldsboro, NC	1.8	2.9	5.1	238
Oklahoma City, OK	19.7	32.3	5.1	239
Texarkana, AR-TX	2.2	3.6	5.0	240
Lansing-East Lansing, MI	9.9	16.1	5.0	241
Saginaw-Bay City-Midland, MI	7.8	12.7	5.0	242
Trenton, NJ	11.4	18.5	5.0	243
Elmira, NY	2.3	3.7	5.0	244
New York, NY	269.6	437.8	5.0	245
Utica-Rome, NY	7.3	11.9	5.0	246
Tulsa, OK	15.8	25.7	5.0	247
Scranton-Wilkes-Barre-Hazelton, PA	12.6	20.6	5.0	248
Williamsport, PA	2.5	4.1	5.0	249
Brazoria, TX	3.8	6.2	5.0	250
Racine, WI	3.2	5.3	5.0	251
Florence, AL	2.1	3.4	4.9	252
Alexandria, LA	2.2	3.6	4.9	253
Lewiston-Auburn, ME	1.9	3.0	4.9	254
Benton Harbor, MI	3.3	5.3	4.9	255
Great Falls, MT	1.2	2.0	4.9	256
Toledo, OH	13.2	21.2	4.9	257

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Youngstown-Warren, OH	10.0	16.2	4.9	258
Philadelphia, PA-NJ	112.9	182.4	4.9	259
Providence-Warwick, RI	20.0	32.5	4.9	260
Charlottesville, VA	3.9	6.3	4.9	261
San Francisco, CA	67.2	107.3	4.8	262
Kankakee, IL	2.0	3.2	4.8	263
Newark, NJ	60.2	96.3	4.8	264
Albany-Schenectady-Troy, NY	23.7	37.8	4.8	265
Springfield, IL	7.2	11.4	4.7	266
Muncie, IN	2.2	3.6	4.7	267
Dubuque, IA	2.0	3.1	4.7	268
Sioux City, IA-NE	2.6	4.1	4.7	269
Topeka, KS	4.1	6.5	4.7	270
Wichita, KS	11.0	17.5	4.7	271
Rochester, NY	29.0	45.7	4.7	272
Enid, OK	1.1	1.7	4.7	273
Johnstown, PA	4.2	6.7	4.7	274
Cheyenne, WY	1.7	2.6	4.7	275
Anniston, AL	1.9	3.0	4.6	276
Dothan, AL	2.6	4.1	4.6	277
Bakersfield, CA	12.1	18.9	4.6	278
Monroe, LA	3.2	5.0	4.6	279
Bergen-Passaic, NJ	37.9	59.3	4.6	280
Jamestown, NY	3.1	4.9	4.6	281
Canton-Massillon, OH	8.1	12.7	4.6	282
Parkersburg-Marietta, WV-OH	2.9	4.5	4.6	283
Pine Bluff, AR	1.3	2.1	4.5	284
Davenport-Moline-Rock Isld, IA-IL	8.3	13.0	4.5	285
Lake Charles, LA	4.0	6.2	4.5	286
Baltimore, MD	62.0	96.2	4.5	287
Vineland-Millville-Bridgeton, NJ	3.6	5.6	4.5	288
Buffalo-Niagara Falls, NY	30.9	47.8	4.5	289
Danville, VA	2.3	3.6	4.5	290
Casper, WY	1.9	2.9	4.5	291
Hartford, CT	41.8	64.3	4.4	292
Champaign-Urbana, IL	3.7	5.7	4.4	293
Gary, IN	10.4	16.1	4.4	294
Terre Haute, IN	2.7	4.2	4.4	295
Bangor, ME	2.8	4.3	4.4	296
Pittsfield, MA	3.2	5.0	4.4	297
Springfield, MA	13.6	20.9	4.4	298
Huntington-Ashland, WV-KY-OH	5.0	7.6	4.4	299
Cumberland, MD-WV	1.8	2.8	4.3	300

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
St. Joseph, MO	1.9	3.0	4.3	301
Rocky Mount, NC	3.1	4.7	4.3	302
Dayton-Springfield, OH	20.4	31.2	4.3	303
Rockford, IL	9.5	14.3	4.2	304
Syracuse, NY	19.9	30.1	4.2	305
Wheeling, WV-OH	2.8	4.2	4.2	306
Lima, OH	3.6	5.4	4.1	307
Lawton, OK	1.6	2.4	4.0	308
Binghamton, NY	6.7	9.9	3.9	309
Mansfield, OH	3.9	5.7	3.9	310
New Orleans, LA	32.3	46.5	3.7	311
Flint, MI	7.9	11.3	3.7	312
Shreveport-Bossier City, LA	8.7	12.3	3.6	313
Decatur, IL	3.2	4.5	3.5	314
Dutchess County, NY	6.7	9.5	3.5	315
Los Angeles-L Beach, CA	261.7	363.7	3.3	316
Steubenville-Weirton, OH-WV	2.6	3.5	3.1	317
Honolulu, HI	25.1	33.0	2.8	318
Anchorage, AK	10.5	12.8	2.1	319

Table 9 – Gross Product of Countries, U.S. States, and Metro Areas

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, <u>State</u>, or **Metro Area**	Gross Product
1	United States	9963.050
2	Japan	4614.069
3	Germany	1872.608
4	United Kingdom	1410.153
5	<u>California</u>	1301.735
6	France	1285.747
7	China	1103.716
8	Italy	1074.097
9	<u>New York</u>	806.242
10	<u>Texas</u>	760.645
11	Canada	699.339
12	Brazil	665.287
13	Mexico	577.650
14	Spain	556.562
15	India	510.106
16	<u>Florida</u>	483.245
17	Korea, South	480.176
18	<u>Illinois</u>	472.154
19	**New York, NY**	437.777
20	Australia	427.864
21	<u>Pennsylvania</u>	412.657
22	<u>Ohio</u>	380.597
23	<u>New Jersey</u>	364.535
24	**Los Angeles-L Beach, CA**	363.688
25	Netherlands	360.237
26	**Chicago, IL**	332.812
27	<u>Michigan</u>	328.171
28	Taiwan	322.803
29	<u>Georgia</u>	292.877
30	Argentina	283.686
31	<u>Massachusetts</u>	274.769
32	<u>North Carolina</u>	266.614
33	<u>Virginia</u>	264.856
34	Russia	246.767
35	Switzerland	241.279
36	**Boston, MA**	238.831
37	Belgium	227.049
38	Sweden	224.065
39	Turkey	217.583
40	**Washington, DC-MD-VA-WV**	217.045
41	<u>Washington</u>	216.968

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
42	Indiana	194.632
43	Maryland	187.315
44	Austria	184.944
45	Minnesota	183.901
46	**Philadelphia, PA-NJ**	182.353
47	Missouri	181.341
48	Tennessee	180.165
49	Wisconsin	178.831
50	**Houston, TX**	177.549
51	Colorado	166.241
52	Hong Kong	164.631
53	**Atlanta, GA**	164.234
54	Norway	164.034
55	Poland	162.697
56	Connecticut	160.556
57	**Dallas, TX**	159.951
58	Arizona	158.508
59	Denmark	157.982
60	**Detroit, MI**	156.286
61	Louisiana	149.191
62	Indonesia	147.616
63	Saudi Arabia	145.344
64	South Africa	132.267
65	**Orange Co, CA**	129.991
66	Thailand	128.236
67	Kentucky	122.586
68	Alabama	121.812
69	**Minneapolis-St. Paul, MN-WI**	121.256
70	Oregon	118.345
71	Finland	118.018
72	South Carolina	115.180
73	**Seattle-Bellevue-Everett, WA**	115.041
74	**Phoenix-Mesa, AZ**	114.235
75	Greece	110.870
76	Israel	107.966
77	**San Francisco, CA**	107.334
78	**Nassau-Suffolk, NY**	106.819
79	**San Diego, CA**	104.588
80	Venezuela	102.937
81	Portugal	100.508
82	**Newark, NJ**	96.275
83	**Baltimore, MD**	96.231

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
84	Ireland	95.143
85	Iowa	93.954
86	Singapore	93.665
87	Oklahoma	93.505
88	**Oakland, CA**	92.113
89	Egypt	91.452
90	**Denver, CO**	91.100
91	Colombia	90.033
92	**St. Louis, MO-IL**	89.565
93	Malaysia	88.813
94	Kansas	86.041
95	**San Jose, CA**	85.382
96	**Riverside-San Bernardino, CA**	84.106
97	**Tampa-St Petersb-Clrwater, FL**	82.233
98	**Cleveland-Lorain-Elyria, OH**	80.754
99	**Pittsburgh, PA**	80.742
100	Philippines	77.995
101	**N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT**	76.780
102	Nevada	75.997
103	Chile	72.962
104	**Miami, FL**	71.631
105	**Portland-Vancouver, OR-WA**	71.536
106	Arkansas	69.341
107	Mississippi	68.846
108	Utah	68.639
109	Iran	67.107
110	Puerto Rico	65.329
111	**Kansas City, MO-KS**	64.816
112	**Hartford, CT**	64.296
113	**Middlesex-Somerset-Hunterdon, NJ**	63.616
114	**Sacramento, CA**	63.099
115	**Fort Worth-Arlington, TX**	63.012
116	Pakistan	62.748
117	Peru	62.746
118	D. C.	61.279
119	**Charlotte-Gastonia-R Hill, NC-SC**	61.270
120	**Columbus, OH**	60.745
121	United Arab	60.722
122	**Orlando, FL**	59.470
123	**Cincinnati, OH-KY-IN**	59.392
124	**Bergen-Passaic, NJ**	59.280
125	Nebraska	58.561

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
126	**Indianapolis, IN**	57.657
127	New Mexico	56.108
128	Nigeria	54.875
129	**Milwaukee-Waukesha, WI**	54.752
130	**Las Vegas, NV-AZ**	54.621
131	**San Antonio, TX**	53.749
132	Algeria	52.800
133	New Zealand	52.126
134	**Norfolk-Va Beach-Newport News, VA-NC**	51.694
135	Czech	50.805
136	**Austin-San Marcos, TX**	48.154
137	**Buffalo-Niagara Falls, NY**	47.844
138	New Hampshire	47.810
139	Hungary	47.371
140	**Fort Lauderdale, FL**	46.680
141	**New Orleans, LA**	46.532
142	**Salt Lake City-Ogden, UT**	46.407
143	**Greensboro-W-Salem-High Point,NC**	46.332
144	**Rochester, NY**	45.738
145	**Richmond-Petersburg, VA**	45.679
146	West Virginia	45.517
147	**Nashville, TN**	45.214
148	**Raleigh-Durham-Chapel Hill, NC**	44.271
149	Hawaii	43.759
150	**Jacksonville, FL**	42.990
151	**Gr Rapids-Muskegon-Holland, MI**	42.348
152	**Memphis, TN-AR-MS**	38.941
153	**Louisville, KY-IN**	38.651
154	Bangladesh	38.513
155	Delaware	38.501
156	Kuwait	38.048
157	**Albany-Schenectady-Troy, NY**	37.790
158	Maine	37.579
159	Idaho	36.949
160	Syria	35.528
161	Morocco	34.807
162	Rhode Island	34.780
163	**W Palm Beach-Boca Raton, FL**	33.181
164	Romania	33.033
165	**Honolulu, HI**	32.973
166	**Monmouth-Ocean, NJ**	32.953
167	**Providence-Warwick, RI**	32.463

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
168	**Oklahoma City, OK**	32.350
169	**Birmingham, AL**	31.961
170	Ukraine	31.651
171	**Wilmington-Newark, DE**	31.363
172	**Dayton-Springfield, OH**	31.164
173	Vietnam	30.624
174	**Manchester-Nashua, NH**	30.172
175	Alaska	30.065
176	**Syracuse, NY**	30.063
177	**Greenville-Spartanburg-Anderson, SC**	29.862
178	**Jersey City, NJ**	28.147
179	**Harrisburg-Lebanon-Carlisle, PA**	27.076
180	**Fresno, CA**	26.314
181	**Omaha, NE-IA**	26.184
182	**Tulsa, OK**	25.725
183	**Albuquerque, NM**	25.636
184	Iraq	25.487
185	South Dakota	25.170
186	**Ventura, CA**	24.464
187	Wyoming	23.122
188	Montana	22.908
189	**Tucson, AZ**	22.878
190	**Akron, OH**	21.857
191	**Knoxville, TN**	21.516
192	**Toledo, OH**	21.190
193	**Springfield, MA**	20.929
194	**Allentown-Bethlehem-Easton, PA**	20.647
195	**Scranton-Wilkes-Barre-Hazelton, PA**	20.625
196	**Santa Rosa, CA**	20.511
197	Uruguay	20.494
198	**Baton Rouge, LA**	20.389
199	Slovakia	20.169
200	Tunisia	19.965
201	Dominican Republic	19.669
202	North Dakota	19.312
203	**Columbia, SC**	19.139
204	**Ann Arbor, MI**	19.098
205	**Des Moines, IA**	19.073
206	Guatemala	19.050
207	**Tacoma, WA**	19.034
208	Croatia (Hrvatska)	18.951
209	**Bakersfield, CA**	18.920

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
210	Oman	18.818
211	**El Paso, TX**	18.607
212	Vermont	18.582
213	**Fort Wayne, IN**	18.562
214	**Trenton, NJ**	18.504
215	Slovenia	18.465
216	**Madison, WI**	18.446
217	**Little Rock-N. L.Rock, AR**	18.367
218	Kazakhstan	18.242
219	**Lafayette, LA**	18.214
220	Luxembourg	18.098
221	**Lexington, KY**	17.761
222	**Colorado Springs, CO**	17.559
223	**Wichita, KS**	17.464
224	**Chattanooga, TN-GA**	17.455
225	Lebanon	17.357
226	**Santa Barbara-Santa Maria-Lompoc, CA**	17.226
227	**Sarasota-Bradenton, FL**	16.928
228	**Lancaster, PA**	16.537
229	Sri Lanka	16.467
230	**Youngstown-Warren, OH**	16.229
231	**Stockton-Lodi, CA**	16.212
232	**Lansing-East Lansing, MI**	16.139
233	**Gary, IN**	16.131
234	Costa Rica	16.022
235	**Kalamazoo-Battle Creek, MI**	15.742
236	**Atlantic-Cape May, NJ**	15.708
237	**Spokane, WA**	15.408
238	**Modesto, CA**	14.963
239	**Augusta-Aiken, GA-SC**	14.831
240	**Charleston-N Charleston, SC**	14.708
241	**Reno, NV**	14.654
242	Qatar	14.576
243	**Vallejo-Fairfield-Napa, CA**	14.480
244	**Boise City, ID**	14.443
245	**Rockford, IL**	14.273
246	**Jackson, MS**	14.265
247	**Mobile, AL**	14.024
248	**Johnson City-Kingspt-Bristol, TN-VA**	13.900
249	**Salinas, CA**	13.815
250	**Appleton-Oshkosh-Neenah, WI**	13.465
251	**Peoria-Pekin, IL**	13.305

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
252	El Salvador	13.217
253	**Reading, PA**	13.037
254	Ecuador	13.036
255	**Lakeland-Winter Haven, FL**	13.034
256	**Davenport-Moline-Rock Isld, IA-IL**	12.951
257	**Hickory-Morganton, NC**	12.824
258	**Anchorage, AK**	12.809
259	**Saginaw-Bay City-Midland, MI**	12.744
260	**Canton-Massillon, OH**	12.704
261	**Roanoke, VA**	12.641
262	**Corpus Christi, TX**	12.612
263	**York, PA**	12.471
264	**Beaumont-Port Arthur, TX**	12.430
265	**Shreveport-Bossier City, LA**	12.344
266	Uzbekistan	12.299
267	**Odessa-Midland, TX**	12.269
268	Bulgaria	12.228
269	**Macon, GA**	12.017
270	**Melbourne-Titusville-Palm Bay, FL**	12.005
271	**Boulder-Longmont, CO**	12.003
272	**Portland, ME**	11.981
273	**Utica-Rome, NY**	11.905
274	**Springfield, IL**	11.408
275	**Flint, MI**	11.348
276	**Fort Myers-Cape Coral, FL**	11.304
277	Lithuania	11.225
278	Sudan	10.984
279	**Newburgh, NY-PA**	10.947
280	Cote d'Ivoire	10.930
281	**Springfield, MO**	10.786
282	**McAllen-Edinburg-Mission, TX**	10.786
283	Belarus	10.782
284	Kenya	10.601
285	**Huntsville, AL**	10.574
286	**Evansville-Henderson, IN-KY**	10.540
287	**Savannah, GA**	10.510
288	**Pensacola, FL**	10.505
289	**Visalia-Tulare-Porterville, CA**	10.459
290	**Eugene-Springfield, OR**	10.393
291	**Montgomery, AL**	10.386
292	**Daytona Beach, FL**	10.356
293	**New London-Norwich, CT**	10.342

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
294	**Tallahassee, FL**	10.165
295	Cuba	10.068
296	**S L Obispo-Atascadero-Paso Robles, CA**	10.066
297	**Green Bay, WI**	9.987
298	**Salem, OR**	9.945
299	**Binghamton, NY**	9.859
300	**Erie, PA**	9.800
301	**Columbus, GA-AL**	9.790
302	Cameroon	9.671
303	Myanmar	9.609
304	**Lincoln, NE**	9.577
305	**Santa Cruz-Watsonville, CA**	9.530
306	**Dutchess County, NY**	9.464
307	**Biloxi-Gulfport-Pascagoula, MS**	9.438
308	Tanzania	9.315
309	Iceland	9.167
310	**Fayetteville-Springdale-Rogers, AR**	9.033
311	Cyprus	8.935
312	**Elkhart-Goshen, IN**	8.874
313	**Yolo, CA**	8.859
314	**Hamilton-Middletown, OH**	8.577
315	**Houma, LA**	8.559
316	Bolivia	8.544
317	**Longview-Marshall, TX**	8.543
318	**South Bend, IN**	8.539
319	**Lubbock, TX**	8.536
320	**Lynchburg, VA**	8.473
321	**Charleston, WV**	8.439
322	**Fort Collins-Loveland, CO**	8.343
323	**Provo-Orem, UT**	8.280
324	**Bloomington-Normal, IL**	8.201
325	**Duluth-Superior, MN-WI**	8.153
326	**Sioux Falls, SD**	7.993
327	Yemen (Unified)	7.957
328	**Waco, TX**	7.827
329	Jordan	7.750
330	**Wilmington, NC**	7.724
331	**Cedar Rapids, IA**	7.698
332	**Gainesville, FL**	7.696
333	**Huntington-Ashland, WV-KY-OH**	7.606
334	Zimbabwe	7.605
335	**Amarillo, TX**	7.533

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
336	Paraguay	7.490
337	**Asheville, NC**	7.485
338	**Brownsv-Harlingen-San Benito, TX**	7.484
339	**Chico-Paradise, CA**	7.469
340	Libyan Arab Jamahiriya	7.467
341	Panama	7.342
342	Federal Republic of Yugoslavia	7.338
343	Trinidad & Tobago	7.283
344	**Killeen-Temple, TX**	7.254
345	**Galveston-Texas City, TX**	7.231
346	Jamaica	7.179
347	Latvia	7.150
348	Bahrain	7.111
349	**Fayetteville, NC**	7.062
350	**Burlington, VT**	7.000
351	**Myrtle Beach, SC**	6.922
352	**Naples, FL**	6.811
353	**Tyler, TX**	6.807
354	Ethiopia	6.800
355	**Barnstable-Yarmouth, MA**	6.787
356	**Fort Pierce-Port St. Lucie, FL**	6.673
357	**Johnstown, PA**	6.654
358	**Laredo, TX**	6.568
359	**Topeka, KS**	6.539
360	**Redding, CA**	6.452
361	**Olympia, WA**	6.374
362	**Charlottesville, VA**	6.332
363	**Fort Smith, AR-OK**	6.306
364	Ghana	6.303
365	**Lake Charles, LA**	6.212
366	**Yakima, WA**	6.211
367	Uganda	6.195
368	**Richland-Kennewick-Pasco, WA**	6.165
369	**Brazoria, TX**	6.163
370	**Merced, CA**	6.060
371	**St. Cloud, MN**	5.959
372	**Lafayette, IN**	5.936
373	Honduras	5.932
374	**Ocala, FL**	5.928
375	**Fargo-Moorhead, ND-MN**	5.834
376	**Champaign-Urbana, IL**	5.731
377	**Mansfield, OH**	5.722

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
378	**Vineland-Millville-Bridgeton, NJ**	5.568
379	**Joplin, MO**	5.510
380	**Bremerton, WA**	5.471
381	Nepal	5.418
382	**Athens, GA**	5.410
383	**Lima, OH**	5.370
384	**Bellingham, WA**	5.364
385	Botswana	5.360
386	**Bryan-College Station, TX**	5.319
387	**Rochester, MN**	5.307
388	**Benton Harbor, MI**	5.287
389	**Racine, WI**	5.268
390	**Greeley, CO**	5.242
391	Brunei Darussalam	5.210
392	Gabon	5.210
393	**Fort Walton Beach, FL**	5.126
394	**Medford-Ashford, OR**	5.094
395	**Tuscaloosa, AL**	5.017
396	**Monroe, LA**	4.986
397	**Pittsfield, MA**	4.979
398	**Columbia, MO**	4.976
399	West Bank and Gaza	4.939
400	Estonia	4.922
401	**Jamestown, NY**	4.918
402	Azerbaijan	4.896
403	**Wichita Falls, TX**	4.852
404	**Hagerstown, MD**	4.821
405	**Wausau, WI**	4.796
406	**Eau Claire, WI**	4.794
407	**Florence, SC**	4.710
408	**Rocky Mount, NC**	4.669
409	Mauritius	4.601
410	**Albany, GA**	4.570
411	**Abilene, TX**	4.561
412	**La Crosse, WI-MN**	4.548
413	**Decatur, IL**	4.544
414	Senegal	4.530
415	**Parkersburg-Marietta, WV-OH**	4.528
416	**Janesville-Beloit, WI**	4.496
417	**Clarksville-Hopkinsville, TN-KY**	4.493
418	**Panama City, FL**	4.492
419	**Santa Fe, NM**	4.485

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
420	**Glens Falls, NY**	4.472
421	**Jackson, MI**	4.443
422	**State College, PA**	4.437
423	Angola	4.426
424	Turkmenistan	4.404
425	**Waterloo-Cedar Falls, IA**	4.401
426	**Bangor, ME**	4.302
427	**Wheeling, WV-OH**	4.233
428	**Altoona, PA**	4.212
429	**Terre Haute, IN**	4.198
430	Bahamas	4.185
431	**Greenville, NC**	4.179
432	Mozambique	4.170
433	**Pueblo, CO**	4.159
434	**Dothan, AL**	4.139
435	**Sheboygan, WI**	4.121
436	**Williamsport, PA**	4.091
437	**Sioux City, IA-NE**	4.085
438	**Jackson, TN**	4.044
439	Albania	3.894
440	**Billings, MT**	3.843
441	**Dover, DE**	3.830
442	**Bloomington, IN**	3.795
443	Madagascar	3.792
444	**Grand Junction, CO**	3.756
445	**Flagstaff, AZ-UT**	3.746
446	**Yuba City, CA**	3.713
447	**San Angelo, TX**	3.701
448	**Elmira, NY**	3.697
449	**Kokomo, IN**	3.690
450	**Decatur, AL**	3.675
451	Papua New Guinea	3.670
452	**Sherman-Denison, TX**	3.618
453	**Danville, VA**	3.596
454	**Texarkana, AR-TX**	3.591
455	**Muncie, IN**	3.565
456	**Sharon, PA**	3.564
457	**Las Cruces, NM**	3.560
458	**Alexandria, LA**	3.551
459	Malta	3.534
460	**Steubenville-Weirton, OH-WV**	3.526
461	**Iowa City, IA**	3.523

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
462	Namibia	3.505
463	**Florence, AL**	3.423
464	Macedonia	3.408
465	**Victoria, TX**	3.332
466	Congo, Dem. Repub. of	3.278
467	**Kankakee, IL**	3.241
468	**Kenosha, WI**	3.211
469	Guinea	3.210
470	Georgia	3.147
471	**Dubuque, IA**	3.141
472	Cambodia	3.121
473	Zambia	3.096
474	Haiti	3.090
475	**Lewiston-Auburn, ME**	3.009
476	**Rapid City, SD**	3.006
477	**Anniston, AL**	3.000
478	**Hattiesburg, MS**	2.993
479	**St. Joseph, MO**	2.959
480	**Owensboro, KY**	2.950
481	**Goldsboro, NC**	2.928
482	Congo, Republic of	2.919
483	**Casper, WY**	2.875
484	**Bismarck, ND**	2.856
485	**Sumter, SC**	2.790
486	**Cumberland, MD-WV**	2.785
487	**Missoula, MT**	2.779
488	**Grand Forks, ND-MN**	2.765
489	**Lawrence, KS**	2.737
490	Barbados	2.685
491	**Corvallis, OR**	2.681
492	**Yuma, AZ**	2.677
493	Bermuda	2.674
494	**Cheyenne, WY**	2.640
495	**Jacksonville, NC**	2.513
496	Nicaragua	2.502
497	**Auburn-Opelika, AL**	2.484
498	**Gadsden, AL**	2.466
499	Burkina Faso	2.443
500	**Punta Gorda, FL**	2.429
501	Mali	2.399
502	**Lawton, OK**	2.369
503	Benin	2.267

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
504	**Jonesboro, AR**	2.266
505	Liechtenstein	2.248
506	Netherlands Antilles	2.061
507	**Pine Bluff, AR**	2.052
508	Malawi	1.994
509	**Great Falls, MT**	1.978
510	Fiji	1.971
511	Aruba	1.962
512	Rwanda	1.947
513	Armenia	1.919
514	**Pocatello, ID**	1.906
515	**Enid, OK**	1.696
516	Somalia	1.672
517	Niger	1.592
518	Cayman Islands	1.586
519	Chad	1.467
520	Kyrgyzstan	1.304
521	Moldova	1.300
522	Togo	1.294
523	Afghanistan	1.271
524	Swaziland	1.223
525	Lao People's Dem. Repub.	1.088
526	Mongolia	1.029
527	Equatorial Guinea	1.010
528	Tajikistan	1.010
529	Central African Republic	0.989
530	Lesotho	0.946
531	Mauritania	0.905
532	Burundi	0.771
533	Guyana	0.749
534	Eritrea	0.748
535	Belize	0.736
536	Saint Lucia	0.701
537	Antigua & Barbuda	0.687
538	Suriname	0.649
539	Seychelles	0.628
540	Sierra Leone	0.591
541	Djibouti	0.561
542	Cape Verde	0.513
543	Bhutan	0.470
544	Gambia	0.448
545	Maldives	0.443

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
546	Grenada	0.417
547	Solomon Islands	0.386
548	Saint Kitts and Nevis	0.325
549	Saint Vincent and the Grenadines	0.325
550	Dominica	0.282
551	Guinea-Bissau	0.225
552	Vanuatu	0.225
553	Samoa	0.193
554	Comoros	0.177
555	Sao Tome and Principe	0.049

Table 10 - Metro Area Shares of U.S. Production

Shares of U.S. Gross Product (2000) (Billions)	Metro Areas	Rest of United States	United States
Agriculture, Forestry, Fishing	$49	$95	$144
Percentage	34%	66%	
Mining	$102	$72	$174
Percentage	58%	42%	
Construction	$371	$61	$432
Percentage	86%	14%	
Manufacturing	$1,264	$346	$1,610
Percentage	79%	21%	
Transportation & Utilities	$744	$108	$852
Percentage	87%	13%	
Trade	$1,354	$239	$1,586
Percentage	85%	15%	
Financial Services	$1,767	$155	$1,922
Percentage	92%	8%	
Services	$1,895	$232	$2,127
Percentage	89%	11%	
Government	$929	$225	$1,154
Percentage	81%	19%	

Top 100 U.S. Metro Economies*

CONFERENCE OF MAYORS

RANKING (2000)

GROSS METROPOLITAN PRODUCT (GMP), US$ BILLIONS

Rank	U.S. City/County Metro Areas	GMP 2000
1	New York, NY	437.8
2	Los Angeles-L Beach, CA	363.7
3	Chicago, IL	332.8
4	Boston, MA	238.8
5	Washington, DC-MD-VA-WV	217.0
6	Philadelphia, PA-NJ	182.4
7	Houston, TX	177.5
8	Atlanta, GA	164.2
9	Dallas, TX	160.0
10	Detroit, MI	156.3
11	Orange Co, CA	130.0
12	Minneapolis-St. Paul, MN-WI	121.3
13	Seattle-Bellevue-Everett, WA	115.0
14	Phoenix-Mesa, AZ	114.2
15	San Francisco, CA	107.3
16	Nassau-Suffolk, NY	106.8
17	San Diego, CA	104.6
18	Newark, NJ	96.3
19	Baltimore, MD	96.2
20	Oakland, CA	92.1
21	Denver, CO	91.1
22	St. Louis, MO-IL	89.6
23	San Jose, CA	85.4
24	Riverside-San Bernardino, CA	84.1
25	Tampa-St. Petersburg-Clrwater, FL	82.2
26	Cleveland-Lorain-Elyria, OH	80.8
27	Pittsburgh, PA	80.7
28	New Haven-BrPt-Stamford-Danbury-Waterbury, CT	76.8
29	Miami, FL	71.6
30	Portland-Vancouver, OR-WA	71.5
31	Kansas City, MO-KS	64.8
32	Hartford, CT	64.3
33	Middlesex-Somerset-Hunterdon, NJ	63.6
34	Sacramento, CA	63.1
35	Fort Worth-Arlington, TX	63.0
36	Charlotte-Gastonia-Rock Hill, NC-SC	61.3
37	Columbus, OH	60.7
38	Orlando, FL	59.5
39	Cincinnati, OH-KY-IN	59.4
40	Bergen-Passaic, NJ	59.3
41	Indianapolis, IN	57.7
42	Milwaukee-Waukesha, WI	54.8
43	Las Vegas, NV-AZ	54.6
44	San Antonio, TX	53.7
45	Norfolk-Virginia Beach-Newport News, VA-NC	51.7
46	Austin-San Marcos, TX	48.2
47	Buffalo-Niagara Falls, NY	47.8
48	Fort Lauderdale, FL	46.7
49	New Orleans, LA	46.5
50	Salt Lake City-Ogden, UT	46.4
51	Greensboro-W-Salem-High Point,NC	46.3
52	Rochester, NY	45.7
53	Richmond-Petersburg, VA	45.7
54	Nashville, TN	45.2
55	Raleigh-Durham-Chapel Hill, NC	44.3
56	Jacksonville, FL	43.0
57	Gr Rapids-Muskegon-Holland, MI	42.3
58	Memphis, TN-AR-MS	38.9
59	Louisville, KY-IN	38.7
60	Albany-Schenectady-Troy, NY	37.8
61	W Palm Beach-Boca Raton, FL	33.2
62	Honolulu, HI	33.0
63	Monmouth-Ocean, NJ	33.0
64	Providence-Warwick, RI	32.5
65	Oklahoma City, OK	32.3
66	Birmingham, AL	32.0
67	Wilmington-Newark, DE	31.4
68	Dayton-Springfield, OH	31.2
69	Manchester-Nashua, NH	30.2
70	Syracuse, NY	30.1
71	Greenville-Spartanburg-Anderson SC	29.9
72	Jersey City, NJ	28.1
73	Harrisburg-Lebanon-Carlisle, PA	27.1
74	Fresno, CA	26.3
75	Omaha, NE-IA	26.2
76	Tulsa, OK	25.7
77	Albuquerque, NM	25.6
78	Ventura, CA	24.5
79	Tucson, AZ	22.9
80	Akron, OH	21.9
81	Knoxville, TN	21.5
82	Toledo, OH	21.2
83	Springfield, MA	20.9
84	Allentown-Bethlehem-Easton, PA	20.6
85	Scranton-Wilkes-Barre-Hazelton, PA	20.6
86	Santa Rosa, CA	20.5
87	Baton Rouge, LA	20.4
88	Des Moines, IA	19.1
89	Ann Arbor, MI	19.1
90	Columbia, SC	19.1
91	Tacoma, WA	19.0
92	Bakersfield, CA	18.9
93	Fort Wayne, IN	18.6
94	El Paso, TX	18.6
95	Trenton, NJ	18.5
96	Little Rock-North Little Rock, AR	18.4
97	Madison, WI	18.4
98	Lafayette, LA	18.2
99	Lexington, KY	17.8
100	Colorado Springs, CO	17.6

*City/County Metros are the 319 metropolitan areas defined by U.S.OMB.

Source: DRI • WEFA

If U.S. City/County Metro Economies Were Nations

World Rankings on Gross Domestic and Metropolitan Product 2000 (U.S. Billions, Current)

THE UNITED STATES CONFERENCE OF MAYORS

Rank	Nation or Metro Area	GP 2000	Rank	Nation or Metro Area	GP 2000	Rank	Nation or Metro Area	GP 2000	Rank	Nation or Metro Area	GP 2000
1	United States	9,963 00	44	Finland	118.00	87	Cincinnati, OH-KY-IN	59.40	130	Syracuse NY	[illegible]
2	Japan	4,614 00	45	Seattle-Bellevue-Everett, WA	115.00	88	Bergen-Passaic, NJ	59 30	131	Greenville-Spartanburg Anderson SC	[illegible]
3	Germany	1,873.00	46	Phoenix-Mesa, AZ	114.20	89	Indianapolis, IN	57.70	132	Jersey City, NJ	[illegible]
4	United Kingdom	1,410.00	47	Greece	110.90	90	Nigeria	54 90	133	Harrisburg-Lebanon-Carlisle, PA	[illegible]
5	France	1,286.00	48	Israel	108.00	91	Milwaukee-Waukesha, WI	54.80	134	Fresno, CA	[illegible]
6	China	1,104.00	49	SanFrancisco, CA	107 30	92	Las Vegas, NV-AZ	54 60	135	Omaha, NE-IA	[illegible]
7	Italy	1,074.00	50	Nassau-Suffolk, NY	106.80	93	San Antonio, TX	53.70	136	Tulsa, OK	[illegible]
8	Canada	699.00	51	San Diego, CA	104 60	94	Algeria	52.80	137	Albuquerque, NM	[illegible]
9	Brazil	665.00	52	Venezuela	102.90	95	New Zealand	52.10	138	Iraq	[illegible]
10	Mexico	578.00	53	Portugal	100.50	96	Norfolk-Virginia Beach-Newport News, VA-NC	51 70	139	Ventura, CA	[illegible]
11	Spain	557.00	54	Newark, NJ	96.30	97	Czech	50 80	140	Tucson, AZ	[illegible]
12	India	510.00	55	Baltimore, MD	96 20	98	Austin-San Marcos, TX	48 20	141	Akron, OH	[illegible]
13	Korea, South	480.00	56	Ireland	95.10	99	Buffalo-Niagara Falls, NY	47.80	142	Knoxville, TN	[illegible]
14	New York, NY	437 80	57	Singapore	93 70	100	Hungary	47 40	143	Toledo, OH	[illegible]
15	Australia	428.00	58	Oakland, CA	92 10	101	Fort Lauderdale, FL	46.70	144	Springfield, MA	[illegible]
16	Los Angeles-Long Beach, CA	363.70	59	Egypt	91.50	102	New Orleans, LA	46.50	145	Allentown-Bethlehem-Easton, PA	[illegible]
17	Netherlands	360.00	60	Denver, CO	91 10	103	Salt Lake City-Ogden, UT	46.40	146	Scranton-Wilkes-Barre-Hazelton PA	[illegible]
18	Chicago, IL	332.80	61	Colombia	90.00	104	Greensboro Winston-Salem-HighPoint NC	46.30	147	Santa Rosa, CA	[illegible]
19	Taiwan	323.00	62	St. Louis, MO-IL	89 60	105	Rochester, NY	45.70	148	Uruguay	[illegible]
20	Argentina	284.00	63	Malaysia	88.80	106	Richmond-Petersburg, VA	45.70	149	Baton Rouge LA	[illegible]
21	Russia	247.00	64	SanJose, CA	85 40	107	Nashville, TN	45.20	150	Slovakia	[illegible]
22	Switzerland	241.30	65	Riverside-San Bernardino, CA	84 10	108	Raleigh-Durham-Chapel Hill, NC	44 30	151	Tunisia	19 90
23	Boston, MA	238.80	66	Tampa-StPetersb-Clrwater, FL	82 20	109	Jacksonville, FL	43.00	152	Dominican Republic	19 67
24	Belgium	227.00	67	Cleveland-Lorain-Elyria, OH	80.80	110	GrRapids-Muskegon-Holland, MI	42.30	153	Des Moines, IA	19 10
25	Sweden	224.10	68	Pittsburgh, PA	80.70	111	Memphis, TN-AR-MS	38.90	154	Ann Arbor, MI	[illegible]
26	Turkey	217 60	69	Philippines	78.00	112	Louisville, KY-IN	38.70	155	Columbia, SC	[illegible]
27	Washington, DC-MD-VA-WV	217.00	70	New Haven-BrPt Stamford-Danbury-Waterbury CT	76.80	113	Bangladesh	38.50	156	Guatemala	[illegible]
28	Austria	184 90	71	Chile	73.00	114	Kuwait	38.05	157	Tacoma, WA	[illegible]
29	Philadelphia, PA-NJ	182.40	72	Miami, FL	71 60	115	Albany-Schenectady-Troy, NY	37.80	158	Croatia (Hrvatska)	19 00
30	Houston, TX	177.50	73	Portland-Vancouver, OR-WA	71.50	116	Syria	35.53	159	Bakersfield, CA	18 90
31	Hong Kong	164 60	74	Iran	67.10	117	Morocco	34.80	160	Oman	[illegible]
32	Atlanta, GA	164 20	75	Puerto Rico	65 30	118	West Palm Beach-Boca Raton, FL	33.20	161	Fort Wayne, IN	[illegible]
33	Norway	164.00	76	Kansas City, MO-KS	64 80	119	Honolulu, HI	33.00	162	El Paso, TX	[illegible]
34	Poland	163.00	77	Hartford, CT	64.30	120	Monmouth-Ocean, NJ	33.00	163	Trenton, NJ	[illegible]
35	Dallas, TX	160.00	78	Middlesex-Somerset-Hunterdon, NJ	63.60	121	Romania	33 00	164	Slovenia	[illegible]
36	Denmark	158.00	79	Sacramento, CA	63.10	122	Providence-Warwick, RI	32 50	165	Little Rock-North Little Rock, AR	[illegible]
37	Detroit, MI	156 30	80	Fort Worth-Arlington, TX	63 00	123	Oklahoma City, OK	32.30	166	Madison, WI	[illegible]
38	Indonesia	147.60	81	Pakistan	62.70	124	Birmingham AL	32 00	167	Lafayette, LA	[illegible]
39	Saudi Arabia	145 30	82	Peru	62 70	125	Ukraine	31.70	168	Kazakhstan	[illegible]
40	South Africa	132 30	83	Charlotte-Gastonia-Rock Hill, NC-SC	61 30	126	Wilmington-Newark DE	31 40	169	Luxembourg	[illegible]
41	Orange County, CA	130 00	84	Columbus, OH	60.70	127	Dayton-Springfield, OH	31.20	170	Lexington, KY	[illegible]
42	Thailand	128.20	85	United Arab	60 70	128	Vietnam	30.60	171	Colorado Springs, CO	[illegible]
43	Minneapolis-St. Paul, MN-WI	121.30	86	Orlando, FL	59.50	129	Manchester-Nashua, NH	30.20	172	Wichita, KS	[illegible]

■ City/County Metro Areas ■ Nations

Source: DRI • WEFA

THE UNITED STATES CONFERENCE OF MAYORS

City/CountyMetros

GMP VS. GSP (2000)

The Gross Product of the ten largest City/County Metro areas* in the U.S. exceeds the combined output of the following 31 states.

Total Gross Metro Product $2.43 trillion		Total Gross State Product $2.39 trillion
New York, NY Los Angeles-Long Beach, CA Chicago, IL Boston, MA Washington, DC-MD-VA-WV Philadelphia, PA-NJ Houston, TX Atlanta, GA Dallas, TX Detroit, MI	> is greater than	Tennessee Connecticut Colorado Arizona Louisiana Alabama Kentucky South Carolina Oregon Iowa Oklahoma Kansas Nevada Mississippi Arkansas Utah Nebraska New Mexico West Virginia New Hampshire Hawaii Delaware Maine Idaho Rhode Island Alaska South Dakota Montana Wyoming North Dakota Vermont

*City/County Metros are the 319 metropolitan areas defined by U.S.OMB.

Source: DRI • WEFA

METROPOLITAN AREAS 1999

LISTS I-IV

Statistical Policy Office
Office of Management and Budget
Attachments to OMB Bulletin No. 99-04

FIPS Code	Area Title	CMSA, PMSA, MSA	Level	List Specifying Definition and Central Cities
	California			
(0360)	(ANAHEIM-SANTA ANA)			II (49 Los Angeles-Riverside-Orange County CMSA)
0680	BAKERSFIELD	MSA	B	I
1620	CHICO-PARADISE	MSA	C	I
2840	FRESNO	MSA	B	I
49	LOS ANGELES-RIVERSIDE-ORANGE COUNTY	CMSA		II
4480	LOS ANGELES-LONG BEACH	PMSA	A	II (49 Los Angeles-Riverside-Orange County CMSA)
4940	MERCED	MSA	C	I
5170	MODESTO	MSA	B	I
5775	OAKLAND	PMSA	A	II (84 San Francisco-Oakland-San Jose CMSA)
5945	ORANGE COUNTY	PMSA	A	II (49 Los Angeles-Riverside-Orange County CMSA)
(6000)	(OXNARD-VENTURA)			II (49 Los Angeles-Riverside-Orange County CMSA)
6690	REDDING	MSA	C	I
6780	RIVERSIDE-SAN BERNARDINO	PMSA	A	II (49 Los Angeles-Riverside-Orange County CMSA)
82	SACRAMENTO-YOLO	CMSA		II
6920	SACRAMENTO	PMSA	A	II (82 Sacramento-Yolo CMSA)
7120	SALINAS	MSA	B	I
7320	SAN DIEGO	MSA	A	I
84	SAN FRANCISCO-OAKLAND-SAN JOSE	CMSA		II
7360	SAN FRANCISCO	PMSA	A	II (84 San Francisco-Oakland-San Jose CMSA)
7400	SAN JOSE	PMSA	A	II (84 San Francisco-Oakland-San Jose CMSA)
7460	SAN LUIS OBISPO-ATASCADERO-PASO ROBLES	MSA	C	I
7480	SANTA BARBARA-SANTA MARIA-LOMPOC	MSA	B	I
7485	SANTA CRUZ-WATSONVILLE	PMSA	C	II (84 San Francisco-Oakland-San Jose CMSA)
7500	SANTA ROSA	PMSA	B	II (84 San Francisco-Oakland-San Jose CMSA)
8120	STOCKTON-LODI	MSA	B	I
8720	VALLEJO-FAIRFIELD-NAPA	PMSA	B	II (84 San Francisco-Oakland-San Jose CMSA)
8735	VENTURA	PMSA	B	II (49 Los Angeles-Riverside-Orange County CMSA)
8780	VISALIA-TULARE-PORTERVILLE	MSA	B	I
9270	YOLO	PMSA	C	II (82 Sacramento-Yolo CMSA)
9340	YUBA CITY	MSA	C	I
	Colorado			
1125	BOULDER-LONGMONT	PMSA	C	II (34 Denver-Boulder-Greeley CMSA)
1720	COLORADO SPRINGS	MSA	B	I
34	DENVER-BOULDER-GREELEY	CMSA		II
2080	DENVER	PMSA	A	II (34 Denver-Boulder-Greeley CMSA)
2670	FORT COLLINS-LOVELAND	MSA	C	I
2995	GRAND JUNCTION	MSA	D	I
3060	GREELEY	PMSA	C	II (34 Denver-Boulder-Greeley CMSA)
6560	PUEBLO	MSA	C	I

City of Los Angeles
1998 Economic and Demographic Information

The City of Los Angeles is the second most populous City in the United States with an estimated 1998 population in excess of 3.7 million. Los Angeles is the principal city of a metropolitan region stretching from the city of San Buenaventura to the north, the City of San Clemente to the south, and the City of San Bernardino to the east.

Founded in 1781, Los Angeles was for its first century a provincial outpost under a succession of Spanish, Mexican, and American rule. It experienced a population boom following its linkage by rail with San Francisco in 1876. Los Angeles was selected as the Southern California rail terminus because its natural harbor, unlike San Diego's, seemed to offer little challenge to San Francisco, home of the railroad barons. But what the region lacked in commerce and industry, it made up in temperate climate and unspoiled real estate, and soon tens and then hundreds of thousands of people living in the northeastern and midwestern United States migrated to new homes in the region. Its population climbed to 50,000 in 1890, and then swelled to 1.5 million by 1940. Agricultural and oil production, followed by the creation of a deep water port, the opening of the Panama Canal, and the completion of the City-financed Owens Valley Aqueduct to provide additional water, all contributed to an expanding economic base. During this same period, the motor car became the principal mode of American transportation, and Los Angeles developed as the first major city of the automotive age. Following World War II, Los Angeles became the focus of a new wave of migration, with its population reaching 2.4 million by 1960.

Both the City and its surrounding metropolitan region have continued to experience growth in population and in economic diversity. Services, wholesale and retail trade, manufacturing, government, financial service industries, transportation, utilities, and construction contribute significantly to local employment. The City's 470 square miles contain 11.5% of the area and 38.8% of the population of the County of Los Angeles (the "County). The County is the top ranked county in manufacturing in the United States, producing more than 10% of the nation's production of such diverse items as aircraft, aircraft equipment, aluminum, dental equipment, games and toys, gas transmissions and distribution equipment, guided missiles, space vehicles and propulsion units, and women's apparel. Fueled by trade with the Pacific Rim countries, the Port of Los Angeles/Long Beach ranks first in the nation in volume. As home to the film, television and recording industries, as well as important cultural facilities, Los Angeles serves as a principal global cultural center. With Los Angeles International Airport serving as the new "Ellis Island" for foreign immigration to this country, the metropolitan region has achieved a new ethnic and cultural diversity.

ECONOMIC AND DEMOGRAPHIC INFORMATION

Introduction

The economic and demographic information provided below has been collected from sources which the City deems to be reliable. Because it is difficult to obtain timely regional economic and demographic information, the impact on the City of the recent recession and the City's recovery from the recession may not be fully apparent in all of the publicly available regional economic statistics provided herein.

Population

The City's population expanded by 4.8% during the 1970's and by more than 17.4% from 1980 to 1990. This latter expansion compares to an 18.5% growth rate for the County and a 25.1% growth rate for the State of California (the "State") during the same period. Table 1 summarizes City, County, and State population estimated at January 1 of each year.

Table 1
CITY, COUNTY AND STATE POPULATION STATISTICS

	City of Los Angeles	County of Los Angeles	State of California
1980	2,968,579	7,477,517	23,780,000
1981	2,989,500	7,550,300	24,267,000
1982	3,029,500	7,679,100	24,786,000
1983	3,087,700	7,830,000	25,309,000
1984	3,145,000	7,961,900	25,780,000
1985	3,199,600	8,091,900	26,358,000
1986	3,268,200	8,250,000	26,999,000
1987	3,318,800	8,410,800	27,655,000
1988	3,362,200	8,537,800	28,323,000
1989	3,399,000	8,652,800	29,063,000
1990	3,485,398	8,863,164	29,760,021
1991	3,536,799	8,988,754	30,351,000
1992	3,575,000	9,074,400	30,982,000
1993	3,607,700	9,158,400	31,552,000
1994	3,620,500	9,230,600	31,960,000
1995	3,625,800	9,327,300	31,910,000
1996	3,638,100	9,369,800	32,231,000
1997	3,681,700	9,488,200	32,609,000
1998	3,722,500	9,603,300	33,252,000

Source: U. S. Census for 1980 and 1990; other figures are State Department of Finance estimates as of January 1 of each year.

Table 2 summarizes the age distribution of the City, County, and State population estimated at January 1, 1997.

Table 2
CITY, COUNTY, AND STATE POPULATION BY AGE GROUP
Estimated January 1, 1997

	% OF POPULATION BY AGE GROUP			
	18-24 Years	25-34 Years	35-49 Years	50 & Over
City of Los Angeles	11.2%	18.3%	22.9%	22.2%
County of Los Angeles	10.5	17.4	23.0	22.2
State of California	9.7	16.7	23.7	23.2

Source: Sales and Marketing Management Magazine "1997 Survey of Buying Power".

Table 3 summarizes the income distribution of the City, County, and State population estimated at January 1, 1997.

Table 3
CITY, COUNTY, AND STATE POPULATION BY INCOME GROUP
Estimated January 1, 1997

	% OF POPULATION BY INCOME GROUP		
	$20,000-$34,999	$35,000-$49,999	$50,000 and Over
City of Los Angeles	24.1%	18.3%	25.2%
County of Los Angeles	23.2	17.9	29.5
State of California	22.9	18.5	31.7

Source: Sales and Marketing Management Magazine "1997 Survey of Buying Power".

Industry and Employment

Table 4 summarizes the State Department of Employment Development's estimated average annual employment of nonagricultural wage and salary workers in the County between 1996 and March 1998. Percentages indicate the percentage of the total employment for each type of employment for the given year. For purposes of comparison, employment for the United States is also summarized for 1996 through 1998.

The services sector has been the major employment sector in the County through April 1998, employing 32.9% of the nonagricultural wage and salary workers in the County. (Separate figures for the City are not maintained). Wholesale and retail trade, at 21.9%, is the second highest employment sector in the County, followed closely by manufacturing, which employs 17.2% of the nonagricultural wage and salary workers in the County. From 1996 to April 1998, total employment for nonagricultural wage and salary workers increased by 3.9%

Table 4
LOS ANGELES COUNTY
ESTIMATED AVERAGE ANNUAL EMPLOYMENT
NONAGRICULTURAL WAGE AND SALARY WORKERS
(in thousands)

	County						United States					
	1996	% of Total	1997	% of Total	1998 [1]	% of Total	1996	% of Total	1997	% of Total	1998 [1]	% of Total
Mining	5.7	0.1%	5.7	0.2%	5.6	0.1%	574	0.5%	574	0.5%	560	0.5%
Construction	108.6	2.9	110.0	2.8	111.6	2.8	5,400	4.5	5,747	4.6	5,659	4.5
Manufacturing							18,547	15.5				
Durable Goods	352.5	9.3	363.8	9.4	370.3	9.4	--	--	11,048	8.9	11,082	8.9
Non-Durable Goods	293.6	7.7	299.5	7.7	309.7	7.8	--	--	7,626	6.2	7,546	6.1
Transportation and Public Utilities	204 4	5.4	210.2	5.4	215.4	5.5	6,261	5.2	6,478	5.2	6,528	5.2
Wholesale Trade	258.6	6.8	264.3	6.8	269.2	6.8	6,483	5.4	6,746	5.5	6,798	5.5
Retail Trade	583.2	15.3	594.1	15.3	597.9	15.1	21,625	18.1	22,450	18.1	22,247	17.9
Finance, Insurance & Real Estate	216.7	5.7	219.5	5.7	223.3	5.7	6,899	5.8	7,151	5.8	7,219	5.8
Services	1,245.3	32.8	1,267.3	32.7	1,300.3	32.9	34,377	28.7	36,276	29.3	36,765	29.5
Government	533.3	14.0	537.8	13 9	548.3	13.9	19,447	16.3	19,770	16.0	20,219	16.2
Total[2]	3,801.9		3,872.2		3,951.6		119,613		123,866		124,623	

[1] Preliminary data as of April 1998. Data not adjusted for seasonality.
[2] Totals may not add due to independent rounding.

Sources: California Employment Development Department, Labor Market Information Division for the County; U.S. Bureau of Labor, Department of Labor Statistics for the U. S.

The average number of employed and unemployed residents of the County, together with the average annual unemployment rate is summarized in Table 5.

Table 5
ESTIMATED AVERAGE ANNUAL EMPLOYMENT AND UNEMPLOYMENT OF RESIDENT LABOR FORCE

Civilian Labor Force County of Los Angeles ***(in thousands)***	1991	1992	1993	1994[1]	1995	1996	1997[2]	1998[3]
Employed	4,142	4,099	3,984	3,971	4,016	4,052	4,189	4,311
Unemployed	360	436	427	445	343	362	308	279
Total	4,502	4,535	4,411	4,416	4,359	4,414	4,497	4,590
Unemployment Rates								
County	9.8%	9.6%	9.7%	9.4%	7.9%	8.2%	6.8%	6.1%
State	7.5	9.1	9.2	8.6	7.8	7.2	5.5	6.0
United States	6.7	7.4	6.8	6.1	5.6	5.4	4.9	4.3

[1] The Federal Government began using a new method for calculating labor force statistics in January 1994. As a result of this change, labor force data for 1994 are not comparable to prior years' data.
[2] Data not adjusted for seasonality.
[3] Preliminary data as of March 1998. Data not adjusted for seasonality.

Source: California Employment Development Department, Labor Market Information Division for the State and County; U.S. Bureau of Labor, Department of Labor Statistics for the U.S

Major Employers

The economic base of Los Angeles is diverse, with no one sector being dominant. Some of the leading activities include business/professional management services (including engineering), health services (including training and cutting-edge research), tourism, distribution, and entertainment. The job loss in the technology sector has ended, while major new investments are being made in entertainment and tourism. The ten leading employers in the Los Angeles Five County Area, as reported in March 1996, are listed in Table 6. A five-year history is not available.

Table 6
TEN LEADING EMPLOYERS IN THE LOS ANGELES FIVE COUNTY AREA(1)
March 1996

Company/Organization	Product	Number of Employees(2)
Los Angeles County	Government	84,616
U.S. Government	Government	64,404
City of Los Angeles	Government	55,964
Los Angeles Unified School District	Public Schools	55,727
Bank of America	Financial Services	26,563
Hughes Electronics Corporation	Aerospace	26,000
Kaiser Permanente	Health Services	24,163
American Stores	Retail	23,525
UCLA	Higher Education	23,492
Sears, Roebuck & Company	Retail	21,370

(1) Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties.
(2) Approximately two-thirds of the total number of employees for each company work in Los Angeles County except for the County of Los Angeles, the Los Angeles Unified School District and the City of Los Angeles. For these employers, virtually one hundred percent of the employees work in Los Angeles County.

Source: Economic Development Corporation of Los Angeles County

Effective Buying Income

"Effective Buying Income" ("EBI"), also referred to as "disposable" or "after tax" income, consists of personal income less personal tax and certain non-tax payments. Personal income includes wages and salaries, other labor-related income (such as employer contributions to private pension funds), and certain other income (e.g. proprietor's income; rental income; dividends and interest; pensions; and welfare assistance). Deducted from this total are personal taxes (federal, state and local) certain non-tax payments (e.g. fines, fees and penalties), and personal contributions to a retirement program.

Table 7 shows the top ten metropolitan areas in total EBI for 1996.

Table 7
TOTAL EFFECTIVE BUYING INCOME
TOP TEN METROPOLITAN AREAS
(in thousands)

New York	$153,157,977
Chicago	144,581,178
Los Angeles	133,522,302
Washington	96,070,010
Philadelphia	92,004,188
Boston	74,465,840
Detroit	73,618,478
Houston	66,442,495
Atlanta	61,320,569
Dallas	56,860,802
U. S. Total	$4,161,512,384

Source: Sales & Marketing Management Magazine "1997 Survey of Buying Power"

Retail Sales

As the largest city in the County, the City accounted for $24,906,839,000 (or 30.2%) of the total $82,620,919,000 in County taxable sales for 1996. Table 8 sets forth a history of taxable sales for the City from 1992 through 1996. Total City taxable sales in 1996 increased 3.9% as compared to the total City taxable sales in 1995.

Table 8
TAXABLE SALES
CITY OF LOS ANGELES
(thousands)

	1992	1993	1994	1995	1996
Apparel stores	$1,381,296	$1,331,850	$1,300,699	$1,311,704	$1,409,904
General merchandise stores	1,961,368	1,901,383	1,763,149	1,879,970	1,815,289
Drugstores	462,919	443,154	446,471	432,670	461,909
Food stores	1,611,507	1,290,914	1,263,025	1,289,584	1,336,969
Packaged liquor stores	257,822	229,056	227,482	218,577	218,054
Eating and drinking establishments	2,623,632	2,529,397	2,659,527	2,696,453	2,837,548
Home furnishings and appliances	1,012,244	984,415	1,129,061	1,079,697	994,734
Building materials and farm implements	965,751	909,669	1,067,869	1,070,534	1,050,092
Auto dealers and auto supplies	1,851,408	1,798,421	1,989,019	2,084,185	2,119,459
Service stations	1,852,518	1,924,428	1,968,331	1,894,828	2,085,145
Other retail stores	2,803,492	2,726,372	2,946,628	3,078,136	3,241,042
Retail Stores Total	$16,783,957	$16,069,059	$16,761,261	$17,036,338	$17,570,145
All other outlets	6,820,019	6,310,233	6,677,498	6,924,416	7,336,694
TOTAL ALL OUTLETS	$23,603,976	$22,379,292	$23,438,759	$23,960,754	$24,906,839

Source: California State Board of Equalization, Research and Statistics Division

Construction Activity

The total valuation of building permits issued in the City exceeded $1.8 billion in 1997, which represents a 5% increase from 1996. Residential valuation as a percentage of total valuation was 47.5% in 1997. Table 9 provides a summary of building permit valuations and number of new dwelling units in the City for the years 1992 through April 1998.

Table 9
BUILDING VALUATIONS AND PERMITS
CITY OF LOS ANGELES

	1992	1993	1994	1995	1996	1997	1998[2]
Valuation:							
Residential [1]	$870,249	$611,372	$1,207 942	$1,029,978	$814,491	$877,155	$350,697
Non-residential [1]	940,928	1,235,401	1,405,824	1,237,016	944,456	970,079	379,834
TOTAL [1]	$1,811,177	$1,846,773	$2,613,766	$2,266,994	$1,758,947	$1,847,234	$730,531
New Dwelling Units:							
Single Family	910	461	906	494	873	1,244	450
Multifamily	1,680	1,663	1,629	1,174	1,246	1,859	429
TOTAL	2,590	2,124	2,535	1,668	2,119	3,103	879

(1) In thousands.
(2) Through April 1998 only.

Source: City of Los Angeles, Department of Building and Safety

In May 1988 the City Council passed an interim ordinance that limited, with certain exceptions, the issuance of building permits within the City for certain projects that would discharge sewage into the Hyperion Treatment System. Applications for building permits are below the maximum limitations under the sewer limitation ordinance, due to economic conditions.

Commercial Real Estate Markets in Los Angeles

The largest commercial real estate concentrations in the City are located in the Central Business District ("CBD") and western Los Angeles areas. For the quarter ended December 31, 1997, the vacancy rate in the CBD was 22.9% down from 23.4% for the 3rd quarter, 1997. No new office space has been added to the CBD since 1992.

Table 10 shows vacancy rates and rents for office space in the central business district of the City.

Table 10
OFFICE VACANCY RATES AND RENTS[1]

	Vacancy Rates[2]			Rents[3]		
	1997-2Q	1997-3Q	1997-4Q	1997-2Q	1997-3Q	1997-4Q
Central Business District	24.4%	23.4%	22.9%	$18.36	$18.36	$18.48
Century City	12.6%	11 4%	10.3%	$24.12	$25.92	$28.32

(1) Above statistics are quoted as overall which includes space offered for sublease.
(2) Vacancy rates are as of the last day of the quarter.
(3) Gross annual weighted average asking rates per square foot

Source: Cushman & Wakefield, Inc., Los Angeles.

Education

The Los Angeles Unified School District ("LAUSD"), administers public instruction for grades K-12, adult, and occupational schools in the City and all or significant portions of a number of the smaller cities and unincorporated territory. The LAUSD, which encompasses approximately 708 square miles, was formed in 1854 as the Common Schools for the City of Los Angeles, and became a unified school district in 1960.

During fiscal year 1998, the LAUSD will operate 419 elementary schools, 71 middle/junior high schools, 49 high schools, five multi-level schools, 44 continuing education, 132 magnet schools and centers, 18 special education schools, 8 opportunity schools and centers, 106 children's and infant's centers, 1 adult program facility, four primary school centers and two orientation or newcomers centers. The LAUSD is governed by a seven-member Board of Education, elected by district to serve alternating four-year terms. As of September 1996, the LAUSD employed 36,521 certificated employees and 27,728 classified employees. Although the LAUSD employs part-time and temporary employees, it does not track these numbers.

Table 11 provides a summary of the Enrollment and Average Daily Attendance of Students ("ADA") of the LAUSD for the fiscal years 1988-89 through 1996-97.

Table 11
LOS ANGELES UNIFIED SCHOOL DISTRICT
TOTAL AVERAGE DAILY ATTENDANCE

Fiscal Year	Enrollment[1]	Average Daily Attendance[2]
1988-89	815,975	634,077
1989-90	796,832	660,226
1990-91	780,357	680,966
1991-92	790,523	690,769
1992-93	797,684	685,612
1993-94	792,239	683,075
1994-95	795,494	684,800
1995-96	811,713	703,978
1996-97	849,039	725,672

(1) Includes adult recreational and skill center students and students admitted under a federally funded program pursuant to provisions of the Amnesty Act. Does not include children's center enrollment.
(2) Includes the equivalent ADA of summer school hours of attendance.

Source: Los Angeles Unified School District.

There are many public and private colleges and universities located in the City. Major universities located within the City include the University of California at Los Angeles, the University of Southern California, California State University at Los Angeles, California State University at Northridge, Occidental College and Loyola Marymount University. There are seven community colleges located within the City.

MUNICIPAL GOVERNMENT

Under the State Constitution, charter cities are generally independent of the state legislature in matters relating to municipal affairs, and in their ability to raise revenues. The City is a charter city originally incorporated in 1850. The present City charter was adopted in 1925 and has since been amended from time to time.

Los Angeles is governed by the Mayor and the Council. The Mayor is elected at large for a 4-year term. As executive officer of the City, the Mayor has the overall responsibility of administration.. The Mayor recommends and submits the annual budget to the Council and passes upon subsequent appropriations and transfers, approves or vetoes ordinances, and appoints certain City officials and commissioners. He supervises the administrative process of the local government and works with the Council in matters relating to legislation, budget, and finance. As prescribed by the Charter and City ordinances, the Mayor operates an executive department, of which he is the ex-officio head. Richard Riordan has been Mayor since July 1, 1993.

The Council, the governing body of the City, is a full time council and enacts ordinances subject to the approval or veto of the Mayor. The Council may override the veto of the Mayor by a two-thirds vote. It orders elections, levies taxes, authorizes public improvements, approves contracts, adopts zoning and other land use controls, and adopts traffic regulations. The Council adopts or modifies the budget proposed by the Mayor. It creates positions, fixes salaries, and authorizes the number of employees in budgetary departments. The Council consists of 15 members elected by district for 4-year terms.

The other two elective offices of the City are the Controller and the City Attorney, both elected for 4-year terms. The Controller is the chief accounting officer for the City. The current Controller, Rick Tuttle, was elected to his fourth term at the April 1997 election. The City Attorney is attorney and legal advisor to the Council and all officers, boards, and departments of the City, and prosecutes misdemeanors. The current City Attorney, James K. Hahn, was elected to his fourth term at the April 1997 election.

The City Administrative Officer ("CAO"), appointed by the Mayor and confirmed by the Council, is the chief financial advisor to the Mayor and Council and reports directly to both. The current CAO, Keith Comrie, was appointed by Mayor Tom Bradley and confirmed by the Council in 1979.

The Treasurer, appointed by the Mayor and confirmed by the Council, receives and is the custodian of most funds of the City and affiliated entities. The current Treasurer, J. Paul Brownridge, was appointed by Mayor Tom Bradley and confirmed by the Council in March 1991.

The City has 36 departments, bureaus, commissions and offices for which operating funds are annually budgeted by the Council. In addition, six departments (the Department of Water and Power, Harbor, Airports, and three pension systems), the Community Redevelopment Agency of the City of Los Angeles and the Housing Authority of the City of Los Angeles are under the control of Boards appointed by the Mayor and confirmed by the Council.

Public services that are provided by the City include police; fire and paramedics; residential refuse collection and disposal, wastewater collection and treatment, street maintenance, and other public works functions; enforcement of ordinances and statutes relating to building safety; public libraries; recreation and parks; community development, housing and aging services; and planning.

BUDGET AND REVENUES

Budgetary Process

The City's fiscal year extends from July 1 through June 30. Under the City Charter, the Mayor is required each year to submit to the Council a Proposed Budget by April 20. The Proposed Budget is based on the Mayor's budget priorities, the responses of the City Administrative Officer and City Departments to the Mayor's policy letter which is distributed early in the fiscal year, and estimates of receipts from the City's various revenue sources

The Mayor's Proposed Budget is reviewed by the Council's Budget and Finance Committee, which reports its recommendations to the full Council. The Council is required by law to adopt the Mayor's Proposed Budget, as modified by the Council, by June 1. The Mayor has five working days after adoption to approve or veto any items modified by the Council. The Council then has five working days to override by a two-thirds vote any items vetoed by the Mayor.

The final Adopted Budget is subject to revision to reflect any changes in revenue projections and to make necessary adjustments to appropriations.

Fiscal Year 1997-98 Budget

The 1997-98 budget incorporates projected growth (2% to 4%) in several important revenue categories, including sales tax, utility users tax, transient occupancy tax, vehicle license fees and property tax. A higher growth rate is projected for municipal court fines due to an anticipated $13 million in revenue expected as a result of additional officers added for parking enforcement and increased fines. Franchise income is also expected to increase ($10 million) as a result of an increase in the wastewater franchise fee from 2% to 5%. The documentary transfer tax is expected to grow by $7 million as a result of recent increases in the number of deeds recorded and the revenue per deed (an indication that real estate prices are rising). As compared to the prior fiscal year, it is anticipated that total General Fund revenues will experience modest growth (1.5% or $36 million).

The budget maintains level expenditures as compared to the prior fiscal year. The total budget being $4.1 billion in 1996-97 and $4.0 billion in 1997-98. The budget continues new programs to reduce operating expenditures, and promotes the continued restructuring of fleet operations and purchasing reform to generate savings from current expense levels. More than 470 positions are eliminated, offset by new positions for public safety and public services. Through the addition of 165 new police officers, civilianization of 218 positions, new technology and additional overtime funds, the 1997-98 budget adds the equivalent of 846 officers.

The 1997-98 Estimated Results

Revenues through April 1998 are exactly on target. Projected general receipts in the budget were $2.59 billion. The City currently estimates that actual General Fund receipts will come in at $2.6 billion. While there are revenue reductions in some categories (Street Deterioration Fee, Airport Reimbursements) these are offset by higher revenues in property tax, utility users tax, hotel tax and property transfer tax.

The 1997-98 Budget provided for a new Street Deterioration Fee. This new fee was intended to recover the long-term damages associated with cuts in public streets made by private and public utilities. The reduction in expected revenue is due to delays in implementing the new fee.

The Budget anticipated $26 million in reimbursements from the Department of Airports for services funded by the General Fund. Since budget adoption, federal audit findings have disallowed some prior-year reimbursements. These disallowed prior-year receipts will offset a portion of the transfer from the department this year. The City believes a $7.2 million reduction in reimbursements is most likely.

As part of continuing to control expenditures, the City has extended its hiring freeze through the end of the fiscal year. In addition, the Mayor and Council have implemented various expenditure reductions and revenue options as part of the mid-year budget review in order to maintain a balanced budget. These actions have been implemented as of February 1998.

1998-99 Proposed Budget

The total 1998-99 Proposed Budget is $4.07 billion representing a very modest increase of about 1% over the previous year's budget of $4.02 billion. The Proposed Budget maintains City staffing at about the same level as the previous year and incorporates an end to the citywide hiring freeze.

Some of the major initiatives in 1998-99 include the funding of a new firefighter recruit training program for 126 new recruits; funding of a new fire station to improve response time in the San Fernando Valley; funding for technology and equipment to improve library services while maintaining expanded hours; funding for newly created Department on Disability to upgrade City facilities for disabled access; commitment to reducing solid waste to landfills by 60% by the year 2000, and funding of technological enhancements in payroll, personnel, accounting and budgeting in order to improve overall efficiency.

The 1998-99 Proposed Budget reaffirms the City's commitment to maintain fiscal stability by increasing undesignated cash reserves to $44 million (an increase from $38.3 in the prior year) and decreasing the annual transfer to the Budget (designated cash) to $8 million, the lowest in the last ten years. The Proposed Budget reduces reliance on one-time revenues by 27% from the previous year and continues to reduce expenditures across expense accounts.

The City expects to adopt a formal debt policy that will become effective in 1998-99. The proposed policy would limit non-voter approved debt payments to 7.5% of General Fund revenues in any given year, and would limit voter-approved and non-voter approved debt payments to an overall cap of 15% of General Fund revenues in any given year adjusted for incremental taxes from voter-approved debt. The formulation and adoption of a formal debt policy will be a key element in the City's ongoing efforts to maintain low debt levels.

Budgeted revenues in 1998-99 represent a 4% increase over fiscal year 1997-98, reflecting continued economic growth. Business Tax is expected to grow by 4% ($11.5 million) due to increased collection efforts, a new home-based business tax and general economic improvement. Sales Tax and Vehicle License Fees are also expected to grow by 4% due to improvements in the local economy. Transient Occupancy Tax revenue is expected to increase by 10% as a result of strong growth in the City's hotel tax and increased tourism from new attractions such as the new Getty Center and California Science Center. Documentary Transfer Tax is expected to increase by 15% due to continued improvement in the real estate market. Other revenues are expected to remain fairly level or to show modest increases.

Table 12
1998-99 FISCAL YEAR PROPOSED BUDGET
(ALL BUDGETED FUND TYPES)
CITY OF LOS ANGELES
(in thousands)

Summary of Revenues, Transfers and Available Balances	**1998-99**
Taxes[1]	$2,170,390
Licenses and Permits and Fines	422,765
Intergovernmental[2]	362,322
Charges for Services [3]	820,736
Special Assessments	103,337
Interest	28,872
Other[4]	46,079
Subtotal Revenues	$3,954,501
Available Balances	115,391
Total Revenues, Transfers and Available Balances	$4,069,892
Summary of Appropriations	
General Government	$998,859
Protection of Persons and Property	1,283,554
Public Works	626,832
Health and Sanitation	183,693
Transportation	91,910
Cultural and Recreational Services	217,815
Community Development	69,956
Pensions and Retirement Contributions	348,234
Capital Outlay [5]	249,039
Total Appropriations	$4,069,892

(1) Major tax revenue sources include Property Tax, Utility Users Tax, Sales Tax, Business Tax, State Motor Vehicle License fees, and Parking Users Tax.

(2) Major revenue sources include Housing and Community Development Block Grant and local transportation sales tax revenues. Also includes proprietary department transfers.

(3) Major revenue source is revenues of the Sewer Construction and Maintenance Fund.

(4) Includes transfers from Reserve Fund.

(5) Does not include capital outlay appropriations to be funded through general obligation bonds or other General Fund obligations.

Source: The Office of the City Administrative Officer.

Budgeted Revenues and Expenditures versus Actual Results

Table 13 contains budgeted and actual summaries of the General Fund of the City from the City's audited financial statements for the fiscal years 1992-93 through 1996-97.

Table 13
SCHEDULE OF REVENUES AND EXPENDITURES
GENERAL FUND
BUDGET AND ACTUAL (NON-GAAP BUDGETARY BASIS)
Fiscal Years Ended June 30,
(in thousands)

	1993		1994		1995		1996		1997	
	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual
REVENUES										
Taxes	$1,762,853	$1,679,108	$1,705,656	$1,603,792	$1,620,330	$1,636,306	$1,652,526	$1,632,556	$1,664,918	$1,718,196
Licenses, Permits and Fines	359,791	380,966	364,293	383,663	407,627	453,406	408,185	408,768	518,193	441,628
Intergovernmental	162,878	154,992	176,243	186,712	165,846	148,990	156,099	161,008	178,482	181,714
Charges for Services	3,613	3,447	3,850	3,164	3,535	3,093	3,732	3,103	2,757	2,696
Special Assessments	0	1,388	0	0	0	0	0	0	0	0
Interest	45,800	22,863	16,800	18,176	18,200	20,202	27,730	30,202	38,240	37,533
Other	1,600	1,104	600	615	600	595	625	534	610	606
TOTAL REVENUES	2,336,535	2,243,868	2,267,442	2,196,122	2,216,138	2,262,592	2,248,897	2,236,171	2,403,200	2,382,373
EXPENDITURES										
Current:										
General Government	794,898	696,030	773,515	690,393	784,694	690,988	806,173	725,689	596,576	569,142
Protection of Persons and Property	869,039	865,926	891,310	888,159	941,171	938,422	991,396	989,217	1,156,661	1,140,845
Public Works	214,962	200,871	208,769	194,660	228,717	213,654	215,925	208,146	235,229	225,809
Health and Sanitation	166,201	165,185	163,557	160,204	161,094	155,470	166,343	163,248	203,120	199,980
Transportation	82,710	81,362	82,209	78,967	80,771	77,378	82,672	79,816	95,008	93,026
Cultural and Recreational Services	47,410	45,248	52,440	46,907	67,954	67,359	85,465	85,361	83,994	83,677
Community Development	54,263	53,085	56,431	52,989	60,934	55,532	65,044	61,141	65,733	60,536
Pensions and Retirement Contributions	475,627	475,627	488,398	488,346	475,548	462,386	476,436	476,421	101,577	101,571
Capital Outlay	46,851	35,075	99,600	75,554	232,717	192,060	26,351	10,931	14,500	8,778
TOTAL EXPENDITURES	2,751,961	2,618,409	2,816,229	2,676,179	3,033,600	2,853,249	2,915,805	2,799,970	2,552,398	2,483,364
EXCESS (DEFICIENCY) OF REVENUES	(415,426)	(374,541)	(548,787)	(480,057)	(817,462)	(590,657)	(666,908)	(563,799)	(149,198)	(100,991)
OTHER FINANCING SOURCES (USES)										
Operating Transfers In	535,334	547,607	691,316	655,143	963,904	842,404	817,763	677,756	658,375	597,416
Loans From Other Funds	0	0	0	0	0	0	4,913	4,913	0	3,843
Operating Transfers Out	(134,288)	(134,288)	(142,529)	(141,698)	(146,743)	(144,487)	(155,984)	(154,949)	(511,159)	(507,000)
Appropriation of Fund Balance and Carry forward Appropriations	0	0	0	0	301	0	216	0	1,982	0
Loan to Other Funds	0	0	0	0	0	0	0	0	0	0
TOTAL OTHER FINANCING SOURCES (USES)	401,046	413,319	548,787	513,445	817,462	697,917	666,908	527,720	149,198	94,259
EXCESS (DEFICIENCY) OF REVENUES AND OTHER SOURCES OVER EXPENDITURES AND OTHER USES	$(14,380)	$38,778	$0	$33,388	$0	$107,260	$0	$(36,079)	$0	$(6,732)

Source: City of Los Angeles General Purpose Financial Statements.

MAJOR GENERAL FUND REVENUE SOURCES

Following is a discussion of the City's principal General Fund revenue sources.

Property Taxes

Under Article XIII A of the State Constitution (enacted in 1978 through the passage of Proposition 13) and its implementing legislation, ad valorem taxes on real property (other than taxes relating to certain voter-approved indebtedness) are limited to one percent of the "full cash value". Full cash value is generally defined as the valuation of real property as shown on the 1975-76 tax bill, or thereafter, as the appraised value of property when purchased or newly constructed after the 1975 assessment period. Real property valuation may be increased to reflect inflation, not to exceed two percent a year. (See "LIMITATIONS ON TAXES AND APPROPRIATIONS" herein.)

The assessed valuation of property is established by the County Assessor, and reported at 100% of the full cash value as of January 1, except for public utility property, which is assessed by the State Board of Equalization. Beginning in 1983, State law provided for the establishment of a "supplemental roll"; real property is reassessed at market value on the date property changes ownership or upon completion of new construction (known as the "floating lien date"). A supplemental tax is collected for the remainder of the tax year.

The County collects the ad valorem taxes. Taxes arising from the one percent levy are apportioned among local taxing agencies on the basis of a formula established by State law in 1979. Under this formula, the City receives a base year allocation plus an allocation on the basis of growth in assessed value (consisting of new construction, change of ownership and inflation). Taxes relating to voter-approved indebtedness are allocated to the relevant taxing agency. Beginning in fiscal year 1990-91 (with the adoption of new State legislation), the County deducts the pro-rata cost of collecting property taxes from the City's allocation.

The State Constitution and statutes provide exemption from reassessment for certain changes of ownership, and from ad valorem property taxation for certain classes of property such as local governments, churches, colleges, non-profit hospitals, and charitable institutions. State law also allows exemptions from ad valorem property taxation at $7,000 of full value of owner occupied dwellings and 100 percent of business inventories. Revenue losses to the City from the homeowners exemption are replaced by the State.

The California Community Redevelopment Law authorizes redevelopment agencies to receive the allocation of tax revenues resulting from increases in assessed valuations of properties within designated project areas. In effect, the other local taxing authorities realize tax revenues from such properties only on the base year valuations which are frozen at the time a redevelopment project area is created. The tax revenues which result from increases in assessed valuations flow to the redevelopment areas. The City has created redevelopment project areas pursuant to California law. Generally, funds must be spent within the redevelopment areas in which the tax increment revenues were generated, and may only be spent on projects which qualify under California redevelopment law.

All taxable real and personal property is classified as either "secured" or "unsecured" and is listed accordingly on separate parts of the assessment roll. The "secured roll" contains real property (land and improvements), certain taxable personal property (such as business equipment on business-owned property), and possessory interests (a leasehold on otherwise exempt government property). The "unsecured roll" contains taxable property that is not secured by the underlying real property, the majority of which is business equipment on leased or rented premises, and other taxable personal property such as boats and aircraft, as well as delinquent possessory interests. The balance of personal property has been exempted by State law from property taxes. Approximately 94% of the City's assessed valuation represents property contained on the secured roll.

Property taxes on the secured roll are due in two installments: on November 1 and February 1 of the fiscal year. If unpaid, such taxes become delinquent after December 10 and April 10, respectively, and a 10% penalty is added to delinquent taxes. In addition, property on the secured roll on which taxes are delinquent has a delinquency certificate recorded after June 30 of the fiscal year. Such property may thereafter be redeemed by payment of the delinquent taxes and the delinquency penalty, plus a redemption penalty of 1½% per month to the time of redemption. If taxes are unpaid for a period of five years or more, the property is deeded to the State and is subject to sale by the County Tax Collector.

Property taxes on the unsecured roll are due as of March 1 and become delinquent on August 31. A 10% penalty attaches to delinquent taxes on property on the unsecured roll, and an additional penalty of 1½% per month begins to accrue on November 1. The taxing authority has four ways of collecting delinquent unsecured personal property taxes: (1) a civil action against the taxpayer; (2) filing a certificate in the Office of the County Clerk specifying certain facts in order to obtain a judgment lien on certain property of the taxpayer; (3) filing a certificate of delinquency for recordation in the County Recorder's Office, in order to obtain a lien on certain property of the taxpayer; and (4) seizure and sale of personal property, improvements or possessory interest belonging or assessed to the delinquent taxpayer.

Table 14
ASSESSED VALUATIONS, TAX COLLECTION AND PROPERTY TAX REVENUES CITY OF LOS ANGELES
(in thousands)

Fiscal Year	Assessed Valuation [1]	Assessed Valuation for Revenue Purposes [2]	Total Current Tax Levy [3]	Total Current Collections	Current Year Delinquency [4]	Total Collections [5]	State Replacement Funds [6]	Total Property Tax Revenues
1987-88	$126,867,088	$118,427,175	$388,493	$362,310	6.7%	$407,633	$15,389	$423,022
1988-89	135,192,653	126,197,294	422,448	399,495	5.4%	445,862	10,706	456,568
1989-90	150,633,825	137,754,575	470,986	439,576	6.7%	488,830	8,926	497,756
1990-91	166,926,812	155,266,738	506,678[7]	485,902[7]	4.1%	532,425[7]	10,105	542,530[7]
1991-92	182,145,896	169,092,967	556,566[7]	516,942[7]	7.1%	600,812[7]	10,124	610,936[7]
1992-93	192,455,766	178,691,450	544,201[7]	513,973[7]	5.6%	579,159[7]	9,445	558,604[7]
1993-94	195,673,258	181,744,178	493,276[7]	432,893[7]	12.2%	520,327[7]	9,013	529,340[7]
1994-95	196,583,498	183,275,821	486,482[7]	429,926[7]	11.6%	556,800[7]	6,332	563,132[7]
1995-96	187,984,683	176,475,057	472,383[7]	438,431[7]	7.2%	538,138[7]	7,885	546,023[7]
1996-97	185,464,851	178,092,857	472,855[7]	430,919[7]	8.9%	534,130[7]	8,749	542,879[7]
1997-98	185,490,644	176,692,481	475,288[7]	408,668[7][8]	N/A	513,982[7][8]	4,292[8]	518,264[7][8]

(1) Represents secured and unsecured assessed valuations.

(2) Consists of gross assessed valuations, less deduction for homeowners exemptions and redevelopment project area incremental assessed valuations, the taxes on which are payable to the Community Redevelopment Agency of the City of Los Angeles.

(3) City's allocated share of one percent basic levy, which is a General Fund revenue; excludes City levy for debt service.

(4) Percent of total City tax levy that was uncollected or unremitted by the County as of June 30 for the given tax year.

(5) Includes collections received for delinquent prior year taxes and penalties and current year receipts from supplemental taxes levied due to reassessment upon change of ownership.

(6) State replacement payments for lost revenues due to homeowners exemption and for 1987-88 business inventory exemption.

(7) Excludes administrative charges deducted from the levy pursuant to State legislation enacted in 1990-91.

(8) Collections as of April 20, 1998.

Source: City Controller's Office.

In preparing its budget, the City forecasts property taxes based on each of the specific categories of receipts (secured and unsecured, current and delinquent receipts, and State replacement funds). Current receipts are based on the County Assessor's estimate of growth in assessed valuation, adjusted for estimates in growth for redevelopment project areas. The estimate of current secured levy receipts is discounted by eight percent for delinquencies; current unsecured levy receipts are discounted by one percent. Estimates of other property tax receipts are primarily based on historical collections.

A list of the ten largest taxpayers, based on secured assessed valuations, within the City for the 1997-98 fiscal year are listed in Table 15. The total secured assessed valuation of these taxpayers represents approximately 3.2% of the total City assessed valuation for fiscal year 1997-98.

Table 15
TEN LARGEST TAXPAYERS
CITY OF LOS ANGELES
1997-98 SECURED ASSESSED VALUATION

Name	Amount
J. Paul Getty Museum	$1,004,878,717
Anheuser-Busch Inc.	704,129,714
Beacon Oil Company	597,109,209
Shuwa Investments Corporation	595,878,000
Maguire Thomas Partners	511,859,222
Union Oil Company of California	498,947,976
Texaco Refining and Marketing Inc.	479,849,438
Maguire Partners Crocker	382,785,105
MCA, Inc.	336,037,626
New TMC, Inc.	320,060,878
	$5,431,535,885

Source: California Municipal Statistics, Inc.

Other Taxes

The revenue category of "Other Taxes" consists of receipts from: Utility Users Tax, Sales Tax, Business Tax, State Motor Vehicle License Fees, Transient Occupancy Tax, State Cigarette Tax, Real Property Transfer Tax, and other miscellaneous taxes. A discussion of the major revenue sources within this category follows.

Utility Users Tax

The Utility Users Tax is imposed on all users of natural gas, electricity and telephone services within the City's limits. The tax rate is established by the City Council. The tax is a percentage of utility charges based on the following rates: Residential – 10% of utility bill for users of electricity, gas, and telephone services and commercial – 10% of utility bill for users of gas and telephone services and 12½% of utility bill for users of electricity. These tax rates have been in effect since July 1983. Effective October 1, 1987, the telephone users tax was expanded to include interstate and international long distance calls. Prior to that date, the tax included local and intra state calls only. In connection with the 1993-94 Budget, the Council extended the telephone users tax to cellular phone usage.

An exemption from the Utility Users Tax is available to senior citizens over the age of 62 and to disabled individuals, provided that the combined adjusted gross income of all household members is below $15,300. As provided by the State Constitution, insurance companies are exempt from the tax. In addition, county, state, federal and foreign governments within the City are not subject to this tax as the City has no authority to impose a tax on these entities. Exemptions account for approximately 10% of the total tax base.

Utility taxes are forecast based on analysis of each of the three taxed commodities. Electricity tax revenues are derived from the Department of Water and Power's long-term power sales forecast, modified by an analysis of recent trends and a forecast of business activities. Natural gas sales are based on Southern California Gas Company historical trends, modified by approved and anticipated rate increases. Both electricity and natural gas sales are sensitive to weather (warm winters and cool summers reduce demand); forecasts are based on average weather. Telephone services forecasts are based on historical trends of major telephone companies, adjusted by growth in volume and major pending rate adjustments.

Utility companies, with the exception of the Department of Water and Power, collect and transmit the tax monthly to the City Clerk who deposits the revenue into the General Fund. Tax revenue collected by the Department of Water and Power is transferred directly to the General Fund on a monthly basis.

Table 16 shows the actual or budgeted receipts from the Utility Users Tax since fiscal year 1991-92:

Table 16
UTILITY USERS TAX RECEIPTS
CITY OF LOS ANGELES

Fiscal Year	Receipts
1991-92	$406,071,791
1992-93	415,069,047
1993-94	433,533,319
1994-95	426,479,057
1995-96	428,167,000
1996-97	466,206,000
1997-98 (Estimated)	478,122,000
1998-99 (Proposed Budget)	477,625,000

Sales Tax

A sales tax is imposed on retail sales or consumption of personal property. The tax rate is established by the State Legislature. Effective July 15, 1991, the statewide tax rate became 7.25 percent (up from 6 percent). An additional 1 percent is collected in Los Angeles County for transportation purposes. The State collects and administers the tax, and makes distributions on taxes collected within the City as follows:

State General Fund	5.50%
Public Safety Augmentation	.50%
County	.25%
City	1.00%
Metropolitan Transportation Authority	1.00%
Total	8.25%

The State's administrative costs of 0.82% are deducted before distribution to the City. Sales Tax revenue collected by the State is directly deposited monthly to the City's General Fund.

The City's budgeting forecast of Sales Tax receipts is based on State officials' estimates and the forecast of local economists. The City's budgeting forecast also includes a half-cent sales tax extension approved by the voters on the November 1993 ballot. This half-cent sales tax is deducted from the State's six percent and allocated to cities and counties to fund public safety.

Table 17 shows the actual or budgeted receipts from the Sales Tax since fiscal year 1991-92:

Table 17
SALES TAX RECEIPTS
CITY OF LOS ANGELES

Fiscal Year	Receipts
1991-92	$270,382,765
1992-93	267,238,080
1993-94	257,685,776
1994-95	268,870,794
1995-96	277,468,000
1996-97	283,604,000
1997-98 (Estimated)	297,250,000
1998-99 (Proposed Budget)	309,140,000

Business Tax

The Business Tax is imposed on persons engaged in a business in the City. The tax rate formula, which is established by the City Council, varies based upon the type of business. Most businesses are taxed on gross receipts at rates varying from $1.18 per $1,000 of gross receipts for wholesalers to $5.91 per $1,000 of gross receipts for selected businesses and occupations.

The City's budgeting forecast of Business Tax receipts is based on State officials' estimates and the forecast of local economists. The City's estimate is adjusted for anticipated rate adjustments and major refunds and temporary tax amnesties.

The California Supreme Court rendered a decision unfavorable to the City on July 29, 1991 in the *California Federal Savings and Loan Association v. City of Los Angeles,* a coordinated action involving more than 90 separate claims for refund of business taxes paid by financial corporations. This decision resulted in the need to refund approximately $225 million in past Business Taxes and an annual loss of approximately $22 million in Business Tax receipts beginning in Fiscal Year 1991-92. The City financed payment of the Business Tax refund through the issuance of $198.3 million Judgment Obligation Bonds, Series 1992-A on August 4, 1992 and $15.4 million Judgment Obligation Bonds, Series 1993-A on March 3, 1993.

The California Supreme Court has denied the City's petition for review in *General Motors v. City of Los Angeles*, an action filed in the Los Angeles Superior Court for the refund of business taxes. The California Court of Appeals, in a reversal of a Superior Court ruling, has ruled that the City's Business License Tax, under which an out-of-City manufacturer wholesaling in the City pays a wholesaling tax which an in-City manufacturer wholesaling in the City does not, is discriminatory against interstate and intercity commerce and unconstitutional. The City does not plan to appeal the California Supreme Court decision. In February 1996 the City Council eliminated the manufacturer's tax altogether so that only selling activities within the City are taxed, regardless of where the manufacturing occurred. Preliminary estimates of the reduction in City business tax revenues from the elimination of the manufacturer's tax total $10 million. The General Motors case was settled for $7,200,000. The potential liability in other related cases, including some that were recently settled, could be as much as $25,000,000.

Table 18 shows the actual or budgeted receipts from the Business Tax since fiscal year 1991-92:

Table 18
BUSINESS TAX RECEIPTS
CITY OF LOS ANGELES

Fiscal Year	Receipts
1991-92	$257,962,442
1992-93	273,305,113
1993-94	267,721,131
1994-95	268,474,803
1995-96	283,200,000
1996-97	283,384,000
1997-98 (Estimated)	287,400,000
1998-99 (Proposed Budget)	298,900,000

State Motor Vehicle License Fee

A license fee equivalent to two percent of the market value of motor vehicles is imposed annually by the State in lieu of local property taxes. The rate is established by the State Legislature. The State allocates proceeds to the Department of Motor Vehicles and the California Highway Patrol to cover operating expenses, and to the State General Fund for administrative expenses. The remaining revenues are apportioned equally between counties and cities on the basis of relative population within the State. While the City's population has been increasing over time, it has not increased at the same rate as other cities and counties. As a consequence, the City's percentage share of receipts has declined from 14.4% in 1991-92 to 13.7% in 1996-97. Revenues received are also affected by the stock of cars maintained and the number of new car sales. The actual receipts received from the State have continued to increase due to a concurrent increase in car stock during this period.

The fiscal year 1998-99 budget for these revenues is derived from a forecast of statewide license receipts, which are prorated according to the ratio of the City's population to the State's population. The statewide receipts forecast is based on historical data, State Officials' estimates and the forecast of local economists.

Table 19 shows the actual or budgeted receipts from State Motor Vehicle License Fees since fiscal year 1991-92:

Table 19
STATE MOTOR VEHICLE LICENSE FEE RECEIPTS
CITY OF LOS ANGELES

Fiscal Year	Receipts
1991-92	$121,279,721
1992-93	125,743,595
1993-94 (1)	139,922,330
1994-95	126,460,023
1995-96	134,035,000
1996-97	141,800,000
1997-98 (Estimated)	148,800,000
1998-99 (Proposed Budget)	153,201,000

(1) Includes a one-time transfer of $20 million from the State to offset property taxes taken by the State to balance its budget.

Licenses, Permits and Fees

Receipts received from Licenses, Permits and Fees are based primarily on charges imposed to meet regulatory measures by City departments. A significant portion is generated from fees in connection with construction-related activities. Consequently, economic conditions and interest rates for construction loans have a direct effect on this revenue source.

The fiscal year 1998-99 budgeted amount for these revenues is based on the UCLA Business Forecasting Project's forecast of building permits in California, historical averages adjusted for more recent trends in construction activity and known and anticipated changes in permit rates. Construction-related receipts are derived primarily from fees charged by the Department of Building and Safety. The fee is set according to a formula established by the City Council. Table 20 shows the actual or budgeted receipts from the Department of Building and Safety since fiscal year 1991-92:

Table 20
DEPARTMENT OF BUILDING AND SAFETY RECEIPTS
CITY OF LOS ANGELES

Fiscal Year	Receipts
1991-92	$45,694,714
1992-93	42,400,703
1993-94	41,019,805
1994-95	43,496,661
1995-96	39,525,000
1996-97 (1)	53,518,000
1997-98 (Estimated)	57,138,942
1998-99 (Proposed Budget)	60,100,187

(1) Significant increase from1995-96 receipts is due to building permit fee increase.

Examples of other major sources from which receipts are accounted for as Licenses, Permits and Fees are as follows: parking revenues; animal licenses; paramedic ambulance services; reimbursements from the Sewer Construction and Maintenance Fund for staff costs for maintenance and operation of wastewater facilities; and reimbursement from the Departments of Airports, Harbor and Water and Power for services provided by other departments (e.g. Information Technology Agency for computer-related activities, Department of General Services for building maintenance, and Department of Public Works for engineering and construction-related services).

Fines, Forfeits and Penalties

The significant source of these receipts is parking fines. The schedule of fines is established by the City Council. Other receipts include fees charged for laboratory work in connection with sobriety tests conducted by the Los Angeles Police Department, and fines paid for citations issued for violations of the Los Angeles Municipal Code (e.g. lease law violations).

Parking ticket revenue forecasts are based on the number of parking enforcement officers employed by the City's Department of Transportation, an estimate of average revenues per ticket based on historical trends, and an estimate of average worker productivity.

Table 21 shows the actual or budgeted receipts from parking fines since fiscal year 1991-92:

Table 21 RECEIPTS FROM PARKING FINES CITY OF LOS ANGELES	
Fiscal Year	Receipts
1991-92	$66,852,454
1992-93	60,555,475
1993-94	61,346,226
1994-95	62,037,642
1995-96	59,936,000
1996-97 [1]	77,661,000
1997-98 (Estimated)	84,000,000
1998-99 (Proposed Budget)	86,497,000

[1] Increase over 1995-96 receipts is due to additional officers added for enforcement in 1996-97.

Transfers to General Fund

The largest revenue source in this category is the annual transfer to the General Fund of approximately five percent of the total operating revenue of the Power Revenue Fund in the preceding fiscal year. The transfer is made pursuant to Charter Section 382 which provides that, with the consent of the Board of Water and Power Commissioners, the Council may direct by ordinance the transfer of surplus revenue to the General Fund. The transfer is restricted by the City Charter and the Department's revenue bond covenants which specify that a transfer may not be greater than the previous fiscal year's net income, nor may it result in a reduction of the surplus to less than 33 1/3% of the Department's total outstanding debt. Transfers are made periodically following Council's adoption of the ordinance. Budget estimates for the succeeding year are based on actual revenues for the first three quarters for the final quarter of the current fiscal year.

Table 22 shows the actual or budgeted transfers from the Power Revenue Fund since fiscal year 1991-92:

Table 22 TRANSFERS FROM POWER REVENUE FUND CITY OF LOS ANGELES	
Fiscal Year	Receipts
1991-92	$90,597,000
1992-93	74,160,000
1993-94	101,880,000
1994-95	131,648,000
1995-96	62,717,000
1996-97 [1]	97,343,000
1997-98 (Estimated)	85,000,000
1998-99 (Proposed Budget)	106,910,000

[1] Includes transfer from the sale of surplus oil ($4 million) and from the sale of other assets ($4.9 million). The normal transfer would have otherwise been $92 million.

Another transfer of funds to the General Fund is from the Harbor Department. Public Resources Code Section 6010 (enacted October 1992) permits the transfer of "discretionary reserves", as defined in the statute, from a port to the City of which it is part, to be spent for municipal purposes. To date, $69,315,000 has been transferred to the City. Litigation has arisen over the transfers from the Power Revenue Fund and from the Harbor Department. For more discussion, see "LITIGATION" herein.

Impact of Assembly Bill 62 on Revenues

At the present time it is uncertain as to whether the Valley Secession Bill ("AB62") will impact future revenues and expenses of the City. Should an area of the City be successful in a detachment proceeding, all revenues from existing taxes could be reduced as well as operations and expenses of the City's refuse collection and disposal system. It is possible that the residents of the San Fernando Valley may file a petition for detachment from the City. However, the timing, outcome and impact of such an effort cannot be determined at this time.

LIMITATIONS ON TAXES AND APPROPRIATIONS

Article XIII A of the California Constitution – Proposition 13

Article XIII A of the California Constitution limits the amount of ad valorem taxes on real property to one percent of "full cash value" as determined by the County Assessor. Article XIII A defines "full cash value" to mean the County assessor's valuation of real property as shown on the 1975-76 tax bill under full cash value, or thereafter, the appraised value of real property when purchased, newly constructed, or when a change in ownership has occurred after the 1975 assessment period. The full cash value may be adjusted annually to reflect inflation at a rate, as shown by the consumer price index, not to exceed two percent per year, or may be reduced. Article XIII A also permits the reduction of the "full cash value" base in the event of declining property values caused by damage, destruction or other factors. Article XIII A exempts from the one percent tax limitation any taxes to repay (a) indebtedness approved by the voters prior to July 1, 1978, or (b) any bonded indebtedness for the acquisition or improvement of real property approved on or after July 1, 1978 by two-thirds of the votes cast by the voters voting on the proposition.

On June 3, 1986 California voters approved Proposition 46, which added an additional exemption to the one percent tax limitation imposed by Article XIII A. Under this amendment to Article XIII A, local governments and school districts may increase the property tax rate above one percent for the period necessary to retire new general obligation bonds, if two-thirds of those voting in a local election approve the issuance of such bonds and the money raised through the sale of the bonds is used exclusively to acquire or improve real property.

On June 18, 1992, the United States Supreme Court upheld the constitutionality of certain challenged provisions of Article XIII A in connection with its review of the *Nordinger v. Hahn* case.

Article XIII B of the California Constitution – Gann Limit

On November 6, 1979, California voters approved Proposition 4, the so-called Gann Initiative, which added Article XIII B to the California Constitution. In June 1990, Article XIII B was amended by the voters through their approval of Proposition 111. Article XIII B of the California Constitution limits the annual appropriations of the State and any city, county, school district, authority or other political subdivision of the State to the level of appropriations for the prior fiscal year, as adjusted annually for changes in the cost of living, population and services rendered by the governmental entity. The "base year" for establishing such appropriation limit used to be the 1978-79 fiscal year, but is now the 1986-87 fiscal year as a result of Proposition 111. Increase in appropriations by a governmental entity are also permitted (i) if financial responsibility for providing services is transferred to the governmental entity, or (ii) for emergencies so long as the appropriations limits for three years following the emergency are reduced to prevent any aggregate increase above the Constitutional limit. Decreases are required where responsibility for providing services is transferred from the government entity.

Appropriations subject to Article XIII B include generally any authorization to expend during the fiscal year the "proceeds of taxes" levied by the State or other entity of local government, exclusive of certain State subventions, refunds of taxes, benefit payments from retirement, unemployment insurance and disability insurance funds.

"Proceeds of taxes" include, but are not limited to, all tax revenues and the proceeds to any entity of government from: (1) regulatory licenses, user charges, and user fees to the extent such proceeds exceed the cost of providing the service or regulation; (2) the investment of tax revenues; and (3) certain State subventions received by local governments. Article XIII B includes a requirement that if any entity's revenues in any year exceed the amounts permitted to be spent, the excess would have to be returned by revising tax rates or fee schedules over the subsequent two fiscal years.

Appropriations subject to limitation pursuant to Article XIII B do not include debt service on indebtedness existing or legally authorized as of January 1, 1979, on bonded indebtedness thereafter approved according to law by a vote of the electors of the issuing entity voting in an election for such purpose or appropriations required to comply with mandates of courts or the federal government.

As amended in June 1990, the appropriations limit for the City in each year is based on the limit for the prior year, adjusted annually for changes in the cost of living and changes in population, and adjusted, where applicable, for transfer of financial responsibility of providing services to or from another unit of government. The change in the cost of living is, at the City's option, either (1) the percentage change in California per capita personal income, or (2) the percentage change in the local assessment roll for the jurisdiction due to the addition of nonresidential new construction. The change in population is, at the City's option, either the percentage change in the City or County population.

Article XIII B permits any government entity to change the appropriations limit by vote of the electorate in conformity with statutory and Constitutional voting requirements, but any such voter-approved change can only be effective for a maximum of four years.

Table 23 is a comparison of the City's appropriations limit and appropriations subject to limitation for the past seven fiscal years and for fiscal year 1998-99.

Table 23
APPROPRIATIONS LIMITS AND APPROPRIATIONS SUBJECT TO LIMITATIONS
CITY OF LOS ANGELES

Fiscal Year	Appropriations Limit	Appropriations Subject to Limitations	Amount Appropriations are Under the Limit
1991-92	$2,144,379,936	$1,873,438,009	$270,941,927
1992-93	2,156,388,427	1,832,939,344	323,449,083
1993-94	2,199,978,184	1,817,229,950	382,748,234
1994-95	2,231,104,002	1,863,442,118	367,661,884
1995-96	2,341,766,758	1,806,731,403	535,035,355
1996-97	2,460,949,932	1,829,359,156	631,590,776
1997-98	2,601,962,363	1,922,138,184	679,824,179
1998-99 (Estimated)	2,792,502,850	1,990,279,620	802,223,230

Note: All figures reflect revised formula for calculating the spending limitation and appropriations subject to limitations following passage of Proposition 111.

Source: Office of the City Administrative Officer

Statutory Spending Limitations – Proposition 62

In November 1986, California voters approved a statutory initiative ("Proposition 62") that established certain voter requirements in order for local governments, such as cities, counties and districts to impose or raise taxes. Various provisions of Proposition 62 were declared unconstitutional at the appellate court level. In *Fielder v. City of Los Angeles,* the California Court of Appeal held in 1993 that charter cities, such as the City, have sovereign power over municipal affairs and that Proposition 62 does not necessarily restrict the power of a charter city to impose all taxes. On September 28, 1995, the California Supreme Court, in *Santa Clara County Local Transportation Authority v. Guardino*, upheld the constitutionality of the portion of Proposition 62 requiring a two-thirds vote in order for a local government or district to impose a special tax, and upheld by implication a parallel provision requiring a majority vote in order for a local government or district to impose a special tax, and upheld by implication a parallel provision requiring a majority vote in order for a local government or district to impose any general tax.

The Impact of the Right to Vote on Taxes Act – Proposition 218

On November 5, 1996, California voters approved an initiative known as the Right to Vote on Taxes Act ("Proposition 218") that adds Articles XIII C and XIII D to the California Constitution. Proposition 218 requires majority voter approval before the imposition, extension or increase of general taxes, and 2/3 voter approval before the imposition, extension or increase of special taxes by a local government, which is defined in Proposition 218 to include charter cities such as the City. Such voter approval requirements would apply to all general and special taxes that were newly-created or increased after January 1, 1995. Proposition 218 also extends the initiative power to reducing or repealing local taxes, assessments, and property related fees and charges, regardless of the date such taxes, assessments, fees and chargers were imposed. In addition, Proposition 218 limits the application of assessments, and fees and charges and requires them to be submitted to property owners for approval or rejection, after notice and public hearing.

Proposition 218 will restrict the City's ability to impose or increase certain taxes and assessments and land-based user fees and charges and would subject existing sources of City revenue to reduction or repeal.

Impact of Proposition 218 on Current Revenue

At the present time, the City is unable to predict whether or to what extent Proposition 218 may be held to be constitutional. If certain portions are substantially upheld, the City believes that Proposition 218 could result in the loss of approximately $31 million in General Fund revenue in the areas described below. Proposition 218 would not affect revenues from existing taxes at existing levels such as the Utility Users Tax, Documentary Transfer Tax, Parking User Tax, Sales Tax, Vehicle License Fees, Municipal Court Fines, Transient Occupancy Tax, and Licenses, Permits, Fees and Fines. The City's Sanitation Equipment Charge and fees may be subject to Proposition 218 if such change is deemed a property-related fee. Fees and charges of the Power System and the Power System Transfer are exempted from Proposition 218.

Business Tax Surcharge: Proposition 218 provides that any general tax imposed, extended, or increased, without voter approval, by any local government on or after January 1, 1995, shall continue to be imposed only if approved by a majority vote of the electorate by November 6, 1998. The City business tax surcharge was extended by ordinance in July 1995. This increase in the Business Tax of 3.7% was placed on the April 1997 ballot for a vote of the electorate. The measure failed to pass by a majority vote. As a result, the City will not collect an estimated $10 million from the Business Tax Surcharge in 1997-98. The City Attorney advises there is no impact to previously collected revenue during 1996-97.

Impact of Proposition 218 on Future Revenue

Proposition 218 will require a vote of the electorate to either increase an existing tax or levy any new tax. Assuming Proposition 218 withstands likely legal challenges, the impact on future revenues will depend on the willingness of the electorate to support new taxes and cannot be determined at this time.

A lawsuit has been filed against the City of Modesto, California claiming that the transfers from the sewer and water funds to the city's general fund are prohibited by Proposition 218. The Los Angeles City Attorney has stated that the basis for the water and sewer charges in the City of Modesto differs from the City's. The City of Los Angeles bases its water and sewer charges on usage for both commercial and residential customers. As such, they are not property related taxes or fees as defined in Proposition 218. Accordingly, an adverse decision on the Modesto case should not impact the transfer from the Department of Water and Power or the Franchise fee for the City's Wastewater System. The legality of the City's transfers from the Department of Water and Power franchise fee has not been challenged. However, the legality of the City's Wastewater System franchise fee has been challenged based on Proposition 218 (See "LITIGATION").

FINANCIAL OPERATIONS

Financial Statements

For the 1996-97 fiscal year, the City has issued its audited General Purpose Financial Statements prepared in accordance with generally accepted accounting principles (GAAP), which meet the Charter requirements for an annual audit.

Tables 24 and 25 summarize financial information contained in the City's General Purpose Financial Statements for the periods indicated. The tables include information solely on the General Fund of the City and the debt service funds which are funded from General Fund revenues.

Table 24
COMBINED BALANCE SHEET FOR THE GENERAL FUND AND DEBT SERVICE FUNDS[1]
MEMORANDUM TOTALS
June 30, 1993 through 1997
(in thousands)

	1993	1994	1995	1996	1997
ASSETS:					
Cash and Pooled Investments	$311,493	$405,366	$513,799	$447,786	$456,091
Other Investments	362,394	154,772	118,226	86,478	81,839
Taxes Receivable	159,590	189,082	166,339	142,420	157,874
Accounts Receivable	25,140	27,867	20,343	17,111	15,287
Special Assessments Receivable	2,337	2,393	2,904	2,833	3,263
Investment Income Receivable	13,445	14,800	19,873	21,865	26,677
Due from Other Government Entities	14,108	16,311	18,943	15,265	13,380
Loans Receivable	105	6,709	3,805	2,621	100
Due from Other Funds	88,925	128,300	263,407	59,709	51,798
Inventories	32,637	32,264	33,955	28,403	27,460
Prepaid Items and Other Assets	223	281	1,499	88	94
Advances to Other Entities	5,224	0	0	0	0
Advances to Other Funds	13,536	13,066	14,185	16,278	15,120
TOTAL ASSETS	$1,029,157	$991,211	$1,177,278	$840,857	$848,983
LIABILITIES AND FUND EQUITY					
LIABILITIES:					
Accounts, Contracts and Retainage Payable	$32,905	$52,385	$50,606	$40,942	$39,439
Obligations Under Reverse Repurchase Agreements	171,665	0	0	0	0
Obligations Under Securities Lending Transactions	0	0	0	0	97,061
Accrued Wages and Overtime Payable	89,895	83,425	95,313	96,031	45,202
Accrued Compensated Absences Payable	8,470	7,756	8,095	8,461	12,189
Estimated Claims and Judgments Payable	56,391	92,635	64,752	80,445	80,259
Due to Other Government Entities	38	433	47	478	54
Due to Other Funds	20,816	30,292	14,267	50,874	40,172
Deposits and Advances	130,869	160,450	194,450	31,868	26,855
Deferred Revenue and Other Credits	0	183	273	91,298	96,373
Advances from Other Funds	0	0	0	0	6,192
Interest Payable	5,853	1,034	11	630	39
Bonds and Notes Payable -- Current Portion	190	420	170	35	35
Other Liabilities	3,070	3,341	3,766	4,146	4,487
TOTAL LIABILITIES	520,162	432,354	431,750	405,208	448,357
FUND EQUITY					
Fund Balances:					
Reserved for Encumbrances	$110,222	$116,947	$129,497	$101,953	$86,205
Reserved for Assets Not Available for Appropriation	51,618	45,595	53,444	47,386	42,774
Reserved for Debt Service	234,576	224,027	211,367	203,817	238,303
Designated for Special Purposes	55,323	80,839	167,134	71,160	45,543
Unreserved and Undesignated	57,256	91,449	184,086	11,333	(12,199)
TOTAL FUND EQUITY					
General Fund Equity	$274,135	$331,854	$530,339	$231,639	$162,181
Debt Service Funds Equity	234,860	227,003	215,189	204,010	238,445
TOTAL LIABILITIES AND FUND EQUITY	$1,029,157	$991,211	$1,177,278	$840,857	$848,983

(1) Excludes debt service funds of the Community Redevelopment Agency and Other Debt Service Funds.

Source: City of Los Angeles, General Purpose Financial Statements.

Table 25
COMBINED STATEMENT OF REVENUES, EXPENDITURES AND CHANGES IN FUND BALANCE FOR THE GENERAL FUND AND DEBT SERVICE FUNDS[1]
MEMORANDUM TOTALS
June 30, 1993 through 1997
(in thousands)

	1993	1994	1995	1996	1997
REVENUES:					
Property Taxes	$560,805	$499,850	$482,388	$475,571	$543,728
Sales Taxes	266,655	256,967	269,090	278,466	283,604
Utility Users Taxes	416,523	436,261	427,587	430,211	466,206
Business Taxes	272,588	268,841	268,423	282,580	283,384
Other Taxes	165,415	164,868	172,959	183,279	213,667
Licenses and Permits	24,811	25,414	23,894	20,742	27,062
Intergovernmental	138,164	143,792	132,392	148,684	151,641
Charges for Services	272,171	225,924	236,325	251,867	260,012
Services to Enterprise Funds	137,256	164,196	192,580	184,257	180,337
Fines	61,969	63,238	78,045	67,256	77,661
Special Assessments	1,162	1,475	2,295	1,109	1,704
General Fund Interest	20,595	19,127	26,196	30,486	29,490
Debt Service Fund Interest	10,072	19,599	6,544	11,522	12,231
Other	32,178	42,046	34,174	42,382	46,866
TOTAL REVENUES	2,380,364	2,331,598	2,352,892	2,408,412	2,577,592
EXPENDITURES:					
Current:					
General Government	831,073	635,586	553,998	694,809	495,765
Protection of Persons and Property	1,223,427	1,196,376	1,235,403	1,285,091	1,430,799
Public Works	155,892	142,925	31,974	104,959	147,623
Health and Sanitation	185,396	170,980	162,909	171,295	192,016
Transportation	60,837	47,569	53,375	59,615	82,124
Cultural and Recreational Services	35,129	39,272	32,481	33,770	28,236
Community Development	27,918	23,207	23,010	20,466	23,380
Capital Outlay	43,793	37,392	37,975	39,478	17,208
Debt Service:					
Principal	33,505	64,455	86,155	105,185	139,935
Interest	82,554	82,424	88,613	97,166	119,205
Cost of Issuance	0	11,421	0	0	1,286
TOTAL EXPENDITURES	2,679,524	2,451,607	2,305,893	2,611,834	2,677,577
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENDITURES	(299,160)	(120,009)	46,999	(203,422)	(99,985)
OTHER FINANCING SOURCES (USES)					
General Obligation Bond Proceeds	213,735	0	117	0	0
Certificates of Participation Proceeds	30,353	61,357	2,987	22,196	16,585
Proceeds of Refunding Bonds	0	628,484	0	0	0
Operating Transfers In	198,707	474,940	300,824	255,233	322,888
Operating Transfers Out	(184,174)	(347,632)	(220,371)	(205,927)	(277,135)
Payment to Refunding Bond Escrow Agent	0	(621,944)	(353)	0	0
Other Financing Sources	32	221	0	0	0
TOTAL OTHER FINANCING SOURCES (USES)	258,653	195,426	83,204	71,502	62,338
EXCESS (DEFICIENCY) OF REVENUES AND OTHER SOURCES OVER EXPENDITURES AND OTHER USES	(40,507)	75,417	130,203	(131,920)	(37,647)
FUND BALANCES, JULY 1, RESTATED [12]	543,455	483,312	558,857	570,595	435,649
DECREASE IN RESERVE FOR INVENTORIES	0	0	0	(5,553)	(945)
RESIDUAL EQUITY TRANSFERS	6,047	128	56,468	2,527	3,569
FUND BALANCE GENERAL FUND, JUNE 30,	274,135	331,854	530,339	231,639	162,181
FUND BALANCE DEBT SERVICE FUNDS, JUNE 30,	$234,860	$227,003	$215,189	$204,010	$238,445

[1] Excludes debt service funds of the Community Redevelopment Agency and Other Debt Service Funds.
[2] Prior period adjustments occurred in 1994 and 1996. Accordingly, prior year ending fund balances do not equal beginning fund balance for those years.

Source: City of Los Angeles, General Purpose Financial Statements.

Reserve Fund and Unappropriated Balance

The Reserve Fund was created by the City Charter and contains those actual General Fund cash receipts which are not otherwise appropriated to the City's Adopted Budget. The City expects that funds will be transferred from the Reserve Fund as part of the Adopted Budget or throughout the fiscal year for appropriation, or may be transferred as a loan to other funds to maintain those funds on a parity with their obligations. All unencumbered cash amounts in the General Fund revert to the Reserve Fund at the end of the fiscal year; some of those funds will be reappropriated at the beginning of the following fiscal year (primarily for General Fund capital projects). The Reserve Fund is reported as part of the General Fund in the City's General Purpose Financial Statements.

An analysis of the City's Reserve Fund as a percent of General Fund revenues is shown in Table 26.

Table 26
ANALYSIS OF RESERVE FUND BALANCES
CITY OF LOS ANGELES
(in millions)

	Available Reserve Fund Balance				
Fiscal Year as of June 30,	Designated[1]	Undesignated	Total	Budget Basis General Fund Revenues	Available Cash Balance as Percent of Revenues
1989-90	$90.7	$20.7	$111.4	$2,260.4	4.9%
1990-91	61.4	69.4	130.8	2,371.3	5.5
1991-92	33.9	6.0	39.8	2,420.2	1.6
1992-93	33.0	7.0	40.0	2,382.1	1.7
1993-94	16.1	64.4	80.5	2,355.5	3.4
1994-95	30.7	111.1	141.8	2,491.9	5.7
1995-96	71.1	11.1	82.2	2,462.5	3.3
1996-97	33.2	0[2]	33.2	2,542.3	1.3
1997-98 (Estimated)	21.9	38.3	60.2	2,604.9	2.3

(1) Consist primarily of year-end cash balance which is (a) reappropriated for prior year's unencumbered capital improvement appropriations or (b) transferred to the subsequent year's budget.

(2) Total reserve fund balance ($33.2 million designated and $0 undesignated) at year-end were lower than anticipated primarily due to decreased receipts in the Licenses, Permits Fees & Fines revenue category which were not recognized until late in the year, and interfund loans which will not be repaid until fiscal year 1997-98. In fiscal year 1997-98, the City has implemented closer oversight of these revenues and has taken corrective action earlier in the year to achieve a higher undesignated reserve balance than the budgeted $28.8 million.

Source: Office of the City Administrative Officer

As part of its budget process, the City targets a beginning year Reserve Fund cash balance. In addition to its Reserve Fund, the City annually allocates funds to the Unappropriated Balance to be available for appropriations later in the fiscal year to meet contingencies as they may arise. Any funds remaining at the end of the fiscal year revert to the Reserve Fund.

A summary of budgeted allocations to the Unappropriated Balance and Budgeted Reserves is listed in Tables 27 and 28.

Table 27
BUDGETED UNAPPROPRIATED BALANCE
CITY OF LOS ANGELES
(in millions)

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99[2]
General	$1.0	$2.8	$3.0	$5.1	$2.0	$2.6
Liability Claims	37.0	37.0	0[1]	0[1]	0[1]	0[1]
Compensation Adjustments	0	25.0	2.4	0	23.0	0
Systems Studies/Projects	0.7	10.0	0	0	1.9	0
Solid Waste Alternative/Citywide Curbside Recycling	0	0	0	0	0	0
Public Compensation	0	27.0	0	12.0	0	0
Police Special Services	0	0	11.5	21.1	3.4	0
Worker's Compensation/Contingency Liability Claims	10.4	19.9	14.4	10.8	8.0	0
Other	0	0	0	0	6.0	8.1
Total	$49.1	$121.7	$31.3	$49.0	$44.3	$10.7

(1) Beginning in FY 1995-96 liability claims are budgeted as a separate item outside of the unappropriated balance. The 1998-99 liability claims budget is $53.2 million of which $42.7 million would have been previously included in the unappropriated balance (liability claims over $100,000).

(2) Proposed budget.

Source: Office of the City Administrative Officer.

Table 28
BUDGETED RESERVES
CITY OF LOS ANGELES
(in millions)

	Reserve Fund Components				
Budget for Fiscal Year Ending June 30,	Budget Unappropriated Balance	Litigation Fund[1]	Budgeted Reserve Fund	Total Reserves	% of Total General Fund Revenues
1991-92	$27.5	$29.5	$30.6	$87.6	3.6%
1992-93	18.4	40.0	30.0	88.4	3.7
1993-94	12.1	46.0	30.0	88.1	3.7
1994-95	84.7	54.3	26.3	165.3	6.6
1995-96	31.3	56.4	32.8	120.5	4.8
1996-97	49.0	55.2	28.1	132.3	5.2
1997-98	44.3	55.2	28.8	128.3	4.9
1998-99	10.7	53.2	44.0	107.9	4.0

(1) Prior to FY 1995-96, the Litigation Fund budget was split between the Unappropriated Balance and the City Attorney's Budget.

Source: Office of the City Administrative Officer

Risk Retention Program

Because of its size and its financial capacity, the City has long followed the practice of directly assuming virtually all insurable risks without procuring commercial insurance policies. The extent and variety of City exposure is such that the cost of the premiums would outweigh the benefits of such coverage. The City administers, adjusts, settles, defends, and pays claims out of budgeted resources. Additionally, the City is self-insured for workers' compensation as permitted under State law. The City procures commercial insurance when required by bond or lease financing covenants and for other limited purposes.

California

The state profile is designed [illegible] with the county data for comparison purposes. Some of the statewide data, specifically Wage and Salary Employment (BLS series) [illegible] income, may not incorporate the latest revisions or be the latest available.

POPULATION

Land area (acres)	99,822,800	Leading counties	Population 1-1-00	Leading counties	Population 1-1-00
Population, 7-1-99	34,036,000	Los Angeles	9,884,300	San Francisco	801,400
Population, 1-1-00	34,336,000	San Diego	2,911,500	Ventura	756,500
		Orange	2,828,400	San Mateo	730,000
		Santa Clara	1,736,700	Kern	658,900
1-1-00		San Bernardino	1,689,300	San Joaquin	566,600
Population in households	33,540,987	Riverside	1,522,900	Sonoma	450,100
Population/household	2.959	Alameda	1,454,300	Stanislaus	441,400
		Sacramento	1,209,500	Santa Barbara	414,200
		Contra Costa	930,000	Monterey	399,300
		Fresno	805,000	Solano	399,000

EDUCATION

Median years of school, 1990 ***	13.4
Enrollment, Fall 1999 (public & private schools)	
Kindergarten-12	6,592,414
Enrollment, Fall 1996	
University of California	166,718
California State Universities	336,803
Public community colleges	1,407,335
Private colleges	222,709
Other public institutions	1,291

Spending on education	1998-99 ($ mill)
School districts*	40,680.2
Community colleges**	5,044.4

* Not including community college districts.
** Includes governmental, proprietary and fiduciary group funds.
*** May not be comparable to the 1980 census. The 1990 median was computed on the basis of educational attainment. The 1980 median was based on actual years of school completed.

LABOR FORCE AND EMPLOYMENT

Civilian labor force, 2000	17,090,800
Civilian employment	16,245,600
Unemployment	845,200
Unemployment rate	4.9
Nonagricultural wage & salary employment, 2000 (BLS series)	14,518,600
Mining	23,300
Construction	733,600
Manufacturing	1,944,200
Transportation-utility	745,600
Trade	3,300,800
Finance-insurance-real estate	823,200
Services	4,626,800
Federal government	274,400
State-local government	2,046,900

Totals may not add due to rounding.

Number of establishments by industry and employment size, 1998

Employment size	All industries *	Mining/Utilities Construction	Manufacturing	Trade **	Transportation & Information	FIRE ***	Services
1-4	419,782	39,784	17,618	78,519	17,976	48,753	215,672
5-9	146,466	11,502	8,750	38,938	5,531	14,439	66,908
10-19	96,672	7,446	8,135	23,971	4,511	9,069	43,295
20-49	69,203	4,871	8,235	14,387	3,994	4,938	32,601
50-99	23,873	1,414	3,714	5,249	1,610	1,458	10,371
100-249	12,936	696	2,484	2,710	1,033	725	5,250
250-499	3,219	127	739	492	276	214	1,363
500-999	1,153	48	262	65	112	90	575
1000 +	621	19	113	15	63	43	368
Total	773,925	65,907	50,050	164,346	35,106	79,729	376,403

* Includes forestry, fishing, hunting, and agriculture support
** Wholesale and retail
*** Finance, insurance, real estate, rental, and leasing

INCOME AND SALES

Personal income, 1998 ($ mill.)	$920,452.2
Per capita income, 1998	28,163
Avg. earnings per job, 1998	36,539
Avg. wages per job, 1998	34,690
Avg. earnings per nonfarm proprietor, 1998	26,828
Sales and Use tax rate	7.00%

	1979	1989
Median family income, Census	21,537	40,559
Median household income, Census	18,243	35,798

	1998	1999
Total taxable sales ($ millions)	358,858.4	394,736.2
Taxable retail sales	229,406.5	255,589.4

Median adjusted gross income based on personal income tax returns, 1998:

Individual	$28,251
Joint	$52,145

FOREIGN TRADE

($ millions)	Exports	Imports	Total
1991	73,860.3	100,744.1	174,604.4
1992	81,139.0	111,547.6	192,686.6
1993	82,173.5	125,348.4	207,521.9
1994	95,614.6	144,002.0	239,616.6
1995	116,825.5	165,044.8	281,870.3
1996	124,120.0	169,980.7	294,100.7
1997	131,142.7	184,683.7	315,826.4
1998	116,282.4	189,943.4	306,225.8
1999	122,092.8	209,025.3	331,118.1

California (continued)

HOUSING AND CONSTRUCTION

	4-1-90	1-1-00		Units	Valuation ($ mill.)
Housing stock	11 182 882	12 242 576	Housing authorizations, 1999		
Single family	6 930 949	7 694,494	Total	140,137	$25,783 3
Multiple family	3,571,993	3,962,986	Single family	101,711	19,262.7
Mobile homes, trailers, etc.	679,940	585,096	Multi-family	38,426	3,187.5
Vacancy rate (percent)	7.2	7.4			
			Nonresidential permits	--	$16,582.3

MANUFACTURING

	1992	1997		
Value added by manufacture, ($ mill.)	154,678 2	195,872.8	Capital expenditures:	($ mill.)
			1992	9,729.1
Leading industries:			1997	16,422.2
Computer & electronic products		65,716.5		
Food		16,831.1	Payroll in manufacturing:	($ mill.)
Transportation equipment		16,187.3	1990	67,826.5
Fabricated metal products		13,939.5	1998	73,353.5
Chemicals		11,498.7		
Machinery		9,935.7	Number of mfg. establishments:	
Plastics & rubber products		6,944.2	1990	51,694
Apparel		6,161.5	1998	50,050
Printing & related support activities		5,935.5		
Timber production, 1999 (Thousands of board feet)		2,144,151		

AGRICULTURE

Number of farms, 1997	74,126	**Leading commodities with value of production, 1999**	$ mill.
Acreage in farms, 1997	27,698,779		
% of land area	27.7		
		Milk and cream	4,089.9
Agricultural employment, 2000	408,000	Grapes	2,737.8
		Nursery	1,985.8
Value of production, 1999 ($ mill.) *	28,446.1	Cattle and calves	1,223.1
Livestock and livestock products	5,861.8	Tomatoes	1,104.9
Poultry and poultry products	1,301.5	Lettuce	1,088.5
Field crops	3,521.1	Strawberries	889.2
Vegetables	5,871.3	Flowers and foliage	775.2
Fruits and nuts	8,730.6	Hay	693.3
Nursery products	2,771.8	Almonds	693.2
Seed crops	294.3		
Apiary products	93.5		

* Excludes Alpine County - No Agricultural Commissioner.

TRANSPORTATION

Vehicle registrations, 1999 *			
Total	25,655,659	Miles of streets, roads and highways, 1999	150,489.6
Automobiles	18,237,822		
Per capita (7-1-99 pop.)	0.54		
Trucks	4,946,917		
Motorcycles	411,683		
Trailers	2,059,237		

* Sum of the counties.

PUBLIC FINANCE

Revenues:

1997-98	$ mill.	Per capita *	Per $1,000 income **
County Government tax collections, total ***	4,343.8	131 80	5.03
Property tax	3,480.0	105 59	4.03
Sales tax	391.9	11 89	0.45
Total state tax revenue	64,788.0	1,965 83	75.09
Individual income tax	27,925 1	847.32	32.37
Retail sales and use taxes	19,554 5	593.33	22.67
Total receipts, local government, 1996-97	117,684.6		

Expenditures:

1998-99	$ mill.
Federal	166,049.7
Defense	29,112.5
1997-98	**$ mill.**
County ***	28,228.5
City	34,210.6
School districts	37,827.8
Special districts	n.a.
Redevelopment agencies	3,377.9

n.a. Not available at the time of publication.

* 7-1-97 population
** 1997 personal income
*** Sum of the counties, excluding City and County of San Francisco.

Los Angeles County

POPULATION

		Leading cities	Population 1-1-00	Leading cities	Population 1-1-00
Land area (acres)	2 596 380				
Population, 7-1-99	9 790 000	Los Angeles	3,823,000	Norwalk	104,500
Percent of California	28 8	Long Beach	457,600	Downey	102,100
Population, 1-1-00	9,884,300	Glendale	203,700	Compton	98,000
		Santa Clarita	151,300	Santa Monica	96,500
1-1-00		Pomona	147,700	South Gate	95,300
Population in households	9,709,283	Torrance	147,400	Carson	93,200
Population/household	3 140	Pasadena	143,900	Alhambra	92,800
		Lancaster	132,400	Whittier	86,200
		Palmdale	122,400	Lakewood	81,000
		Inglewood	121,000	Hawthorne	80,500
		El Monte	120,000	Baldwin Park	77,100
		West Covina	107,600	Lynwood	69,300
		Burbank	106,500	Unincorporated	1,036,300

EDUCATION

Median years of school, 1990 ***	13.0
Enrollment, Fall 1999 (public & private schools)	
Kindergarten-12	1,873,960
Enrollment, Fall 1987	
College/University	499,417
UCLA	35,435
California State Universities	111,808
Community colleges	301,289
Private colleges	50,885

Spending on education	1998-99 ($ mill)
School districts*	11,590.6
Community colleges**	386.0

* Not including community college districts.
** Includes governmental, proprietary and fiduciary group funds.
*** May not be comparable to the 1980 census. The 1990 median was computed on the basis of educational attainment. The 1980 median was based on actual years of school completed.

LABOR FORCE AND EMPLOYMENT

Civilian labor force, 2000	4,761,400
Civilian employment	4,506,100
Unemployment	255,300
Unemployment rate	5.4
Nonagricultural wage & salary employment, 2000 (BLS series)	4,084,500
Percent of California	29.2
Mining	4,000
Construction	133,200
Manufacturing	629,400
Transportation-utility	243,500
Trade	908,200
Finance-insurance-real estate	231,100
Services	1,352,900
Federal government	57,900
State-local government	524,200

Number of establishments by industry and employment size, 1998

Employment size	All industries *	Mining/Utilities Construction	Manufacturing	Trade **	Transportation & Information	FIRE ***	Services
1-4	122,807	7,267	6,012	25,261	7,195	13,391	63,600
5-9	38.859	2,271	3,082	10,997	1,806	3,502	17,168
10-19	26,030	1,419	3,119	6,435	1,410	2,416	11,219
20-49	19.747	964	3,240	4,104	1,237	1,420	8,770
50-99	7,102	284	1,366	1,504	510	454	2,981
100-249	3,852	138	926	736	340	230	1,481
250-499	982	29	247	158	97	59	392
500-999	347	8	75	25	37	25	177
1000 +	207	2	24	3	25	19	134
Total	219,933	12,382	18,091	49,223	12,657	21,516	105,922

* Includes forestry, fishing, hunting, and agriculture support
** Wholesale and retail
*** Finance, insurance, real estate, rental, and leasing
Totals may not add due to rounding

INCOME AND SALES

Personal income, 1998 (mill.)	246,949.2
Percent of California	*26.8*
County Rank	1
Per capita income, 1998	26,773
Percent of California	*95.1*
County Rank	17
Avg. earnings per job, 1998	37,804
Avg. wages per job, 1998	36,073
Avg earnings per nonfarm proprietor, 1998	28,231

	1979	1989
Median family income Census	21,135	39,035
Median household income. Census	17,563	34,965

$ [illegible]	1998	1999
Total ta[illegible]	90,205.6	97,316.8
Percent [illegible]	*25.1*	*24.7*
Taxable [illegible]	57,500.5	63,271.1

Sales [illegible] includes state, local, and district taxes) 8.00%

Median [illegible] income based on personal income tax returns, 1998:

Individual	$24,495
Joint	$44,928

FOREIGN TRADE

($ millions)	Exports	Imports	Total
1991	46,050.5	66,651.0	112 701 5
1992	49,399.6	72,580.9	121,980 5
1993	48,279.8	80,169.8	128,449 6
1994	55,834.7	90,239 4	146,074 1
1995	67,011.3	97,008.9	164,020.2
1996	68,923.2	101,184.8	170,108.0
1997	74,009.6	111,844.4	185,854.0
1998	63,754.8	117,756.4	181,511.2
1999	66,610.5	130,503.6	197,114.1

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Los Angeles County (continued)

HOUSING AND CONSTRUCTION

	4-1-90	1-1-00		Units	Valuation ($ mill.)	Median home price, *	
Housing stock	3 163 343	3 272 169	Housing authorizations, 1999			December 1999	$180,000
Percent of California	*28 3*	*26 7*	Total	14,383	$3,305 0	December 2000	$203,000
Single family	1,745,663	1,800,905	*Percent of California*	*10.3*	*12.8*		
Multiple family	1,325,270	1,415,474	Single family	7,858	1,852 9	* Derived from all types of	
Mobile homes, trailers, etc.	92,410	55,790	Multi-family	6,525	586.7	home sales: new and existing,	
Vacancy rate (percent).	5.5	5.5				condos and single-family	
			Nonresidential permits	–	$3,676.3		
			Percent of California		*22.2*		

MANUFACTURING

	1992	1997
Value added by manufacture, ($ mill.)	48,775.9	53,692.0
Percent of California	*31.5*	*27.4*
Leading industries:		
Transportation equipment		8,358.7
Computer & electronic products		7,784.7
Fabricated metal products		5,310.3
Apparel		4,138.2
Chemical		4,011.2
Food		3,807.0
Petroleum & coal products		3,014.6
Printing & related support activities		2,301.1
Machinery		2,227.8
Plastics & rubber products		1,956.7
Furniture & related products		1,474 9
Beverage & tobacco products		1,398.5

Capital expenditures:	($ mill.)
1992	2,561 5
1997	3,549.7
Payroll in manufacturing:	($ mill.)
1990	26,264.2
1998	22,046.3
Number of mfg. establishments:	
1990	19,649
1998	18,091

AGRICULTURE

Number of farms, 1997	1,226
Acreage in farms, 1997	130,838
% of land area	*5.0*
Agricultural employment, 2000	7,500
Value of production, 1999 ($ mill.)	253.0
Percent of California	*0.9*
County Rank	25
Livestock and livestock products	0.0
Poultry and poultry products	0.0
Field crops	7.6
Vegetables	42.7
Fruits and nuts	21.0
Nursery products	180.8
Seed crops	0.0
Apiary products	0.9

Leading commodities with value of production, 1999	$ mill
Trees and shrubs, ornamental	131.0
Plants, bedding	32.5
Vegetables, root	21.2
Peaches	13.9
Onions, dry	13.4
Plants and foliage, indoor	5.9
Hay, alfalfa	5.1
Strawberries	3.5
Herbs	3.2
Ground covers	1.5

TRANSPORTATION

Vehicle registrations, 1999	
Total	6,290,976
Automobiles	4,935,605
Per capita (7-1-99 pop.)	0.50
Trucks	991,315
Motorcycles	75,569
Trailers	288,487

Miles of streets, roads and highways, 1999 — 20,553.0

PUBLIC FINANCE

Revenues:

1997-98	$ mill	Per capita*	Per $1,000 income**
County government tax collections, total	1,413.4	148.39	6.06
Property tax	1,241.3	130.33	5.32
Sales tax	34.8	3.66	0.15
Total receipts, local government, 1996-97	36,254.0		

Expenditures:

1998-99	$ mill.
Federal	43,465.6
Defense	7,968.1
1997-98	**$ mill.**
County	8,830.6
City	12,611.1
School districts	10,564.5
Special districts	n.a.
Redevelopment agencies	1,037.8

* 7-1-97 population
** 1997 personal income

n.a. Not available at the time of publication.

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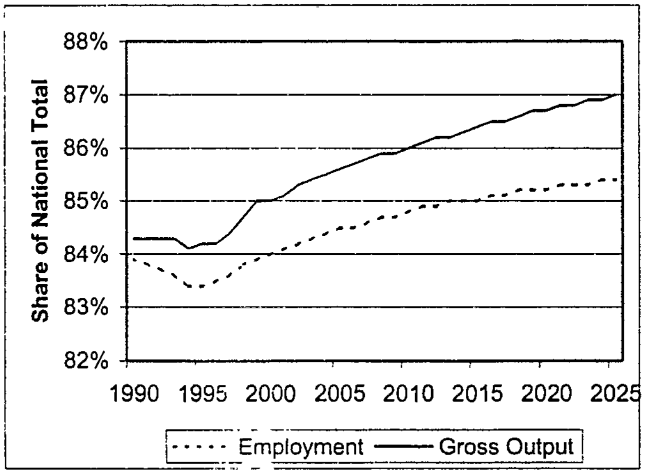
The Role of Metropolitan Areas in the National Economy

As the focal points of economic activity, metropolitan areas are vital to the nation's economic development. While states are defined by geographic and political boundaries, metro areas are shaped by economic activity, sometimes across state or national borders. The concentration of people and business in metro areas creates unique economic conditions that give rise to new industries, speed the diffusion of knowledge, spur technological innovation, and increase productivity. The economic dynamism and creativity found in metro areas enables American industries to thrive in global competition. Historically, most of the largest U.S. industries began in cities, where access to labor, capital, and customers fostered business development. Today, metro areas generate more than 80% of the nation's employment, income, and production of goods and services.

1 The Recent Performance of Metropolitan Area Economies

The contribution of metro areas to the national economy has increased over the last decade, a trend that is expected to continue over the next twenty-five years. Metro area employment increased from 92.1 million in 1990 to 110.8 million in 2000, growing at a 1.9% annual rate over the decade. In 2000, metro area employment posted a solid 2.6% gain. The share of employment in metro areas fell slightly in the first half of the 1990s before rebounding to a new high of 84.0% last year.

Figure 1 - The Contribution of Metro Areas to the National Economy Will Continue to Grow



Gross metropolitan product, the value of goods and services produced in metro areas, increased from $4.812 trillion in 1990 to $8.476 trillion in 2000, an average gain of 5.8%

annually. After adjusting for inflation, this represented an annual growth rate of 3.5%. The share of the nation's output produced in metro areas advanced from 84.3% at the beginning of the decade to 84.7% in 2000. DRI-WEFA projects that the contribution of metro areas to U.S. gross domestic product will increase steadily over the next 25 years, reaching 86.9% by 2025.

Metro area economies now compare even more favorably with international economies than they did a decade ago. The ranking of New York City's gross metro product among international economies rose from 21st in 1990 to 14th last year; its economy is now ranked ahead of Australia's. The economy of the Washington, D.C. metro area ranks 27th, up from 35th in 1990, and ahead of Austria and Hong Kong; the gross product of the Dallas metro area surpassed Denmark, Saudi Arabia, and Thailand on its rise from 47th to 35th. Denver's ranking increased from 77th to 60th, as it's GDP grew to exceed those of Malaysia and the Philippines.

Many other key indicators of the contribution of metro areas to the national economy have also increased steadily. Metro area employment in the financial services and transportation, communications, and utilities sectors, which are two of the nation's highest value-added industries, grew 1.3% and 2.0% annually, respectively, from 1990 to 2000. Metro area business services payrolls rose 6.8% annually. Following the national pattern, high-tech employment in metro areas declined from 1990 to 1993 in response to defense spending reductions. In the second half of the 1990s, high-tech employment surged 5.4% annually, lifting its ten-year growth rate to 2.6%. Metro area per capita income increased by 4.4% over the last decade, a gain of over $3,100. After accounting for inflation, this represented a real gain of 2.1% annually.

2 The Contribution of Metropolitan Areas to the National Economy

2.1 The Scope of Metro Area Economies

The size of metro area economies illustrates their importance to the nation. If they were counted as a single country, the gross product of the five largest U.S. metropolitan areas ($1.59 trillion) would rank fourth among the world's economies, trailing only the U.S. ($9.96 trillion), Japan ($4.6 trillion) and Germany ($1.87 trillion). The importance of metro area economies can also be illustrated by their size relative to the output of U.S. states. The gross product of the 10 largest U.S. metro areas exceeds the combined output of the 31 smallest states. Last year, the five largest metro areas produced more goods and services than California; $1.59 trillion compared with $1.3 trillion.

Within a particular state, a single metropolitan area often dominates the state's economy. For example, the Atlanta metro area provides 55% of Georgia's employment and 56% of gross state product. In Minnesota, the Minneapolis-St. Paul metro area produces 66% of the state's output and employs 65% of the work force. In highly urbanized states, almost all economic activity occurs in metro areas. In Pennsylvania, 97% of employment and 98% of output is generated within metro areas.

2.2 Employment and Output

As previously noted, most of the economic activity in the United States occurs within metro area cities and counties. A total of 110.8 million workers were employed in metro areas in 2000, or 84.0% of national employment. The total value of goods and services produced in metro areas last year was $8.476 trillion, 85% of U.S. gross domestic product. Metro areas, though geographically smaller, contribute much more to the national economy than non-metro areas. The metro area percentages of national employment and gross domestic product both exceed metro area shares of population and land area, highlighting the geographic concentration of economic activity within urban and suburban areas.

This geographic concentration of companies and people is one of the main reasons metro areas are able to make a disproportionately large contribution to the national economy. Close proximity between producers and consumers reduces the costs of business operations, allowing more goods and services to be produced per person and per acre of land.

Table 1 - Most Economic Activity Occurs in Metro Areas

Shares of U.S. Economy (2000)		Metro Areas	Rest of United States	United States
Size	Population (Millions)	226	55	281
	Percentage	80%	20%	
	Land Area (Square Miles, 000s)	719	2,873	3,592
	Percentage	20%	80%	
Jobs & Output	Employment (Millions)	111	21	131
	Percentage	84%	16%	
	Gross Domestic Product (Billions)	$8,476	$1,501	$9,977
	Percentage	85%	15%	
High Value Added Employment Sectors	Financial Services (Thousands)	6,882	720	7,602
	Percentage	91%	9%	
	Transportation & Utilities (Thousands)	6,096	928	7,024
	Percentage	87%	13%	

The clustering of two of the nation's highest value added sectors in urban locations also magnifies the metro area contribution to the national economy. In 2000, 91% of financial services employment and 87% of transportation, communications, and utilities sector employment was located within metropolitan areas. The financial services sector had the highest level of output per employee last year, $257,000. Financial services companies choose to locate in metro areas for proximity to major securities and commodity markets and access to highly skilled workers. Companies maximize the efficiency of their transportation and communications networks by locating hubs and distribution centers in metro areas, taking advantage of extensive road, rail, shipping, and communications infrastructure.

From 1990 to 2000, most of the economic gains made in the United States were generated within cities and counties in metro areas. Of the 22.2 million jobs created in the U.S. over that period, 18.7 million, or 84%, were created in metropolitan areas. The contribution of metro areas to gross domestic product, meanwhile, increased by nearly $3.7 trillion in the last decade, representing 86% of the national gain.

Table 2 - Most Economic Gains Were Made in Metro Areas

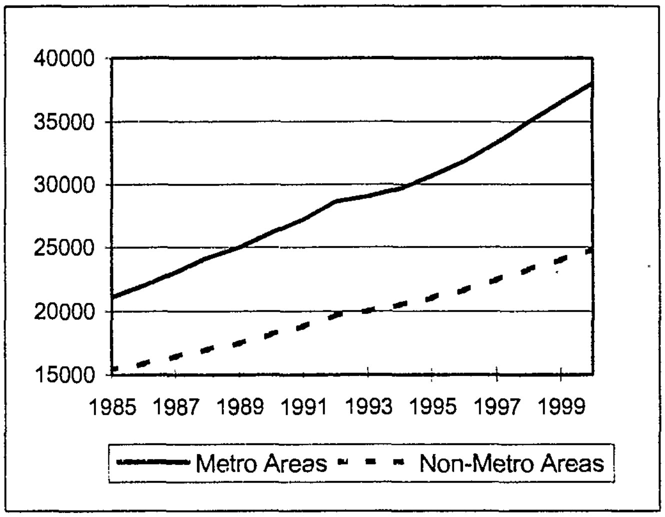
Additions to U.S. Economy (1990 to 2000)		Metro Areas	Rest of United States	United States
Size	Population (Millions)	28	5	33
	Percentage	84%	16%	
Jobs & Output	Employment (Millions)	18.7	3.5	22.2
	Percentage	84%	16%	
	Gross Domestic Product	$3,664	$606	$4,270
	Percentage	86%	14%	
High Value Added Employment Sectors	Financial Services (Thousands)	804	106	910
	Percentage	88%	12%	
	Transportation & Utilities (Thousands)	1,116	124	1,240
	Percentage	90%	10%	

2.3 Income Creation

Most of the nation's labor income is also generated by metro area economies. In 2000, metro area workers earned $4.22 trillion in wages and salaries, while non-metro area workers earned $554 billion. Metro area economies also create more income per person than non-metro areas. Last year, the average metro area worker collected $38,000 in wages and benefits, while the average non-metro area worker earned $24,800, a difference of $13,200 per worker. The gap between metro and non-metro area workers has grown consistently since 1985, when the difference between metro area and non-metro area earnings was only $4,600.

In most labor markets, earnings are directly related to labor productivity--workers that are more productive receive higher wages and benefits. Figure 2, therefore, provides an indirect measure of the higher labor productivity in cities and counties within metro areas. Metro area workers are able to produce more goods and services than non-metro area workers because of the clustering of specialized industries within urban areas, access to superior training and educational facilities, and a greater degree of knowledge-transfer and interaction between companies.

Figure 2 - Metro Area Workers Earn More Than Non-Metro Area Workers



2.4 Generating New Industries

With few exceptions[1], most major industries in the United States started in cities, including automobile manufacturing (Detroit), television broadcasting (New York), and personal computer manufacturing (San Jose). Metro areas provide new industries with crucial amenities--a diverse and ample supply of labor, financial and physical capital, access to national and international markets, a local base of technical knowledge--that are essential for their initial development and eventual success. As an industry matures, technological advances often allow companies within that industry to move to non-urban locations. As a consequence, newer, faster-growing industries tend to cluster within metro areas, while older, slower-growing industries are less tied to urban locations.

Table 3 shows that two of the fastest-growing segments of the U.S. economy, high-tech and business services, are almost entirely concentrated within metro areas. These two sectors of the economy contain some of the nation's newest and most innovative industries, including computer hardware, computer software, telecommunications equipment, optical instruments, Internet publishing, and management consulting. From

[1] The major exceptions are resource-extraction industries (e.g., forestry, coal mining, oil drilling) which are tied to the geographic location of a particular natural resource.

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1990 to 2000, employment in high-tech industries grew 2.6% per year, while employment in the business services sector increased by a remarkable 6.8% per year.

Table 3 - Most High-Tech and Business Services Employment is Located in Metro Areas

Shares of U.S. Employment (2000)		Metro Areas	Rest of United States	United States
High Growth Employment Sectors	High-Tech (Thousands)	7,345	524	7,869
	Percentage	93%	7%	
	Business Services (Thousands)	9,140	642	9,783
	Percentage	93%	7%	

Over the past ten years, the majority of these new jobs in the high-tech and business services segments have been created in metro areas. Metro area business services employment increased by close to 4.4 million from 1990 to 2000, compared with an increase of only 312,000 outside of metro areas. Over the same period, almost 1.66 million jobs were created by high-tech companies in metro areas, while only 52,500 jobs were added outside of metro areas.

In the future, metro areas will play a larger and larger role in the national economy. The movement of people from rural to urban areas will continue unabated, providing a steady stream of labor, knowledge, and capital to the businesses located there.

Table 4 - Gross Product of Metro Areas

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
New York, NY	363.19	383.60	407.60	437.80	1
Los Angeles-L Beach, CA	303.09	321.03	339.45	363.70	2
Chicago, IL	283.03	299.81	314.30	332.80	3
Boston, MA	193.99	208.04	221.59	238.80	4
Washington, DC-MD-VA-WV	172.74	187.02	200.79	217.00	5
Philadelphia, PA-NJ	152.95	161.59	170.92	182.40	6
Houston, TX	139.74	148.86	159.13	177.50	7
Atlanta, GA	129.10	141.05	152.88	164.20	8
Dallas, TX	125.56	136.19	146.55	160.00	9
Detroit, MI	131.97	139.87	147.32	156.30	10
Orange Co, CA	101.15	110.82	119.67	130.00	11
Minneapolis-St. Paul, MN-WI	99.98	105.98	113.07	121.30	12
Seattle-Bellevue-Everett, WA	91.51	101.92	108.02	115.00	13
Phoenix-Mesa, AZ	87.93	96.33	104.45	114.20	14
San Francisco, CA	88.59	94.49	99.54	107.30	15
Nassau-Suffolk, NY	86.96	92.10	99.81	106.80	16
San Diego, CA	81.22	88.67	96.46	104.60	17
Newark, NJ	81.03	84.89	90.44	96.30	18
Baltimore, MD	80.89	85.15	90.38	96.20	19
Oakland, CA	74.44	78.95	84.67	92.10	20
Denver, CO	71.08	77.96	83.93	91.10	21
St. Louis, MO-IL	77.09	80.74	84.76	89.60	22
San Jose, CA	67.81	72.51	76.78	85.40	23
Riverside-San Bernardino, CA	64.14	69.16	76.41	84.10	24
Tampa-St Petersb-Clrwater, FL	64.93	70.19	75.57	82.20	25
Cleveland-Lorain-Elyria, OH	69.01	72.27	76.27	80.80	26
Pittsburgh, PA	68.08	71.62	75.81	80.70	27
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	63.83	67.50	71.87	76.80	28
Miami, FL	60.78	63.55	66.68	71.60	29
Portland-Vancouver, OR-WA	59.73	63.81	66.82	71.50	30
Kansas City, MO-KS	53.66	57.39	60.82	64.80	31
Hartford, CT	54.57	57.45	60.37	64.30	32
Middlesex-Somerset-Hunterdon, NJ	51.75	54.18	58.57	63.60	33
Sacramento, CA	49.23	53.97	58.94	63.10	34
Fort Worth-Arlington, TX	49.03	53.20	57.50	63.00	35
Charlotte-Gastonia-R Hill, NC-SC	47.73	51.81	56.39	61.30	36
Columbus, OH	50.30	53.51	57.04	60.70	37
Orlando, FL	46.77	51.12	55.82	59.50	38
Cincinnati, OH-KY-IN	50.39	53.22	55.99	59.40	39

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Bergen-Passaic, NJ	50.55	53.60	56.50	59.30	40
Indianapolis, IN	47.38	50.59	53.81	57.70	41
Milwaukee-Waukesha, WI	46.86	49.29	51.95	54.80	42
Las Vegas, NV-AZ	41.05	44.69	49.45	54.60	43
San Antonio, TX	42.92	46.03	49.70	53.70	44
Norfolk-Va Beach-Newport News, VA-NC	42.75	46.16	48.66	51.70	45
Austin-San Marcos, TX	36.11	39.73	43.47	48.20	46
Buffalo-Niagara Falls, NY	40.85	42.63	45.21	47.80	47
Fort Lauderdale, FL	38.23	40.55	43.13	46.70	48
New Orleans, LA	40.79	41.08	42.66	46.50	49
Salt Lake City-Ogden, UT	38.12	40.65	43.22	46.40	50
Greensboro-W-Salem-High Point,NC	38.65	41.23	43.55	46.30	51
Rochester, NY	38.66	40.58	42.89	45.70	52
Richmond-Petersburg, VA	37.24	40.03	42.64	45.70	53
Nashville, TN	37.14	39.97	42.48	45.20	54
Raleigh-Durham-Chapel Hill, NC	35.17	38.23	41.16	44.30	55
Jacksonville, FL	34.82	37.13	39.62	43.00	56
Gr Rapids-Muskegon-Holland, MI	34.92	37.31	39.51	42.30	57
Memphis, TN-AR-MS	32.93	34.78	36.77	38.90	58
Louisville, KY-IN	31.55	33.62	35.63	38.70	59
Albany-Schenectady-Troy, NY	31.92	33.63	35.62	37.80	60
W Palm Beach-Boca Raton, FL	26.42	28.59	30.42	33.20	61
Honolulu, HI	29.68	30.27	31.24	33.00	62
Monmouth-Ocean, NJ	27.47	28.71	30.71	33.00	63
Providence-Warwick, RI	27.20	28.41	30.18	32.50	64
Oklahoma City, OK	26.88	28.08	29.88	32.30	65
Birmingham, AL	27.02	28.44	30.22	32.00	66
Wilmington-Newark, DE	25.24	27.43	29.30	31.40	67
Dayton-Springfield, OH	27.58	28.64	29.67	31.20	68
Manchester-Nashua, NH	23.85	25.94	27.88	30.20	69
Syracuse, NY	25.41	26.71	28.41	30.10	70
Greenville-Spartanburg-Anderson, SC	24.90	26.26	27.56	29.90	71
Jersey City, NJ	22.49	23.55	25.28	28.10	72
Harrisburg-Lebanon-Carlisle, PA	23.28	24.32	25.36	27.10	73
Fresno, CA	21.69	22.67	24.39	26.30	74
Omaha, NE-IA	21.95	23.11	24.64	26.20	75
Tulsa, OK	21.30	22.59	23.75	25.70	76
Albuquerque, NM	21.51	22.14	23.54	25.60	77
Ventura, CA	18.73	20.27	22.30	24.50	78
Tucson, AZ	18.02	19.24	20.80	22.90	79
Akron, OH	18.75	19.52	20.61	21.90	80
Knoxville, TN	17.98	19.13	20.24	21.50	81
Toledo, OH	18.14	18.97	20.06	21.20	82

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Springfield, MA	17.33	18.38	19.53	20.90	83
Allentown-Bethlehem-Easton, PA	17.08	18.06	19.20	20.60	84
Scranton-Wilkes-Barre-Hazelton, PA	17.55	18.28	19.14	20.60	85
Santa Rosa, CA	15.30	17.14	18.27	20.50	86
Baton Rouge, LA	16.90	17.89	18.86	20.40	87
Des Moines, IA	15.69	16.90	18.18	19.10	88
Ann Arbor, MI	15.88	16.87	17.98	19.10	89
Columbia, SC	16.28	17.28	18.19	19.10	90
Tacoma, WA	15.63	16.99	17.92	19.00	91
Bakersfield, CA	15.18	15.74	16.93	18.90	92
Fort Wayne, IN	15.68	16.61	17.46	18.60	93
El Paso, TX	15.87	16.87	17.57	18.60	94
Trenton, NJ	15.51	16.18	17.42	18.50	95
Little Rock-N. L.Rock, AR	15.07	16.09	17.23	18.40	96
Madison, WI	15.73	16.50	17.40	18.40	97
Lafayette, LA	14.39	14.52	14.80	18.20	98
Lexington, KY	14.48	15.58	16.66	17.80	99
Colorado Springs, CO	13.85	15.10	16.27	17.60	100
Wichita, KS	15.16	16.18	16.70	17.50	101
Chattanooga, TN-GA	14.29	15.31	16.36	17.50	102
Santa Barbara-Santa Maria-Lompoc, CA	13.58	14.65	15.49	17.20	103
Sarasota-Bradenton, FL	13.51	14.25	15.50	16.90	104
Lancaster, PA	13.77	14.38	15.32	16.50	105
Stockton-Lodi, CA	14.58	14.99	15.57	16.20	106
Youngstown-Warren, OH	13.08	13.75	14.83	16.20	107
Gary, IN	14.06	14.67	15.28	16.10	108
Lansing-East Lansing, MI	14.31	15.10	15.61	16.10	109
Kalamazoo-Battle Creek, MI	14.26	14.38	14.97	15.70	110
Atlantic-Cape May, NJ	13.08	13.67	14.72	15.70	111
Spokane, WA	12.90	13.87	14.54	15.40	112
Modesto, CA	11.28	12.45	13.33	15.00	113
Augusta-Aiken, GA-SC	11.86	12.70	13.85	14.80	114
Reno, NV	11.58	12.51	13.45	14.70	115
Charleston-N Charleston, SC	11.82	12.63	13.49	14.70	116
Vallejo-Fairfield-Napa, CA	11.08	11.90	13.14	14.50	117
Boise City, ID	10.85	11.94	12.97	14.40	118
Rockford, IL	12.22	12.82	13.38	14.30	119
Jackson, MS	12.41	13.12	13.73	14.30	120
Mobile, AL	12.01	12.63	13.32	14.00	121
Johnson City-Kingspt-Bristol, TN-VA	12.09	12.43	13.07	13.90	122
Salinas, CA	10.85	11.68	12.42	13.80	123
Appleton-Oshkosh-Neenah, WI	11.13	11.72	12.53	13.50	124
Peoria-Pekin, IL	11.37	12.06	12.57	13.30	125

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Lakeland-Winter Haven, FL	10.97	11.37	12.08	13.00	126
Davenport-Moline-Rock Isld, IA-IL	10.29	11.25	12.04	13.00	127
Reading, PA	10.98	11.72	12.24	13.00	128
Anchorage, AK	11.02	11.64	12.21	12.80	129
Hickory-Morganton, NC	10.52	10.73	11.28	12.80	130
Saginaw-Bay City-Midland, MI	11.24	11.65	12.10	12.70	131
Canton-Massillon, OH	10.77	11.40	11.96	12.70	132
Corpus Christi, TX	10.24	11.09	11.80	12.60	133
Roanoke, VA	10.43	10.90	11.49	12.60	134
York, PA	10.56	10.90	11.57	12.50	135
Beaumont-Port Arthur, TX	10.39	11.00	11.54	12.40	136
Shreveport-Bossier City, LA	10.77	10.90	11.28	12.30	137
Odessa-Midland, TX	9.73	9.54	9.99	12.30	138
Boulder-Longmont, CO	9.70	10.43	11.14	12.00	139
Melbourne-Titusville-Palm Bay, FL	9.85	10.49	11.16	12.00	140
Macon, GA	9.39	10.32	11.08	12.00	141
Portland, ME	9.57	10.07	11.00	12.00	142
Utica-Rome, NY	9.81	10.47	11.19	11.90	143
Springfield, IL	9.71	10.40	10.88	11.40	144
Fort Myers-Cape Coral, FL	11.04	11.06	11.22	11.30	145
Flint, MI	8.93	9.78	10.53	11.30	146
Newburgh, NY-PA	8.82	9.53	10.23	10.90	147
Springfield, MO	8.71	9.33	9.90	10.80	148
McAllen-Edinburg-Mission, TX	9.12	9.62	10.17	10.80	149
Huntsville, AL	8.94	9.50	9.98	10.60	150
Visalia-Tulare-Porterville, CA	8.94	9.45	9.99	10.50	151
Pensacola, FL	8.57	9.11	9.75	10.50	152
Savannah, GA	8.68	9.22	9.81	10.50	153
Evansville-Henderson, IN-KY	8.22	8.92	9.46	10.50	154
Montgomery, AL	8.58	9.22	9.74	10.40	155
Daytona Beach, FL	8.70	9.34	9.83	10.40	156
Eugene-Springfield, OR	8.48	9.03	9.65	10.40	157
New London-Norwich, CT	8.76	9.14	9.73	10.30	158
Tallahassee, FL	8.53	9.08	9.59	10.20	159
S L Obispo-Atascadero-Paso Robles, CA	7.87	8.55	9.07	10.10	160
Green Bay, WI	8.10	8.68	9.29	10.00	161
Binghamton, NY	8.22	8.70	9.26	9.90	162
Salem, OR	8.18	8.67	9.24	9.90	163
Columbus, GA-AL	8.27	8.58	9.12	9.80	164
Erie, PA	7.94	8.62	9.13	9.80	165
Lincoln, NE	7.93	8.50	9.01	9.60	166
Santa Cruz-Watsonville, CA	7.35	8.09	8.56	9.50	167
Dutchess County, NY	7.79	8.24	8.86	9.50	168

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Biloxi-Gulfport-Pascagoula, MS	7.74	8.47	9.01	9.40	169
Fayetteville-Springdale-Rogers, AR	7.32	7.78	8.36	9.00	170
Yolo, CA	7.21	7.88	8.38	8.90	171
Elkhart-Goshen, IN	6.95	7.54	7.98	8.90	172
Houma, LA	7.09	7.62	8.03	8.60	173
Hamilton-Middletown, OH	6.97	6.95	7.09	8.60	174
South Bend, IN	6.89	7.19	7.53	8.50	175
Longview-Marshall, TX	7.24	7.77	8.18	8.50	176
Lubbock, TX	7.15	7.62	7.98	8.50	177
Lynchburg, VA	6.80	7.43	7.92	8.50	178
Charleston, WV	7.06	7.41	7.91	8.40	179
Fort Collins-Loveland, CO	6.45	7.12	7.68	8.30	180
Provo-Orem, UT	6.63	7.17	7.72	8.30	181
Bloomington-Normal, IL	6.44	7.39	7.76	8.20	182
Duluth-Superior, MN-WI	6.66	7.07	7.52	8.20	183
Sioux Falls, SD	6.10	6.57	7.35	8.00	184
Waco, TX	6.55	6.95	7.31	7.80	185
Gainesville, FL	6.25	6.78	7.21	7.70	186
Cedar Rapids, IA	6.37	6.92	7.27	7.70	187
Wilmington, NC	6.46	6.88	7.28	7.70	188
Huntington-Ashland, WV-KY-OH	6.63	6.82	7.16	7.60	189
Chico-Paradise, CA	6.24	6.61	6.96	7.50	190
Asheville, NC	6.32	6.75	7.09	7.50	191
Amarillo, TX	6.22	6.64	6.98	7.50	192
Brownsv-Harlingen-San Benito, TX	5.96	6.42	6.77	7.50	193
Killeen-Temple, TX	5.97	6.39	6.73	7.30	194
Galveston-Texas City, TX	5.93	6.32	6.67	7.20	195
Fayetteville, NC	5.98	6.45	6.73	7.10	196
Burlington, VT	5.75	6.05	6.50	7.00	197
Myrtle Beach, SC	5.30	5.79	6.33	6.90	198
Naples, FL	5.14	5.69	6.25	6.80	199
Barnstable-Yarmouth, MA	5.58	5.84	6.15	6.80	200
Tyler, TX	5.43	5.76	6.27	6.80	201
Fort Pierce-Port St. Lucie, FL	5.35	5.78	6.21	6.70	202
Johnstown, PA	5.66	5.83	6.18	6.70	203
Laredo, TX	5.36	5.49	5.81	6.60	204
Redding, CA	5.61	5.81	6.13	6.50	205
Topeka, KS	5.20	5.55	5.86	6.50	206
Olympia, WA	5.22	5.63	5.97	6.40	207
Fort Smith, AR-OK	5.00	5.45	5.86	6.30	208
Charlottesville, VA	5.27	5.51	5.84	6.30	209
Lake Charles, LA	5.43	5.54	5.72	6.20	210
Brazoria, TX	5.17	5.52	5.83	6.20	211

Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Richland-Kennewick-Pasco, WA	5.30	5.48	5.76	6.20	212
Yakima, WA	5.09	5.29	5.57	6.20	213
Merced, CA	4.76	5.11	5.44	6.10	214
St. Cloud, MN	4.91	5.27	5.59	6.00	215
Ocala, FL	4.99	5.34	5.65	5.90	216
Lafayette, IN	4.62	5.10	5.49	5.90	217
Fargo-Moorhead, ND-MN	4.88	5.25	5.52	5.80	218
Champaign-Urbana, IL	4.91	5.17	5.41	5.70	219
Mansfield, OH	5.02	5.15	5.40	5.70	220
Vineland-Millville-Bridgeton, NJ	4.69	4.86	5.19	5.60	221
Joplin, MO	4.68	4.95	5.19	5.50	222
Bremerton, WA	4.60	4.83	5.12	5.50	223
Athens, GA	4.35	4.69	5.01	5.40	224
Lima, OH	4.62	4.83	5.06	5.40	225
Bellingham, WA	4.33	4.71	5.00	5.40	226
Benton Harbor, MI	4.25	4.64	4.90	5.30	227
Rochester, MN	4.26	4.69	5.00	5.30	228
Bryan-College Station, TX	4.72	4.84	5.03	5.30	229
Racine, WI	4.39	4.60	4.91	5.30	230
Greeley, CO	3.89	4.32	4.71	5.20	231
Fort Walton Beach, FL	4.23	4.52	4.82	5.10	232
Medford-Ashford, OR	4.17	4.46	4.74	5.10	233
Tuscaloosa, AL	4.21	4.46	4.72	5.00	234
Monroe, LA	4.28	4.48	4.67	5.00	235
Pittsfield, MA	4.12	4.39	4.66	5.00	236
Columbia, MO	4.22	4.43	4.71	5.00	237
Jamestown, NY	4.06	4.28	4.58	4.90	238
Wichita Falls, TX	4.11	4.22	4.42	4.90	239
Hagerstown, MD	4.19	4.48	4.73	4.80	240
Eau Claire, WI	3.96	4.19	4.47	4.80	241
Wausau, WI	3.94	4.21	4.49	4.80	242
Rocky Mount, NC	3.86	4.13	4.40	4.70	243
Florence, SC	4.04	4.25	4.43	4.70	244
Albany, GA	3.84	4.06	4.29	4.60	245
Abilene, TX	3.90	3.93	4.13	4.60	246
Panama City, FL	3.72	3.98	4.25	4.50	247
Decatur, IL	3.96	4.14	4.28	4.50	248
Santa Fe, NM	3.98	4.08	4.28	4.50	249
Glens Falls, NY	3.84	3.92	4.19	4.50	250
Clarksville-Hopkinsville, TN-KY	3.74	3.98	4.21	4.50	251
Parkersburg-Marietta, WV-OH	3.65	3.95	4.20	4.50	252
Janesville-Beloit, WI	3.88	4.07	4.28	4.50	253
La Crosse, WI-MN	3.69	3.90	4.18	4.50	254

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Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Waterloo-Cedar Falls, IA	3.87	4.03	4.20	4.40	255
Jackson, MI	3.71	3.85	4.10	4.40	256
State College, PA	3.80	3.99	4.16	4.40	257
Bangor, ME	3.53	3.74	4.00	4.30	258
Pueblo, CO	3.60	3.77	3.96	4.20	259
Terre Haute, IN	3.55	3.70	3.92	4.20	260
Greenville, NC	3.61	3.81	4.01	4.20	261
Altoona, PA	3.47	3.72	3.94	4.20	262
Wheeling, WV-OH	3.30	3.60	3.86	4.20	263
Dothan, AL	3.58	3.76	3.94	4.10	264
Sioux City, IA-NE	3.38	3.60	3.84	4.10	265
Williamsport, PA	3.43	3.58	3.80	4.10	266
Sheboygan, WI	3.55	3.67	3.86	4.10	267
Jackson, TN	3.34	3.55	3.78	4.00	268
Grand Junction, CO	3.17	3.40	3.60	3.80	269
Dover, DE	3.17	3.40	3.63	3.80	270
Bloomington, IN	3.26	3.41	3.60	3.80	271
Billings, MT	2.93	3.19	3.45	3.80	272
Decatur, AL	3.14	3.27	3.45	3.70	273
Flagstaff, AZ-UT	2.94	3.17	3.36	3.70	274
Yuba City, CA	3.05	3.26	3.40	3.70	275
Kokomo, IN	3.06	3.24	3.46	3.70	276
Elmira, NY	3.10	3.29	3.50	3.70	277
San Angelo, TX	3.12	3.34	3.49	3.70	278
Texarkana, AR-TX	3.00	3.18	3.34	3.60	279
Muncie, IN	3.06	3.26	3.43	3.60	280
Alexandria, LA	3.07	3.20	3.36	3.60	281
Las Cruces, NM	3.11	3.26	3.41	3.60	282
Sharon, PA	2.92	3.13	3.32	3.60	283
Sherman-Denison, TX	3.10	3.21	3.37	3.60	284
Danville, VA	3.03	3.22	3.35	3.60	285
Iowa City, IA	3.00	3.23	3.34	3.50	286
Steubenville-Weirton, OH-WV	2.92	3.15	3.33	3.50	287
Florence, AL	3.12	3.12	3.26	3.40	288
Victoria, TX	2.68	2.76	2.91	3.30	289
Kankakee, IL	2.81	2.92	3.05	3.20	290
Kenosha, WI	2.61	2.80	2.99	3.20	291
Dubuque, IA	2.74	2.83	2.96	3.10	292
Anniston, AL	2.44	2.59	2.77	3.00	293
Owensboro, KY	2.30	2.59	2.78	3.00	294
Lewiston-Auburn, ME	2.61	2.74	2.86	3.00	295
Hattiesburg, MS	2.51	2.62	2.80	3.00	296
St. Joseph, MO	2.59	2.70	2.83	3.00	297

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Nominal Gross Product (Billions, $Current)					
Metro Area	**1997**	**1998**	**1999**	**2000**	**Rank**
Rapid City, SD	2.45	2.60	2.76	3.00	298
Goldsboro, NC	2.53	2.68	2.79	2.90	299
Bismarck, ND	2.26	2.26	2.42	2.90	300
Casper, WY	2.36	2.54	2.69	2.90	301
Cumberland, MD-WV	2.30	2.45	2.61	2.80	302
Missoula, MT	2.49	2.62	2.75	2.80	303
Grand Forks, ND-MN	2.29	2.41	2.58	2.80	304
Sumter, SC	2.36	2.49	2.62	2.80	305
Yuma, AZ	2.32	2.44	2.57	2.70	306
Lawrence, KS	2.30	2.41	2.52	2.70	307
Corvallis, OR	2.15	2.30	2.42	2.70	308
Cheyenne, WY	2.20	2.35	2.47	2.60	309
Auburn-Opelika, AL	2.14	2.28	2.38	2.50	310
Gadsden, AL	2.18	2.24	2.36	2.50	311
Jacksonville, NC	2.12	2.22	2.33	2.50	312
Punta Gorda, FL	1.94	2.10	2.27	2.40	313
Lawton, OK	2.10	2.17	2.26	2.40	314
Jonesboro, AR	1.89	2.01	2.12	2.30	315
Pine Bluff, AR	1.79	1.86	1.95	2.10	316
Great Falls, MT	1.65	1.73	1.84	2.00	317
Pocatello, ID	1.58	1.66	1.78	1.90	318
Enid, OK	1.47	1.51	1.58	1.70	319

Table 5 – Gross Product of Countries and Metro Areas

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
1	United States	9963.00
2	Japan	4614.00
3	Germany	1873.00
4	United Kingdom	1410.00
5	France	1286.00
6	China	1104.00
7	Italy	1074.00
8	Canada	699.00
9	Brazil	665.00
10	Mexico	578.00
11	Spain	557.00
12	India	510.00
13	South Korea	480.00
14	***New York, NY***	437.80
15	Australia	428.00
16	***Los Angeles-Long Beach, CA***	363.70
17	Netherlands	360.00
18	***Chicago, IL***	332.80
19	Taiwan	323.00
20	Argentina	284.00
21	Russia	247.00
22	Switzerland	241.30
23	***Boston, MA***	238.80
24	Belgium	227.00
25	Sweden	224.10
26	Turkey	217.60
27	***Washington, DC-MD-VA-WV***	217.00
28	Austria	184.90
29	***Philadelphia, PA-NJ***	182.40
30	***Houston, TX***	177.50
31	Hong Kong	164.60
32	***Atlanta, GA***	164.20
33	Norway	164.00
34	Poland	163.00
35	***Dallas, TX***	160.00
36	Denmark	158.00
37	***Detroit, MI***	156.30
38	Indonesia	147.60
39	Saudi Arabia	145.30
40	South Africa	132.30
41	***Orange County, CA***	130.00
42	Thailand	128.20

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
43	***Minneapolis-St.Paul, MN-WI***	121.30
44	Finland	118.00
45	***Seattle-Bellevue-Everett, WA***	115.00
46	***Phoenix-Mesa, AZ***	114.20
47	Greece	110.90
48	Israel	108.00
49	***San Francisco, CA***	107.30
50	***Nassau-Suffolk, NY***	106.80
51	***San Diego, CA***	104.60
52	Venezuela	102.90
53	Portugal	100.50
54	***Newark, NJ***	96.30
55	***Baltimore, MD***	96.20
56	Ireland	95.10
57	Singapore	93.70
58	***Oakland, CA***	92.10
59	Egypt	91.50
60	***Denver, CO***	91.10
61	Colombia	90.00
62	***St. Louis, MO-IL***	89.60
63	Malaysia	88.80
64	***San Jose, CA***	85.40
65	***Riverside-San Bernardino, CA***	84.10
66	***Tampa-St Petersburg-Clearwater, FL***	82.20
67	***Cleveland-Lorain-Elyria, OH***	80.80
68	***Pittsburgh, PA***	80.70
69	Philippines	78.00
70	***New Haven, CT***	76.80
71	Chile	73.00
72	***Miami, FL***	71.60
73	***Portland-Vancouver, OR-WA***	71.50
74	Iran	67.10
75	Puerto Rico	65.30
76	***Kansas City, MO-KS***	64.80
77	***Hartford, CT***	64.30
78	***Middlesex-Somerset-Hunterdon, NJ***	63.60
79	***Sacramento, CA***	63.10
80	***Fort Worth-Arlington, TX***	63.00
81	Pakistan	62.70
82	Peru	62.70
83	***Charlotte-Gastonia-RHill, NC-SC***	61.30
84	***Columbus, OH***	60.70
85	United Arab	60.70

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
86	***Orlando, FL***	59.50
87	***Cincinnati, OH-KY-IN***	59.40
88	***Bergen-Passaic, NJ***	59.30
89	***Indianapolis, IN***	57.70
90	Nigeria	54.90
91	***Milwaukee-Waukesha, WI***	54.80
92	***Las Vegas,NV-AZ***	54.60
93	***San Antonio,TX***	53.70
94	Algeria	52.80
95	New B131Zealand	52.10
96	***Norfolk-Virginia Beach-Newport News,VA-NC***	51.70
97	Czech	50.80
98	***Austin-San Marcos,TX***	48.20
99	***Buffalo-Niagara Falls,NY***	47.80
100	Hungary	47.40
101	***Fort Lauderdale,FL***	46.70
102	***New Orleans,LA***	46.50
103	***Salt Lake City-Ogden,UT***	46.40
104	***Greensboro--Winston-Salem--HighPoint,NC***	46.30
105	***Rochester,NY***	45.70
106	***Richmond-Petersburg,VA***	45.70
107	***Nashville,TN***	45.20
108	***Raleigh-Durham-ChapelHill, NC***	44.30
109	***Jacksonville, FL***	43.00
110	***GrRapids-Muskegon-Holland, MI***	42.30
111	***Memphis, TN-AR-MS***	38.90
112	***Louisville, KY-IN***	38.70
113	Bangladesh	38.50
114	Kuwait	38.05
115	***Albany-Schenectady-Troy, NY***	37.80
116	Syria	35.53
117	Morocco	34.80
118	***WPalmBeach-BocaRaton, FL***	33.20
119	***Honolulu, HI***	33.00
120	***Monmouth-Ocean, NJ***	33.00
121	Romania	33.00
122	***Providence-Warwick, RI***	32.50
123	***OklahomaCity, OK***	32.30
124	***Birmingham, AL***	32.00
125	Ukraine	31.70
126	***Wilmington-Newark, DE***	31.40
127	***Dayton-Springfield, OH***	31.20
128	Vietnam	30.60

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
129	***Manchester-Nashua, NH***	30.20
130	***Syracuse, NY***	30.10
131	***Greenville-Spartanburg-Anderson, SC***	29.90
132	***Jersey City, NJ***	28.10
133	***Harrisburg-Lebanon-Carlisle, PA***	27.10
134	***Fresno, CA***	26.30
135	***Omaha, NE-IA***	26.20
136	***Tulsa, OK***	25.70
137	***Albuquerque, NM***	25.60
138	Iraq	25.50
139	***Ventura, CA***	24.50
140	***Tucson, AZ***	22.90
141	***Akron, OH***	21.90
142	***Knoxville, TN***	21.50
143	***Toledo, OH***	21.20
144	***Springfield, MA***	20.90
145	***Allentown-Bethlehem-Easton, PA***	20.60
146	***Scranton-Wilkes-Barre-Hazelton, PA***	20.60
147	***Santa Rosa, CA***	20.50
148	Uruguay	20.49
149	***Baton Rouge, LA***	20.40
150	Slovakia	20.20
151	Tunisia	19.96
152	Dominican Republic	19.67
153	***DesMoines, IA***	19.10
154	***AnnArbor, MI***	19.10
155	***Columbia, SC***	19.10
156	Guatemala	19.05
157	***Tacoma, WA***	19.00
158	Croatia(Hrvatska)	19.00
159	***Bakersfield, CA***	18.90
160	Oman	18.82
161	***FortWayne, IN***	18.60
162	***ElPaso, TX***	18.60
163	***Trenton, NJ***	18.50
164	Slovenia	18.47
165	***LittleRock-N.L.Rock, AR***	18.40
166	***Madison, WI***	18.40
167	***Lafayette, LA***	18.20
168	Kazakhstan	18.20
169	Luxembourg	18.10
170	***Lexington, KY***	17.80
171	***ColoradoSprings, CO***	17.60

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
172	***Wichita, KS***	17.50
173	***Chattanooga, TN-GA***	17.50
174	Lebanon	17.36
175	***SantaBarbara-SantaMaria-Lompoc, CA***	17.20
176	***Sarasota-Bradenton, FL***	16.90
177	***Lancaster, PA***	16.50
178	SriLanka	16.47
179	***Stockton-Lodi, CA***	16.20
180	***Youngstown-Warren, OH***	16.20
181	***Gary, IN***	16.10
182	***Lansing-EastLansing, MI***	16.10
183	CostaRica	16.02
184	***Kalamazoo-BattleCreek, MI***	15.70
185	***Atlantic-CapeMay, NJ***	15.70
186	***Spokane, WA***	15.40
187	***Modesto, CA***	15.00
188	***Augusta-Aiken, GA-SC***	14.80
189	***Reno, NV***	14.70
190	***Charleston-NCharleston, SC***	14.70
191	Qatar	14.58
192	***Vallejo-Fairfield-Napa, CA***	14.50
193	***BoiseCity, ID***	14.40
194	***Rockford, IL***	14.30
195	***Jackson, MS***	14.30
196	***Mobile, AL***	14.00
197	***JohnsonCity-Kingspt-Bristol, TN-VA***	13.90
198	***Salinas, CA***	13.80
199	***Appleton-Oshkosh-Neenah, WI***	13.50
200	***Peoria-Pekin, IL***	13.30
201	El Salvador	13.22
202	Ecuador	13.04
203	***Lakeland-WinterHaven, FL***	13.00
204	***Davenport-Moline-RockIsld, IA-IL***	13.00
205	***Reading, PA***	13.00
206	***Anchorage, AK***	12.80
207	***Hickory-Morganton, NC***	12.80
208	***Saginaw-BayCity-Midland, MI***	12.70
209	***Canton-Massillon, OH***	12.70
210	***CorpusChristi, TX***	12.60
211	***Roanoke, VA***	12.60
212	***York, PA***	12.50
213	***Beaumont-PortArthur, TX***	12.40
214	***Shreveport-BossierCity, LA***	12.30

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
215	***Odessa-Midland, TX***	12.30
216	Uzbekistan	12.30
217	Bulgaria	12.23
218	***Boulder-Longmont, CO***	12.00
219	***Melbourne-Titusville-PalmBay, FL***	12.00
220	***Macon, GA***	12.00
221	***Portland, ME***	12.00
222	***Utica-Rome, NY***	11.90
223	***Springfield, IL***	11.40
224	***FortMyers-CapeCoral, FL***	11.30
225	***Flint, MI***	11.30
226	Lithuania	11.23
227	Sudan	10.98
228	Coted'Ivoire	10.93
229	***Newburgh, NY-PA***	10.90
230	***Springfield, MO***	10.80
231	***McAllen-Edinburg-Mission, TX***	10.80
232	Belarus	10.78
233	***Huntsville, AL***	10.60
234	Kenya	10.60
235	***Visalia-Tulare-Porterville, CA***	10.50
236	***Pensacola, FL***	10.50
237	***Savannah, GA***	10.50
238	***Evansville-Henderson, IN-KY***	10.50
239	***Montgomery, AL***	10.40
240	***DaytonaBeach, FL***	10.40
241	***Eugene-Springfield, OR***	10.40
242	***NewLondon-Norwich, CT***	10.30
243	***Tallahassee, FL***	10.20
244	***SLObispo-Atascadero-PasoRobles, CA***	10.10
245	Cuba	10.10
246	***GreenBay, WI***	10.00
247	***Binghamton, NY***	9.90
248	***Salem, OR***	9.90
249	***Columbus, GA-AL***	9.80
250	***Erie, PA***	9.80
251	Cameroon	9.67
252	Myanmar	9.61
253	***Lincoln, NE***	9.60
254	***SantaCruz-Watsonville, CA***	9.50
255	***DutchessCounty, NY***	9.50
256	***Biloxi-Gulfport-Pascagoula, MS***	9.40
257	Tanzania	9.32

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
258	Iceland	9.17
259	***Fayetteville-Springdale-Rogers, AR***	9.00
260	Cyprus	8.94
261	***Yolo, CA***	8.90
262	***Elkhart-Goshen, IN***	8.90
263	***Houma, LA***	8.60
264	***Hamilton-Middletown, OH***	8.60
265	Bolivia	8.54
266	***SouthBend, IN***	8.50
267	***Longview-Marshall, TX***	8.50
268	***Lubbock, TX***	8.50
269	***Lynchburg, VA***	8.50
270	***Charleston, WV***	8.40
271	***FortCollins-Loveland, CO***	8.30
272	***Provo-Orem, UT***	8.30
273	***Bloomington-Normal, IL***	8.20
274	***Duluth-Superior, MN-WI***	8.20
275	***SiouxFalls, SD***	8.00
276	Yemen(Unified)	7.96
277	***Waco, TX***	7.80
278	Jordan	7.75
279	***Gainesville, FL***	7.70
280	***CedarRapids, IA***	7.70
281	***Wilmington, NC***	7.70
282	Zimbabwe	7.61
283	***Huntington-Ashland, WV-KY-OH***	7.60
284	***Chico-Paradise, CA***	7.50
285	***Asheville, NC***	7.50
286	***Amarillo, TX***	7.50
287	***Brownsv-Harlingen-SanBenito, TX***	7.50
288	Paraguay	7.49
289	Libyan Arab Jamahiriya	7.47
290	Panama	7.34
291	***Killeen-Temple, TX***	7.30
292	Federal Republic of Yugoslavia	7.30
293	Trinidad & Tobago	7.28
294	***Galveston-TexasCity, TX***	7.20
295	Jamaica	7.18
296	Latvia	7.15
297	Bahrain	7.11
298	***Fayetteville, NC***	7.10
299	***Burlington, VT***	7.00
300	***Myrtle Beach, SC***	6.90

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
301	***Naples, FL***	6.80
302	***Barnstable-Yarmouth, MA***	6.80
303	***Tyler, TX***	6.80
304	Ethiopia	6.80
305	***FortPierce-PortSt.Lucie, FL***	6.70
306	***Johnstown, PA***	6.70
307	***Laredo, TX***	6.60
308	***Redding, CA***	6.50
309	***Topeka, KS***	6.50
310	***Olympia, WA***	6.40
311	***FortSmith, AR-OK***	6.30
312	***Charlottesville, VA***	6.30
313	Ghana	6.30
314	***LakeCharles, LA***	6.20
315	***Brazoria, TX***	6.20
316	***Richland-Kennewick-Pasco, WA***	6.20
317	***Yakima, WA***	6.20
318	Uganda	6.20
319	***Merced, CA***	6.10
320	***St.Cloud, MN***	6.00
321	Honduras	5.93
322	***Ocala, FL***	5.90
323	***Lafayette, IN***	5.90
324	***Fargo-Moorhead, ND-MN***	5.80
325	***Champaign-Urbana, IL***	5.70
326	***Mansfield, OH***	5.70
327	***Vineland-Millville-Bridgeton, NJ***	5.60
328	***Joplin, MO***	5.50
329	***Bremerton, WA***	5.50
330	Nepal	5.42
331	***Athens, GA***	5.40
332	***Lima, OH***	5.40
333	***Bellingham, WA***	5.40
334	Botswana	5.36
335	***BentonHarbor, MI***	5.30
336	***Rochester, MN***	5.30
337	***Bryan-CollegeStation, TX***	5.30
338	***Racine, WI***	5.30
339	Brunei Darussalam	5.21
340	Gabon	5.21
341	***Greeley, CO***	5.20
342	***FortWaltonBeach, FL***	5.10
343	***Medford-Ashford, OR***	5.10

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
344	***Tuscaloosa, AL***	5.00
345	***Monroe, LA***	5.00
346	***Pittsfield, MA***	5.00
347	***Columbia, MO***	5.00
348	WestBank and Gaza	4.94
349	Estonia	4.92
350	***Jamestown, NY***	4.90
351	***WichitaFalls, TX***	4.90
352	Azerbaijan	4.90
353	***Hagerstown, MD***	4.80
354	***EauClaire, WI***	4.80
355	***Wausau, WI***	4.80
356	***RockyMount, NC***	4.70
357	***Florence, SC***	4.70
358	***Albany, GA***	4.60
359	***Abilene, TX***	4.60
360	Mauritius	4.60
361	Senegal	4.53
362	***PanamaCity, FL***	4.50
363	***Decatur, IL***	4.50
364	***Santa Fe, NM***	4.50
365	***Glens Falls, NY***	4.50
366	***Clarksville-Hopkinsville, TN-KY***	4.50
367	***Parkersburg-Marietta, WV-OH***	4.50
368	***Janesville-Beloit, WI***	4.50
369	***LaCrosse, WI-MN***	4.50
370	Angola	4.43
371	***Waterloo-CedarFalls, IA***	4.40
372	***Jackson, MI***	4.40
373	***StateCollege, PA***	4.40
374	Turkmenistan	4.40
375	***Bangor, ME***	4.30
376	***Pueblo, CO***	4.20
377	***TerreHaute, IN***	4.20
378	***Greenville, NC***	4.20
379	***Altoona, PA***	4.20
380	***Wheeling, WV-OH***	4.20
381	Bahamas	4.19
382	Mozambique	4.17
383	***Dothan, AL***	4.10
384	***Sioux City, IA-NE***	4.10
385	***Williamsport, PA***	4.10
386	***Sheboygan, WI***	4.10

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
387	***Jackson, TN***	4.00
388	Albania	3.89
389	***GrandJunction, CO***	3.80
390	***Dover, DE***	3.80
391	***Bloomington, IN***	3.80
392	***Billings, MT***	3.80
393	Madagascar	3.79
394	***Decatur, AL***	3.70
395	***Flagstaff, AZ-UT***	3.70
396	***YubaCity, CA***	3.70
397	***Kokomo, IN***	3.70
398	***Elmira, NY***	3.70
399	***San Angelo, TX***	3.70
400	PapuaNewGuinea	3.67
401	***Texarkana, AR-TX***	3.60
402	***Muncie, IN***	3.60
403	***Alexandria, LA***	3.60
404	***Las Cruces, NM***	3.60
405	***Sharon, PA***	3.60
406	***Sherman-Denison, TX***	3.60
407	***Danville, VA***	3.60
408	Malta	3.53
409	Namibia	3.51
410	***IowaCity, IA***	3.50
411	***Steubenville-Weirton, OH-WV***	3.50
412	Macedonia	3.41
413	***Florence, AL***	3.40
414	***Victoria, TX***	3.30
415	Congo, Dem.Repub.of	3.28
416	Guinea	3.21
417	***Kankakee, IL***	3.20
418	***Kenosha, WI***	3.20
419	Georgia	3.15
420	Cambodia	3.12
421	***Dubuque, IA***	3.10
422	Zambia	3.10
423	Haiti	3.09
424	***Anniston, AL***	3.00
425	***Owensboro, KY***	3.00
426	***Lewiston-Auburn, ME***	3.00
427	***Hattiesburg, MS***	3.00
428	***St.Joseph, MO***	3.00
429	***RapidCity, SD***	3.00

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
430	Congo	2.92
431	***Goldsboro, NC***	2.90
432	***Bismarck, ND***	2.90
433	***Casper, WY***	2.90
434	***Cumberland, MD-WV***	2.80
435	***Missoula, MT***	2.80
436	***GrandForks, ND-MN***	2.80
437	***Sumter, SC***	2.80
438	***Yuma, AZ***	2.70
439	***Lawrence, KS***	2.70
440	***Corvallis, OR***	2.70
441	Barbados	2.69
442	Bermuda	2.67
443	***Cheyenne, WY***	2.60
444	***Auburn-Opelika, AL***	2.50
445	***Gadsden, AL***	2.50
446	***Jacksonville, NC***	2.50
447	Nicaragua	2.50
448	BurkinaFaso	2.44
449	***PuntaGorda, FL***	2.40
450	***Lawton, OK***	2.40
451	Mali	2.40
452	***Jonesboro, AR***	2.30
453	Benin	2.27
454	Liechtenstein	2.25
455	***PineBluff, AR***	2.10
456	NetherlandsAntilles	2.06
457	***GreatFalls, MT***	2.00
458	Malawi	1.99
459	Fiji	1.97
460	Aruba	1.96
461	Rwanda	1.95
462	Armenia	1.92
463	***Pocatello, ID***	1.90
464	***Enid, OK***	1.70
465	Somalia	1.67
466	Niger	1.59
467	Cayman Islands	1.59
468	Chad	1.47
469	Kyrgyzstan	1.30
470	Moldova	1.30
471	Togo	1.29
472	Afghanistan	1.27

Gross Product, 2000 (US $ Billions, Current)		
Rank	Country or ***Metro Area***	Gross
473	Swaziland	1.22
474	Laos	1.09
475	Mongolia	1.03
476	Equatorial Guinea	1.01
477	Tajikistan	1.01
478	Central African Republic	0.99
479	Lesotho	0.95
480	Mauritania	0.91
481	Burundi	0.77
482	Guyana	0.75
483	Eritrea	0.75
484	Belize	0.74
485	Saint Lucia	0.70
486	Antigua & Barbuda	0.69
487	Suriname	0.65
488	Seychelles	0.63
489	SierraLeone	0.59
490	Djibouti	0.56
491	CapeVerde	0.51
492	Bhutan	0.47
493	Gambia	0.45
494	Maldives	0.44
495	Grenada	0.42
496	Solomon Islands	0.39
497	Saint Kitts and Nevis	0.33
498	Saint Vincent and the Grenadines	0.33
499	Dominica	0.28
500	Guinea-Bissau	0.23
501	Vanuatu	0.23
502	Samoa	0.19
503	Comoros	0.18
504	Sao Tome and Principe	0.05

Table 6

The Gross Product of the Top 10 Metro areas in 2000 exceeds the combined output of the following 31 States.

Total Gross Metro Product $2.43 trillion		Total Gross State Product $2.15 trillion
New York, NY Los Angeles-L Beach, CA Chicago, IL Boston, MA Washington, DC-MD-VA-WV Philadelphia, PA-NJ Houston, TX Atlanta, GA Dallas, TX Detroit, MI	Is greater than >	Vermont North Dakota Montana Wyoming South Dakota Alaska Rhode Island Idaho Maine Delaware Hawaii West Virginia New Hampshire New Mexico Nebraska D. C. Utah Mississippi Arkansas Nevada Kansas Oklahoma Iowa South Carolina Oregon Alabama Kentucky Louisiana Arizona Connecticut Colorado

Table 7 – Gross Product of Metro Areas

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Las Vegas, NV-AZ	20.5	54.6	166.3	1
Austin-San Marcos, TX	18.8	48.2	156.4	2
Laredo, TX	2.7	6.6	144.4	3
Provo-Orem, UT	3.4	8.3	144.1	4
Boise City, ID	5.9	14.4	144.1	5
Phoenix-Mesa, AZ	47.3	114.2	141.4	6
Colorado Springs, CO	7.3	17.6	141.1	7
Myrtle Beach, SC	2.9	6.9	137.9	8
Fort Collins-Loveland, CO	3.5	8.3	137.1	9
Greeley, CO	2.2	5.2	136.4	10
Yolo, CA	3.9	8.9	128.2	11
Albuquerque, NM	11.3	25.6	126.5	12
Yuma, AZ	1.2	2.7	125.0	13
Corvallis, OR	1.2	2.7	125.0	14
Atlanta, GA	73.4	164.2	123.7	15
Grand Junction, CO	1.7	3.8	123.5	16
Sioux Falls, SD	3.6	8.0	122.2	17
Boulder-Longmont, CO	5.4	12.0	122.2	18
Salt Lake City-Ogden, UT	21.1	46.4	119.9	19
Fayetteville-Springdale-Rogers, AR	4.1	9.0	119.5	20
Denver, CO	41.8	91.1	117.9	21
Santa Rosa, CA	9.5	20.5	115.8	22
Raleigh-Durham-Chapel Hill, NC	20.7	44.3	114.0	23
Wilmington, NC	3.6	7.7	113.9	24
Green Bay, WI	4.7	10.0	112.8	25
Naples, FL	3.2	6.8	112.5	26
McAllen-Edinburg-Mission, TX	5.1	10.8	111.8	27
Orlando, FL	28.2	59.5	111.0	28
Jackson, TN	1.9	4.0	110.5	29
Pueblo, CO	2.0	4.2	110.0	30
Portland-Vancouver, OR-WA	34.1	71.5	109.7	31
Charlotte-Gastonia-R Hill, NC-SC	29.3	61.3	109.2	32
Killeen-Temple, TX	3.5	7.3	108.6	33
Tucson, AZ	11.0	22.9	108.2	34
San Antonio, TX	25.8	53.7	108.1	35
Nashville, TN	21.9	45.2	106.4	36
Dallas, TX	77.6	160.0	106.2	37
S L Obispo-Atascadero-Paso Robles, CA	4.9	10.1	106.1	38
Santa Fe, NM	2.2	4.5	104.5	39
Clarksville-Hopkinsville, TN-KY	2.2	4.5	104.5	40
Manchester-Nashua, NH	14.8	30.2	104.1	41
Medford-Ashford, OR	2.5	5.1	104.0	42

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Bryan-College Station, TX	2.6	5.3	103.8	43
Ocala, FL	2.9	5.9	103.4	44
Salem, OR	4.9	9.9	102.0	45
Fort Worth-Arlington, TX	31.4	63.0	100.6	46
Athens, GA	2.7	5.4	100.0	47
Bloomington-Normal, IL	4.1	8.2	100.0	48
Columbia, MO	2.5	5.0	100.0	49
Springfield, MO	5.4	10.8	100.0	50
Las Cruces, NM	1.8	3.6	100.0	51
Eugene-Springfield, OR	5.2	10.4	100.0	52
Rapid City, SD	1.5	3.0	100.0	53
Bellingham, WA	2.7	5.4	100.0	54
Reno, NV	7.4	14.7	98.6	55
Gr Rapids-Muskegon-Holland, MI	21.4	42.3	97.7	56
Brownsv-Harlingen-San Benito, TX	3.8	7.5	97.4	57
Tampa-St Petersb-Clrwater, FL	41.7	82.2	97.1	58
Merced, CA	3.1	6.1	96.8	59
Sarasota-Bradenton, FL	8.6	16.9	96.5	60
Joplin, MO	2.8	5.5	96.4	61
Jacksonville, FL	21.9	43.0	96.3	62
Fort Walton Beach, FL	2.6	5.1	96.2	63
Columbus, GA-AL	5.0	9.8	96.0	64
Biloxi-Gulfport-Pascagoula, MS	4.8	9.4	95.8	65
Waco, TX	4.0	7.8	95.0	66
Victoria, TX	1.7	3.3	94.1	67
Olympia, WA	3.3	6.4	93.9	68
Knoxville, TN	11.1	21.5	93.7	69
St. Cloud, MN	3.1	6.0	93.5	70
Houston, TX	91.8	177.5	93.4	71
W Palm Beach-Boca Raton, FL	17.2	33.2	93.0	72
Lawrence, KS	1.4	2.7	92.9	73
Spokane, WA	8.0	15.4	92.5	74
Chico-Paradise, CA	3.9	7.5	92.3	75
Modesto, CA	7.8	15.0	92.3	76
Amarillo, TX	3.9	7.5	92.3	77
Eau Claire, WI	2.5	4.8	92.0	78
Wausau, WI	2.5	4.8	92.0	79
Jonesboro, AR	1.2	2.3	91.7	80
Wilmington-Newark, DE	16.4	31.4	91.5	81
Houma, LA	4.5	8.6	91.1	82
Hamilton-Middletown, OH	4.5	8.6	91.1	83
Greenville, NC	2.2	4.2	90.9	84
Fort Lauderdale, FL	24.5	46.7	90.6	85

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Dover, DE	2.0	3.8	90.0	86
Pocatello, ID	1.0	1.9	90.0	87
Tacoma, WA	10.0	19.0	90.0	88
Lexington, KY	9.4	17.8	89.4	89
Riverside-San Bernardino, CA	44.5	84.1	89.0	90
Barnstable-Yarmouth, MA	3.6	6.8	88.9	91
Longview-Marshall, TX	4.5	8.5	88.9	92
Tyler, TX	3.6	6.8	88.9	93
Seattle-Bellevue-Everett, WA	60.9	115.0	88.8	94
Fort Myers-Cape Coral, FL	6.0	11.3	88.3	95
Kenosha, WI	1.7	3.2	88.2	96
Lincoln, NE	5.1	9.6	88.2	97
Memphis, TN-AR-MS	20.7	38.9	87.9	98
Fort Wayne, IN	9.9	18.6	87.9	99
Richland-Kennewick-Pasco, WA	3.3	6.2	87.9	100
Visalia-Tulare-Porterville, CA	5.6	10.5	87.5	101
Panama City, FL	2.4	4.5	87.5	102
Owensboro, KY	1.6	3.0	87.5	103
Hattiesburg, MS	1.6	3.0	87.5	104
Appleton-Oshkosh-Neenah, WI	7.2	13.5	87.5	105
La Crosse, WI-MN	2.4	4.5	87.5	106
Fargo-Moorhead, ND-MN	3.1	5.8	87.1	107
Middlesex-Somerset-Hunterdon, NJ	34.0	63.6	87.1	108
Minneapolis-St. Paul, MN-WI	64.9	121.3	86.9	109
Indianapolis, IN	30.9	57.7	86.7	110
Mobile, AL	7.5	14.0	86.7	111
Missoula, MT	1.5	2.8	86.7	112
Sumter, SC	1.5	2.8	86.7	113
Chattanooga, TN-GA	9.4	17.5	86.2	114
Jersey City, NJ	15.1	28.1	86.1	115
Omaha, NE-IA	14.1	26.2	85.8	116
Fort Smith, AR-OK	3.4	6.3	85.3	117
Greensboro-W-Salem-High Point,NC	25.0	46.3	85.2	118
Flagstaff, AZ-UT	2.0	3.7	85.0	119
San Angelo, TX	2.0	3.7	85.0	120
Macon, GA	6.5	12.0	84.6	121
Punta Gorda, FL	1.3	2.4	84.6	122
Iowa City, IA	1.9	3.5	84.2	123
El Paso, TX	10.1	18.6	84.2	124
Albany, GA	2.5	4.6	84.0	125
Madison, WI	10.0	18.4	84.0	126
Rochester, MN	2.9	5.3	82.8	127
Yakima, WA	3.4	6.2	82.4	128

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Fayetteville, NC	3.9	7.1	82.1	129
Sacramento, CA	34.7	63.1	81.8	130
Elkhart-Goshen, IN	4.9	8.9	81.6	131
Salinas, CA	7.6	13.8	81.6	132
Vallejo-Fairfield-Napa, CA	8.0	14.5	81.3	133
Bismarck, ND	1.6	2.9	81.3	134
Lubbock, TX	4.7	8.5	80.9	135
Lynchburg, VA	4.7	8.5	80.9	136
Louisville, KY-IN	21.4	38.7	80.8	137
Florence, SC	2.6	4.7	80.8	138
Redding, CA	3.6	6.5	80.6	139
Kansas City, MO-KS	35.9	64.8	80.5	140
Little Rock-N. L.Rock, AR	10.2	18.4	80.4	141
Lafayette, LA	10.1	18.2	80.2	142
Corpus Christi, TX	7.0	12.6	80.0	143
Galveston-Texas City, TX	4.0	7.2	80.0	144
Sherman-Denison, TX	2.0	3.6	80.0	145
Janesville-Beloit, WI	2.5	4.5	80.0	146
San Jose, CA	47.6	85.4	79.4	147
Lancaster, PA	9.2	16.5	79.3	148
Montgomery, AL	5.8	10.4	79.3	149
Santa Cruz-Watsonville, CA	5.3	9.5	79.2	150
Gainesville, FL	4.3	7.7	79.1	151
Cedar Rapids, IA	4.3	7.7	79.1	152
Columbus, OH	33.9	60.7	79.1	153
Tallahassee, FL	5.7	10.2	78.9	154
Lafayette, IN	3.3	5.9	78.8	155
Auburn-Opelika, AL	1.4	2.5	78.6	156
Tuscaloosa, AL	2.8	5.0	78.6	157
Jacksonville, NC	1.4	2.5	78.6	158
Asheville, NC	4.2	7.5	78.6	159
Savannah, GA	5.9	10.5	78.0	160
Richmond-Petersburg, VA	25.7	45.7	77.8	161
Chicago, IL	187.5	332.8	77.5	162
Abilene, TX	2.6	4.6	76.9	163
Des Moines, IA	10.8	19.1	76.9	164
Jackson, MS	8.1	14.3	76.5	165
Monmouth-Ocean, NJ	18.7	33.0	76.5	166
Portland, ME	6.8	12.0	76.5	167
Fort Pierce-Port St. Lucie, FL	3.8	6.7	76.3	168
Daytona Beach, FL	5.9	10.4	76.3	169
Decatur, AL	2.1	3.7	76.2	170
State College, PA	2.5	4.4	76.0	171

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Greenville-Spartanburg-Anderson, SC	17.0	29.9	75.9	172
Baton Rouge, LA	11.6	20.4	75.9	173
Birmingham, AL	18.2	32.0	75.8	174
Lakeland-Winter Haven, FL	7.4	13.0	75.7	175
Pensacola, FL	6.0	10.5	75.0	176
Harrisburg-Lebanon-Carlisle, PA	15.5	27.1	74.8	177
Norfolk-Va Beach-Newport News, VA-NC	29.7	51.7	74.1	178
San Diego, CA	60.2	104.6	73.8	179
Boston, MA	137.8	238.8	73.3	180
Odessa-Midland, TX	7.1	12.3	73.2	181
Washington, DC-MD-VA-WV	125.3	217.0	73.2	182
Peoria-Pekin, IL	7.7	13.3	72.7	183
Bloomington, IN	2.2	3.8	72.7	184
Billings, MT	2.2	3.8	72.7	185
Roanoke, VA	7.3	12.6	72.6	186
Beaumont-Port Arthur, TX	7.2	12.4	72.2	187
Evansville-Henderson, IN-KY	6.1	10.5	72.1	188
Ann Arbor, MI	11.1	19.1	72.1	189
Columbia, SC	11.1	19.1	72.1	190
Bremerton, WA	3.2	5.5	71.9	191
Johnson City-Kingspt-Bristol, TN-VA	8.1	13.9	71.6	192
Hagerstown, MD	2.8	4.8	71.4	193
Sharon, PA	2.1	3.6	71.4	194
Charleston, WV	4.9	8.4	71.4	195
Ventura, CA	14.3	24.5	71.3	196
Charleston-N Charleston, SC	8.6	14.7	70.9	197
Duluth-Superior, MN-WI	4.8	8.2	70.8	198
Sheboygan, WI	2.4	4.1	70.8	199
Orange Co, CA	76.2	130.0	70.6	200
Newburgh, NY-PA	6.4	10.9	70.3	201
Fresno, CA	15.5	26.3	69.7	202
Detroit, MI	92.3	156.3	69.3	203
Waterloo-Cedar Falls, IA	2.6	4.4	69.2	204
Erie, PA	5.8	9.8	69.0	205
Wichita Falls, TX	2.9	4.9	69.0	206
York, PA	7.4	12.5	68.9	207
New London-Norwich, CT	6.1	10.3	68.9	208
Allentown-Bethlehem-Easton, PA	12.2	20.6	68.9	209
Reading, PA	7.7	13.0	68.8	210
Stockton-Lodi, CA	9.6	16.2	68.8	211
Cincinnati, OH-KY-IN	35.2	59.4	68.8	212
Akron, OH	13.0	21.9	68.5	213
Hickory-Morganton, NC	7.6	12.8	68.4	214

Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Yuba City, CA	2.2	3.7	68.2	215
Augusta-Aiken, GA-SC	8.8	14.8	68.2	216
Kokomo, IN	2.2	3.7	68.2	217
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	45.7	76.8	68.1	218
Altoona, PA	2.5	4.2	68.0	219
Cleveland-Lorain-Elyria, OH	48.1	80.8	68.0	220
Gadsden, AL	1.5	2.5	66.7	221
South Bend, IN	5.1	8.5	66.7	222
Great Falls, MT	1.2	2.0	66.7	223
Glens Falls, NY	2.7	4.5	66.7	224
Burlington, VT	4.2	7.0	66.7	225
Milwaukee-Waukesha, WI	32.9	54.8	66.6	226
Oakland, CA	55.4	92.1	66.2	227
Pittsburgh, PA	48.6	80.7	66.0	228
Racine, WI	3.2	5.3	65.6	229
St. Louis, MO-IL	54.1	89.6	65.6	230
Santa Barbara-Santa Maria-Lompoc, CA	10.4	17.2	65.4	231
Kalamazoo-Battle Creek, MI	9.5	15.7	65.3	232
Atlantic-Cape May, NJ	9.5	15.7	65.3	233
Nassau-Suffolk, NY	64.8	106.8	64.8	234
Grand Forks, ND-MN	1.7	2.8	64.7	235
Miami, FL	43.5	71.6	64.6	236
Melbourne-Titusville-Palm Bay, FL	7.3	12.0	64.4	237
Williamsport, PA	2.5	4.1	64.0	238
Oklahoma City, OK	19.7	32.3	64.0	239
Texarkana, AR-TX	2.2	3.6	63.6	240
Muncie, IN	2.2	3.6	63.6	241
Alexandria, LA	2.2	3.6	63.6	242
Scranton-Wilkes-Barre-Hazelton, PA	12.6	20.6	63.5	243
Brazoria, TX	3.8	6.2	63.2	244
Huntsville, AL	6.5	10.6	63.1	245
Utica-Rome, NY	7.3	11.9	63.0	246
Jackson, MI	2.7	4.4	63.0	247
Saginaw-Bay City-Midland, MI	7.8	12.7	62.8	248
Tulsa, OK	15.8	25.7	62.7	249
Lansing-East Lansing, MI	9.9	16.1	62.6	250
Providence-Warwick, RI	20.0	32.5	62.5	251
New York, NY	269.6	437.8	62.4	252
Trenton, NJ	11.4	18.5	62.3	253
Youngstown-Warren, OH	10.0	16.2	62.0	254
Florence, AL	2.1	3.4	61.9	255
Philadelphia, PA-NJ	112.9	182.4	61.6	256
Pine Bluff, AR	1.3	2.1	61.5	257

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Charlottesville, VA	3.9	6.3	61.5	258
Goldsboro, NC	1.8	2.9	61.1	259
Elmira, NY	2.3	3.7	60.9	260
Benton Harbor, MI	3.3	5.3	60.6	261
Toledo, OH	13.2	21.2	60.6	262
Kankakee, IL	2.0	3.2	60.0	263
Newark, NJ	60.2	96.3	60.0	264
San Francisco, CA	67.2	107.3	59.7	265
Johnstown, PA	4.2	6.7	59.5	266
Albany-Schenectady-Troy, NY	23.7	37.8	59.5	267
Wichita, KS	11.0	17.5	59.1	268
Topeka, KS	4.1	6.5	58.5	269
Springfield, IL	7.2	11.4	58.3	270
Jamestown, NY	3.1	4.9	58.1	271
Anniston, AL	1.9	3.0	57.9	272
Lewiston-Auburn, ME	1.9	3.0	57.9	273
St. Joseph, MO	1.9	3.0	57.9	274
Dothan, AL	2.6	4.1	57.7	275
Sioux City, IA-NE	2.6	4.1	57.7	276
Rochester, NY	29.0	45.7	57.6	277
Canton-Massillon, OH	8.1	12.7	56.8	278
Davenport-Moline-Rock Isld, IA-IL	8.3	13.0	56.6	279
Danville, VA	2.3	3.6	56.5	280
Bergen-Passaic, NJ	37.9	59.3	56.5	281
Monroe, LA	3.2	5.0	56.3	282
Pittsfield, MA	3.2	5.0	56.3	283
Bakersfield, CA	12.1	18.9	56.2	284
Terre Haute, IN	2.7	4.2	55.6	285
Cumberland, MD-WV	1.8	2.8	55.6	286
Vineland-Millville-Bridgeton, NJ	3.6	5.6	55.6	287
Parkersburg-Marietta, WV-OH	2.9	4.5	55.2	288
Baltimore, MD	62.0	96.2	55.2	289
Dubuque, IA	2.0	3.1	55.0	290
Lake Charles, LA	4.0	6.2	55.0	291
Gary, IN	10.4	16.1	54.8	292
Buffalo-Niagara Falls, NY	30.9	47.8	54.7	293
Enid, OK	1.1	1.7	54.5	294
Champaign-Urbana, IL	3.7	5.7	54.1	295
Hartford, CT	41.8	64.3	53.8	296
Springfield, MA	13.6	20.9	53.7	297
Bangor, ME	2.8	4.3	53.6	298
Dayton-Springfield, OH	20.4	31.2	52.9	299
Cheyenne, WY	1.7	2.6	52.9	300

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Nominal Gross Metro Product	1990	2000	Percent Change	Rank
(Billions, $Current)			(%)	
Casper, WY	1.9	2.9	52.6	301
Huntington-Ashland, WV-KY-OH	5.0	7.6	52.0	302
Rocky Mount, NC	3.1	4.7	51.6	303
Syracuse, NY	19.9	30.1	51.3	304
Rockford, IL	9.5	14.3	50.5	305
Lima, OH	3.6	5.4	50.0	306
Lawton, OK	1.6	2.4	50.0	307
Wheeling, WV-OH	2.8	4.2	50.0	308
Binghamton, NY	6.7	9.9	47.8	309
Mansfield, OH	3.9	5.7	46.2	310
New Orleans, LA	32.3	46.5	44.0	311
Flint, MI	7.9	11.3	43.0	312
Dutchess County, NY	6.7	9.5	41.8	313
Shreveport-Bossier City, LA	8.7	12.3	41.4	314
Decatur, IL	3.2	4.5	40.6	315
Los Angeles-L Beach, CA	261.7	363.7	39.0	316
Steubenville-Weirton, OH-WV	2.6	3.5	34.6	317
Honolulu, HI	25.1	33.0	31.5	318
Anchorage, AK	10.5	12.8	21.9	319

Table 8 –Gross Product Metro Areas

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Las Vegas, NV-AZ	20.5	54.6	10.3	1
Austin-San Marcos, TX	18.8	48.2	9.8	2
Boise City, ID	5.9	14.4	9.4	3
Laredo, TX	2.7	6.6	9.4	4
Phoenix-Mesa, AZ	47.3	114.2	9.2	5
Fort Collins-Loveland, CO	3.5	8.3	9.2	6
Provo-Orem, UT	3.4	8.3	9.2	7
Colorado Springs, CO	7.3	17.6	9.1	8
Greeley, CO	2.2	5.2	9.1	9
Myrtle Beach, SC	2.9	6.9	9.1	10
Yolo, CA	3.9	8.9	8.5	11
Grand Junction, CO	1.7	3.8	8.5	12
Albuquerque, NM	11.3	25.6	8.5	13
Atlanta, GA	73.4	164.2	8.4	14
Corvallis, OR	1.2	2.7	8.4	15
Boulder-Longmont, CO	5.4	12.0	8.3	16
Sioux Falls, SD	3.6	8.0	8.3	17
Salt Lake City-Ogden, UT	21.1	46.4	8.2	18
Fayetteville-Springdale-Rogers, AR	4.1	9.0	8.1	19
Denver, CO	41.8	91.1	8.1	20
Santa Rosa, CA	9.5	20.5	8.0	21
Yuma, AZ	1.2	2.7	7.9	22
Naples, FL	3.2	6.8	7.9	23
Raleigh-Durham-Chapel Hill, NC	20.7	44.3	7.9	24
Wilmington, NC	3.6	7.7	7.9	25
Orlando, FL	28.2	59.5	7.8	26
McAllen-Edinburg-Mission, TX	5.1	10.8	7.8	27
Green Bay, WI	4.7	10.0	7.8	28
Charlotte-Gastonia-R Hill, NC-SC	29.3	61.3	7.7	29
Portland-Vancouver, OR-WA	34.1	71.5	7.7	30
Jackson, TN	1.9	4.0	7.7	31
Tucson, AZ	11.0	22.9	7.6	32
San Antonio, TX	25.8	53.7	7.6	33
S L Obispo-Atascadero-Paso Robles, CA	4.9	10.1	7.5	34
Medford-Ashford, OR	2.5	5.1	7.5	35
Nashville, TN	21.9	45.2	7.5	36
Dallas, TX	77.6	160.0	7.5	37
Pueblo, CO	2.0	4.2	7.4	38
Manchester-Nashua, NH	14.8	30.2	7.4	39
Santa Fe, NM	2.2	4.5	7.4	40
Bryan-College Station, TX	2.6	5.3	7.4	41
Killeen-Temple, TX	3.5	7.3	7.4	42

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Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Ocala, FL	2.9	5.9	7.3	43
Salem, OR	4.9	9.9	7.3	44
Clarksville-Hopkinsville, TN-KY	2.2	4.5	7.3	45
Fort Walton Beach, FL	2.6	5.1	7.2	46
Eugene-Springfield, OR	5.2	10.4	7.2	47
Fort Worth-Arlington, TX	31.4	63.0	7.2	48
Athens, GA	2.7	5.4	7.1	49
Bloomington-Normal, IL	4.1	8.2	7.1	50
Gr Rapids-Muskegon-Holland, MI	21.4	42.3	7.1	51
Biloxi-Gulfport-Pascagoula, MS	4.8	9.4	7.1	52
Springfield, MO	5.4	10.8	7.1	53
Reno, NV	7.4	14.7	7.1	54
Brownsv-Harlingen-San Benito, TX	3.8	7.5	7.1	55
Jacksonville, FL	21.9	43.0	7.0	56
Sarasota-Bradenton, FL	8.6	16.9	7.0	57
Tampa-St Petersb-Clrwater, FL	41.7	82.2	7.0	58
Pocatello, ID	1.0	1.9	7.0	59
Las Cruces, NM	1.8	3.6	7.0	60
Merced, CA	3.1	6.1	6.9	61
Columbus, GA-AL	5.0	9.8	6.9	62
Columbia, MO	2.5	5.0	6.9	63
Joplin, MO	2.8	5.5	6.9	64
Rapid City, SD	1.5	3.0	6.9	65
Bellingham, WA	2.7	5.4	6.9	66
Olympia, WA	3.3	6.4	6.9	67
Modesto, CA	7.8	15.0	6.8	68
W Palm Beach-Boca Raton, FL	17.2	33.2	6.8	69
Knoxville, TN	11.1	21.5	6.8	70
Houston, TX	91.8	177.5	6.8	71
Victoria, TX	1.7	3.3	6.8	72
Waco, TX	4.0	7.8	6.8	73
Spokane, WA	8.0	15.4	6.8	74
Eau Claire, WI	2.5	4.8	6.8	75
Flagstaff, AZ-UT	2.0	3.7	6.7	76
Wilmington-Newark, DE	16.4	31.4	6.7	77
Fort Lauderdale, FL	24.5	46.7	6.7	78
Lawrence, KS	1.4	2.7	6.7	79
Houma, LA	4.5	8.6	6.7	80
Barnstable-Yarmouth, MA	3.6	6.8	6.7	81
St. Cloud, MN	3.1	6.0	6.7	82
Missoula, MT	1.5	2.8	6.7	83
Amarillo, TX	3.9	7.5	6.7	84
Longview-Marshall, TX	4.5	8.5	6.7	85

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Tyler, TX	3.6	6.8	6.7	86
Tacoma, WA	10.0	19.0	6.7	87
Wausau, WI	2.5	4.8	6.7	88
Chico-Paradise, CA	3.9	7.5	6.6	89
Riverside-San Bernardino, CA	44.5	84.1	6.6	90
Dover, DE	2.0	3.8	6.6	91
Lexington, KY	9.4	17.8	6.6	92
Lincoln, NE	5.1	9.6	6.6	93
Greenville, NC	2.2	4.2	6.6	94
Fargo-Moorhead, ND-MN	3.1	5.8	6.6	95
Hamilton-Middletown, OH	4.5	8.6	6.6	96
Seattle-Bellevue-Everett, WA	60.9	115.0	6.6	97
Fort Smith, AR-OK	3.4	6.3	6.5	98
Jonesboro, AR	1.2	2.3	6.5	99
Visalia-Tulare-Porterville, CA	5.6	10.5	6.5	100
Fort Myers-Cape Coral, FL	6.0	11.3	6.5	101
Fort Wayne, IN	9.9	18.6	6.5	102
Indianapolis, IN	30.9	57.7	6.5	103
Minneapolis-St. Paul, MN-WI	64.9	121.3	6.5	104
Middlesex-Somerset-Hunterdon, NJ	34.0	63.6	6.5	105
Memphis, TN-AR-MS	20.7	38.9	6.5	106
Richland-Kennewick-Pasco, WA	3.3	6.2	6.5	107
Kenosha, WI	1.7	3.2	6.5	108
La Crosse, WI-MN	2.4	4.5	6.5	109
Mobile, AL	7.5	14.0	6.4	110
Macon, GA	6.5	12.0	6.4	111
Iowa City, IA	1.9	3.5	6.4	112
Omaha, NE-IA	14.1	26.2	6.4	113
Jersey City, NJ	15.1	28.1	6.4	114
Greensboro-W-Salem-High Point,NC	25.0	46.3	6.4	115
Chattanooga, TN-GA	9.4	17.5	6.4	116
Appleton-Oshkosh-Neenah, WI	7.2	13.5	6.4	117
Panama City, FL	2.4	4.5	6.3	118
Rochester, MN	2.9	5.3	6.3	119
Hattiesburg, MS	1.6	3.0	6.3	120
Sumter, SC	1.5	2.8	6.3	121
El Paso, TX	10.1	18.6	6.3	122
Madison, WI	10.0	18.4	6.3	123
Sacramento, CA	34.7	63.1	6.2	124
Vallejo-Fairfield-Napa, CA	8.0	14.5	6.2	125
Punta Gorda, FL	1.3	2.4	6.2	126
Albany, GA	2.5	4.6	6.2	127
Fayetteville, NC	3.9	7.1	6.2	128

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Jacksonville, NC	1.4	2.5	6.2	129
Lubbock, TX	4.7	8.5	6.2	130
San Angelo, TX	2.0	3.7	6.2	131
Yakima, WA	3.4	6.2	6.2	132
Tuscaloosa, AL	2.8	5.0	6.1	133
Little Rock-N. L.Rock, AR	10.2	18.4	6.1	134
Salinas, CA	7.6	13.8	6.1	135
Louisville, KY-IN	21.4	38.7	6.1	136
Lafayette, LA	10.1	18.2	6.1	137
Kansas City, MO-KS	35.9	64.8	6.1	138
Asheville, NC	4.2	7.5	6.1	139
Bismarck, ND	1.6	2.9	6.1	140
Corpus Christi, TX	7.0	12.6	6.1	141
Galveston-Texas City, TX	4.0	7.2	6.1	142
Montgomery, AL	5.8	10.4	6.0	143
San Jose, CA	47.6	85.4	6.0	144
Santa Cruz-Watsonville, CA	5.3	9.5	6.0	145
Tallahassee, FL	5.7	10.2	6.0	146
Elkhart-Goshen, IN	4.9	8.9	6.0	147
Cedar Rapids, IA	4.3	7.7	6.0	148
Owensboro, KY	1.6	3.0	6.0	149
Columbus, OH	33.9	60.7	6.0	150
Lancaster, PA	9.2	16.5	6.0	151
Florence, SC	2.6	4.7	6.0	152
Lynchburg, VA	4.7	8.5	6.0	153
Janesville-Beloit, WI	2.5	4.5	6.0	154
Redding, CA	3.6	6.5	5.9	155
Gainesville, FL	4.3	7.7	5.9	156
Savannah, GA	5.9	10.5	5.9	157
Chicago, IL	187.5	332.8	5.9	158
Lafayette, IN	3.3	5.9	5.9	159
Des Moines, IA	10.8	19.1	5.9	160
Portland, ME	6.8	12.0	5.9	161
Jackson, MS	8.1	14.3	5.9	162
Abilene, TX	2.6	4.6	5.9	163
Sherman-Denison, TX	2.0	3.6	5.9	164
Richmond-Petersburg, VA	25.7	45.7	5.9	165
Birmingham, AL	18.2	32.0	5.8	166
Fort Pierce-Port St. Lucie, FL	3.8	6.7	5.8	167
Lakeland-Winter Haven, FL	7.4	13.0	5.8	168
Pensacola, FL	6.0	10.5	5.8	169
Baton Rouge, LA	11.6	20.4	5.8	170
Monmouth-Ocean, NJ	18.7	33.0	5.8	171

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Greenville-Spartanburg-Anderson, SC	17.0	29.9	5.8	172
Sheboygan, WI	2.4	4.1	5.8	173
San Diego, CA	60.2	104.6	5.7	174
Daytona Beach, FL	5.9	10.4	5.7	175
Peoria-Pekin, IL	7.7	13.3	5.7	176
Boston, MA	137.8	238.8	5.7	177
Billings, MT	2.2	3.8	5.7	178
Harrisburg-Lebanon-Carlisle, PA	15.5	27.1	5.7	179
State College, PA	2.5	4.4	5.7	180
Norfolk-Va Beach-Newport News, VA-NC	29.7	51.7	5.7	181
Roanoke, VA	7.3	12.6	5.7	182
Auburn-Opelika, AL	1.4	2.5	5.6	183
Washington, DC-MD-VA-WV	125.3	217.0	5.6	184
Bloomington, IN	2.2	3.8	5.6	185
Evansville-Henderson, IN-KY	6.1	10.5	5.6	186
Hagerstown, MD	2.8	4.8	5.6	187
Columbia, SC	11.1	19.1	5.6	188
Johnson City-Kingspt-Bristol, TN-VA	8.1	13.9	5.6	189
Beaumont-Port Arthur, TX	7.2	12.4	5.6	190
Odessa-Midland, TX	7.1	12.3	5.6	191
Decatur, AL	2.1	3.7	5.5	192
Orange County, CA	76.2	130.0	5.5	193
Ventura, CA	14.3	24.5	5.5	194
Yuba City, CA	2.2	3.7	5.5	195
New London-Norwich, CT	6.1	10.3	5.5	196
Waterloo-Cedar Falls, IA	2.6	4.4	5.5	197
Ann Arbor, MI	11.1	19.1	5.5	198
Duluth-Superior, MN-WI	4.8	8.2	5.5	199
Newburgh, NY-PA	6.4	10.9	5.5	200
Reading, PA	7.7	13.0	5.5	201
Sharon, PA	2.1	3.6	5.5	202
Charleston-N Charleston, SC	8.6	14.7	5.5	203
Bremerton, WA	3.2	5.5	5.5	204
Charleston, WV	4.9	8.4	5.5	205
Fresno, CA	15.5	26.3	5.4	206
Stockton-Lodi, CA	9.6	16.2	5.4	207
Detroit, MI	92.3	156.3	5.4	208
Cincinnati, OH-KY-IN	35.2	59.4	5.4	209
Allentown-Bethlehem-Easton, PA	12.2	20.6	5.4	210
Altoona, PA	2.5	4.2	5.4	211
Erie, PA	5.8	9.8	5.4	212
York, PA	7.4	12.5	5.4	213
Gadsden, AL	1.5	2.5	5.3	214

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT	45.7	76.8	5.3	215
Augusta-Aiken, GA-SC	8.8	14.8	5.3	216
Kokomo, IN	2.2	3.7	5.3	217
Hickory-Morganton, NC	7.6	12.8	5.3	218
Akron, OH	13.0	21.9	5.3	219
Cleveland-Lorain-Elyria, OH	48.1	80.8	5.3	220
Oakland, CA	55.4	92.1	5.2	221
Santa Barbara-Santa Maria-Lompoc, CA	10.4	17.2	5.2	222
South Bend, IN	5.1	8.5	5.2	223
Kalamazoo-Battle Creek, MI	9.5	15.7	5.2	224
St. Louis, MO-IL	54.1	89.6	5.2	225
Atlantic-Cape May, NJ	9.5	15.7	5.2	226
Grand Forks, ND-MN	1.7	2.8	5.2	227
Pittsburgh, PA	48.6	80.7	5.2	228
Wichita Falls, TX	2.9	4.9	5.2	229
Burlington, VT	4.2	7.0	5.2	230
Milwaukee-Waukesha, WI	32.9	54.8	5.2	231
Huntsville, AL	6.5	10.6	5.1	232
Melbourne-Titusville-Palm Bay, FL	7.3	12.0	5.1	233
Miami, FL	43.5	71.6	5.1	234
Jackson, MI	2.7	4.4	5.1	235
Glens Falls, NY	2.7	4.5	5.1	236
Nassau-Suffolk, NY	64.8	106.8	5.1	237
Goldsboro, NC	1.8	2.9	5.1	238
Oklahoma City, OK	19.7	32.3	5.1	239
Texarkana, AR-TX	2.2	3.6	5.0	240
Lansing-East Lansing, MI	9.9	16.1	5.0	241
Saginaw-Bay City-Midland, MI	7.8	12.7	5.0	242
Trenton, NJ	11.4	18.5	5.0	243
Elmira, NY	2.3	3.7	5.0	244
New York, NY	269.6	437.8	5.0	245
Utica-Rome, NY	7.3	11.9	5.0	246
Tulsa, OK	15.8	25.7	5.0	247
Scranton-Wilkes-Barre-Hazelton, PA	12.6	20.6	5.0	248
Williamsport, PA	2.5	4.1	5.0	249
Brazoria, TX	3.8	6.2	5.0	250
Racine, WI	3.2	5.3	5.0	251
Florence, AL	2.1	3.4	4.9	252
Alexandria, LA	2.2	3.6	4.9	253
Lewiston-Auburn, ME	1.9	3.0	4.9	254
Benton Harbor, MI	3.3	5.3	4.9	255
Great Falls, MT	1.2	2.0	4.9	256
Toledo, OH	13.2	21.2	4.9	257

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
Youngstown-Warren, OH	10.0	16.2	4.9	258
Philadelphia, PA-NJ	112.9	182.4	4.9	259
Providence-Warwick, RI	20.0	32.5	4.9	260
Charlottesville, VA	3.9	6.3	4.9	261
San Francisco, CA	67.2	107.3	4.8	262
Kankakee, IL	2.0	3.2	4.8	263
Newark, NJ	60.2	96.3	4.8	264
Albany-Schenectady-Troy, NY	23.7	37.8	4.8	265
Springfield, IL	7.2	11.4	4.7	266
Muncie, IN	2.2	3.6	4.7	267
Dubuque, IA	2.0	3.1	4.7	268
Sioux City, IA-NE	2.6	4.1	4.7	269
Topeka, KS	4.1	6.5	4.7	270
Wichita, KS	11.0	17.5	4.7	271
Rochester, NY	29.0	45.7	4.7	272
Enid, OK	1.1	1.7	4.7	273
Johnstown, PA	4.2	6.7	4.7	274
Cheyenne, WY	1.7	2.6	4.7	275
Anniston, AL	1.9	3.0	4.6	276
Dothan, AL	2.6	4.1	4.6	277
Bakersfield, CA	12.1	18.9	4.6	278
Monroe, LA	3.2	5.0	4.6	279
Bergen-Passaic, NJ	37.9	59.3	4.6	280
Jamestown, NY	3.1	4.9	4.6	281
Canton-Massillon, OH	8.1	12.7	4.6	282
Parkersburg-Marietta, WV-OH	2.9	4.5	4.6	283
Pine Bluff, AR	1.3	2.1	4.5	284
Davenport-Moline-Rock Isld, IA-IL	8.3	13.0	4.5	285
Lake Charles, LA	4.0	6.2	4.5	286
Baltimore, MD	62.0	96.2	4.5	287
Vineland-Millville-Bridgeton, NJ	3.6	5.6	4.5	288
Buffalo-Niagara Falls, NY	30.9	47.8	4.5	289
Danville, VA	2.3	3.6	4.5	290
Casper, WY	1.9	2.9	4.5	291
Hartford, CT	41.8	64.3	4.4	292
Champaign-Urbana, IL	3.7	5.7	4.4	293
Gary, IN	10.4	16.1	4.4	294
Terre Haute, IN	2.7	4.2	4.4	295
Bangor, ME	2.8	4.3	4.4	296
Pittsfield, MA	3.2	5.0	4.4	297
Springfield, MA	13.6	20.9	4.4	298
Huntington-Ashland, WV-KY-OH	5.0	7.6	4.4	299
Cumberland, MD-WV	1.8	2.8	4.3	300

Nominal Gross Product	1990	2000	Avg. Annual Growth Rate	Rank
(Billions, $Current)			(%)	
St. Joseph, MO	1.9	3.0	4.3	301
Rocky Mount, NC	3.1	4.7	4.3	302
Dayton-Springfield, OH	20.4	31.2	4.3	303
Rockford, IL	9.5	14.3	4.2	304
Syracuse, NY	19.9	30.1	4.2	305
Wheeling, WV-OH	2.8	4.2	4.2	306
Lima, OH	3.6	5.4	4.1	307
Lawton, OK	1.6	2.4	4.0	308
Binghamton, NY	6.7	9.9	3.9	309
Mansfield, OH	3.9	5.7	3.9	310
New Orleans, LA	32.3	46.5	3.7	311
Flint, MI	7.9	11.3	3.7	312
Shreveport-Bossier City, LA	8.7	12.3	3.6	313
Decatur, IL	3.2	4.5	3.5	314
Dutchess County, NY	6.7	9.5	3.5	315
Los Angeles-L Beach, CA	261.7	363.7	3.3	316
Steubenville-Weirton, OH-WV	2.6	3.5	3.1	317
Honolulu, HI	25.1	33.0	2.8	318
Anchorage, AK	10.5	12.8	2.1	319

Table 9 – Gross Product of Countries, U.S. States, and Metro Areas

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
1	United States	9963.050
2	Japan	4614.069
3	Germany	1872.608
4	United Kingdom	1410.153
5	California	1301.735
6	France	1285.747
7	China	1103.716
8	Italy	1074.097
9	New York	806.242
10	Texas	760.645
11	Canada	699.339
12	Brazil	665.287
13	Mexico	577.650
14	Spain	556.562
15	India	510.106
16	Florida	483.245
17	Korea, South	480.176
18	Illinois	472.154
19	**New York, NY**	437.777
20	Australia	427.864
21	Pennsylvania	412.657
22	Ohio	380.597
23	New Jersey	364.535
24	**Los Angeles-L Beach, CA**	363.688
25	Netherlands	360.237
26	**Chicago, IL**	332.812
27	Michigan	328.171
28	Taiwan	322.803
29	Georgia	292.877
30	Argentina	283.686
31	Massachusetts	274.769
32	North Carolina	266.614
33	Virginia	264.856
34	Russia	246.767
35	Switzerland	241.279
36	**Boston, MA**	238.831
37	Belgium	227.049
38	Sweden	224.065
39	Turkey	217.583
40	**Washington, DC-MD-VA-WV**	217.045
41	Washington	216.968

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
42	Indiana	194.632
43	Maryland	187.315
44	Austria	184.944
45	Minnesota	183.901
46	**Philadelphia, PA-NJ**	182.353
47	Missouri	181.341
48	Tennessee	180.165
49	Wisconsin	178.831
50	**Houston, TX**	177.549
51	Colorado	166.241
52	Hong Kong	164.631
53	**Atlanta, GA**	164.234
54	Norway	164.034
55	Poland	162.697
56	Connecticut	160.556
57	**Dallas, TX**	159.951
58	Arizona	158.508
59	Denmark	157.982
60	**Detroit, MI**	156.286
61	Louisiana	149.191
62	Indonesia	147.616
63	Saudi Arabia	145.344
64	South Africa	132.267
65	**Orange Co, CA**	129.991
66	Thailand	128.236
67	Kentucky	122.586
68	Alabama	121.812
69	**Minneapolis-St. Paul, MN-WI**	121.256
70	Oregon	118.345
71	Finland	118.018
72	South Carolina	115.180
73	**Seattle-Bellevue-Everett, WA**	115.041
74	**Phoenix-Mesa, AZ**	114.235
75	Greece	110.870
76	Israel	107.966
77	**San Francisco, CA**	107.334
78	**Nassau-Suffolk, NY**	106.819
79	**San Diego, CA**	104.588
80	Venezuela	102.937
81	Portugal	100.508
82	**Newark, NJ**	96.275
83	**Baltimore, MD**	96.231

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
84	Ireland	95.143
85	Iowa	93.954
86	Singapore	93.665
87	Oklahoma	93.505
88	**Oakland, CA**	92.113
89	Egypt	91.452
90	**Denver, CO**	91.100
91	Colombia	90.033
92	**St. Louis, MO-IL**	89.565
93	Malaysia	88.813
94	Kansas	86.041
95	**San Jose, CA**	85.382
96	**Riverside-San Bernardino, CA**	84.106
97	**Tampa-St Petersb-Clrwater, FL**	82.233
98	**Cleveland-Lorain-Elyria, OH**	80.754
99	**Pittsburgh, PA**	80.742
100	Philippines	77.995
101	**N Haven-BrPt-Stmfd-Dbry-Wtrbry, CT**	76.780
102	Nevada	75.997
103	Chile	72.962
104	**Miami, FL**	71.631
105	**Portland-Vancouver, OR-WA**	71.536
106	Arkansas	69.341
107	Mississippi	68.846
108	Utah	68.639
109	Iran	67.107
110	Puerto Rico	65.329
111	**Kansas City, MO-KS**	64.816
112	**Hartford, CT**	64.296
113	**Middlesex-Somerset-Hunterdon, NJ**	63.616
114	**Sacramento, CA**	63.099
115	**Fort Worth-Arlington, TX**	63.012
116	Pakistan	62.748
117	Peru	62.746
118	D. C.	61.279
119	**Charlotte-Gastonia-R Hill, NC-SC**	61.270
120	**Columbus, OH**	60.745
121	United Arab	60.722
122	**Orlando, FL**	59.470
123	**Cincinnati, OH-KY-IN**	59.392
124	**Bergen-Passaic, NJ**	59.280
125	Nebraska	58.561

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
126	**Indianapolis, IN**	57.657
127	New Mexico	56.108
128	Nigeria	54.875
129	**Milwaukee-Waukesha, WI**	54.752
130	**Las Vegas, NV-AZ**	54.621
131	**San Antonio, TX**	53.749
132	Algeria	52.800
133	New Zealand	52.126
134	**Norfolk-Va Beach-Newport News, VA-NC**	51.694
135	Czech	50.805
136	**Austin-San Marcos, TX**	48.154
137	**Buffalo-Niagara Falls, NY**	47.844
138	New Hampshire	47.810
139	Hungary	47.371
140	**Fort Lauderdale, FL**	46.680
141	**New Orleans, LA**	46.532
142	**Salt Lake City-Ogden, UT**	46.407
143	**Greensboro-W-Salem-High Point,NC**	46.332
144	**Rochester, NY**	45.738
145	**Richmond-Petersburg, VA**	45.679
146	West Virginia	45.517
147	**Nashville, TN**	45.214
148	**Raleigh-Durham-Chapel Hill, NC**	44.271
149	Hawaii	43.759
150	**Jacksonville, FL**	42.990
151	**Gr Rapids-Muskegon-Holland, MI**	42.348
152	**Memphis, TN-AR-MS**	38.941
153	**Louisville, KY-IN**	38.651
154	Bangladesh	38.513
155	Delaware	38.501
156	Kuwait	38.048
157	**Albany-Schenectady-Troy, NY**	37.790
158	Maine	37.579
159	Idaho	36.949
160	Syria	35.528
161	Morocco	34.807
162	Rhode Island	34.780
163	**W Palm Beach-Boca Raton, FL**	33.181
164	Romania	33.033
165	**Honolulu, HI**	32.973
166	**Monmouth-Ocean, NJ**	32.953
167	**Providence-Warwick, RI**	32.463

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
168	**Oklahoma City, OK**	32.350
169	**Birmingham, AL**	31.961
170	Ukraine	31.651
171	**Wilmington-Newark, DE**	31.363
172	**Dayton-Springfield, OH**	31.164
173	Vietnam	30.624
174	**Manchester-Nashua, NH**	30.172
175	Alaska	30.065
176	**Syracuse, NY**	30.063
177	**Greenville-Spartanburg-Anderson, SC**	29.862
178	**Jersey City, NJ**	28.147
179	**Harrisburg-Lebanon-Carlisle, PA**	27.076
180	**Fresno, CA**	26.314
181	**Omaha, NE-IA**	26.184
182	**Tulsa, OK**	25.725
183	**Albuquerque, NM**	25.636
184	Iraq	25.487
185	South Dakota	25.170
186	**Ventura, CA**	24.464
187	Wyoming	23.122
188	Montana	22.908
189	**Tucson, AZ**	22.878
190	**Akron, OH**	21.857
191	**Knoxville, TN**	21.516
192	**Toledo, OH**	21.190
193	**Springfield, MA**	20.929
194	**Allentown-Bethlehem-Easton, PA**	20.647
195	**Scranton-Wilkes-Barre-Hazelton, PA**	20.625
196	**Santa Rosa, CA**	20.511
197	Uruguay	20.494
198	**Baton Rouge, LA**	20.389
199	Slovakia	20.169
200	Tunisia	19.965
201	Dominican Republic	19.669
202	North Dakota	19.312
203	**Columbia, SC**	19.139
204	**Ann Arbor, MI**	19.098
205	**Des Moines, IA**	19.073
206	Guatemala	19.050
207	**Tacoma, WA**	19.034
208	Croatia (Hrvatska)	18.951
209	**Bakersfield, CA**	18.920

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
210	Oman	18.818
211	**El Paso, TX**	18.607
212	Vermont	18.582
213	**Fort Wayne, IN**	18.562
214	**Trenton, NJ**	18.504
215	Slovenia	18.465
216	**Madison, WI**	18.446
217	**Little Rock-N. L.Rock, AR**	18.367
218	Kazakhstan	18.242
219	**Lafayette, LA**	18.214
220	Luxembourg	18.098
221	**Lexington, KY**	17.761
222	**Colorado Springs, CO**	17.559
223	**Wichita, KS**	17.464
224	**Chattanooga, TN-GA**	17.455
225	Lebanon	17.357
226	**Santa Barbara-Santa Maria-Lompoc, CA**	17.226
227	**Sarasota-Bradenton, FL**	16.928
228	**Lancaster, PA**	16.537
229	Sri Lanka	16.467
230	**Youngstown-Warren, OH**	16.229
231	**Stockton-Lodi, CA**	16.212
232	**Lansing-East Lansing, MI**	16.139
233	**Gary, IN**	16.131
234	Costa Rica	16.022
235	**Kalamazoo-Battle Creek, MI**	15.742
236	**Atlantic-Cape May, NJ**	15.708
237	**Spokane, WA**	15.408
238	**Modesto, CA**	14.963
239	**Augusta-Aiken, GA-SC**	14.831
240	**Charleston-N Charleston, SC**	14.708
241	**Reno, NV**	14.654
242	Qatar	14.576
243	**Vallejo-Fairfield-Napa, CA**	14.480
244	**Boise City, ID**	14.443
245	**Rockford, IL**	14.273
246	**Jackson, MS**	14.265
247	**Mobile, AL**	14.024
248	**Johnson City-Kingspt-Bristol, TN-VA**	13.900
249	**Salinas, CA**	13.815
250	**Appleton-Oshkosh-Neenah, WI**	13.465
251	**Peoria-Pekin, IL**	13.305

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
252	El Salvador	13.217
253	**Reading, PA**	13.037
254	Ecuador	13.036
255	**Lakeland-Winter Haven, FL**	13.034
256	**Davenport-Moline-Rock Isld, IA-IL**	12.951
257	**Hickory-Morganton, NC**	12.824
258	**Anchorage, AK**	12.809
259	**Saginaw-Bay City-Midland, MI**	12.744
260	**Canton-Massillon, OH**	12.704
261	**Roanoke, VA**	12.641
262	**Corpus Christi, TX**	12.612
263	**York, PA**	12.471
264	**Beaumont-Port Arthur, TX**	12.430
265	**Shreveport-Bossier City, LA**	12.344
266	Uzbekistan	12.299
267	**Odessa-Midland, TX**	12.269
268	Bulgaria	12.228
269	**Macon, GA**	12.017
270	**Melbourne-Titusville-Palm Bay, FL**	12.005
271	**Boulder-Longmont, CO**	12.003
272	**Portland, ME**	11.981
273	**Utica-Rome, NY**	11.905
274	**Springfield, IL**	11.408
275	**Flint, MI**	11.348
276	**Fort Myers-Cape Coral, FL**	11.304
277	Lithuania	11.225
278	Sudan	10.984
279	**Newburgh, NY-PA**	10.947
280	Cote d'Ivoire	10.930
281	**Springfield, MO**	10.786
282	**McAllen-Edinburg-Mission, TX**	10.786
283	Belarus	10.782
284	Kenya	10.601
285	**Huntsville, AL**	10.574
286	**Evansville-Henderson, IN-KY**	10.540
287	**Savannah, GA**	10.510
288	**Pensacola, FL**	10.505
289	**Visalia-Tulare-Porterville, CA**	10.459
290	**Eugene-Springfield, OR**	10.393
291	**Montgomery, AL**	10.386
292	**Daytona Beach, FL**	10.356
293	**New London-Norwich, CT**	10.342

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
294	**Tallahassee, FL**	10.165
295	Cuba	10.068
296	**S L Obispo-Atascadero-Paso Robles, CA**	10.066
297	**Green Bay, WI**	9.987
298	**Salem, OR**	9.945
299	**Binghamton, NY**	9.859
300	**Erie, PA**	9.800
301	**Columbus, GA-AL**	9.790
302	Cameroon	9.671
303	Myanmar	9.609
304	**Lincoln, NE**	9.577
305	**Santa Cruz-Watsonville, CA**	9.530
306	**Dutchess County, NY**	9.464
307	**Biloxi-Gulfport-Pascagoula, MS**	9.438
308	Tanzania	9.315
309	Iceland	9.167
310	**Fayetteville-Springdale-Rogers, AR**	9.033
311	Cyprus	8.935
312	**Elkhart-Goshen, IN**	8.874
313	**Yolo, CA**	8.859
314	**Hamilton-Middletown, OH**	8.577
315	**Houma, LA**	8.559
316	Bolivia	8.544
317	**Longview-Marshall, TX**	8.543
318	**South Bend, IN**	8.539
319	**Lubbock, TX**	8.536
320	**Lynchburg, VA**	8.473
321	**Charleston, WV**	8.439
322	**Fort Collins-Loveland, CO**	8.343
323	**Provo-Orem, UT**	8.280
324	**Bloomington-Normal, IL**	8.201
325	**Duluth-Superior, MN-WI**	8.153
326	**Sioux Falls, SD**	7.993
327	Yemen (Unified)	7.957
328	**Waco, TX**	7.827
329	Jordan	7.750
330	**Wilmington, NC**	7.724
331	**Cedar Rapids, IA**	7.698
332	**Gainesville, FL**	7.696
333	**Huntington-Ashland, WV-KY-OH**	7.606
334	Zimbabwe	7.605
335	**Amarillo, TX**	7.533

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
336	Paraguay	7.490
337	**Asheville, NC**	7.485
338	**Brownsv-Harlingen-San Benito, TX**	7.484
339	**Chico-Paradise, CA**	7.469
340	Libyan Arab Jamahiriya	7.467
341	Panama	7.342
342	Federal Republic of Yugoslavia	7.338
343	Trinidad & Tobago	7.283
344	**Killeen-Temple, TX**	7.254
345	**Galveston-Texas City, TX**	7.231
346	Jamaica	7.179
347	Latvia	7.150
348	Bahrain	7.111
349	**Fayetteville, NC**	7.062
350	**Burlington, VT**	7.000
351	**Myrtle Beach, SC**	6.922
352	**Naples, FL**	6.811
353	**Tyler, TX**	6.807
354	Ethiopia	6.800
355	**Barnstable-Yarmouth, MA**	6.787
356	**Fort Pierce-Port St. Lucie, FL**	6.673
357	**Johnstown, PA**	6.654
358	**Laredo, TX**	6.568
359	**Topeka, KS**	6.539
360	**Redding, CA**	6.452
361	**Olympia, WA**	6.374
362	**Charlottesville, VA**	6.332
363	**Fort Smith, AR-OK**	6.306
364	Ghana	6.303
365	**Lake Charles, LA**	6.212
366	**Yakima, WA**	6.211
367	Uganda	6.195
368	**Richland-Kennewick-Pasco, WA**	6.165
369	**Brazoria, TX**	6.163
370	**Merced, CA**	6.060
371	**St. Cloud, MN**	5.959
372	**Lafayette, IN**	5.936
373	Honduras	5.932
374	**Ocala, FL**	5.928
375	**Fargo-Moorhead, ND-MN**	5.834
376	**Champaign-Urbana, IL**	5.731
377	**Mansfield, OH**	5.722

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Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
378	**Vineland-Millville-Bridgeton, NJ**	5.568
379	**Joplin, MO**	5.510
380	**Bremerton, WA**	5.471
381	Nepal	5.418
382	**Athens, GA**	5.410
383	**Lima, OH**	5.370
384	**Bellingham, WA**	5.364
385	Botswana	5.360
386	**Bryan-College Station, TX**	5.319
387	**Rochester, MN**	5.307
388	**Benton Harbor, MI**	5.287
389	**Racine, WI**	5.268
390	**Greeley, CO**	5.242
391	Brunei Darussalam	5.210
392	Gabon	5.210
393	**Fort Walton Beach, FL**	5.126
394	**Medford-Ashford, OR**	5.094
395	**Tuscaloosa, AL**	5.017
396	**Monroe, LA**	4.986
397	**Pittsfield, MA**	4.979
398	**Columbia, MO**	4.976
399	West Bank and Gaza	4.939
400	Estonia	4.922
401	**Jamestown, NY**	4.918
402	Azerbaijan	4.896
403	**Wichita Falls, TX**	4.852
404	**Hagerstown, MD**	4.821
405	**Wausau, WI**	4.796
406	**Eau Claire, WI**	4.794
407	**Florence, SC**	4.710
408	**Rocky Mount, NC**	4.669
409	Mauritius	4.601
410	**Albany, GA**	4.570
411	**Abilene, TX**	4.561
412	**La Crosse, WI-MN**	4.548
413	**Decatur, IL**	4.544
414	Senegal	4.530
415	**Parkersburg-Marietta, WV-OH**	4.528
416	**Janesville-Beloit, WI**	4.496
417	**Clarksville-Hopkinsville, TN-KY**	4.493
418	**Panama City, FL**	4.492
419	**Santa Fe, NM**	4.485

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
420	**Glens Falls, NY**	4.472
421	**Jackson, MI**	4.443
422	**State College, PA**	4.437
423	Angola	4.426
424	Turkmenistan	4.404
425	**Waterloo-Cedar Falls, IA**	4.401
426	**Bangor, ME**	4.302
427	**Wheeling, WV-OH**	4.233
428	**Altoona, PA**	4.212
429	**Terre Haute, IN**	4.198
430	Bahamas	4.185
431	**Greenville, NC**	4.179
432	Mozambique	4.170
433	**Pueblo, CO**	4.159
434	**Dothan, AL**	4.139
435	**Sheboygan, WI**	4.121
436	**Williamsport, PA**	4.091
437	**Sioux City, IA-NE**	4.085
438	**Jackson, TN**	4.044
439	Albania	3.894
440	**Billings, MT**	3.843
441	**Dover, DE**	3.830
442	**Bloomington, IN**	3.795
443	Madagascar	3.792
444	**Grand Junction, CO**	3.756
445	**Flagstaff, AZ-UT**	3.746
446	**Yuba City, CA**	3.713
447	**San Angelo, TX**	3.701
448	**Elmira, NY**	3.697
449	**Kokomo, IN**	3.690
450	**Decatur, AL**	3.675
451	Papua New Guinea	3.670
452	**Sherman-Denison, TX**	3.618
453	**Danville, VA**	3.596
454	**Texarkana, AR-TX**	3.591
455	**Muncie, IN**	3.565
456	**Sharon, PA**	3.564
457	**Las Cruces, NM**	3.560
458	**Alexandria, LA**	3.551
459	Malta	3.534
460	**Steubenville-Weirton, OH-WV**	3.526
461	**Iowa City, IA**	3.523

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
462	Namibia	3.505
463	**Florence, AL**	3.423
464	Macedonia	3.408
465	**Victoria, TX**	3.332
466	Congo, Dem. Repub. of	3.278
467	**Kankakee, IL**	3.241
468	**Kenosha, WI**	3.211
469	Guinea	3.210
470	Georgia	3.147
471	**Dubuque, IA**	3.141
472	Cambodia	3.121
473	Zambia	3.096
474	Haiti	3.090
475	**Lewiston-Auburn, ME**	3.009
476	**Rapid City, SD**	3.006
477	**Anniston, AL**	3.000
478	**Hattiesburg, MS**	2.993
479	**St. Joseph, MO**	2.959
480	**Owensboro, KY**	2.950
481	**Goldsboro, NC**	2.928
482	Congo, Republic of	2.919
483	**Casper, WY**	2.875
484	**Bismarck, ND**	2.856
485	**Sumter, SC**	2.790
486	**Cumberland, MD-WV**	2.785
487	**Missoula, MT**	2.779
488	**Grand Forks, ND-MN**	2.765
489	**Lawrence, KS**	2.737
490	Barbados	2.685
491	**Corvallis, OR**	2.681
492	**Yuma, AZ**	2.677
493	Bermuda	2.674
494	**Cheyenne, WY**	2.640
495	**Jacksonville, NC**	2.513
496	Nicaragua	2.502
497	**Auburn-Opelika, AL**	2.484
498	**Gadsden, AL**	2.466
499	Burkina Faso	2.443
500	**Punta Gorda, FL**	2.429
501	Mali	2.399
502	**Lawton, OK**	2.369
503	Benin	2.267

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
504	**Jonesboro, AR**	2.266
505	Liechtenstein	2.248
506	Netherlands Antilles	2.061
507	**Pine Bluff, AR**	2.052
508	Malawi	1.994
509	**Great Falls, MT**	1.978
510	Fiji	1.971
511	Aruba	1.962
512	Rwanda	1.947
513	Armenia	1.919
514	**Pocatello, ID**	1.906
515	**Enid, OK**	1.696
516	Somalia	1.672
517	Niger	1.592
518	Cayman Islands	1.586
519	Chad	1.467
520	Kyrgyzstan	1.304
521	Moldova	1.300
522	Togo	1.294
523	Afghanistan	1.271
524	Swaziland	1.223
525	Lao People's Dem. Repub.	1.088
526	Mongolia	1.029
527	Equatorial Guinea	1.010
528	Tajikistan	1.010
529	Central African Republic	0.989
530	Lesotho	0.946
531	Mauritania	0.905
532	Burundi	0.771
533	Guyana	0.749
534	Eritrea	0.748
535	Belize	0.736
536	Saint Lucia	0.701
537	Antigua & Barbuda	0.687
538	Suriname	0.649
539	Seychelles	0.628
540	Sierra Leone	0.591
541	Djibouti	0.561
542	Cape Verde	0.513
543	Bhutan	0.470
544	Gambia	0.448
545	Maldives	0.443

Gross Product, 2000 (US$ Billions, Current)		
Rank	Country, State, or **Metro Area**	Gross Product
546	Grenada	0.417
547	Solomon Islands	0.386
548	Saint Kitts and Nevis	0.325
549	Saint Vincent and the Grenadines	0.325
550	Dominica	0.282
551	Guinea-Bissau	0.225
552	Vanuatu	0.225
553	Samoa	0.193
554	Comoros	0.177
555	Sao Tome and Principe	0.049

Table 10 - Metro Area Shares of U.S. Production

Shares of U.S. Gross Product (2000) (Billions)	Metro Areas	Rest of United States	United States
Agriculture, Forestry, Fishing	$49	$95	$144
Percentage	34%	66%	
Mining	$102	$72	$174
Percentage	58%	42%	
Construction	$371	$61	$432
Percentage	86%	14%	
Manufacturing	$1,264	$346	$1,610
Percentage	79%	21%	
Transportation & Utilities	$744	$108	$852
Percentage	87%	13%	
Trade	$1,354	$239	$1,586
Percentage	85%	15%	
Financial Services	$1,767	$155	$1,922
Percentage	92%	8%	
Services	$1,895	$232	$2,127
Percentage	89%	11%	
Government	$929	$225	$1,154
Percentage	81%	19%	

Top 100 U.S. Metro Economies

CONFERENCE OF MAYORS

RANKING (2000)

GROSS METROPOLITAN PRODUCT (GMP), US$ BILLIONS

Rank	U.S. City/County Metro Areas	GMP 2000	Rank	U.S. City/County Metro Areas	GMP 2000
1	New York, NY	437.8	51	Greensboro-W-Salem-High Point,NC	46.3
2	Los Angeles-L Beach, CA	363.7	52	Rochester, NY	45.7
3	Chicago, IL	332.8	53	Richmond-Petersburg, VA	45.7
4	Boston, MA	238.8	54	Nashville, TN	45.2
5	Washington, DC-MD-VA-WV	217.0	55	Raleigh-Durham-Chapel Hill, NC	44.3
6	Philadelphia, PA-NJ	182.4	56	Jacksonville, FL	43.0
7	Houston, TX	177.5	57	Gr Rapids-Muskegon-Holland, MI	42.3
8	Atlanta, GA	164.2	58	Memphis, TN-AR-MS	38.9
9	Dallas, TX	160.0	59	Louisville, KY-IN	38.7
10	Detroit, MI	156.3	60	Albany-Schenectady-Troy, NY	37.8
11	Orange Co, CA	130.0	61	W Palm Beach-Boca Raton, FL	33.2
12	Minneapolis-St. Paul, MN-WI	121.3	62	Honolulu, HI	33.0
13	Seattle-Bellevue-Everett, WA	115.0	63	Monmouth-Ocean, NJ	33.0
14	Phoenix-Mesa, AZ	114.2	64	Providence-Warwick, RI	32.5
15	San Francisco, CA	107.3	65	Oklahoma City, OK	32.3
16	Nassau-Suffolk, NY	106.8	66	Birmingham, AL	32.0
17	San Diego, CA	104.6	67	Wilmington-Newark, DE	31.4
18	Newark, NJ	96.3	68	Dayton-Springfield, OH	31.2
19	Baltimore, MD	96.2	69	Manchester-Nashua, NH	30.2
20	Oakland, CA	92.1	70	Syracuse, NY	30.1
21	Denver, CO	91.1	71	Greenville-Spartanburg-Anderson, SC	29.9
22	St. Louis, MO-IL	89.6	72	Jersey City, NJ	28.1
23	San Jose, CA	85.4	73	Harrisburg-Lebanon-Carlisle, PA	27.1
24	Riverside-San Bernardino, CA	84.1	74	Fresno, CA	26.3
25	Tampa-St. Petersburg-Clrwater, FL	82.2	75	Omaha, NE-IA	26.2
26	Cleveland-Lorain-Elyria, OH	80.8	76	Tulsa, OK	25.7
27	Pittsburgh, PA	80.7	77	Albuquerque, NM	25.6
28	New Haven-BrPt-Stamford-Danbury-Waterbury, CT	76.8	78	Ventura, CA	24.5
29	Miami, FL	71.6	79	Tucson, AZ	22.9
30	Portland-Vancouver, OR-WA	71.5	80	Akron, OH	21.9
31	Kansas City, MO-KS	64.8	81	Knoxville, TN	21.5
32	Hartford, CT	64.3	82	Toledo, OH	21.2
33	Middlesex-Somerset-Hunterdon, NJ	63.6	83	Springfield, MA	20.9
34	Sacramento, CA	63.1	84	Allentown-Bethlehem-Easton, PA	20.6
35	Fort Worth-Arlington, TX	63.0	85	Scranton-Wilkes-Barre-Hazelton, PA	20.6
36	Charlotte-Gastonia-Rock Hill, NC-SC	61.3	86	Santa Rosa, CA	20.5
37	Columbus, OH	60.7	87	Baton Rouge, LA	20.4
38	Orlando, FL	59.5	88	Des Moines, IA	19.1
39	Cincinnati, OH-KY-IN	59.4	89	Ann Arbor, MI	19.1
40	Bergen-Passaic, NJ	59.3	90	Columbia, SC	19.1
41	Indianapolis, IN	57.7	91	Tacoma, WA	19.0
42	Milwaukee-Waukesha, WI	54.8	92	Bakersfield, CA	18.9
43	Las Vegas, NV-AZ	54.6	93	Fort Wayne, IN	18.6
44	San Antonio, TX	53.7	94	El Paso, TX	18.6
45	Norfolk-Virginia Beach-Newport News, VA-NC	51.7	95	Trenton, NJ	18.5
46	Austin-San Marcos, TX	48.2	96	Little Rock-North Little Rock, AR	18.4
47	Buffalo-Niagara Falls, NY	47.8	97	Madison, WI	18.4
48	Fort Lauderdale, FL	46.7	98	Lafayette, LA	18.2
49	New Orleans, LA	46.5	99	Lexington, KY	17.8
50	Salt Lake City-Ogden, UT	46.4	100	Colorado Springs, CO	17.6

*City/County Metros are the 319 metropolitan areas defined by U.S.OMB.

Source: DRI • WEFA

If U.S. City/County Metro Economies Were Nations

THE UNITED STATES CONFERENCE OF MAYORS

World Rankings on Gross Domestic and Metropolitan Product 2000 (U.S. Billions, Current)

Rank	Nation or Metro Area	GP 2000
1	United States	9,963.00
2	Japan	4,614.00
3	Germany	1,873.00
4	United Kingdom	1,410.00
5	France	1,286.00
6	China	1,104.00
7	Italy	1,074.00
8	Canada	699.00
9	Brazil	665.00
10	Mexico	578.00
11	Spain	557.00
12	India	510.00
13	Korea, South	480.00
14	New York, NY	437.80
15	Australia	428.00
16	Los Angeles-Long Beach, CA	363.70
17	Netherlands	360.00
18	Chicago, IL	332.80
19	Taiwan	323 00
20	Argentina	284.00
21	Russia	247.00
22	Switzerland	241.30
23	Boston, MA	238.80
24	Belgium	227.00
25	Sweden	224.10
26	Turkey	217.60
27	Washington, DC-MD-VA-WV	217.00
28	Austria	184.90
29	Philadelphia, PA-NJ	182.40
30	Houston, TX	177.50
31	Hong Kong	164.60
32	Atlanta, GA	164.20
33	Norway	164.00
34	Poland	163.00
35	Dallas, TX	160.00
36	Denmark	158.00
37	Detroit, MI	156.30
38	Indonesia	147.60
39	Saudi Arabia	145.30
40	South Africa	132.30
41	Orange County, CA	130.00
42	Thailand	128.20
43	Minneapolis-St. Paul, MN-WI	121.30
44	Finland	118.00
45	Seattle-Bellevue-Everett, WA	115.00
46	Phoenix-Mesa, AZ	114.20
47	Greece	110.90
48	Israel	108.00
49	SanFrancisco, CA	107.30
50	Nassau-Suffolk, NY	106.80
51	San Diego, CA	104.60
52	Venezuela	102.90
53	Portugal	100.50
54	Newark, NJ	96.30
55	Baltimore, MD	96.20
56	Ireland	95.10
57	Singapore	93.70
58	Oakland, CA	92.10
59	Egypt	91.50
60	Denver, CO	91.10
61	Colombia	90.00
62	St..Louis, MO-IL	89.60
63	Malaysia	88.80
64	SanJose, CA	85 40
65	Riverside-San Bernardino, CA	84.10
66	Tampa-StPetersb-Clrwater, FL	82.20
67	Cleveland-Lorain-Elyria, OH	80.80
68	Pittsburgh, PA	80.70
69	Philippines	78.00
70	New Haven-BrPt-Stamford-Danbury-Waterbury, CT	76 80
71	Chile	73.00
72	Miami, FL	71.60
73	Portland-Vancouver, OR-WA	71.50
74	Iran	67.10
75	Puerto Rico	65.30
76	Kansas City, MO-KS	64.80
77	Hartford, CT	64.30
78	Middlesex-Somerset-Hunterdon, NJ	63.60
79	Sacramento, CA	63.10
80	Fort Worth-Arlington, TX	63.00
81	Pakistan	62.70
82	Peru	62.70
83	Charlotte-Gastonia-Rock Hill, NC-SC	61.30
84	Columbus, OH	60.70
85	United Arab	60.70
86	Orlando, FL	59.50
87	Cincinnati, OH-KY-IN	59.40
88	Bergen-Passaic, NJ	59.30
89	Indianapolis, IN	57.70
90	Nigeria	54.90
91	Milwaukee-Waukesha, WI	54.80
92	Las Vegas, NV-AZ	54.60
93	San Antonio, TX	53.70
94	Algeria	52.80
95	New Zealand	52.10
96	Norfolk-Virginia Beach-Newport News, VA-NC	51.70
97	Czech	50.80
98	Austin-San Marcos, TX	48.20
99	Buffalo-Niagara Falls, NY	47.80
100	Hungary	47.40
101	Fort Lauderdale, FL	46.70
102	New Orleans, LA	46.50
103	Salt Lake City-Ogden, UT	46.40
104	Greensboro-Winston-Salem-HighPoint, NC	46.30
105	Rochester, NY	45.70
106	Richmond-Petersburg, VA	45.70
107	Nashville, TN	45 20
108	Raleigh-Durham-Chapel Hill, NC	44.30
109	Jacksonville, FL	43.00
110	GrRapids-Muskegon-Holland, MI	42.30
111	Memphis, TN-AR-MS	38.90
112	Louisville, KY-IN	38.70
113	Bangladesh	38.50
114	Kuwait	38.05
115	Albany-Schenectady-Troy, NY	37.80
116	Syria	35.53
117	Morocco	34.80
118	West Palm Beach-Boca Raton, FL	33.20
119	Honolulu, HI	33.00
120	Monmouth-Ocean, NJ	33.00
121	Romania	33.00
122	Providence-Warwick, RI	32.50
123	Oklahoma City, OK	32.30
124	Birmingham, AL	32.00
125	Ukraine	31.70
126	Wilmington-Newark, DE	31.40
127	Dayton-Springfield, OH	31.20
128	Vietnam	30.60
129	Manchester-Nashua, NH	30.20
130	Syracuse, NY	30.10
131	Greenville-Spartanburg-Anderson, SC	29 90
132	Jersey City, NJ	28 10
133	Harrisburg-Lebanon-Carlisle, PA	27 10
134	Fresno, CA	26 30
135	Omaha, NE-IA	26 [illegible]
136	Tulsa, OK	25 70
137	Albuquerque, NM	25 [illegible]
138	Iraq	25 50
139	Ventura, CA	24 50
140	Tucson, AZ	22 90
141	Akron, OH	21 90
142	Knoxville, TN	21 50
143	Toledo, OH	21 20
144	Springfield, MA	20 90
145	Allentown-Bethlehem-Easton, PA	20 60
146	Scranton-Wilkes-Barre-Hazelton, PA	20 60
147	Santa Rosa, CA	20 50
148	Uruguay	20 49
149	Baton Rouge, LA	20 40
150	Slovakia	20 20
151	Tunisia	19 96
152	Dominican Republic	19 67
153	Des Moines, IA	19 10
154	Ann Arbor, MI	19 10
155	Columbia, SC	19 10
156	Guatemala	19.05
157	Tacoma, WA	19 00
158	Croatia (Hrvatska)	19 00
159	Bakersfield, CA	18 90
160	Oman	18 82
161	Fort Wayne, IN	18 60
162	El Paso, TX	18.60
163	Trenton, NJ	18.50
164	Slovenia	18 47
165	Little Rock-North Little Rock, AR	18.40
166	Madison, WI	18.40
167	Lafayette, LA	18 20
168	Kazakhstan	18 20
169	Luxembourg	18 10
170	Lexington, KY	17 80
171	Colorado Springs, CO	17 60
172	Wichita, KS	17 50

City/County Metro Areas   Nations

Source: DRI • WEFA

R0011076

City/CountyMetros

GMP VS. GSP (2000)

The Gross Product of the ten largest City/County Metro areas* in the U.S. exceeds the combined output of the following 31 states.

Total Gross Metro Product $2.43 trillion		Total Gross State Product $2.39 trillion
New York, NY	> is greater than	Tennessee
Los Angeles-Long Beach, CA		Connecticut
Chicago, IL		Colorado
Boston, MA		Arizona
Washington, DC-MD-VA-WV		Louisiana
Philadelphia, PA-NJ		Alabama
Houston, TX		Kentucky
Atlanta, GA		South Carolina
Dallas, TX		Oregon
Detroit, MI		Iowa
		Oklahoma
		Kansas
		Nevada
		Mississippi
		Arkansas
		Utah
		Nebraska
		New Mexico
		West Virginia
		New Hampshire
		Hawaii
		Delaware
		Maine
		Idaho
		Rhode Island
		Alaska
		South Dakota
		Montana
		Wyoming
		North Dakota
		Vermont

*City/County Metros are the 319 metropolitan areas defined by U.S.OMB.

Source: DRI • WEFA

METROPOLITAN AREAS 1999

LISTS I-IV

Statistical Policy Office
Office of Management and Budget
Attachments to OMB Bulletin No. 99-04

FIPS Code	Area Title	CMSA, PMSA, MSA	Level	List	Specifying Definition and Central Cities
	California				
(0360)	(ANAHEIM-SANTA ANA)			II	(49 Los Angeles-Riverside-Orange County CMSA)
0680	BAKERSFIELD	MSA	B	I	
1620	CHICO-PARADISE	MSA	C	I	
2840	FRESNO	MSA	B	I	
49	LOS ANGELES-RIVERSIDE-ORANGE COUNTY	CMSA		II	
4480	LOS ANGELES-LONG BEACH	PMSA	A	II	(49 Los Angeles-Riverside-Orange County CMSA)
4940	MERCED	MSA	C	I	
5170	MODESTO	MSA	B	I	
5775	OAKLAND	PMSA	A	II	(84 San Francisco-Oakland-San Jose CMSA)
5945	ORANGE COUNTY	PMSA	A	II	(49 Los Angeles-Riverside-Orange County CMSA)
(6000)	(OXNARD-VENTURA)			II	(49 Los Angeles-Riverside-Orange County CMSA)
6690	REDDING	MSA	C	I	
6780	RIVERSIDE-SAN BERNARDINO	PMSA	A	II	(49 Los Angeles-Riverside-Orange County CMSA)
82	SACRAMENTO-YOLO	CMSA		II	
6920	SACRAMENTO	PMSA	A	II	(82 Sacramento-Yolo CMSA)
7120	SALINAS	MSA	B	I	
7320	SAN DIEGO	MSA	A	I	
84	SAN FRANCISCO-OAKLAND-SAN JOSE	CMSA		II	
7360	SAN FRANCISCO	PMSA	A	II	(84 San Francisco-Oakland-San Jose CMSA)
7400	SAN JOSE	PMSA	A	II	(84 San Francisco-Oakland-San Jose CMSA)
7460	SAN LUIS OBISPO-ATASCADERO-PASO ROBLES	MSA	C	I	
7480	SANTA BARBARA-SANTA MARIA-LOMPOC	MSA	B	I	
7485	SANTA CRUZ-WATSONVILLE	PMSA	C	II	(84 San Francisco-Oakland-San Jose CMSA)
7500	SANTA ROSA	PMSA	B	II	(84 San Francisco-Oakland-San Jose CMSA)
8120	STOCKTON-LODI	MSA	B	I	
8720	VALLEJO-FAIRFIELD-NAPA	PMSA	B	II	(84 San Francisco-Oakland-San Jose CMSA)
8735	VENTURA	PMSA	B	II	(49 Los Angeles-Riverside-Orange County CMSA)
8780	VISALIA-TULARE-PORTERVILLE	MSA	B	I	
9270	YOLO	PMSA	C	II	(82 Sacramento-Yolo CMSA)
9340	YUBA CITY	MSA	C	I	
	Colorado				
1125	BOULDER-LONGMONT	PMSA	C	II	(34 Denver-Boulder-Greeley CMSA)
1720	COLORADO SPRINGS	MSA	B	I	
34	DENVER-BOULDER-GREELEY	CMSA		II	
2080	DENVER	PMSA	A	II	(34 Denver-Boulder-Greeley CMSA)
2670	FORT COLLINS-LOVELAND	MSA	C	I	
2995	GRAND JUNCTION	MSA	D	I	
3060	GREELEY	PMSA	C	II	(34 Denver-Boulder-Greeley CMSA)
6560	PUEBLO	MSA	C	I	

R0011079

fourth largest economy in the world ($1.59 trillion), trailing only the U.S., Japan and Germany.

National

- The combined gross economic output of the top ten U.S. metro areas in 2000 was $2.43 trillion—an amount greater than the combined economic output of 31 states ($2.39 trillion).
- In 2000, U.S. metro areas contributed to the U.S. economy 84 percent of employment (111 million jobs); 85 percent of Gross Domestic Product ($8.476 trillion); and 88 percent of labor income ($4.22 trillion).
- Over the past decade, the majority of new jobs in the financial services and transportation and utilities sectors were created within cities: 88 percent, or 804,000 jobs in financial services, and 90 percent, or 1.116 million jobs in transportation and utilities.

The 1990s

- U.S. metro areas' contribution to Gross Domestic Product grew from 84.3 percent in 1990 to 84.7 percent in 2000 and is forecast to increase steadily over the next 25 years, reaching 86.9 percent in 2025.
- U.S. metro areas contributed an astounding 86 percent, or $3.66 trillion, of economic growth to the U.S. economy during the 1990s—an amount larger than the 2000 gross domestic product of Germany and the United Kingdom combined.
- Las Vegas (10.3%), Austin (9.8%), Boise (9.4%), Laredo (9.4%) and Phoenix (9.2%) had the fastest average annual growth rate for gross metropolitan product in the 1990s.

Mayors believe national and international economic policies must focus on the needs of the 319 economically potent metropolitan regions surveyed in the report. "We believe that the data we've seen sustain our call to the Congress and the Administration to support local and metropolitan economic growth by investing in transportation, distressed communities, and education and training," Morial said.

Nationwide Competitive Cities Tour

Mayor Morial also announced a nationwide "Competitive Cities Tour" to promote America's metro areas as competitive powerhouses in the national and international economic arenas.

The tour, scheduled to begin in September, will highlight the best practices and strategies employed by Mayors across the country to foster what Mayor Morial calls the *six keys to keeping cities competitive:*

- Safe streets and communities;
- A skilled workforce;
- The arts, as both a cultural/educational and economic force in communities;
- Strong infrastructure;
- Good, affordable housing; and
- Strong economies.

"America's cities are cultural destinations for people around the world," Morial said in his address. "Cities are economic powerhouses. You may not see it, but every day, in cities across the nation, Mayors are working to forge partnerships on the national and international economic stages. What does it mean when the City of Denver opens trade offices in London and China, or negotiates with airlines for international non-stop flights bringing tourism and business travel into the city? Or when the Mayor of Akron brokers an agreement which locates a German business in that city, bringing with it 70 new jobs and millions of dollars annually in economic output?

"It might mean, if you really think about it, that there are a number of Mayors in this country who are taking their rightful places as world economic leaders. Because of their economic clout, in the coming years you will see mayors leading trade delegations as much if not more so than governors. Institutions involved in promoting trade, such as the Commerce Department, will have to reinvent themselves to think metro economies, not states." Morial continued." If this nationwide tour of America's Competitive Cities accomplishes one goal, I hope that it's to secure our cities' rightful place in the dialogue on national and international economic issues and development."

Copies of the report, charts, graphs and accompanying data and information, as well as the full text of Mayor Morial's address, will be posted on the Conference's website, www.usmayors.org, as of 2:00pm EST on Tuesday, July 10.

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The U. S. Conference of Mayors is the official nonpartisan organization of cities with populations of 30,000 or more. There are about 1,200 such cities in the country today. Each city is represented in the Conference by its chief elected official, the Mayor.

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PRESS RELEASES HOMEPAGE

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Storm Water 2000

Monitoring Efforts

1. History of storm water monitoring in Santa Monica Bay

Storm water monitoring in Santa Monica Bay began more than 30 years ago. Water quality data was collected in Ballona Creek as early as 1967 by the then Los Angeles County Flood Control District (now the County Dept. of Public Works). Water quality data collection continued, though intermittently, through the 70s and 80s. In addition to Ballona Creek, scattered data exist for Ashland Ave. drain, Pico-Kenter drain, Imperial Hwy. drain, Ave. I drain, Malibu Creek, Santa Monica Canyon, Topanga Canyon, Trancas Canyon, Solstice Canyon, Corral Canyon, Santa Ynex Canyon, Dume Creek, etc. as well as drains at several urban street intersections. However, data from these time and locations were all collected as a one-time event such as part of a special study. Usefulness of the data (for estimating loading, trend and impacts) is severely limited by their small size, the absence of continuous time series, and the lack of flow rate information.

2. Overview of existing storm water monitoring programs

Systematic and continuous monitoring of the urban runoff/storm water quality in Southern California was first started in the Santa Monica Bay watershed during the 1994-95 storm season, as required under the 1990 Municipal Storm Water NPDES permit. This is a result of a tiered approach designed for implementation of the 1990 municipal permit, which required municipalities located within the Bay watershed to implement a set of early actions, including the monitoring components. The SMBRP played a key role in facilitating the early implementation of the permit in the Bay watershed. In particular, by initiating a series of three technical studies[1] the SMBRP was instrumental in designing the first watershed-wide monitoring program implemented in Southern California. LAC-DPW, which as the Principal Permittee for the Los Angeles County Municipal Storm Water NPDES permit bears the primarily responsibility for conducting storm water monitoring in the County, adopted key recommendations of the SMBRP with regard to monitoring objectives, pollutants of concern, and land use models.

Monitoring objectives

- Mass loading estimate
- Land uses
- Critical Sources

[1] The three studies were: Assessment of Annual Pollutant Loadings to Santa Monica Bay from Storm Water Runoff, Review of Water and Wastewater Sampling Techniques with an Emphasis on Storm Water Monitoring Requirements, and Development of a Surface Drainage Water Quality Monitoring Program Plan.

- Receiving water impacts

The first two years of monitoring fell under the 1990 Permit and the main objective of the monitoring was to collect base-line mass loading information (watershed-wide and four key land uses) for the pollutants of concern. Since then the monitoring efforts in the region has been enhanced gradually both in geographical scale and in monitoring components. The current monitoring program, which is defined in the 1996 Municipal Permit collect monitoring data throughout the County and consists of four major elements: mass emission monitoring, land use runoff monitoring, critical industry monitoring, and Santa Monica Bay receiving water impacts study. Several peripheral and supportive studies were also conducted since 1996. Those consisted of a study of sampling in wide channels, a study of the feasibility of sampling storms down to 0.1" rainfall, an El Niño season supplemental study, and freshwater toxicity studies on the Los Angeles and San Gabriel Rivers. In 1999, the County also voluntarily funded half of a study of impacts on stormwater quality from aerial deposition.

Meanwhile, besides the County-wide monitoring program carried out by the LAC-DPW, storm water monitoring has also be conducted by California Department of Transportation (CalTrans) and industrial dischargers, under the State-wide CalTrans and industrial permits respectively. Up to now, monitoring of the bacterial indicators in the receiving water (surfzone near storm drain outlets) are conducted by the City of Los Angeles, Bureau of Sanitation, Los Angeles County Sanitation District, and the Los Angeles County Department of Health Services.

LAC-DPW Monitoring Program

In compliance with the 1996 municipal storm water permit, the LAC-DPW currently maintains 24 automated sampling stations within in the County. Among the 24 station, 10 were designated as mass emissions stations and the rest 14 were designated as land use specific stations. Nine of the 24 stations are located in the Santa Monica Bay watershed. Currently, there are two mass emission stations in the Bay watershed, one for Ballona Creek, and one for Malibu Creek.

The primary focus of the County's monitoring program is flow and concentration measurements of storm events during wet weather. Mass loading of each pollutant of concern was later calculated for from the flow and concentration measurements for the monitored areas, and estimated using a GIS model for the unmonitored areas. The GIS model was first introduced by the UCLA and employed by the SMBRP to produce the first estimated annual pollutant loadings to Santa Monica Bay in 1991. In essence, the model derives a loading estimate through three steps: 1) calculate runoff volume from observed rainfall volume and assigned runoff coefficient; 2) calculate land use-specific loading using observed and assigned event mean concentrations (EMC) and the modeled runoff volume for each land use; and 3) add up loading from each land use to derive total loading from the entire study area.

CalTrans' Monitoring program

Caltrans' storm water monitoring in the region began in 1997 as part of its statewide 3-Year Storm Water Monitoring and Research Plan. The Monitoring and Research Plan was developed to comply with a statewide NPDES storm water permit, the NPDES storm water permit for Caltrans' District 7 (Los Angeles) and for complying a 1996 court order under a litigation settlement with the Natural Resources Defense Council. The primary focus of Caltrans' monitoring is understandably transportation land use. Specifically, CalTrans' program has included monitoring and research in the areas of

- storm water characterization,
- pollutant source identification,
- management practice assessment,
- watershed planning
- Solids transport

Until now, most Caltrans' monitoring efforts have been described as elements of separate "studies" in its reports, indicating that the monitoring objectives, locations, frequencies, etc. may change in future years based on the knowledge and experiences gained from these studies. Table XX summarizes the studies that Caltrans has completed, continues to conduct, or plans to conduct statewide. Many of the studies are located in the Los Angeles region. Even for studies that are not taking place in this region, most of their results are considered applicable.

In Los Angeles region up to the end of 1999 wet season, Caltrans has collected water quality data from 130 locations (Figure XX). Among these locations, three are "permanent" storm water monitoring stations. One is located adjacent to I-405 North in the West LA area between Olympic and Santa Monica Blvd. and is designated to collect mass emission information. The other two (Interstate 210 mile post 40.8 and Interstate 91 mile post 8.92) were designated to collect information on the effectiveness of inlet cleaning as well as information on mass emission. The remaining locations were used in sampling events associated with studies in the region (Table XX).

Study Name	Number of Stations
District 7 Storm Water Monitoring	3
Roadside Erosion-Control Effectiveness	2
Drain Inlet Cleaning Effectiveness Study	8
District 7 BMP Evaluation Pilot Studies	21
Solids Transport and Deposition Study	72
Litter Management Pilot Studies	24

3. Brief Summary of Monitoring Results

The ultimate goal of storm water monitoring is to provide technical data and information to support implementation of an effective storm water quality management program. With that in mind, all monitoring efforts combined should achieve the following:

- Track status and trend in water quality (concentration) and pollutant loads (mass emission) from specific land uses and watershed areas.
- Identify pollutants of concern
- Identify sources of pollutants in stormwater runoff
- Assess the impacts of stormwater runoff on receiving waters (within the watershed and coastal waters)
- Evaluate the effectiveness of management programs, including pollutant reductions achieved by implementation of best management practices (BMPs)

This section briefly summarize the monitoring efforts and findings (if available) in each of the above five areas over the last six years. In general, there has been significant achievement, thanks for the resourcefulness of agencies involved and professionism and diligence of their employees. Unlike many other type of monitoring, people who conduct storm water monitoring must cope with unexpected seasonal events and hazardous situations. Uncommon climatological events, such as the El Niño in 1997-98 (twice the normal annual rainfall) and the La Niña 1998-99 (less than half the normal annual rainfall) certainly created new logistical and technical challenge. Since January 1995, 212 mass emission and 396 land use monitoring station events have been sampled by the LAC-DPW alone.

Achievements are evident in every one of the five areas of storm water monitoring. Yet, there is more progress in some areas than in others, reflecting partly whether the area of monitoring has been implemented for years or just started recently. It has been augured that many of the relatively new monitoring efforts could not be initiated sooner because there was no existing scientifically valid monitoring tool.

Track status and trend in water quality and pollutant loads

This area is the core of the storm water monitoring program in Los Angeles County. It is also the area where the longest time series and most amount of data have been collected up to date. Basically, a network of so-called mass emission stations has been established in the watershed since 1995. A subset of these stations are located near the ocean outlets of major river and storm drain channels while the rest are placed upstream, usually collecting runoff from an area dominated by a single land use. The purposes of this arrangement are to obtain direct measurements of the mass loading for all major watersheds in the region, and indirectly model and calculate mass loading from other watershed areas where directly monitoring were thought to be either too difficult or not cost-effective.

Data on pollutant mass loading from the two largest sub-watersheds in Santa Monica Bay, Ballona Creek and Malibu Creek have been collected since 1994-95. Since 1996-97 Total annual pollutant loading from the entire Santa Monica Bay watershed was estimated using model calibrated with land use monitoring data. The results of these loading measurements and estimates are summarized in Table 3.

Existing data summarized in Table 3 reveal no obvious upward or downward trends in pollutant loading from year to year except that loading in 1997-98 season is much higher than other years. 1997-98 happened to be the wettest among the four years based on precipitation records though the total runoff volume from the Santa Monica Bay watershed were not the highest over years. On the other hand, pollutant concentrations measured during 1997-98 were significantly higher than other years, which seems to be the key factor that results in the high mass loadings in that year. The loading estimates are generally lower comparing to the estimates made by the SMBRP in 1992, several degree of magnitude lower in some cases. These disparities most are due to the high concentration estimate used in the SMBRP study. Higher runoff volume estimate also contributed to the disparity.

Generally speaking, he mass emission element of the monitoring program has been successful in achieving its objective of tracking water quality status from year to year. Determine trends in pollutant loading may require at least several more years of data from this monitoring elements, given the expected high variations in annual runoff volumes. The strategy of combining direct measurements with land-use calibrated modeling is scientifically sound, cost-effective and seems to work well.

On the other hand, improvement may be needed in accuracy of sampling and lab analysis. For example, the non-detection of lead in 98-99 and 99-00 seasons and non-detection of zinc in 99-00 season, both in Malibu Creek, are hard to explain except for analytical errors.

Water quality status, pollutant trends and loads were successfully addressed by all of the major monitoring program elements: the Santa Monica Bay receiving waters impact study, the mass emission monitoring element, the land use monitoring element, and the critical source monitoring element. The total cost incurred by the monitoring program to date has been more than $4.8 million.

Identify Pollutants of Concern

The objectives of the storm water monitoring program with regard to pollutant identification are three-fold: they include (1). Determine if known pollutants are discharged above the levels of concern; (2). Determine which pollutants or forms of pollutants are of concern because of their impacts; and (3). Detect and identify unknown pollutants in storm water.

The core list of constituents monitored under the County Program covers most of the pollutants of concern identified in the Bay Restoration Plan. The list was developed initially by the LARWQCB and the LAC-DPW with input from the SMBRP as well as other stakeholers. In addition to those pollutants of concern already identified for Santa Monica Bay, the LAC-DPW was required to analyze additional constituents, especially

SVOCs and pesticides in light of evidence that certain pesticide (diazinon, etc.) found in runoff has contributed to toxicity.

Toxicity test of storm water runoff, which was first conducted by the SMBRP in 1994, has also become a routine part of the County's storm water monitoring program. (Test . done by other agencies?). Most significantly, between 1996 and 1998, the LAC-DPW funded a project to study the impacts of storm water runoff on Santa Monica Bay. The study collected water column and sediment quality data, data on bethos, as well as toxicity and TIE.

Up to date, he results of the monitoring activities aimed at pollutant identification are mixed. Several pollutants, including indicator bacteria, copper, lead, zinc (both total and dissolved), phenanthrene, and pyrene have been shown discharged at concentrations (undiluted) above existing water quality criteria (Ocean Plan, Basin Plan, AB 411, California Toxics Rule). However, because there has been no numerical effluent limits established for storm water runoff and no sediment quality criteria, it is still difficult to determine if current loading of these pollutants are above a level of concern. On the other hand, from TIE work done by the SMBRP and during the Santa Monica Bay Impacts study, Copper and Zinc have been identified as likely causes of toxicity.

Monitoring since 1994 (for some since 1996) have generally found low levels on non-detect of pesticides in storm water runoff. However, whether appropriate detection limits were applied in analysis of those pesticides is up to debate.

Trash is the only major pollutants of concern that has not been systematically monitored in the watershed. Studies have been carried out in targeted areas upstream, including monitoring of cleaned catch basin, CDS, and trash net, and the trash characterization study conducted by Caltrans. However, there is no reliable estimate on the annual trash load into the Bay and contributions of major land uses.

The monitoring program was successful at identifying toxic levels of zinc and copper from Ballona Creek discharge, toxicity in the Los Angeles and San Gabriel Rivers, and the extent and severity of bacterial indicators in both dry and wet weather.

Identify sources of pollutants in storm water runoff

Source identification has been primarily carried out through two-tiers of monitoring. Under the LAC-DPW monitoring program, the first-tier is composed of a number of land use stations aimed at assessing pollutant loads from specific land uses and watershed areas. The second-tier is done through the critical source monitoring project. This monitoring element is also supported by the County and city's efforts in identifying and eliminating illicit discharges, by Caltrans' monitoring of highway runoff (equivalent of land use monitoring), by special studies such as the City of LA's study on street washing, and by the SMBRP and other agency's effort to develop sanitary survey tools.

Samples have been collected between 1994 and 2000 from eight land use categories (commercial, vacant, high density single family residential, transportation, light industrial educational, multifamily residential, and mixed residential). Data from analysis of these samples seem to suggest wide dispersion of pollutants across different land uses with a few exceptions. The land use monitoring identified light industrial, transportation, and retail/commercial land uses as developing the highest median concentrations for total and dissolved zinc. Light industrial and transportation land uses displayed the highest median concentrations for total and dissolved copper, and light industrial produced the highest concentrations of suspended solids. Higher bacterial indicator counts were found in commercial and high-density residential land uses. Open space seems to generate higher amount of TSS but lower amount of heavy metals and bacteria.

As part of its Marina del Rey/Ballona Creek feasibility study, the Army Corps of Engineers in 1999 did a summary

Five commercial/industrial categories were currently included in the critical sources monitoring which was started in 1999. These six categories are auto dismantlers, automotive repair, fabricated metal products, motor freight companies, auto dealers. Available data from three of the.categories, auto dismantlers, auto repairs, and fabricated metal businesses, showed that these categories produce significantly higher concentration of many pollutants than the land use and watershed stations. The pollutants with high concentrations are primarily those associated with the operations of these businesses such as copper, lead, zinc, nickel, TSS, COD, oil and grease. Fabricated metal businesses produced the highest concentrations of zinc, copper and suspended solid; and auto repairs produced highest concentration of lead. Indicator bacterial counts were also extremely high at these sites(with auto dismantlers being the highest) though not as high as in some commercial and residential land uses.

Each Permittee has a program to identify and eliminate illicit connections to the storm drain system to the maximum extent practicable. The County has been successful in the inspection of open channels and underground storm drains to identify illicit connections. Most Permittees perform random area surveillance during dry and wet weather to inspect for potential illegal discharges. The Permittees also conduct educational site visits at businesses. During these visits, flyers with information on Best Management Practices (BMPs) applicable to that business are distributed. As of July of 1999, routine inspections hav resulted in the discovery of 1,992 undocumented connections. However, the type and amount of pollutant loading these connections would contribute had they been not removed are not clear.

In general, monitoring data collected by Caltrans over the last few years have revealed that transportation-related land use/activities could be a major source for several pollutants of concern especially copper, lead, nickel, zinc, and bacterial indicators. Analysis of samples from storm water runoff off freeways have shown not only the highest average concentration but also the highest maximum concentration for these contaminants. Also, there seems to be several hot spots in the County's freeway system, one being on Interstate 91 and one being on Interstate 60. However, since Caltrans monitoring reports reveal little detail on the characteristics of its monitoring locations, no analysis can be conducted to establish a cause-effect relationship.

Assess the impacts of storm water runoff on receiving waters (within the watershed and coastal waters)

Currently there is no routine monitoring specifically conducted to collect information on the impacts of storm water runoff on receiving waters. Most information to date come from the receiving water study, which was conducted between 1996 and 1998 storm seasons by the SCCWRP, the USC, and UCSB, and funded by the LAC-DPW. The study discerned the existence and extent of the storm water plume in Santa Monica Bay, identified two trace metals in Ballona Creek. Storm water discharge that are toxic to simple sea creatures, and concluded that sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants. This study, one of the first in the nation to assess storm water impacts on the marine environment, was successful at assessing storm water impacts on Santa Monica Bay. The study's findings and techniques explored during the study set the stage for development and implementation of a long-term impact monitoring program.

A re-tooled shoreline bacteriology monitoring program has since the summer 1994 tracked the impacts of bacteria-contaminated runoff on Santa Monica Bay beaches. It is conducted collaboratively by the City of Los Angeles' Bureau of Sanitation, County Sanitation District of Los Angeles, and the Los Angeles County Department of Health Services. Information collected under this program has been used by Heal the Bay to publish weekly Beach Report Card. Recently, as part of the pathogen TMDL development, the LARWQCB initiated a study to model the dispersion/degradation patterns of indicator bacteria from storm water runoff in surfzone.

The Bight'98 survey of 99-00 collected a wide range of information from nearshore areas potentially impacted by storm water runoff. The dry and wet weather microbiological survey showed clearly high bacterial counts attributable to storm water runoff. Analysis of the survey data on sediment quality, water quality, benthic infauna, and fish population is in progress.

Much more need to be done to further assess the impacts of storm water runoff in ocean receiving waters. On the other hand, even more work is needed to assess the impacts of storm water runoff in freshwater bodies within the watershed. Systematic bio-monitoring and assessment virtually did not exist until recently when a watershed monitoring prgram was developed for the Malibu Watershed and Heal the Bay initiated bio-monitoring efforts in the watershed through its Stream Team project. The SMBRP recently initiated a sediment transport study in the Topanga Creek watershed.

Evaluate the Effectiveness of Management Programs, including Pollutant Reductions Achieved by Implementation of Best Management Practices (BMPs)

As part of the Critical Source element of the monitoring program, in 1999-2000 season LAC-DPW examined the potential effectiveness of several voluntary good housekeeping and preventive types of Best Management Practices at one critical source industry. There was no significant difference at other critical source industries at which BMPs were implemented. The inability to control the voluntary usage of good housekeeping BMPs at these critical industries may have compromised the study's effectiveness for those industries.

During the 1998-99 season, CalTrans also conducted several studies to evaluate the effectiveness of several BMPs including roadside erosion control, drain inlet cleaning, highway extended detention basin, sand filter, media filter, drain insert, and four litter management measures. Data are available from several of these studies and findings were mixed as shown by the following brief summary.

The drain inlet cleaning effectiveness study monitored the runoff quality from four cleaned and four uncleaned drain inlets. The monitoring data revealed no significant difference in runoff quality between cleaned and uncleaned sites.

Monitoring data characterizing ***the effectiveness of extended detention basin treatment of highway runoff*** were collected at four sites (two in this region and two in District 11). Comparison of influent and effluent from the detention basins at each site showed that the detention basin is effective in removal of total suspended solids but not in removal of hydrocarbons, metals, and nutrients.

Monitoring data characterizing ***the effectiveness of sand filters in the treatment of maintenance yard and park & ride runoff*** was collected at five sites. Comparison of influent and effluent from the two park and ride sites (in District 11) showed that sand filter is effective in removing TSS and some heavy metals (Pb and Zn), but not in removing hydrocarbons and nutrients. Results from the three maintenance yard sites (2 in LA region) are similar to the park and ride sites.

The four litter management measures evaluated in Caltrans studies include ***street sweeping, litter pickup, modified grate, and bicycle grate***. Statistical analysis of the data indicates that increasing the frequency of street sweeping from monthly to weekly does not reduce the count or weight of litter, but increasing the frequency of litter pickup from monthly to weekly does. Also, the standard Caltrans bicycle grate does not reduce litter but the modified inlet grate does. On the other hand, these litter control measures generally do not help to reduce the load of other contaminants such as TSS, hydrocarbons, heavy metals, nutrients and indicator bacteria.

4. Major achievements and deficiencies

Achievements

It is fair to say that the key achievement in this area is the establishment of a baseline program for loading of major pollutants of concern. Though many improvements are needed and we may need few more years of data for meaningful trend analysis, this baseline program nevertheless is the backbone of all storm water monitoring components. It will provide for the first time baseline storm water quality information, both temporary and spatial, that are critical for any subsequent monitoring efforts to be meaningful. It also laid the groundwork and set the standards for all other monitoring components such as those discussed in this report.

Other major achievements of the current monitoring efforts include the basic understanding of land use characteristics, preliminary understanding of the major sources of pollutants of concern, and preliminary understanding of the storm water impacts on nearshore environments. Although most of the knowledge we have in these areas is preliminary at the best, what we know now is a big leap forward compared to ten years ago. In ten years, we have moved from very little to wide recognition that storm water runoff is the major source of beach pollution, that land uses characteristics play an important role in pollutant loading and, that the pollution is attributable to a wide range of daily activities. There is no doubt that the results of many important monitoring and research projects, several are spearheaded by the SMBPR, are the catalytic to these changes.

Deficiencies

Collecting and conducting meaningful analysis of storm water monitoring data remain a daunting challenge for both storm water management agencies and academia. Two to three years might have been lost due the slow set up of the baseline monitoring program. This slow start-up could be blamed partly by the lack of political will, but also many technical difficulties one could expect in setting up a new system.

Even after a slow start, the current monitoring program is far from perfect. One of the major deficiencies of the current program is the lack of monitoring data for a couple of pollutants of concern. On the top of this list is trash. There is no systematic monitoring of trash in the watershed and therefore its loading is poorly characterized. It is encouraging that trash monitoring has become a priority because of the TMDL process. However, more efforts are needed to develop a standardized protocol for estimate trash loads.

Although except for trash most pollutants of concern identified by the Bay Restoration Plan are routinely monitored under the baseline program, there is an imbalance between monitoring taking place upstream and downstream. On one hand, in the case of bacterial monitoring, most storm drain outlets along Santa Monica Bay are monitored daily, there are only infrequent in channel bacterial monitoring at limited locations. In general, the effort devoted to source identification of bacterial contamination is deemed insufficient and there is a lack of coordination among the already limited efforts.

On the other hand, there seems to be an over-emphasis on monitoring of effluents for toxic chemicals in contrast to the receiving water. Little has been known about the fate and transport of toxic contaminants in the receiving water, thus up to date it is still difficult to link pollutant loading to potential impacts.

Many issues need to be addressed in order to improve the quality of the monitoring data and the reliability of loading estimates. Understandably loading estimates are much difficult to make and less reliable for storm water discharge primarily because of the high variability in rainfall and flow volume. However, the loading estimate can be improved based on knowledge of the characteristics of the storm water discharge. This knowledge can be obtained through studies of pollutagraph, power analysis of existing monitoring data, and development and application of new computer models.

An issue related to estimation of mass loading is the adequacy of detection limits used in currently monitoring program. The hit-or-miss nature of storm water monitoring plus a relative high detection limit often result in a large proportion of a data set rendered as non-detect, thus hindered the value of the monitoring efforts.

Perhaps the biggest challenge that the storm water monitoring program facing today is how to collect and use monitoring data to evaluate the effectiveness of BMPs. So far, the results from limited efforts in this area are mixed to say the best and sometime contradictory. A major research program is needed to study what tools, indicators, and methodology should be used, or be developed, for assessment of the BMP effectiveness.

Demonstrating the impacts of storm water runoff on receiving waters is probably equally challenging as BMP evaluation. The storm water impact study over the last three years is a good start. Yet the information is limited in time and scale and most evidence of impact the study provide are indirect in nature. There is a need to develop and implement a long-term program for monitoring the impacts of storm water runoff. As part of this process, major effort is needed to conduct baseline bioassessment develop biological indictors.

Finally, there is a growing need for development of a comprehensive watershed monitoring program that integrate various monitoring components and coordinate activities of different monitoring agencies in order to answer key, regional management questions. The need for such coordination and integration was not imperative when LAC-DPW was the agency who had taken on the responsibility of storm water agency for the region. However, other agencies/organizations have implemented new monitoring programs in recent years, including the programs/projects of Caltrans, local cities, Heal the Bay, and Santa Monica Bay Keeper. While some of the agency have coordinated with the LAC-DPW in developing their programs/projects, others have essentially no coordination at all. The lack of coordination is most obvious between LAC-DPW and Caltrans.

Ultimately, a comprehensive monitoring program similar to the one for Santa Monica Bay should be developed for the Bay watershed. Under this new comprehensive program, existing efforts and resources from all agencies organizations should be combined to collective monitoring data in a most meaningful and cost-effective manner. These agencies/organizations should collaborate in building consensus on monitoring objectives, coordinating monitoring location, time and frequency, standardizing protocol, methodology, detection limits, and data transfer format, developing an integrated data management system, and coordinating in data analysis and other research projects.

5. Recommendations

Recently, storm water management agencies in Southern California collaboratively established a Storm Water Monitoring research Cooperative Program. Its initial project is the development and prioritization of a research agenda with the assistance of water quality resources management/regulatory experts. The following is a list of the issues that the Program would like to see being addressed by future research/monitoring projects:

- Develop monitoring designs appropriate to assess storm water discharges, potential water quality impacts, and the effectiveness of storm water management programs.
- Develop standardized field and laboratory protocols.
- Develop (standardized, meaningful) tests to evaluate the toxicity of urban pollutants of concern.
- Evaluate the aquatic toxicity of heavy metals and their relationship to water quality thresholds
- Improve methodologies for identifying unknown toxicants.
- Develop biological indicators and biocriteria.
- Evaluate the impacts of physical characteristics (e.g. flow rate, volume, temperature, etc.) of urban storm water discharges.
- Improve understanding of fate, transport and plume dynamics of urban storm water discharges.
- Use advanced information technologies in monitoring, modeling and information exchange.
- Study the use of sensitivity analysis in evaluating the effectiveness of BMPs.
- Develop appropriate pathogen indicators.

Table 1. Summary of storm water monitoring in Los Angeles County (Santa Monica Bay) in FY 1999-00.

Monitoring Agency	Type of Station	# of Station (# in SM Bay)	Sampling Season	# of Sampling Events	Monitoring Constituents	Sampling Methods
LAC-DPW	Mass emission	10 (2)	Wet	12/station		Mostly automatic composite
	Land Use	14 (5)	Wet	77 total station events		Automatic composite
	Critical Source					
CalTrans	General, transportation landuse	1	Wet	1?		Automatic sampler
	Special studies	127	Wet	?		Grab?
Industrial						
Citizen/volunteer						

Table 2. Storm water monitoring (study) efforts by Caltrans

Title	Location	Status (as of Oct. 2000)
Evaluation of Potential Impacts from Highway Segments Discharging to Small Streams	North Coast	On-going
Dry Weather Field Screening Pilot Study	San Diego	On-going
Bridge Runoff Characterization Study	SF Bay, LA (Inner Harbor)	On-going
Maintenance yard Runoff Characterization Study	Central Valley, SF Bay, Central Coast	On-going
North Coast River Loading Study	North Coast	On-going
Management of Pathogens Associated with Storm Drain Discharge	San Diego	On-going
Drain Inlet Sediment Characterization Study	San Diego	On-going
Water Quality Standards Inventory and Database	N/A	On-going
Highway Runoff Toxicity Testing Literature Review and Monitoring	N/A	On-going
Construction Site Runoff Characterization Monitoring	Not determined.	On-going
Evaluation of Lead in California Highway Soils	Statewide(LA sites included)	Completed
Solids Transport and Deposition Study	LA	On-going
Constituent Concentration and Load prediction Model	N/A	On-going
Detention Basin Monitoring Studies	Orange, San Diego (with requirement to represent LA)	Completed
Compost Storm Water Filter System Monitoring Studies	LA (N. Hollywood)	Completed
Statewide Vegetation Management Practice Enhancement and MEP Study	Statewide	On-going
Drain Inlet Cleaning Effectiveness Study	LA (Artesia, Glendale?)	On-going
Roadside Erosion-Control Effectiveness Studies	LA (4 sites), San Diego (3 sites)	On-going
Erosion Control Pilot Studies	LA	On-going
Statewide Erosion Control practice Review	Statewide	On-going
Liter Management Pilot Studies	LA (105 & 60 Fwys.)	On-going
Evaluation of Alternative Inlet Protection BMPs at Construction Sites	San Mateo, Alameda	On-going
BMP[2] Evaluation Pilot Studies	LA, San Diego	On-going
Spill Risk Assessment and Spill Containment Feasibility Study	N/A	On-going
Retrofit Program Study	San Diego	On-going

[2] The types of devices proposed for possible siting include trapping catch basins, drain inlet inserts, biofiltration strips, biofiltration swales, infiltration basins, infiltration trenches, media filters, extended detention basins, wet basin, and oil/water separators.

Table 3. Summary of Research Efforts

Title	Lead	Status
Assessment of annual pollutants loading to Santa Monica Bay from storm water runoff	SMBRP	Completed in 1992
Review of Water and Wastewater Sampling Techniques with an Emphasis on Storm Water Monitoring Requirements	SMBRP	Completed in 1992
Development of a Surface Drainage Water Quality Monitoring Program Plan	SMBRP	Completed in 1992
Study of Toxicity of Dry Weather Urban Runoff	SMBRP	Completed in 1993
Study of Toxicity of Wet Weather Runoff and Sediment	SMBRP	Completed in 1994
Evaluation of Potential Catchbasin Retrofit		
Study of Air Transport/Deposition of Toxic Contaminants to Santa Monica Bay	SMBRP, LAC-DPW, SCCWRP, UCLA	On-going
An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses from Two Santa Monica Bay Storm Drains	SMBRP	Completed in 1991
Storm Drain as a Source of Surfzone Bacterial Indicators and Human Enteric Viruses to Santa Monica Bay	SMBRP	Completed in 1992
Pathogens and Indicators in Storm Drains within the Santa Monica Bay Watershed	SMBRP	Completed in 1993
An Epidemiological Study of Possible Adverse health Effects of Swimming in Santa Monica Bay	SMBRP	Completed in 1995
Study of Coprostanol and Other Sterols as Innovative Indicators for Human Pathogens	SMBRP	Completed in 1994
Development of a Regional Shoreline Bacteriological Monitoring Program	SMBRP	Completed in 1994
Development of a Regional Sources and Loading Monitoring Program	SMBRP	Completed in 1998
Assessment of Monitoring and Data Management Needs in Santa Monica Bay	SMBRP	Completed in 1990
Development of a Comprehensive Regional Comprehensive Framework	SMBRP	Completed in 1992
An assessment of Compliance Monitoring in Santa Monica Bay	SMBRP	Completed in 2000
Santa Monica Bay Storm Water Impacts Study	LAC-DPW, SCCWRP, USC, UCSB	Completed in 1998
Ballona Creek Feasibility Study	USAOE	Completed in 1998
Malibu Creek Watershed Monitoring Plan	Malibu Creek Watershed Council	Completed in 1998
Bight' 98	SCCWRP	On-going
City of LA Santa Monica Canyon Study	City of LA	Completed in 1994?
City of LA Street Washing Study	City of LA	Completed in 1999
Santa Monica Bay runoff dispersion study	LARWQCB, SCCWRP, City of LA, Heal the Bay	On-going
City of LA dry-weather diversion feasibility study	City of LA	Completed in 1999

Table 4. Ranking

Program Element/Objective	Current Efforts/ Achievements	Major Deficiencies	Overall Ranking
Tracking status and trends in pollutant loading	Establishment of a baseline loading monitoring program	Problems with reliability of loading estimates (variability issue)	
Identifying pollutants of concern		-Lack of monitoring data for some pollutants of concern (trash, (inland) pathogen) -Problem with detection limits	
Identifying pollutant sources	-Understanding of major land use characteristics -Preliminary understanding of major sources of pollutants of concern		
Identifying and assessing the receiving water impacts	-Preliminary understanding of the storm water impacts in nearshore environments -Preliminary information on toxicity of storm water runoff	-Poor understanding of storm water impacts in urban and rural streams. -Difficulties in demonstrating the storm water impacts on receiving waters. -Lack of bio-monitoring	
Evaluate the BMP effectiveness		-Difficulties in monitoring the effectiveness of BMPs.	

Figure 1. Estimated TSS loading into Santa Monica Bay (lb./yr.).

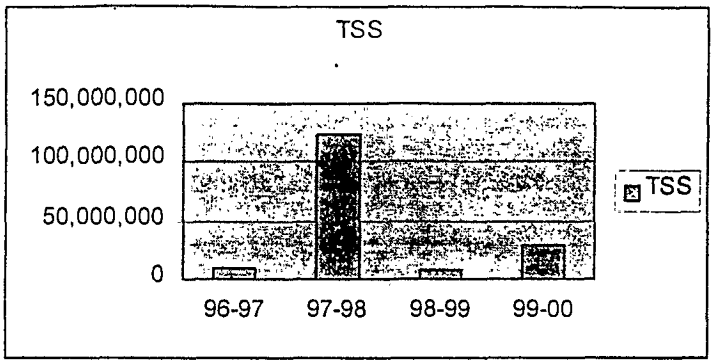

Figure 2. Estimated heavy metal loadings into Santa Monica Bay (lb./yr.)

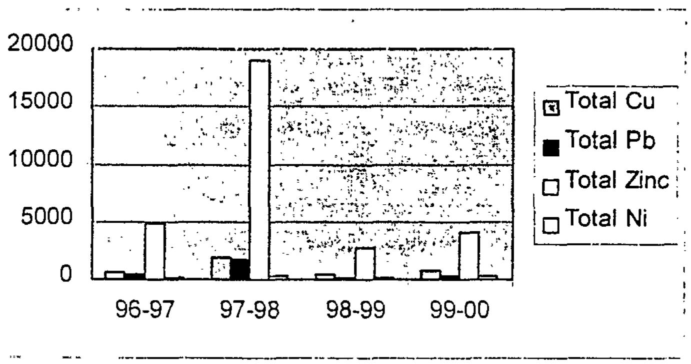

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Figure 3. Comparison of TSS loading between SMBRP estimate and the average of LAC-DPW annual monitoring data.

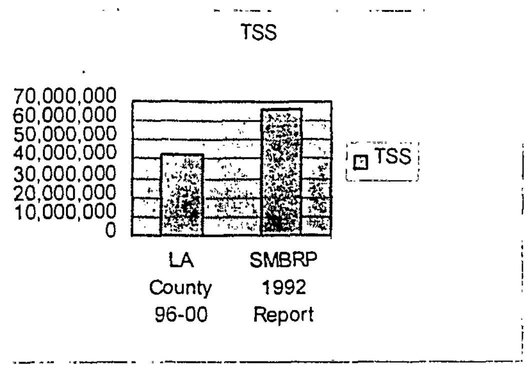


Figure 4. Comparison of metal loading between SMBRP estimate and the average of LAC-DPW annual monitoring data.

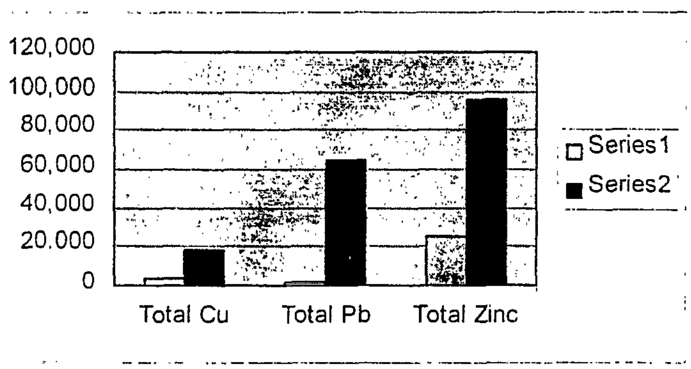
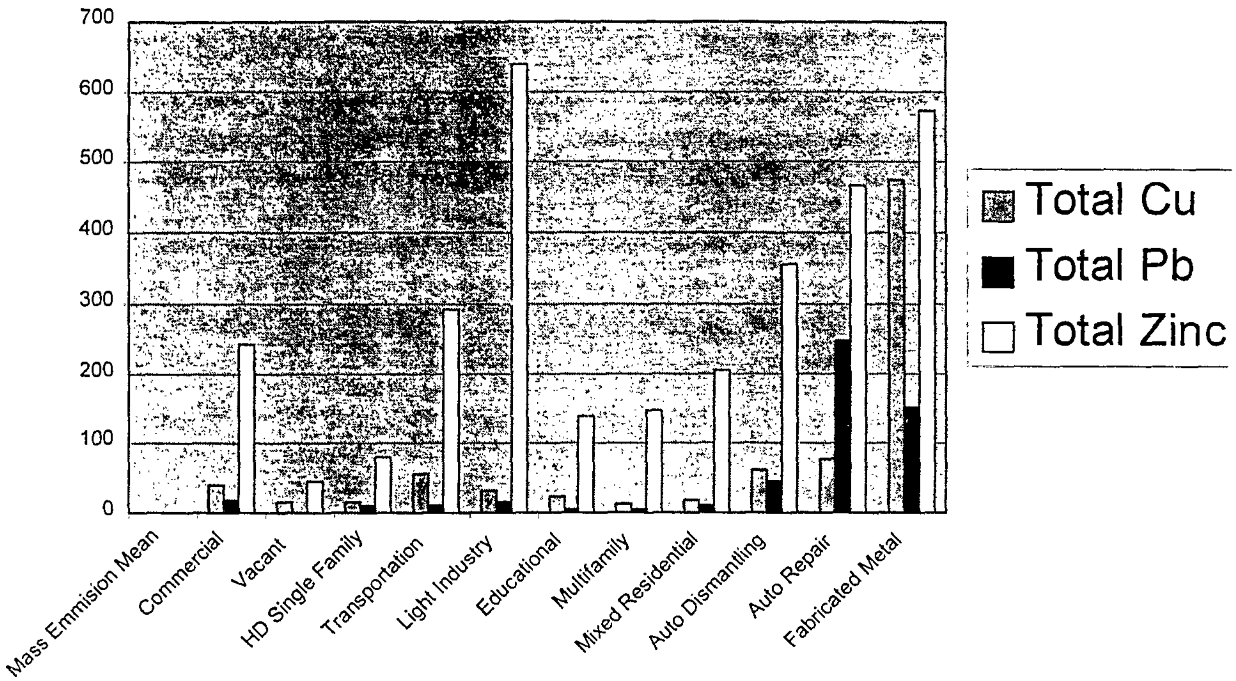
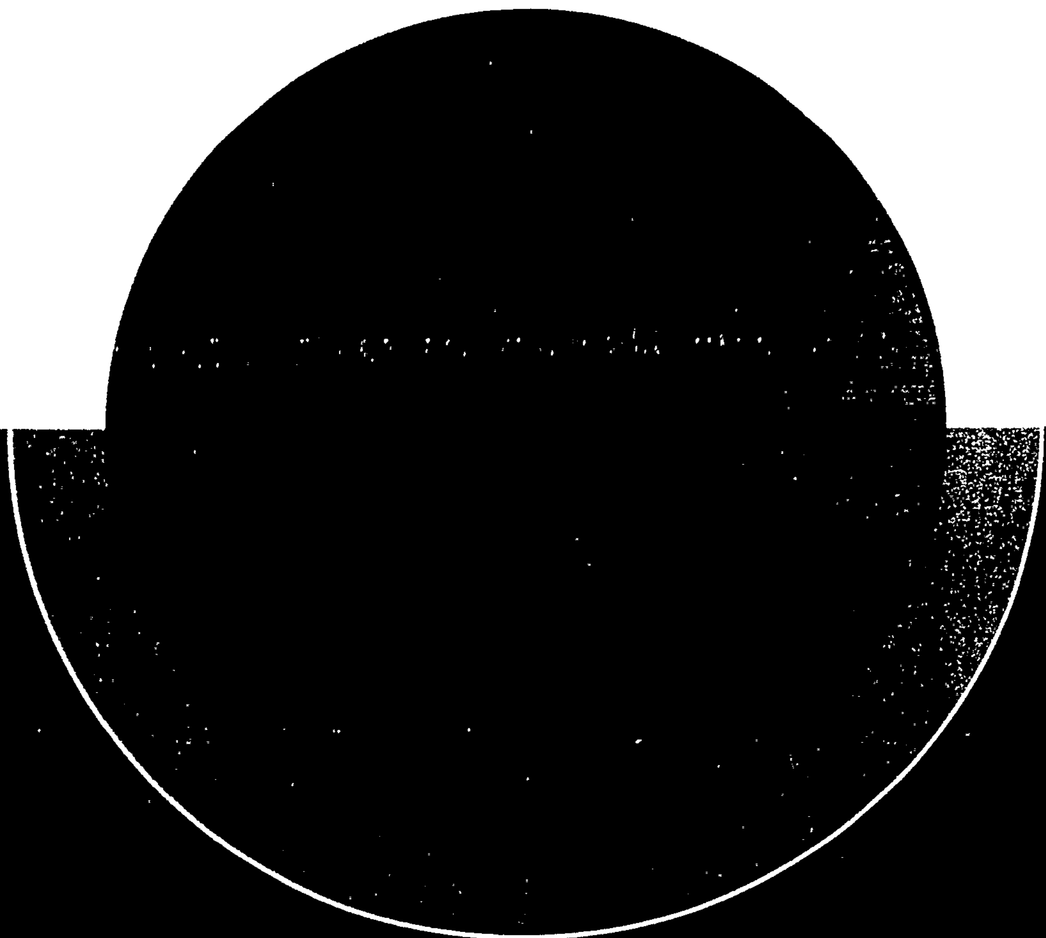


Figure 5. Comparison of metal concentrations (ug/l) in storm water samples collected from different land uses and industrial sites.





Tools to Measure Source Control Program Effectiveness

PROJECT 98-WSM-2

TOOLS TO MEASURE SOURCE CONTROL PROGRAM EFFECTIVENESS

by:
Betsy Elzufon
Larry Walker Associates

2000

Water Environment Research Foundation

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I. EXECUTIVE SUMMARY

INTRODUCTION

Urban storm water is considered as one of the largest sources of pollution to the coastal waters of the United States. Storm drains convey runoff from streets, urban centers, industrial sites, and open spaces into streams, creeks, rivers, beaches, and the ocean. Industrial operations represent one contributor to storm water pollution, but they are known to be a major source of heavy metals, oily waste, and other substances. Many industrial operations involve manufacturing, storage, and shipping activities which, when conducted outside and are exposed to storm water, can be sources of pollutants in storm water.

Federal regulations issued pursuant to the 1987 amendments to the Clean Water Act mandate the regulation of point source discharges of storm water from industry and from municipal separate storm sewer systems serving 100,000 or more people. California, one of 44 states with delegated authority from the United States Environmental Protection Agency (EPA), implements its own storm water program. The State Water Resources Control Board (State Board) and the nine Regional Water Quality Control Boards (RWQCBs) are the state agencies charged with the primary responsibility for overseeing the implementation of storm water regulations in California. In 1991, State Board issued the Industrial Activities Storm Water General Permit (General Permit No. CAS000001; hereafter, GISP), subsequently reissued in 1997, to control pollutants associated with storm water runoff from industrial sources (GISP 1997). As of August 2000, approximately 9,200 industrial facilities in California were covered under the GISP, with nearly one-third of the facilities located in the Los Angeles region.

The overall goal of this study was to assess the effectiveness of the GISP program for one industrial sector, as implemented in the Los Angeles region, in reducing water quality impacts due to storm water pollution. This executive summary is divided into five sections: introduction, background, methodology, key findings, and conclusions. The background provides a general description of the objectives of the study. The methodology summarizes the approaches used in the study to fulfill the objectives. The key findings present highlights on important results. And the conclusions provide synthesis and recommendations based on the key findings.

BACKGROUND

The Los Angeles Regional Water Quality Control Board (the Los Angeles RWQCB) initiated this compliance assessment project in 1998, recognizing the need to adequately characterize the effectiveness of its industrial storm water program, as implemented at the facility level. The specific objectives of this study were: 1) to evaluate the state of compliance of one industrial sector, the auto dismantling industry, with the GISP requirements and associated water quality implications; 2) to identify limitations of the GISP program in effectively controlling pollutants in storm water runoff; and 3) to provide specific recommendations and regulatory alternatives to help guide management actions to improve water quality. This study is one of the few *comprehensive* assessments investigating the state of compliance of a particular industrial sector with storm water regulatory requirements.

This study chose to focus on the auto dismantling industry because the typical operational and material handling practices conducted by the facilities of this industry represent a potential significant source of conventional and toxic pollutants, including heavy metals and certain hydrocarbons, in storm water. Also, the industry represents a significant portion (about 15 percent) of the facilities covered in the Los Angeles RWQCB's GISP program.

For the purpose of evaluating compliance, this study categorized the GISP requirements into the following three tiers:

Initiation (Tier 1)
Facilities subject to coverage under the GISP, based on their standard industrial classification (SIC) codes or other specific conditions stated in the GISP, must file a Notice of Intent (NOI) with the State Board. (The auto dismantling industry with SIC code of 5015 has been mandated for coverage);

Documentation/Reporting (Tier 2)
Facilities must report their self-monitoring activities and results by submitting an Annual Monitoring Report by July 1st of each year. In addition, facilities must prepare an appropriate storm water document, known as Storm Water Pollution Prevention Plan (SWPPP), along with a written monitoring program to help guide their efforts in implementing appropriate storm water control measures and monitoring the quality of storm water runoff from their facilities.

On-site Implementation (Tier 3)
Facilities must implement appropriate storm water control measures known as Best Management Practices (BMPs) described in their SWPPPs and perform the required monitoring activities.

METHODOLOGY

The methods used to conduct this assessment include database analysis, in-depth document review, and onsite case study investigations.

Non-filer Identification
Auto dismantling facilities in Los Angeles County that have failed to apply for coverage under the GISP program by filing a NOI, also known as "non-filer", were characterized using the following sources of information: 1) a list obtained from the California Department of Motor Vehicles, Occupational Licensing Division (DMV) of auto dismantling facilities in Los Angeles County that maintain a current dismantling license issued from the DMV, and 2) results from the door-to-door site visits conducted

by the City of Los Angeles inspectors from January 1999 to May 2000, specifically aimed at identifying non-filers in parts of Los Angeles city. Facility names and addresses were screened using the Los Angeles RWQCB's NOI database to verify their status of coverage under the GISP.

Document review
A detailed review of SWPPPs and written Monitoring Programs was completed for a study pool of 52 auto dismantling facilities. The purpose of the review was to assess the effectiveness of these storm water documents in guiding facility operators into compliance. The 52 facilities were selected randomly from the NOI database using a systematic, replicable process and are considered to be representative of the industry.

Case study investigations
Site inspections and storm water sampling were performed on the nine selected auto dismantling facilities located in San Gabriel River and Los Angeles River watersheds. The nine facilities were selected out of the study pool of 52 facilities, based on their proximity to the San Gabriel River watershed, the Los Angeles RWQCB's priority watershed for the 1999/00 fiscal year.

The purpose of these site-specific investigations was to take a hard look at the onsite component of compliance that may not be readily observable from document review alone. Storm water analytical data were used to evaluate the quality of storm water runoff generated, impact of the BMPs implemented on water quality, and a simple load calculation for the industry. The EPA Simple Method was used to estimate load.

KEY FINDINGS

The following highlights the important findings of this study:

Initiation (Tier 1)

<u>Non-filer Identification</u>
The problem of non-filers among auto dismantling facilities is significant. An assessment based on the DMV list revealed that one out of every five facilities with a valid DMV license was operating as a non-filer. The site visit results indicated a more serious degree of non-compliance for certain parts of Los Angeles city, with more than one-third (37%) of the auto dismantling establishments visited operating without a NOI.

A possible explanation for such a high ratio of non-filers observed from the site visit results- almost twice as that predicted by the DMV analysis- is that some areas of Los Angeles County, including the locations targeted by the City inspectors, potentially have a disproportionately high percentage of non-filers. Also, site visits can account for non-filers that may be operating without a valid dismantling license, thus not included in the DMV database. The actual number of non-filers in Los Angeles County could be somewhat or considerably higher than that predicted by the DMV/NOI analysis (perhaps somewhere between 19% and 37%), considering an unknown number of delinquent facilities operating with neither a dismantling license nor a NOI.

Documentation/Reporting (Tier 2)

Annual (Monitoring) Reports

Since the 1995/96 permit year, the proportion of the 52 selected facilities submitting Annual Reports has been steadily rising, with a peak submittal rate of 96% observed for the two most recent years considered by this study- 1997/98 and 1998/99. This is a significant increase in compliance, considering that less than half complied with the annual reporting requirement in some of the earlier years. Accelerated efforts expended by the Los Angeles RWQCB in outreach and enforcement activities, fueled by legislation such as Assembly Bill 2019 that mandates timely enforcement actions against violators of the GISP requirements, appear to have significantly contributed to an increased compliance.

SWPPPs/Written Monitoring Program

Initially when the Los Angeles RWQCB issued letters requesting for SWPPPs, nearly a quarter of the facility operators responded with phone calls, displaying little or no knowledge of the SWPPP requirement. Following the initial responses, most facilities (50 out of the 52 requested) did submit their SWPPPs and their written monitoring programs to the RWQCB (Formal enforcement actions were taken against the two delinquent facilities for their failure to submit the requested SWPPPs and past Annual Reports.)

This study found nearly all of the SWPPPs to be deficient in more than one area. The majority were boiler-plate documents prepared by consultants that lacked sufficient site-specific and/or procedural details crucial for proper implementation of BMPs. Many SWPPPs provided sets of "ideal" or "proposed" BMPs but were vague about specifying the measures that were chosen for implementation by the facility operator. BMPs considered universally applicable and important for pollution prevention, such as employee training, site inspection, and good housekeeping programs, were missing from a considerable number of the SWPPPs reviewed.

The majority of the written monitoring programs were prepared by consultants and contained many of the deficiencies found in the SWPPPs. Most documents failed to provide sufficient procedural details necessary to ensure proper quality assurance and quality control (QA/QC), especially regarding sample collection, storage, handling, and transport procedures.

On-site Implementation

BMPs

Staff inspections of the nine case study facilities revealed that the facilities were not fully implementing the BMPs outlined in their SWPPPs, especially measures that are more cost- and/or effort– intensive. Judging from the extent of spills and leaks observed on facility ground, it was evident that the existing BMPs, at the level implemented at most of the facilities, were not adequately controlling the pollutant sources present onsite. Some BMPs such as providing an overhead coverage for dismantling areas or storing motor parts in an enclosed area were limited in their effectiveness because dismantling and storing activities were commonly conducted outside of the designated areas due to inadequate workspace or other physical constraints. One facility eliminated the exposure of vehicle parts to storm water by storing them in large autobodies. An example of an innovative, cost-effective BMP that was implemented unsuccessfully at many of the selected facilities was using truckbeds to store vehicle parts. The facilities that used truckbeds for parts storage had failed to seal the cracks in the truckbeds to prevent potential leaks.

One factor that could potentially obscure a facility operator's assessment of compliance is the lack of a clear standard of compliance in the permit; GISP specifies neither a specific set of required BMPs nor a quantifiable performance or pollutant level to be achieved. (Many of the RWQCBs' staff members use and encourage the permittees to use a set of parameter benchmark values from the USEPA's "Final National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities" (most recently reissued in 2000) for the purpose of gauging potential harm or impact on water quality. However, these benchmarks are not specified in the GISP and are typically not used for gauging compliance or for enforcement purposes.)

Facility Self-monitoring

Review of the Annual Reports submitted by 50 of the 52 selected facilities indicated that the degree of compliance with the monitoring requirements did not match the success observed with submitting the monitoring reports. Based on our review of the 1997/98 Annual Reports, less than 20% of those required successfully completed the sampling & analysis requirement. Not all facilities that collected samples analyzed for the required toxic constituents (lead, zinc, and copper). Less than half conducted the monthly visual observation of storm water runoff. Despite the deficiencies in their monitoring activities, many facility operators still self-certified their Annual Reports for compliance.

Water Quality Impacts

Storm Water Sampling and Analysis

There was a wide range in the concentrations of pollutants in storm water samples obtained from the eight (out of the nine) case study facilities. The majority of the storm water analytical data exceeded the USEPA benchmark levels, in particular, for metals and oil & grease. The general trend identified in this study is that facilities that diligently implemented BMPs, especially good housekeeping practices, and had an overall neat and organized site appearance generally had lower pollutant concentrations in their storm water samples, as expected.

Load

A simple load calculation for 1998/99 suggested the following range for pollutant loads in storm water runoff from the auto dismantling industry in Los Angeles County: 30,570 lbs. of total suspended solids, 7,460 lbs. of oil & grease, 40 lbs. of copper, 30 lbs. of lead, and 130 lbs. of zinc.

CONCLUSIONS/RECOMMENDATIONS

- There is still a substantial number of auto dismantling facilities that need to be identified and permitted under the GISP program. A combined approach using currently available databases supplemented by site visits appears to be an effective method for capturing non-filers. The existing agreement between DMV and the State Board offers a good example of interagency cooperation that helps to elucidate the non-filer identification process-- a model that could be applied to other industrial sectors, including but not limited to the transportation and recycling industries. At this time, additional information is needed to evaluate if the quality of storm water from the non-filers is significantly different, on average, from the permitted facilities.

- In general, the level of understanding among the auto dismantling facility operators of the intent and the significance of the GISP program and its requirements appeared to be low when this study was conducted.

- Compliance among many auto dismantling facilities was achieved mostly on paper, primarily reflected in the quantity of the required documents or reports submitted to the agency and perhaps less in terms of the quality. Site inspections revealed that the degree of field compliance achieved through proper implementation of appropriate BMPs is low and trails behind paper compliance.

- In light of the fact that it is only the field implementation component that substantively contributes to pollution reduction and given the high levels of oil & grease and metals found in storm water runoff from auto dismantling facilities, it may be concluded that the GISP program, as currently implemented by many auto dismantling facilities, does not appear effective in controlling storm water pollution.

- Despite an increase in compliance with the annual reporting requirement, incomplete monitoring results, especially the analytical data, limit the usefulness of the Annual Reports in developing a comprehensive data inventory needed to: fully assess the quality of runoff from regulated facilities; measure progress in pollution prevention efforts over the years; assess water quality impacts from industrial storm water runoff based on load estimates; and develop water quality standards, including total daily maximum loads (TMDLs). To improve both the compliance with monitoring requirements and the quality of the Annual Reports being submitted, the RWQCB must step up its efforts to provide timely responses, for compliance assistance and enforcement purposes, when deficiencies are noted.

- Many of the storm water documents - SWPPPs and written monitoring programs- failed to serve as useful guides for facility operators in the selection and implementation of appropriate BMPs and in monitoring activities due to the absence of sufficient procedural and site-specific details. A time-efficient solution recommended by this study is to target those the consultants (who work closely with the industry as a group monitoring leader or prepare storm water documents on behalf of the facilities) for regular training, education, and certification to ensure that SWPPPs and written monitoring programs prepared by third parties are up to par with the GISP requirements.

- One factor that potentially obscures the efforts of facility operators and regulators in assessing compliance is the lack of explicit, quantifiable standards that facilities must attain in order to demonstrate compliance with the GSIP requirements and with applicable water quality standards. Determination of compliance should not be left up to the subjective interpretation of uninformed permittees or regulators. Thus, the GISP program needs a more clear-cut standard of compliance based on a combination of a minimum set of specific BMPs and/or numerical effluent limitations. The following tiered approach is recommended for the auto dismantling industry: 1) a mandatory set of specific, baseline structural (excluding treatment) and non-structural BMPs for facilities with annual vehicle throughput less than 500 (which includes mom-and-pop and medium-sized facilities); and 2) mandatory treatment of storm water for facilities with annual vehicle throughput greater than 500. (Note: The annual volume of vehicles processed at many of the mom-and-pop facilities, which make up over three-quarters of the industry in the Los Angeles Region, is less than 300 vehicles. The threshold of 500 vehicles was chosen to include typical mom-and-pop and medium-sized facilities in the Region). Also, in lieu of requiring treatment, numerical effluent limitations could be applied to the latter group as a standard of compliance. A compliance schedule could help phase facilities into compliance over a certain specified timeframe. Facilities with less than 500 annual vehicle throughput that persistently demonstrate problems with meeting a certain water quality standard, e.g. the USEPA benchmark levels, should also be considered for inclusion in the mandatory storm water treatment category.

- The lack of sufficient resources was identified as the primary reason for the limited compliance assurance and enforcement activities performed by the RWQCB in the past and when this study was being conducted. One way to reduce the workload associated with assessing compliance of industries subject to the GISP requirements is to employ a semi-privatized certification program, such as that implemented in the State of Wisconsin, that relies on licensed, private inspectors to oversee the compliance activities of a group of facilities that voluntarily choose to participate and help fund the program. The aim of such a program is to help reduce some of the workload of the regulators and to allow facilities that diligently work toward and maintain a specified level of compliance to be certified for compliance by professional inspectors. Such certification could (partially) exempt them from certain regulatory responsibilities, such as monitoring activities, and indirectly shield them from third-party lawsuits by reducing the degree of their environmental liability. (Essential to the implementation of this type of program is regular training and (re-)certification of inspectors by the regulating agency to ensure quality assurance and quality control).

II. BACKGROUND

Storm water pollution has received steadily increasing attention from regulating agencies as well as environmental groups in the past decades. In California, efforts to better control industrial storm water pollution have resulted in legislation specifically aimed to improve the efficacy of the GISP program. Examples include Assembly Bill 2019, which mandates aggressive, mandatory enforcement actions to increase compliance with the NOI and annual reporting requirements, and Assembly Bill 1186, designed to substantially increase the funding available for the GISP program (AB 2019; AB 1186). Third-party lawsuits triggered by non-profit environmental organizations have contributed to raising the public's awareness of storm water pollution and of the importance of pollution prevention (P2).

There exist several known evaluations or reports, which have assessed the effectiveness of industrial storm water program, on both the regional and national levels. The Water Environment Federation, under a cooperative agreement with the EPA in 1994, conducted a nationwide assessment of the federal industrial storm water program implemented by USEPA (WEF 1996). The study presented the permittees' perceptions of how effective they thought the individual components of the federal industrial storm water program were in controlling and reducing storm water pollution. Two of the key findings from the study were that 1) of those companies regulated by the storm water permit program, 12.5% appeared to be out of compliance with the requirement to develop and maintain a SWPPP onsite; and that 2) small businesses spend less money on compliance and are more likely to be out of compliance because they lack environmental staff and a clear understanding of the requirements.

On a regional level, a 1998 report by Heal the Bay, a non-profit environmental organization with a primary focus on the protection of Santa Monica Bay in Southern California, criticized the lack of accomplishments of the industrial storm water program implemented by the Los Angeles Regional Water Quality Control Board (Los Angeles RWQCB), in areas of compliance assurance and enforcement activities conducted since the adoption of the GISP in 1991 (HTB 1998). In 1998 a Los Angeles RWQCB staff generated and submitted a draft report to the State Board titled, "Analysis of the Sampling Results: 1996-1997 Annual Report for Storm Water Industrial Activities General Permit". The draft document showed that a substantial fraction of the storm water data submitted for the 1992/93 and 1996/97 years exceeded the USEPA benchmark levels (RWQCB 1998). In February 2000, the National Resources Defense Council, a non-profit organization of attorneys working for environmental causes, submitted a formal written petition to EPA asking it to correct deficiencies or to withdraw from the State of California the delegated authority to implement its own storm water program, *specifically in the Los Angeles Region*. The petition documented the failure of the Los Angeles RWQCB to fully implement its storm water programs and cited the lack of sufficient funding and resources as the primary reason for the noted deficiencies (NRDC 2000). USEPA also cited similar findings in several of its annual audit summaries of the Los Angeles RWQCB's storm water programs and strongly recommended a significant augmentation in the available funding to provide the resources needed to fully implement the program (USEPA 1998; USEPA 2000a).

USEPA recognized that the RWQCB staff had achieved significant accomplishments given severely constrained resources (USEPA 1998).

Whereas many of the cited studies and analyses primarily focused on the deficiencies in the overall programmatic implementation at the RWQCB level, this study shifts the focus of its evaluation to the facility level where pollution control occurs. And by assessing the permittees' performances and compliance with the GISP requirements, this study attempts to shed light on the drawbacks and the barriers associated with the GISP program that must be addressed in order to improve the program's efficacy in controlling industrial storm water pollution. In addition, this study takes a hard look at whether the GISP requirements and its terms of compliance have been defined in such a way as to ensure adequate protection of water quality and beneficial uses of receiving waterbodies. Lastly, this study provides specific recommendations to remedy the deficiencies noted in its evaluation. To fully characterize the state of compliance achieved by the target industry, this study employed a multi-tiered assessment approach looking at the full spectrum of requirements, from initiation of coverage to field implementation.

AUTO DISMANTLING INDUSTRY

Auto dismantling industry was targeted for compliance assessment for the following reasons:

- Auto dismantling facilities, also known as auto salvage yards or auto recycling facilities, represent a significant portion (about 15%) of facilities covered in the Los Angeles RWQCB's GISP program;

- Many of the typical operational and material handling practices conducted at auto dismantling facilities are performed outside and thus are exposed to storm water. Typical activities include dismantling vehicles and automotive parts; draining automotive fluids; storing auto parts, auto bodies and waste fluids, washing and rinsing of parts, and shipping and receiving activities;

- Spills and leaks of waste fluids and waste oil, which are common occurrences at auto dismantling facilities, contribute conventional and toxic pollutants, in particular, heavy metals and certain hydrocarbons, to storm water runoff (Swamikannu 1994); and

- The auto dismantling industry is difficult to regulate because the majority of businesses are small, mom-and pop facilities that tend to change ownership rather quickly, posing a special challenge in outreach and compliance assurance activities for the regulating agency (approximately 70% of all auto dismantling facilities in Los Angeles County covered under the GISP are 1 acre or smaller). Economic and personnel constraints impact the ability of smaller facilities to fully comply with the GISP requirements.

MULTI-TIERED ANALYSIS

Tier 1
File a Notice of Intent (NOI)

Tier 2
Prepare SWPPP and written Monitoring Program
Submit Annual Monitoring Report by July 1st

Tier 3
Implement Best Management Practices (BMPs)
Conduct required monitoring activities

For purposes of evaluation, compliance was divided into three tiers:

Tier 1 (Initiation)
Facilities classified under certain standard industrial classification (SIC) codes specified in the GISP for coverage (including the auto dismantling industry whose SIC code is 5015) must file a NOI to apply for permit coverage. Facilities that are required but fail to file a NOI are referred to as 'non-filers'.

Tier 2 (Reporting/Documentation)

After submitting a NOI, facilities must submit an Annual Monitoring Report by July 1st of each year that summarizes both the qualitative and quantitative results from their monitoring activities. In addition to the annual reporting requirement, facilities must prepare appropriate storm water documents known as a Storm Water Pollution Prevention Plan (SWPPP) and a written Monitoring Program (MP) necessary to guide them in their P2 efforts. The purpose of a SWPPP is to serve as a "blueprint" for achieving compliance by specifying specific BMPs and a schedule of BMP implementation. Written monitoring programs must contain adequate procedural details to ensure that proper monitoring of facility condition and its storm water is provided.

Tier 3 (Implementation):

Facilities must implement BMPs provided in their SWPPP and conduct monitoring activities required by the GISP. BMPs include both non-structural and structural controls that can reduce the level of pollutants in storm water. Monitoring requirements may be broadly grouped into visual observations, storm water sampling and analysis, site inspection, and SWPPP review and update. Storm water sampling and analysis, along with the other monitoring activities, help evaluate the quality of the storm water runoff generated from the facilities and gauge the effectiveness of the facility's efforts to control storm water pollution.

The state of compliance achieved by the permittees is a reflection of how diligently facilities have been implementing the GISP requirements. Knowledge of the current state of compliance achieved and an estimate of associated load can serve many useful purposes. For example, such an understanding could help gauge if an existing program, such as the GISP, has the potential to attain further pollutant load reduction if required, for example, as part of the implementation of a Total Maximum Daily Load (TMDL). TMDL is the "amount of a specific pollutant that a waterbody can receive and still maintain water quality standard" (TWA 2000). If the majority of dischargers permitted under a given regulatory program are shown to be at the high end of a compliance curve, this implies that the program has nearly reached its maximum attainable pollutant reduction. Under such a scenario, opportunities for significant additional reduction in load would be slim. Conversely, if most dischargers are found to be at the bottom of a compliance curve, then there may be opportunities for substantial pollution reduction to be achieved through increased compliance activities.

If the GISP requirements are implemented to their maximum at the facility level, and facilities are still unable to attain the assigned load, then perhaps the standard of compliance defined in the GISP or the existing approach used to implement the GISP program may need to be re-evaluated. California has yet to allocate load associated with industrial storm water pollution. Nevertheless, an understanding of the current state of compliance under the GISP program and getting a good sense of the magnitude of load generated by industrial sectors will no doubt be useful for making critical management decisions. Also, this type of assessment will help to identify priority or high-risk industrial sectors - e.g. those with low compliance and high load contribution - to direct limited resources to the most critical areas.

LACK OF NUMERICAL EFFLUENT LIMITATIONS IN GISP

Standards for compliance can be expressed in various ways. NPDES permits may contain both qualitative and quantitative effluent limitations with which permittees must comply. Numerical effluent limitations may consist of technology- and water quality-based limits. The GISP, which falls under the NPDES framework, does not contain numerical effluent limitations for the majority of dischargers permitted under the program (Facilities among the ten industrial categories listed in USEPA regulations (40 CFR Subchapter N) must comply with the technology-based limits established by USEPA for specific pollutants. These Subchapter N facilities represent only a small portion of the facilities under the RWQCB's GISP program.)

In the absence of numerical effluent limitations, BMPs form the pillar of the GISP program. This is consistent with the "Interim Permitting Approach for Water Quality-based Effluent Limitations in Storm Water Permits" (USEPA 1996). The interim permitting approach uses BMPs in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. While it is recognized that numeric water quality-based effluent limitations could potentially provide a greater degree of confidence that a discharger will not cause or contribute to an exceedance of the water quality standards, the variable nature of storm water discharges and the lack of information on which to base numeric water quality-based effluent limitations are the main reasons that EPA developed the interim permitting approach.

There are several standards or conditions specified in the GISP that dischargers must attain including the Best Available Technology Economically Achievable (BAT) and Best Conventional Pollutant Control Technology (BCT) levels. In addition, one of the prohibitions in the GISP states that storm water discharge shall not cause or contribute to a violation of applicable water quality standards. Specifically, the achievement of BAT and BCT levels must be demonstrated by fulfilling the requirements of the GISP, which states "compliance with the terms and conditions of this General Permit constitutes compliance with BAT/BCT requirements and with requirements to achieve water quality standards." However, as discussed in the preceding section, determining compliance based on BMP implementation and performance is complicated by the absence of clear, uniform standards for measuring compliance, and because each assessment requires site-specific considerations. Prerequisites for successful attainment or measurement of progress toward desired goals are clear and adequate definitions of expectations or goals to be achieved. The lack of quantitative or numerical targets in the GISP inevitably generates questions and confusion as to whether a facility has indeed successfully achieved compliance. And herein lies one of the major handicaps of the GISP program.

A comparison of analytical monitoring data between facilities could shed light on the relative overall effectiveness of BMPs implemented at different sites. However, the bottom-line question is "how effective is effective?" Therefore, quantitative standards of some sort must be provided in order to determine the adequacy of storm water measures provided by facilities. One set of standards that has been used by RWQCBs in California and USEPA for its national storm water program is the USEPA benchmark values provided in the Final National Pollutant Discharge Elimination System Storm Water Multi-sector General Permit for Industrial Activities (hereafter USEPA Multi-sector Permit; USEPA 1995, USEPA 2000b). The benchmarks are indicators of potential impact of discharge but are not enforceable as numerical effluent criteria through the GISP program. These benchmark values are based on several sources of information, including fresh water criteria based on the effects on aquatic species, median concentrations from the National Urban Runoff Program, and minimum levels based on detection limit. However, for these numeric water quality standards to become enforceable through the NPDES framework, they must be translated into appropriate (numeric) *effluent limitations* that typically must be met "end-of-pipe". The Discussions section, under "Case study investigations: storm water analysis," explores the situation in greater depth and recommends some specific means to address this issue of whether compliance can be adequately defined to protect water quality in the absence of numeric effluent limitations.

III. METHODS

This study used database analysis, document review, and case study evaluations consisting of site inspections and storm water sampling and analysis to assess compliance of the selected auto dismantling facilities with the requirements of the GISP program. A mathematical equation, known as the EPA Simple Method, was used to quantify pollutant load in storm water runoff from the auto dismantling industry.

NON-FILER IDENTIFICATION (TIER 1 ANALYSIS)

To assess the non-filer situation, this study used two sources of data as presented in Table 1. First, to perform a county-wide evaluation, staff enlisted the cooperation of the California Department of Motor Vehicles, Occupational License Division (DMV) to obtain a list of auto dismantlers in Los Angeles County who had applied for and maintain a current dismantling license (DMV 1999). Each facility name and address on the DMV list was queried and checked using the RWQCB's NOI database to determine if the facility had filed a NOI. Facilities on the DMV list missing from the NOI database were contacted by phone to verify their operating status and the accuracy of the facility-specific information.

The second analysis focused on a four square-mile area within the County known to have high population of auto dismantling facilities. The data used in this study has been compiled by the City of Los Angeles inspectors who conducted door-to-door site visits between December 1998 and May 2000, specifically to identify non-filers in areas within the City of Los Angeles. The site visits were conducted as a Supplemental Environmental Project (SEP) that the City undertook, as part of its penalty under an Administrative Civil Liability issued by the RWQCB for City's past sewage spill incidents. A group of University of California at Los Angeles (UCLA) professor and students led the efforts to provide data QA/QC and data analysis.

TABLE 1. Data Source and Analytical Procedures for Non-filer Assessment

	Analysis I	Analysis II
Type	Auto Dismantling License Information	Door-to-door Site-visits
Source	California DMV Occupational License Division	RWQCB (City of Los Angeles' Supplemental Environmental Project)
Target area	Los Angeles County	City of Los Angeles (four square-mile area)
Analytical Procedures	1. Cross-check information on DMV list with NOI database 2. Perform over-the-phone verification of operating status and other information 3. Compile and analyze data	1. Query site visit results for auto dismantling facilities (conducted by UCLA) 2. Confirm NOI status (City of LA/ UCLA) 3. Analyze results by area (UCLA)

DETAILED STORM WATER DOCUMENT REVIEW (TIER 2 ANALYSIS)

The next level of evaluation focused on the facilities' compliance with the reporting and documentation requirement. To obtain a smaller pool of facilities for an in-depth review of storm water documents, this study selected 52 facilities from a total of 349 auto dismantling facilities from the NOI database. To ensure a representative pool, the facilities were chosen by first alphabetically sorting the 349 facilities by business name and choosing every sixth facility (A small number of the chosen facilities were located in Ventura County. These facilities were eliminated to limit the focus to Los Angeles County.)

To evaluate permittee compliance with the annual reporting requirement, this study chose to concentrate on trends observed in Annual Report submittal rates over times, based on the 52 selected auto dismantling facilities and on the quality of the Annual Reports submitted for the 1997/98 permit year. The proportion of facilities submitting the Annual Reports, among the 52 selected facilities, was determined by electronically querying the Annual Report databases maintained at the RWQCB. Similarly, the 1997/98 Annual Report database was queried for summaries of monitoring activities conducted by facilities. In addition, Annual Reports were reviewed for more detailed information not electronically available.

SWPPPs and written Monitoring Programs were requested from the selected 52 facilities through a formal letter issued by the RWQCB to each facility operator. An in-depth review of the SWPPPs and the written Monitoring Programs was provided using a checklist (see Appendix A) outlining the requirements specified in Sections A and B of the GISP.

CASE STUDY INVESTIGATIONS (TIER 3 ANALYSIS)

To investigate the onsite component of compliance, this study selected nine out of the 52 facilities for site-specific evaluation. These nine facilities were clustered in the San Gabriel River and Los Angeles River watersheds. Staff inspected all nine sites and collected storm water samples from the eight sites that produced sufficient volume of runoff to enable sample collection. Storm water samples were collected from primary discharge locations that conveyed runoff from the areas where principal industrial activities were conducted. The purpose was to assess the extent to which facilities implemented the BMPs indicated in their SWPPPs and to study the overall effect of the BMPs implemented based on the storm water analytical data. Storm water sampling activity and analysis were carried out under conditions consistent with the requirements in the GISP. Only fully-trained staff and interns participated in the storm water sample collection, handling, storage, and transport activities to ensure adequate QA/QC. Chain of custody forms were completed for all samples. Samples were analyzed by the California Department of Health Services laboratory.

WATER QUALITY IMPACT ASSESSMENT

EPA Simple Method

To provide a perspective on the potential water quality impact(s) associated with storm water runoff generated from the auto dismantling industry, pollutant load was estimated using storm water analytical data from the case study investigations. This study used the EPA Simple Method equation for load assessment:

$$L = 0.227*P*Pj*A*C(0.05 + 0.009*I)$$

where

L = pollutant load (pounds/ per year);
C = average flow-weighted concentration of the pollutant in runoff (mg/L or ppm);

P_j = fraction of rainfall events that produce runoff;
P = annual precipitation in inches per year (inches per year);
A = area of the site (acres);
I = the percent of the site's imperviousness; and,
0.227 = conversion factor (inches/foot)* (acre-feet-ppm/pounds).

IV. DISCUSSION OF RESULTS

This chapter presents key findings on the degree of compliance achieved by auto dismantling facilities; evaluates the quality of storm water runoff generated from selected facilities; estimates the load contributed by the industry in the form of storm water pollution; and discusses water quality implications associated with the key findings of this study.

NON-FILERS

Applying for coverage under the GISP does not guarantee that a facility will actually achieve pollution abatement, but it is an important first step. Also, from the perspective of "leveling the playing field," it is necessary for regulators to characterize the extent of non-compliance with the NOI requirement and take aggressive, timely actions once non-filers are identified to bring them into compliance. Auto dismantling facilities, due to the nature of the industrial activities conducted onsite, are subject to the GISP requirements. Facilities of this industry are informed about the GISP requirements through two main channels. First, auto dismantling facilities are notified about the NOI requirement by the California DMV when they apply for a dismantling license from the DMV's Occupational License Division. The DMV auto dismantling license application includes a questionnaire about whether the facility operator has filed a NOI with the State Board. (The DMV forwards a copy of the completed application to the State Board per pre-established interagency agreement/cooperation between the two state agencies.) The second channel of information regarding the industry's duty to comply is the mass-mailing that the State Board periodically conducts as part of its effort to reach potential non-filers.

Table 2 describes the results of non-filer identification using the DMV dismantling license list. Of the 463 facilities on the list that were checked against the RWQCB's NOI database, 147 were identified as potential non-filers. Phone verification identified 77 of the 147 facilities to be actually operating without a NOI. In other words, approximately one-fifth of the facilities on the DMV list comprised of non-filers. The rest of the 147 facilities had either terminated operation or could not be reached after multiple phone attempts.

Essential to obtaining an accurate estimate of non-filers is an understanding of the total universe of facilities regulated. In screening the DMV list against the NOI database for non-filers, this study assumed that the DMV list represented a relatively thorough estimate of the total universe of auto dismantlers in Los Angeles County. To test this assumption, staff screened to see whether the auto dismantlers in the NOI database appeared on the DMV list. This screening effort yielded 72 facilities that could potentially be operating without a dismantling license. Phone verifications confirmed 35 of these to be in operation. This effort yielded a conservative estimate of 404 for the total universe of auto dismantling facilities operating in Los Angeles County, as of August 1999, when this analysis was conducted. This estimate includes facilities operating with either or both a NOI or a dismantling license. The number of facilities operating with neither a NOI nor a dismantling license is unknown and is needed to

TABLE 2. Non-filers Among Auto Dismantling Facilities, Los Angeles County: DMV Licenses vs. NOIs Filed[1]

DMV COVERAGE[3]	NOI STATUS[2]					
	Active NOI[4]	Suspended NOI	Terminated NOI	No NOI[5] (Potential Non-filers = 147) Verified **Non-filers**	Out of Operation	Unverifiable
DMV Licensed	292	1	23	**77**	25	45 (21)[6]
No DMV License (72)						
Verified Non-licensed[5]	**35**	-[7]	-	Unknown	-	-
Out of Operation	34	-	-	-	-	-
Unverifiable	3	-	-	-	-	-

The proportion of non-filers among auto dismantling facilities operating in Los Angeles County is estimated at 19% (77 out of 404). The total universe of auto dismantlers in Los Angeles County exceeds 400, based on the number of active NOIs and verified non-filers. For a more accurate characterization, those operating with neither a NOI nor a DMV license need to be accounted for in the total universe of facilities.

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[1] Table 2 originally appeared in a doctoral dissertation (*Chang 2001*).
[2] A RWQCB's NOI database contains information on facilities with NOIs.
[3] In California, auto dismantlers are required to obtain a dismantling license from the Department of Motor Vehicles (DMV), Occupational Licensing Department prior to operation. The list of facilities in Los Angeles County with auto dismantling license was obtained from the California DMV in August 1999.
[4] Note that the total number of auto dismantlers in the NOI database with active status is 364, slightly higher than the total number (349) that was used to select the study pool of 52 facilities. The pool of facilities with active NOIs changes over time as facilities begin and terminate coverage.
[5] Facilities that did not appear on both the DMV list and the NOI database were contacted by phone to confirm their operating status. The facilities were categorized as: "verified" non-licensed (DMV); non-filers; out of operation; and unverifiable if they could not be reached by phone after numerous attempts.
[6] Of the 45 facilities in the unverifiable category, 21 did not have phone numbers listed on the DMV list nor with directory assistance. Therefore, the operating status of these facilities could not be verified. The rest did have phone numbers listed but could not be reached.
[7] Dashes mean not applicable.

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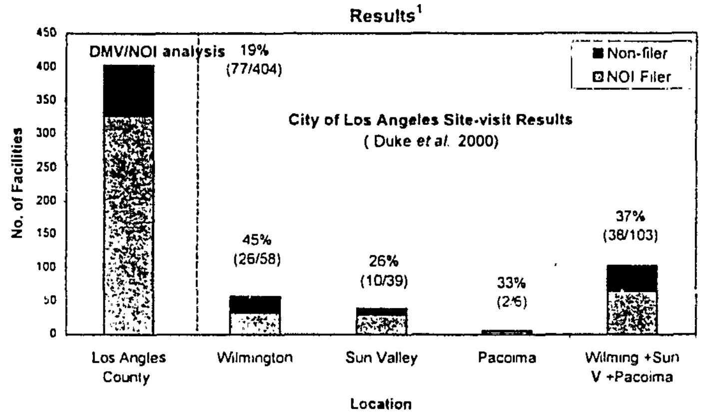
accurately characterize the total universe of facilities, is not known at this time. This estimate lies outside the realm of the objectives and methodology of this study. However, considering the potential severe consequences of violations under both regulatory requirements, the actual number of facilities in this category is probably a small percentage of the total number of auto dismantling facilities in operation.

This study further investigated the 10% (35 of the 364) of auto dismantling facilities with an active NOI that were verified to be operating without a dismantling license. The purpose was to shed some light on reasons that some facilities have apparently chosen to comply with one type of regulatory requirement over another. Each of these facilities were contacted by phone for explanations as to why the facility appeared to be in violation with a regulatory requirement so essential to its operational activities (a valid dismantling license is required for transactions at used auto auctions). It turned out that a small fraction of these facilities (less than 10% of those contacted) actually had a dismantling license, either under a slightly different address or business name, or under the name of the facility's headquarters. Facilities that knew they were in compliance cooperatively shared their dismantling license information with the

RWQCB staff The remaining facilities, however, refrained from revealing their dismantling license number or from discussing possible reasons why the facility is not represented in the DMV dismantling license database, even after repeated assurances from staff that the information was for research purposes only and not for enforcement activities. It is highly likely that these facilities were operating without a valid dismantling license.

Figure 1 illustrates the outcome of the two non-filer analyses, showing the percentages of non-filers for the overall County and at the sub-city level. Presented to the left of the dotted line is DMV/NOI analysis, and to the right are the site visit results. The site visits performed by the City inspectors targeted three areas within the City of Los Angeles boundary-- Wilmington, Sun Valley, and Pacoima-- with the first two areas accounting for over 40% of all auto dismantlers in Los Angeles County with an active NOI. A total of six auto dismantling facilities were identified and visited in Pacoima. Overall, non-filers accounted for 37% of the auto dismantling facilities identified in the three areas. The area with the highest ratio of non-filers was Wilmington (45%), followed by Pacoima (33%) and Sun Valley (26%). Only six auto dismantling facilities were identified in Pacoima.

Figure 1. Non-filers Among Auto Dismantling Facilities in Los Angeles County, CA.: Identified from Database Analysis and Site-visit Results[1]



[1] Figure 1 originally appeared in Chang 2001.

Because the site visits did not cover all of Los Angeles County, the results obtained from the site visits cannot be directly compared with the findings from the DMV license analysis. The site visit results, though, indicate that the proportion of non-filers among auto dismantling facilities in some areas of Los Angeles County could be twice as high as the average estimated by the DMV/NOI analysis for the entire County. Three reasons potentially account for the substantial difference between the ratio of non-filers estimated for the County and at the sub-County levels. First, Wilmington and Pacoima may have disproportionately high percentages of non-filers compared to the rest of Los Angeles County (Sun Valley had a similar percentage of non-filers as estimated by the DMV/NOI analysis). Second, the number of facilities delinquent with both the NOI and the dismantling license requirements could be significant. These facilities may be reflected in the site visit results but not in the DMV database. Another possible explanation is that the areas visited by the inspectors had both disproportionately high percentages of non-filers and non-DMV-licensed facilities. (Note: The RWQCB has started to follow up with facilities, across all industries, which were identified as potential non-filers by the City inspectors. Out of about 430 facilities fully inspected, approximately 200 facilities were identified as potential non-filers and are subject to follow-up activities, including a letter notifying their potential to file a NOI and an inspection, if necessary.)

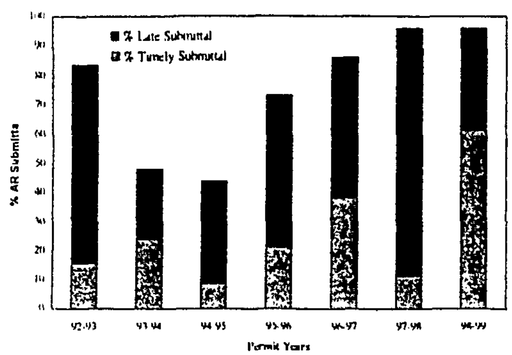
As demonstrated by the statistics, the non-filer problem is significant for the auto dismantling industry. However, to place the non-filer situation in the context of other industries, this study also looked at the City's site visit results for two other major industries mandated for coverage under the GISP- recycling and transportation sectors. Of the three sectors, the auto dismantling industry had the highest compliance rate with the NOI requirement of 63%, followed by transportation with 38%, and recycling with 13% (Duke et al 2000). The higher compliance by the auto dismantling industry could be attributed to the successful interagency coordination between the State Board and the DMV. As a way to effectively identify and reach out to potential non-filers, this study recommends that the State Board actively solicit the cooperation of other state/local agencies to enhance information sharing and to incorporate the NOI requirement by reference into other regulatory requirements, similar to the DMV dismantling application procedures. Auto dismantling licenses and construction grading permits (under the Municipal storm water requirements) are two examples where filing a storm water NOI has become a pre-requisite for license/permit issuance.

In conclusion, full compliance with the NOI requirement has not been attained by the auto dismantling industry. The DMV dismantling license analysis, which probably underestimates the number of non-filers for reasons explained revealed that, at minimum, one out of every five auto dismantling facilities in Los Angeles County is a non-filer. In some areas of Los Angeles County, such as Wilmington, the non-filer problem appears exacerbated, with approximately one out of every two facilities operating without a NOI. The recommended approach for identifying non-filers is to utilize interagency coordination and employ available databases, such as the DMV dismantling license and NOI information supplemented by site visits. Agency-generated data probably offers a higher degree of accuracy than commercially available databases. At this time, it is difficult to draw any quantifiable conclusions about the water quality implications associated with "non-filer" sites, including whether the quality of runoff from non-filers, on average, is expected to differ significantly from runoff from permitted facilities. because there are no known studies or data that specifically target the quality of storm water runoff from non-filer sites.

ANNUAL REPORTS

This sub-section describes the trend in compliance achieved by the 52 selected auto dismantling facilities with the requirement to submit Annual Reports by July 1st of each year. Also characterized are the facilities' performances in implementing the required monitoring activities for the 97-98 permit year. Both qualitative and quantitative monitoring data serve as an indicator of each facility's overall performance with BMP implementation, help build a comprehensive inventory of essential water quality data, assist in developing water quality standards, and more. For instance, analytical monitoring data provided in the Annual Reports present a potential source of information necessary to support the quantification of loads associated with storm water runoff from industrial sources, a step necessary to develop TMDLs. The types of monitoring summaries contained in the Annual Reports, if completed properly by facility operators, could reveal important facility-specific and compliance-related information such as how diligently a facility implemented the required monitoring activities, the quality of the storm water runoff generated from the facility, and whether the facility operator has reviewed and updated the facility's SWPPP, and reassessed the adequacy of existing BMPs in controlling storm water pollution.

Figure 2. Compliance with Annual Reporting Requirement among Selected Auto Dismantlers in Los Angeles County



[1] Figure 2 originally appeared in Chang 2001.

Figure 2 illustrates the trend in facilities' submittal of Annual Reports from 1992 to 1999. The overall height of a bar indicates the total percentage of Annual Reports submitted for a given permit year. The lower, lighter portion of bar indicates the proportion of facilities that submitted Annual Reports on or before July 1st. The upper, darker portion represents late submittals. Compliance is represented in percentages rather than actual number of reports submitted because the number of facilities *required* to submit Annual Reports varied over time because the facilities' coverage under the GISP program was initiated at different times (by 1996, all of the 52 selected facilities had filed a NOI).

As illustrated in Figure 2, compliance was low in the early years, with the majority of the facilities failing to submit the required Annual Reports for the 1993/94 and 1994/95 permit years, and with the majority of the reports arriving late. The lack of sound monitoring data, as a result of deficient reporting, would leave both the regulators and the dischargers in the dark about critical questions such as how successful an individual or a group of facilities' efforts have been in controlling storm water pollution at their site and their progress over the years. In addition, not having adequate analytical data substantially limits regulatory efforts to characterize the quantity of load associated with the storm water runoff from regulated communities. Without the data necessary to self-diagnose their facility's performance and a chance to address the deficiencies in a timely manner, facility operators are really placing themselves in jeopardy of increasing their environmental liability and the chances of regulatory enforcement actions and third-party lawsuits. Therefore, both the dischargers and the regulators are negatively impacted when facilities fail to monitor and report their monitoring results to the appropriate regulating agency.

Observations based on the 52 selected auto dismantling facilities revealed that starting in 1995/96, two-thirds or more of the required facilities submitted their Annual Reports. The highest Annual Report submittal rate (96%) achieved in 1997/98 and 1998/99 is an outcome of increased enforcement activities launched by the RWQCB in recent years and demonstrate the importance of and the need for aggressive, timely regulatory follow-up activities.

Several hundred enforcement letters were issued in 1997/98 to facilities across all industrial sectors that failed to submit Annual Reports on time. As apparent from Figure 2, the majority of the 1997/98 Annual Reports were received late, with most of them probably in response to the enforcement letters. The subsequent permit year had even greater success. While maintaining the Annual Report submittal rate at 96%, there was a substantial increase in the number of reports being submitted on time.

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Evidently, the large-scale enforcement activities, including the issuance of formal violation letters and mandatory penalties for recalcitrant violators, have resulted in tangible results and have demonstrated to be an effective tool for communicating to the regulated community the potential severe consequences of violating storm water regulations.

The usefulness of the Annual Reports to regulators and dischargers alike depends on the accuracy and the completeness of the reports being submitted. In the Los Angeles Region, much of the agency's limited resources have been dedicated in the past to identifying and following up with facilities that have failed to submit Annual Reports. Constrained by resources, limited regulatory attention was focused on the quality of the Annual Reports received or the monitoring results reported in the Annual Reports. This study conducted detailed reviews of the 1997/98 Annual Reports submitted by 50 of the 52 selected facilities to contribute to an increased understanding of the quality of Annual Reports and the monitoring data submitted by auto dismantling facilities.

Figure 3. Storm Water Monitoring Activities Conducted by 52 Selected Auto Dismantling Facilities (1997/98 Annual Reports)

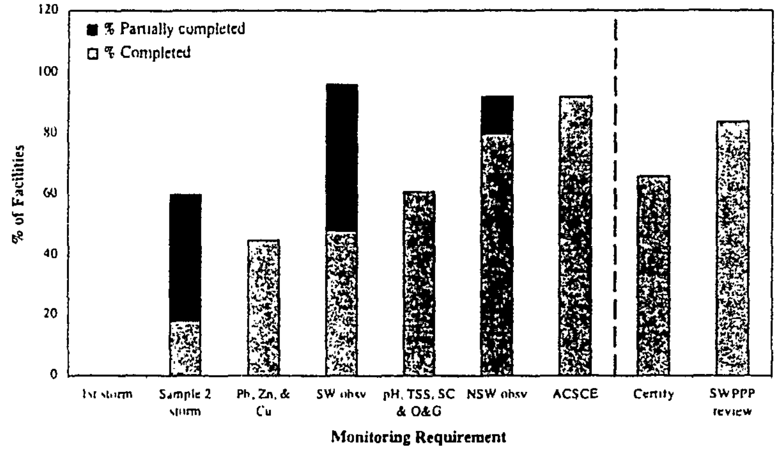

Figure 3 illustrates how successfully the 50 facilities that had submitted the Annual Reports fulfilled their required monitoring activities (two of the 52 facilities did not submit their Annual Reports). Results are presented in the order of low to high compliance, in terms of facilities that fully satisfied a monitoring requirement, as indicated by the bottom, lighter portion of a bar. The upper, darker portion represents facilities that partially completed a required monitoring activity. Bars to the left of the dashed line indicate monitoring activities and to the right are administrative requirements associated with the monitoring program. Monitoring requirements include: visual observations of storm water and non-storm water runoff, storm water sampling and analysis, and an annual comprehensive site evaluation that includes a full-scale site inspection and a SWPPP review and update. Table 3 augments the findings on the monitoring activities with detailed narrative description.

None of the individual categories of monitoring activities were completed by all 50 selected facilities. Overall, facilities were less likely to perform monitoring activities that are more cost- and effort-intensive, such as storm water sampling and analysis, than activities that are simple to perform and involve little or no cost, such as visual observations. This trend was observed even among activities such as visual observations that require minimal resources to perform. Approximately 80% of the facilities fully complied with the quarterly observation of non-storm water (a total of four observations required to be conducted under *dry* weather conditions). A

Table 3. Summary of Monitoring Activities Reported by for 50 Selected Auto Dismantling Facilities (1997/98 Annual Reports)

MONITORING REQUIREMENT	FACILITY COMPLIANCE						COMMENTS
	Completed		Partially Completed		Did Not Attempt		
1. Submit Annual Report by July 1st deadline	31	62%	19	38%	N/A	N/A	• "Completed" means facility submitted the Annual Report before or on 7/1/98. • "Partially Completed" means facility submitted Annual Report after 7/1/98. • "Did Not Attempt" means facility did not submit Annual Report.
2. Sample from two storm events	7	18%	16	42%	15	40%	• "Completed" means facility collected and analyzed sample(s) from two qualifying storm events. • "Partially Completed" means facility collected and analyzed sample(s) from one storm events. • "Did Not Attempt" means facility did not collect or analyze any sample. • Twelve out of the 50 facilities belonged to a Group Monitoring Program and were exempt from sampling during the 97-98 year. Therefore, statistics for Requirements #2-#4 reflect results for 38 facilities. • Most facilities that failed to collect samples from two storm events did not have adequate explanations. The 97-98 wet year is marked by unusually plentiful rainfall due to the El Niño phenomena.
3. Sample from the first storm	0	0%	N/A	N/A	38	100%	• The first flush occurred on a weekend. GISP does not mandate facility operators to collect storm water samples outside of their typical operating hours or under hazardous conditions. • 19 out of the 38 facilities provided inadequate reasons for not sampling from first storm; four out of the 38 facilities that failed to sample from first storm did not provide any explanation.
4. Analyze samples for pH, TSS, SC, and O&G	23	61%	0	0%	15	39%	• About 39% of the facilities failed to collect any samples • All 23 who sampled from at least one storm tested for these basic constituents.
5. Analyze samples for Cu, Pb, and Zn	17	45%	N/A	N/A	21	55%	• Seventeen facilities tested at least one set of samples for Pb, Cu, and Zn. • About 55% of the facilities either failed to sample at all or sampled from at least one storm but failed to analyze for metal.

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Table 3. Summary of Monitoring Activities Reported by for 50 Selected Auto Dismantling Facilities in 1997/98 Annual Reports

(Continued)

MONITORING REQUIREMENT	FACILITY COMPLIANCE						COMMENTS
	Completed		Partially Completed		Did Not Attempt		
6. Conduct quarterly non-storm water visual observations	40	80%	6	12%	4	8%	• "Completed" means facility conducted four quarterly observations. • "Partially Completed" means facility conducted at least one but less than four quarterly observations. • Two facilities attached a narrative description of the type of authorized non-storm water discharges observed from their site. However, when asked in the Annual Report whether the facility ever had authorized non-storm water discharges, both facility operators answered negative.
7. Conduct monthly storm water visual observations during the wet season (Oct. 1st - May 30th)	24	48%	24	48%	2	4%	• "Completed" means facility conducted eight monthly observations during the wet season (October to May). • "Partially Completed" means facility conducted at least one but less than eight monthly observations during the wet season. • If a month had no storm, the facility operator must report so.
8. Conduct annual site evaluation	46	92%	N/A	N/A	4	8%	• Four facilities that failed to conduct Annual Comprehensive Site Compliance Evaluation (ACSCE) provided no explanation.
9. Review SWPPP for BMPs and compliance	42	84%	N/A	N/A	8	16%	• Eight facilities that failed to review SWPPP provided no explanation.
10. Certify for compliance	33	66%	N/A	N/A	17	34%	• Of the 17 facilities that did not certify for compliance, 16 facilities cited their failure to meet one or more of the monitoring requirements as the reason for not certifying. • One facility did not provide any explanation for not certifying for compliance.

substantially smaller proportion of facilities (less than half) completed the storm water runoff observations (a total of eight monthly observations activities during *rain* event).

None of the facilities were able to collect samples from the first storm event because the first storm event of the 1997/98 wet season occurred on a Sunday for most of the Los Angeles region (Facilities are not required to sample outside of their normal business hours or under dangerous conditions). Some facilities did not provide a valid explanation for their failure to sample from the first storm event. Less than 20% of those *required* actually sampled from two storms events, as required by the GISP (note: Some facilities that belong to a group monitoring program are subject to less frequent sampling. This study appropriately accounted for those facilities in its analysis). The 1997/98 wet season was impacted by El Niño and had unusually frequent and intense storm events, therefore ruling out the lack of sufficient rain as one of the valid excuses for not sampling. Less than half of those required actually analyzed for copper, lead, and zinc. And among the facilities that sampled from at least one storm, about a quarter did not analyze for the required metals. Failure of facilities to analyze for the designated constituents --i.e. specific pollutants determined by regulators to be of concern for a particular industry -- really hinders efforts to quantitatively evaluate a facility's performance and to gauge potential water quality impact.

Inherent to self-reported information without QA/QC procedures is the uncertainty in the accuracy of the data provided. Annual Reports are subject to similar deficiencies. Each Annual Report must contain a self-certification of compliance signed by the facility operator or equivalent. Whether self-certifications are a reliable gauge for measuring facility compliance depends on several factors including a facility operators' level of understanding and informed interpretation of the GISP requirements and their ability to appropriately assess and accurately report the facility's compliance status. To evaluate how accurately the Annual Reports reflect facility compliance, this study compared the number of Annual Reports self-certified for compliance against the number of facilities reported to have successfully complied with a particular category of monitoring requirement. We considered a monitoring activity that is required of *all* facilities- monthly visual observation of storm water discharges. According to Table 4, less than half, 48%, completed all eight monthly visual observations of storm water, which implies that an equal or smaller number should have certified for compliance, considering the fact that a facility must also satisfy all the other GISP requirements before certifying for compliance. About two-thirds of the Annual Reports were self-certified, pointing to a discrepancy of at least about 20% between those certifying for compliance and those actually complying. It should be noted that only one monitoring activity was considered here. In reality, the actual gap between the number that self-certified and the number that fully completed all required monitoring activities or all GISP requirements is expected to be considerably larger.

Whether this discrepancy is due to a flawed interpretation of compliance criteria, mere carelessness on the part of the facility operator, or unwillingness to openly expose or admit one's deficiency for fear of potential enforcement, one conclusion that can be drawn is that self-certification is not a perfect indicator of facility compliance and should be used with caution when used to estimate permittee compliance.

STORM WATER POLLUTION PREVENTION PLAN

A hallmark of the P2 approach, which drives the GISP program, is the reliance on the facility operators to identify potential pollutant sources and appropriate site-specific BMPs to achieve P2 at their facility. The underlying assumption is that facility operators are the ones most familiar with the facility operations and other site-specific conditions. Therefore, facility operators are considered the ideal candidates for identifying site-specific solutions for their facility.

The GISP requires each facility operator to develop a SWPPP, which is a site-specific document that lays out exactly how a facility will control storm water pollution associated with its industrial activities. Compliance with the SWPPP requirement has not been well characterized because, unlike Annual Reports, SWPPPs are not required to be submitted to the RWQCB. An in-depth review of SWPPPs that considers the site-specific nature of each facility requires a substantial amount of time. This study is one of the first attempts in California and perhaps in the nation to characterize, on a large scale, the quality of the SWPPPs prepared by and for a specific industrial sector. A detailed review was provided for the 50 SWPPPs received based on specific SWPPP-related requirements outlined in Section A of the GISP. A summary of the deficiencies found in the SWPPPs are described in Table 4.

One major deficiency noted in many of the SWPPPs was that they were boiler-plate documents that lacked specific details on the actual BMPs chosen for implementation by the facility operator. Also missing were procedural details about how the BMPs would be implemented. About 90% of the SWPPPs reviewed were prepared by one of four consulting companies. Many of the SWPPPs were written in a vague manner that made it difficult to determine exactly which measure, among a set of "ideal" or "proposed" BMPs described in the document, was chosen for implementation by the facility operator.

As indicated in italics in Table 4, these SWPPPs provided no or limited information on: 1) the name(s) of individual(s) responsible for the implementation of various monitoring activities; 2) a detailed, comprehensive site map that describes the locations of pollutant sources and where industrial activities are conducted; and 3) BMPs that are fundamental to the P2 efforts, such as employee training, site inspection, and good housekeeping programs. In essence, a SWPPP is a "blue-print" that describes specific measures and a schedule of implementation a facility will employ to achieve P2 and regulatory compliance. The SWPPP should be a "living" document that is regularly updated and reflects the actual site conditions. Given their generally poor quality, the majority of the SWPPPs reviewed fail to effectively guide facility operators in the field implementation phase. From verbal communication with facility operators, it appeared that many SWPPPs were being developed by a third party with little involvement or input from the facility operators or key personnel. About a quarter of the 52 facility operators who had called after receiving the RWQCB's formal request for SWPPPs demonstrated little or no knowledge of the SWPPP requirement, indicating

Table 4. Review of SWPPPs and Written Monitoring Programs Submitted by about[1] 50 Selected Auto Dismantling Facility Operators (Los Angeles County, 1999)

Element Specified in General Permit	Missing	Inadequate Description
A. Storm Water Pollution Prevention Plan		
Pollution Prevention Team	0	31
Site map	2	35
List of significant materials handled or stored on site (describe type, location, and quantity)	5	26
Description of industrial activities and potential pollutant sources	2	16
Assessment of potential pollutant sources, pollutants and locations.	2	9
Spill history	5	0
Investigation of Non-storm water discharges	12	2
Non-structural Best Management Practices	0	18
Good housekeeping program	13	3
Preventive maintenance program	8	6
Spill prevention and response program	8	6
Material handling and storage procedures	8	3
Waste handling & recycling	9	5
Erosion and sediment control	9	1
Employee training program	9	10
Site inspection program	6	3
Recordkeeping and internal reporting	6	6
Quality assurance	5	0
Structural BMPs	2	N/A[2]
Annual Comprehensive Site Compliance Evaluation	2	18
B. Storm Water Monitoring Program		
Quarterly non-storm water visual observations	3	5
Storm water visual observations (monthly from October and May)	0	27
Field sampling procedures	0	12
Sampling program specifying locations and times	0	5
Sample preservation procedures	0	34
Analysis methods	7	11
Specification of constituents mandated for sample analysis	0	37
Retention of all records for at least 5 years	0	11
Submission of Annual Report by July 1st of each year	5	0
C. Standard Provisions		
Certification and signature of facility operator	3	0

[1] SWPPPs and written monitoring programs were received from 50 and 47 of the 52 selected facilities, respectively.
[2] GISP encourages facility operators to consider structural BMPs *if* the non-structural BMPs chosen are considered insufficient to adequately address the pollutants present. Therefore, the review of structural BMPs was limited to evaluating whether the facility had considered any of the five categories of structural BMPs described in the GISP. For example, it was considered adequate for the purpose of this study if a SWPPP cited that structural BMPs were reviewed and considered but not chosen for implementation because the non-structural BMPs were considered sufficient.

how closely they were involved with preparing their facility's SWPPP. Also, discussions with facility operators during the case study investigations indicated that the facility operators were either unfamiliar or unsure about many BMPs described in their SWPPP. Some facility operators admitted to not fully understanding all aspects of the SWPPP, including the BMPs described, and expressed reservations about their ability to implement certain structural BMPs described in the SWPPP, when it was explained to them what those measures were and the potential consequences for failing to fully implement the SWPPP which they had certified to implement. The lack of or limited facility operator involvement in preparing the facility's SWPPP and in selecting the appropriate BMPs for the facility appears to be one of the main reasons for the disconnect observed between the descriptions provided in a facility's SWPPP and what is actually being implemented in the field.

WRITTEN MONITORING PROGRAMS

How does a facility measure its performance or progress in P2 efforts or gauge the effectiveness of the BMPs implemented? By monitoring. As a requirement of the GISP, facilities must prepare a written monitoring program. The purpose of a written monitoring program is to ensure that proper methods are provided so that facility operators may employ these methods consistently in monitoring their site conditions and the storm water runoff generated from their site. In turn, this would generate monitoring results - both qualitative and quantitative - that are representative of the facility's site conditions and which could provide useful information on a facility's progress over the years.

Out of the 52 requested, 47 auto dismantling facilities submitted their written monitoring programs. The majority of the monitoring programs were prepared by consultants, and had characteristically similar problems as the SWPPPs. Table 4 summarizes some of the deficiencies found in the written monitoring programs per requirements outlined in Section B of the GISP. The documents generally lacked in procedural details explaining how each monitoring activity would be performed. For example, sections on sampling and analysis requirements did not describe the type of sampling equipment to be used, QA/QC procedures, or special precautions needed to provide a well-controlled environment for collecting, storing, and transporting the samples to certified laboratories for analysis. The lack of sufficient procedural details in the written monitoring programs raises questions about the QA/QC procedures used by facilities for their monitoring activities, especially during sample collection, storage, and transport. And this deficiency limits the reliability and the credibility of the storm water analytical data reported in the Annual Reports. Thus, regulators should use the monitoring results provided in the Annual Reports with caution, keeping in mind some of the limitations discussed above. Another flaw observed in a significant number of the monitoring programs is outdated information that fails to reflect the changes included in the 1997 reissued permit. For example, the minimum period required for retaining records increased from 3 years to 5 years in the 1997 permit. However, many monitoring programs still specified 3 years for the minimum required record retention period. Also, many still used the old definition of a wet season (September to April) instead of October through May, as defined in the 1997 permit. Failure to update the SWPPP per new permit conditions affects a facility's ability to comply with the regulatory requirements.

Many of the nine case study facilities that hired consultants to prepare their storm water documents also depended entirely on them to conduct many, if not all, of their monitoring activities. It appears, from discussions with facility operators, that some consultants perform the required monitoring activities alone, unaccompanied by any facility personnel, and provide a written report, summarizing qualitative and/or quantitative monitoring results, to the facility operator at a later time. Although this type of monitoring may technically meet certain regulatory requirement(s), it tends to remove from the facility operator or other key facility personnel the opportunity to fully assess and understand the site conditions first-hand and to seek out the additional steps that may be necessary to make further progress.

Increased compliance assurance activities by regulators, including random audits and formal request of SWPPPs and monitoring programs for review, as well as timely follow-up responses, are some ways to enhance the quality of these storm water documents. In addition, since some of the major problems, including the lack of site-specificity of the documents, are due to the consultants working on these documents, a time-efficient and effective approach would be for the regulating agency to target those few consultants who prepare the documents for the majority in the industry for regular education and training them so that the SWPPPs and the monitoring programs they prepare are up to speed with the GISP requirements. Another recommendation is for the regulating agency to consider the option of requiring all SWPPPs prepared by a third party to be certified to ensure that the details of the monitoring programs selected for implementation have been fully discussed, understood, and agreed upon by facility operators, and that a key facility personnel will conduct or personally accompany the consultant(s) on all of the monitoring activities.

CASE STUDY INVESTIGATIONS: SITE INSPECTIONS

The first and second tiers of compliance establish the foundation for achieving pollution reduction and/or prevention. However, it is only the compliance with the third tier requirements, the onsite implementation, that results in actual pollution abatement and directly impacts water quality. Staff conducted field investigations of nine selected auto dismantling facilities to study their onsite performance.

The field compliance component of the industrial storm water program has generally not been well characterized for the Los Angeles region due to lack of resources available for the GISP program in the past and other competing priorities. However, the general perception is that field compliance is low especially among small facilities. Substantial staff time is required to complete a comprehensive site inspection, which includes pre-inspection preparation, the actual inspection, and post-inspection follow-up activities including completing an inspection report.

Table 5 summarizes some characteristics of the nine case study facilities, including their property size, percent of imperviousness, and the estimated annual vehicle throughput or the number of vehicles processed yearly. Percent imperviousness refers to the portion of a facility property that is paved, roofed (including buildings), or covered. As shown in Table 5, the case study facilities span a wide spectrum in terms of their annual vehicle throughput, property size, and percent imperviousness. One facility

Facility	Property Size (Acres)	Percent Imperviousness (% Paved, Roofed or Inside Building)	Annual Vehicle Throughput
A	2	60	175 - 250
B	0.7	100	80 - 120
C	2	100	180
D	1	100	50
E	1.5	100	75 - 200 (trucks)
F	0.7	100	120
G	1.5	100	150 (trucks)
H	13	100	16,800
I	0.6	32	110

Table 5. Characterization of Nine Case Study Auto Dismantling Facilities

(Facility H) offered "self-service"- i.e. it allows customers to dismantle desired parts directly from the vehicles. The rest of the Facilities, A through G and I, offered retail, "over-the-counter" service and sold already dismantled parts to customers.

Table 6 summarizes some key findings on facility BMP implementation based on staff site inspections. A more complete assessment is presented in Table 7, which provides numerical ratings (from 0 to 3) on how well individual case study facilities implemented the BMPs described in the facility's SWPPPs and other BMPs considered either universally applicable or especially effective for the auto dismantling industry. A facility's overall BMP implementation score -- the sum of individual BMP ratings -- was used to evaluate a possible correlation between a facility's performance and water quality impacts, which is presented in a subsequent section (Appendix B augments Table 7 with the information on the kinds of pollutant sources or activities conducted at each facility and the BMPs that were cited in the facility's SWPPP). The SWPPPs prepared for the nine case study facilities included very similar, overlapping BMPs, primarily consisting of non-structural measures. In general, the findings of this study concur with the trend analyzed in a previous study on the transportation industry by Duke and Chung (1996) that concluded that storm water control measures described similarly in SWPPPs at a number of case study facilities were not uniformly implemented and unequally effective at managing storm water pollutants. As shown in Table 6, some BMPs were more frequently implemented than others.

Table 6. Evaluation of BMPs Implemented at the Nine Case Study Auto Dismantling Facilities

BMP Types	Fully	Partially
Overhead cover for dismantling area	0	3
Cover parts	1	7
2° Containment for fluid-storing container	3	2
Overhead cover for fluid storage	4	3
Pave entire site	7	1
Conduct dismantling on impervious area	8	0

This study also found that BMPs that are more resource-intensive or pose physical constraints on daily operational activities are less likely to be implemented. The structural BMPs cited in the case study facilities' SWPPPs were often missing or if provided at all, were not fully implemented. The first four BMPs that appear in Table 6 (overhead coverage for dismantling and fluid storage areas, coverage for stored part, and secondary containment for fluid storage area) are examples of measures specifically designed to help eliminate or reduce the exposure of pollutant sources to storm water, but yield little apparent tangible benefits for daily operational activities. Only a few facilities successfully implemented these BMPs. More often than not, dismantling activities were conducted outside in an open space, even when a designated roofed area (with three-sided walls) was provided. Staff noticed that one deterrent was the

Table 7. BMP Performance Observed at the Nine Case Study Auto Dismantling Facilities

Activity/ Pollutant Source	Applicable BMPs	BMP Rating[a]								
		A	B	C	D	E	F	G	H	I
Dismantling (includes fluid draining)	Conduct Activity on Impervious area	3	3	3	3	3	3	3	3	0
	Provide overhead cover	1	0	2	0	0	2	0	0	0
	Use drip pan	2	2	3	N/O	N/O	3	1	0	N/O
Parts storage (batteries excluded)	Provide permanent or temporary cover	1	0	2	1	1	2	0	0	3
	Drain most fluids prior to storage	1	2	2	2	2	3	1	1	3
	Store parts off-ground	1	1	2	2	2	3	1	2	3
Battery storage	Remove from vehicle	2	3	3	3	3	3	3	3	3
	Provide 2°containment and cover	2	1	3	3	3	2	0	3	3
Fluid management	Under cover;	1	2	3	3	2	0	0	3	3
	2°containment	1	1	0	0	0	0	3	3	3
Parts Washing/ Cleaning	Indoors or in a covered area	3	0	N/O	0	2	3	2	N/A	2
	Contain wash-water	3	0	N/O	2	2	3	2	N/A	3
Spills/leaks	Use drip pan	2	1	2	2	2	3	1	1	3
	Maintain adequate supply of absorbent	0	0	3	2	2	3	3	2	3
Vehicle storage	Close hood or cover vehicles with engine or oily parts	0	2	2	2	N/O	3	N/O	0	3
	Remove all oily/greasy parts from vehicle (esp. engine, transmission, etc.)	2	3	2	3	3	3	2	0	3
Erosion Potential	Pave entire site	2	3	3	3	3	3	3	3	0
	Use erosion control such as bales of hay or berms (or gravel)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Waste fluid handling	Use appropriate disposal method	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O
Auto compaction	Designated area/pre-drain fluids	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A
General	Good housekeeping practices	1	1	2	2	2	3	0	2	3
General	Employee training (documented)	0	0	0	0	2	2	0	3	1
General	Inspection (documented)	2	2	2	2	2	2	1	3	2
General	Recordkeeping (copy of GISP, SWPPP, MP, Annual Reports, monitoring records)	1	1	2	1	3	3	1	3	1
General	Storm water treatment	0	0	0	0	2	0	0	2	0
Overall BMP Score		31	27	39	35	38	48	26	34	46

[a] For BMP implementation rating, 0=Not implemented; 1= Poorly implemented; 2= Somewhat poorly implemented; 3= adequately implemented, N/A= not applicable, N/O= Not observed during site inspection.
[b] An overall BMP score is the sum of individual BMP ratings. Two BMPs that were excluded when calculating an overall BMP rating scores. The two BMPs are related to auto compaction activities and recordkeeping activities. Auto compaction-related BMP was left out because eight out of the nine case study facilities did not perform auto compaction and to consider this BMP would necessarily bias the results against the eight facilities. Recordkeeping has a definite indirect contribution toward the successful implementation of a facility's storm water program, but was not included because it is an administrative procedure and in itself does not result in pollution prevention.

insufficient overhead and work space that restricted the movement or the maneuvering of employees during dismantling activities or imposed limitations in forklift-aided transfer of vehicles to and from the designated area. These limitations could have been avoided with a more careful strategic planning of the BMP, that considers adequate work space.

Some BMPs were not implemented by many facilities because of the effort involved in consistently implementing the BMP and other factors. These BMPs include covering parts during storm events and the use of absorbents to control spills. For example, most facilities cited in their SWPPPs that plastic sheets, tarpaulins, or other types of temporary covers would be used to shield vehicle parts from rain. The use of plastic sheets or tarpaulins involves minimal cost for material acquisition but is beset by the following difficulties: (1) unless secured appropriately, tarps or plastic sheets tend to be blown away by wind and provide minimal protection from rain, if any; (2) providing temporary covers depends entirely on the effort of facility employees and are less likely to be implemented consistently and completely, especially under severe storm conditions or if a storm event starts before or after normal business hours; and (3) some facility operators cited other factors, such as tarps placed over the parts storage areas disappearing over night, most likely claimed by itinerant individuals or children in the neighborhood. Given these limitations associated with using temporary covers, facility operators should be strongly encouraged to install permanent roofs or an overhead coverage to effectively reduce exposure of stored parts to precipitation. Another BMP shown to be inconsistently implemented is the use of absorbents to control spills and leaks. Supply maintenance and timely responses are especially crucial for spill-related BMPs. Many case study facilities were deficient in implementing their spill control measures, judging by the degree of spills, leaks, and stains from past spills present on the facility ground. Failure to maintain an adequate supply of spill absorbents on site, the diligent effort required to address small frequent spills, and the lack of urgency that small spills pose compared to large-scale spills are some reasons cited by facility employees for their failure to provide spill control and response measures mentioned in the facility's SWPPPs. Instead of providing immediate attention, many facility employees delayed spill clean-up activities until the end of the business day.

Several major sources contributing oil and grease in storm water runoff were visually identified during the site inspections. Qualitatively judging from the rainbow-colored sheen floating on top of the storm water runoff, failing secondary containment, such as leaky truckbeds used to store incompletely drained parts, fluid-storage areas missing adequate secondary containment or overhead covers, unprotected dismantling areas, and auto compaction location appeared to be the principal sources introducing high levels of oil and grease into storm water from the case study facilities. All of these sources represent areas associated with principal industrial activities.

A recommendation based on these site inspection observations is to provide both an overhead coverage and an adequate (secondary) containment for areas associated with principal industrial activities. Conducting all activities inside a building or roofed, bermed (or curbed) areas would really help minimize or eliminate the introduction of pollutants into storm water runoff. To maximize the usefulness of these structural BMPs, adequate working space and overhead room are two critical factors that need to be considered in the planning stage of these BMPs. There are BMPs such as storing well-drained parts in large autobodies (as observed at Facility I) that allows facility operators to use materials readily available onsite and does not necessitate building a structure. However, this type of BMP, to be effectively implemented, requires extra effort and vigilance on the part of the facility staff (and are thus less likely to be implemented successfully) since parts must be thoroughly drained prior to being placed inside the autobodies, as opposed to parts stored in bermed areas which prevent runoff of residual fluids. Some specific measures to protect the fluid storage areas that have been shown to be effective in the field include a combination of providing an overhead roof or a clean solid board (placed on top of fluid-storing drums) along with the use of sealed, flat-bottom truckbeds, berms, or a secondary drum large enough to fit another drum inside. Secondary drums should preferably be filled with sand or other spill absorbent material, and sufficiently large and low enough so that the inner fluid-containing drum could easily be transported in and out using a forklift.

The primary cause of significant spills observed during auto compaction is incomplete draining of fluids from parts that remain on the vehicles. Facility H, the only case study facility that conducted auto compaction activities, removed most cores (unwanted parts) prior to vehicle compaction after customers had a chance to claim the desired parts. Based on the substantial spills observed during its auto compaction process, the facility apparently had neglected to completely drain residual fluids from the parts remaining on the vehicles, causing fluids to jet out well beyond the surrounding berm during the compaction process. Complete fluid draining upon vehicle arrival is crucial to preventing spills generated during vehicle staging or compaction process.

Many BMPs must be implemented in combination with other BMPs to be effective. A set of BMPs that appears to be especially effective when implemented together is secondary containment and overhead coverage as mentioned above. Overhead coverage helps to eliminate the exposure of pollutants to storm water runoff but not for spills traveling away from, for example, a roofed fluid-storage area. Similarly, severe storms could flood uncovered, bermed areas and introduce pollutants to storm water runoff. When combined, these BMPs could effectively reduce pollutant contact with storm water. Few facilities provided both of these BMPs for the same source area.

Other BMPs implemented by the case study facilities (storing parts off-ground or removing greasy parts from vehicles) by themselves offer minimal or limited pollution control. For example, mounting partially-drained parts or fluid-storing drums on wooden pallets could appear to reduce contact with storm water runoff; however, spills and leaks generated during parts or fluid transfer typically flow over the pallets and contaminate the site ground and make contact with storm water. Mounting fluid-storing drums on top of pallets does not help contain spills and leaks and is not a secondary containment measure, contrary to the claims of some facility operators. Even when parts are fully drained before being placed on pallets, they must be provided with adequate cover to minimize exposure to storm water. Site pavement, which is considered as a stand-alone solution to controlling sediment in storm water, could only offer some degree of control of solids in storm water when facilities have poor housekeeping practices. Facility B had the entire site paved, but the level of total suspended solids (TSS) in its storm water samples substantially exceeded the USEPA benchmark for this constituent. In fact, the facility's TSS level was comparable to other case study facilities with partial or almost no site pavement. A potential source of sediment in storm water generated from completely paved sites is soil from vehicle tires or customers' shoes.

Several factors were considered in identifying potential reasons for the varying degree of BMP implementation observed at the nine case study facilities. The number of employees, facility size, and annual vehicle throughput did not appear to correlate well with a facility's ability to effectively implement BMPs for facilities with five or less personnel, of two acres or less, or with yearly vehicle throughput of less than 300. The eight facilities that fell within this category demonstrated significant differences in their BMP implementation efforts. Facility H, with 16,800 annual vehicle throughput and a 13-acre site, provided several environmentally-trained personnel onsite, maintained efficient recordkeeping, offered regular training for all its employees, and provided storm water treatment, including an oil and water separator for a portion of the site's storm water runoff and an adequate supply of excelsior in the primary discharge location. However, because of the small study pool, with only one facility of this caliber, it is difficult to arrive at a conclusion as to whether facilities with greater resources are more likely to fully implement their BMPs and other storm water program requirements. The performance of this facility could very well have been compelled by an aggressive third-party lawsuit launched by a local non-profit environmental organization against the facility in the recent past.

Cultural or language barriers and the lack of public outreach were identified as two potential reasons for the deficient BMP implementation. The different ethnic backgrounds represented among auto dismantlers in Los Angeles County include Armenian, Mexican, Korean, Persian, and Caucasian, with the first two groups representing the dominant ethnic groups in some areas. From phone conversations and discussions from the site inspections, it became apparent that many of the ethnic minorities did not fully understand the GISP instructions and some had trouble following the verbal instructions of staff. This may partially explain the apparent disconnect between the consultant-prepared SWPPPs and the actual implementation of BMPs onsite. Many of the case study facility operators displayed complete ignorance and a sense of apathy about the significance of storm water pollution, and complained about having to pay for the discharge of naturally-occurring storm water, clearly missing the key point that it is the *pollution* in the storm water runoff that they are responsible for.

One of the key findings of this present study based on the staff's site-inspection experiences is that determining onsite compliance can be rather challenging and not very straightforward for both dischargers and regulators. This is especially true for facilities that are not grossly deficient or sloppy in their housekeeping or operational practices. More accurately, if compliance is to be defined to ensure protection of waterbodies and to prohibit contributing to possible excursion of all applicable water quality standards, as is stated in the GISP, the task of accurately assessing compliance becomes even more daunting because of the following three reasons.

First, the GISP does not specify a mandatory, minimum set of BMPs that must be implemented by all permittees or by each industry. The GISP basically states that facility operators should *consider* the different categories of BMPs outlined in the permit and then select and implement appropriate BMPs to attain the Best Available

Technology (BAT) level. However, the permit does not define what the BAT level is or how to demonstrate that the BAT level has been ascertained. Therefore, facility operators belonging to the same industry may choose from a range of different BMPs - either a single, highly effective BMP, such as treatment, or a combination of multiple BMPs whose cumulative impact may be equally effective. The P2 approach with its primary reliance on facility operators to identify and implement site-specific solutions offers flexibility and room for economic considerations. However, it also presents difficulties for those charged with the responsibility of assessing whether the BMPs provided and as implemented are sufficiently adequate to ensure that the facility's storm water discharges are not contributing to or causing exceedances of water quality standards. There is still limited information on the effectiveness of specific BMPs or the cumulative effects of combined BMPs. And to leave this task of compliance determination up to the individual operator's judgement seems to be questionable regulatory policy.

Secondly, there are no numerical effluent limitations in the GISP, with the exception of a small group of facilities specified under USEPA regulations (40 CFR Subchapter N), that could provide a clear, objective standard for compliance for all regulated facilities across industries. In the absence of a quantifiable measure of compliance, site inspections can, at most, point out whether certain BMPs in a facility's SWPPP are being implemented and identify evidence of pollution, including spills and leaks, that could visually indicate a facility's overall BMP effectiveness. However, to be able to link (visual) compliance with water quality impacts, one must come up with a quantifiable or numeric compliance standard based on water quality criteria.

Thirdly, not all BMPs are readily observable, in particular the non-structural ones when the activities targeted are not being performed. Thus, the implementation status of certain BMPs can be difficult to determine for individuals not part of the facility since site inspections provide only a snapshot in time of the facility's performance. Examples of such BMPs include preventative maintenance of equipment (unless records are maintained on file) or if special caution is employed for certain operating procedures.

Clearly, the overall success of a facility's BMP implementation efforts could qualitatively be judged based on the evidence of pollution, such as spills and stains. However, such qualitative assessment necessarily introduces the subjectivity of the observer and is prone to different interpretations about how well the facilities may be complying with the intent and the requirements of the GISP. As the saying goes, "how clean is clean?" Should facilities feel "safe" as long as they provide reasonably adequate housekeeping (but according to whose standard?) and maintain an overall neat appearance, or do they need to make sure their site is meticulous? Are facilities considered to be in compliance as long as the BMPs provided in the SWPPP are being implemented, or would they be penalized for choosing BMPs inadequate for their activities? Of course, the use of a "common sense" approach and close interaction with the regulating agency could help facilities to move forward. However, for all these efforts of the regulators and permittees to pay off or result in substantially improved water quality, there must be some type of clear quantifiable standards of compliance that could be enforced.

two facilities which appeared more organized and had signs of good housekeeping practices.

Storm water analytical monitoring data demonstrated a substantial degree of variability between facilities, storm events, and sampling events. For the eight case study facilities, pollutant concentrations or measurements varied by more than a factor of seven for TSS, ten for specific conductance (SC), six for oil & grease (O&G), four for copper (Cu), ten for iron (Fe), eight for lead (Pb), and two for zinc (Zn). The lows and highs in the pollutant concentration range were: 6.8 and 9.0 for pH, 38 and 292 (mg/L) for TSS, 39 and 395 (μmho/com) for specific conductance, 11 and 73 (mg/L) for oil & grease, 812 and 3090 (μg/L) for aluminum, 67 and 259 (μg/L) for copper, 320 and 1170 (μg/L) for iron, 35 and 284 (μg/L) for lead, and 330 and 766 (μg/L) for zinc (some results for aluminum reported as < 1000 μg/L could be less than 812.).

Some interesting trends were observed in the self-monitored storm water analytical data (reported by the case study facilities) for samples collected over multiple years, for a given wet season, and on the same day. Figures 4 through 10, which evaluated the data reported by Facility H for the period between 1993 to 1999, clearly demonstrate the stochastic nature of storm water runoff. No clear increasing or decreasing trend in pollutant concentrations over time is recognized.

An analysis involving five sets of data generated by Facility H for the 1998/99 wet season demonstrated that the highs and the lows in pollutant concentrations of storm water from one facility could vary substantially for a given wet season: by more than a factor of seven for TSS, two for specific conductance, five for oil & grease, three for lead, twelve for aluminum, four for iron, and two for chemical oxygen demand (Facility H had submitted five sets of data for the wet year 1998/99). Again, no consistent trend of increase or decrease was observed in the data set spanning one wet season.

Table 9. Comparison of Pollutant Concentrations in Storm Water Samples Collected on Same Day by Different Individuals for Two Case Study Auto Dismantling Facilities.

Constituents	Facility B (sampled on 2/9/99)		Facility H (sampled on 3/25/99)	
	Facility	Staff	Facility	Staff
pH	9	9	7.42	8
TSS (mg/L)	100	210	183	202
SC (μmho/cm)	160	334	487	395
O&G (mg/L)	9	22	17	65
Pb (mg/L)	0.085	0.284	0.1	0.069
Cu (mg/L)	0.44	0.134	0.21	0.238
Zn (mg/L)	0.3	0.754	0.28	0.33
Al (mg/L)	N/A	N/A	0.21	3.09
Fe (mg/L)	N/A	N/A	4.8	2.8

We evaluated two sites (Facilities B and H) where the facility operator and our staff collected the storm water samples on the same day to determine the extent of variation in pollutant concentrations for samples collected on the same day. Table 9 compares the analytical data reported by the facility versus agency staff. Analytical results on Facilities B and H demonstrated that storm water samples taken on the same day by different individuals, in this case by RWQCB staff and by facility personnel, can display quite different results. Facility H's data (where staff collected samples immediately after a facility employees completed his sampling for the facility) indicated that the reported concentration for the following five constituents (TSS, specific conductance, oil & grease, lead,

Figure 4. Total Suspended Solids in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1993 ~ 1999)

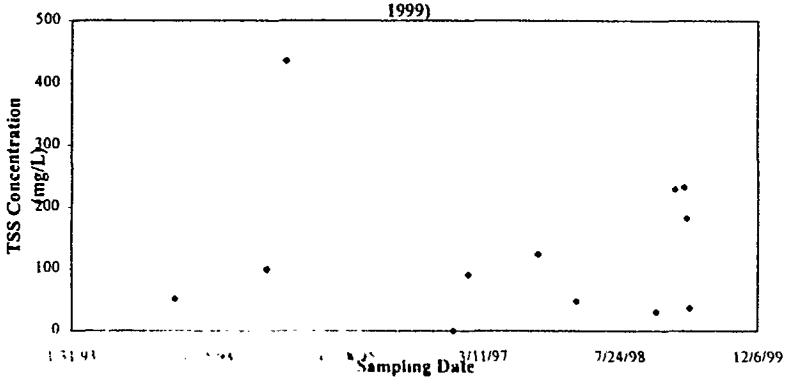


Figure 5. Specific Conductance in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park; Self-reported data for 1993 ~ 1999)

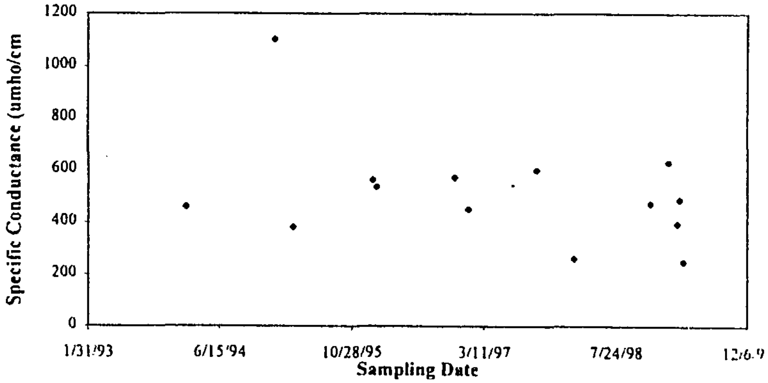


Figure 6. Oil & Grease in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1992 ~ 1999)

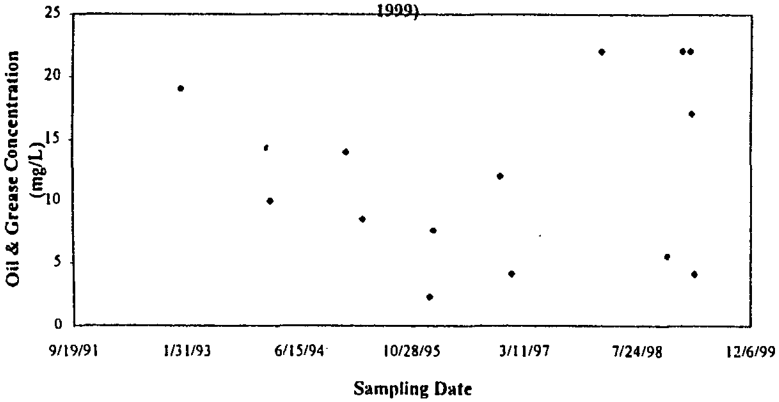


Figure 7. Lead in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

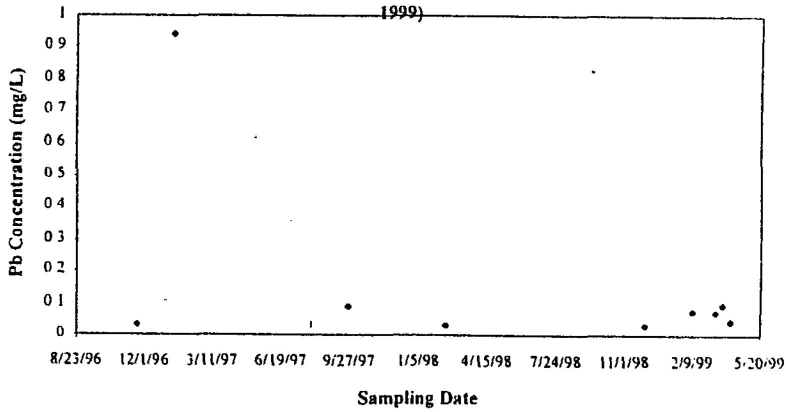


Figure 8. Copper in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

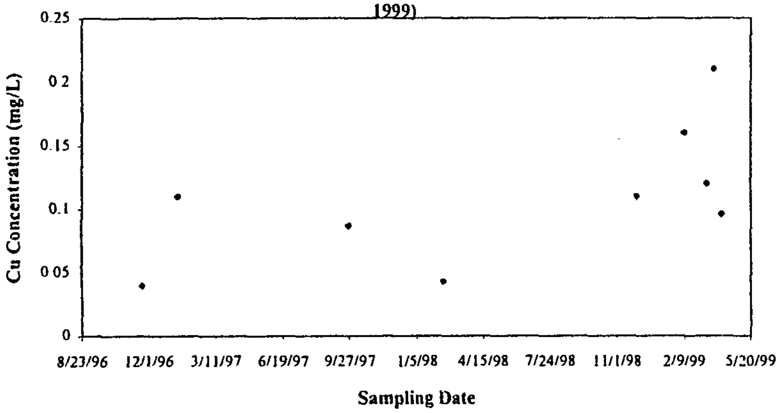


Figure 9. Zinc in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

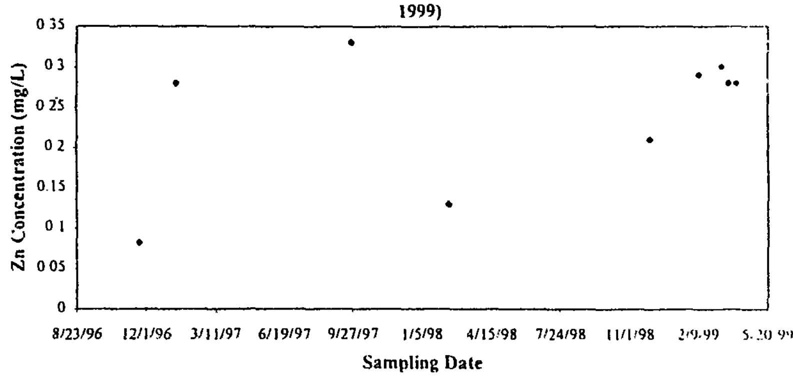
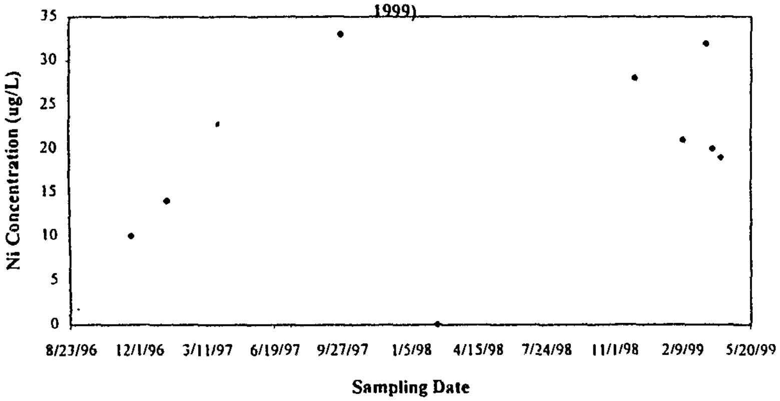


Figure 10. Nickel in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1993 ~ 1999)



copper, and zinc) differed by at least 20% and up to 1400% between the two sets of data, with the most significant differences observed for oil & grease (280%), and for aluminum (1400%). An interesting trend observed with Facility B's data was that for five out of the six constituents (TSS, specific conductance, oil & grease, lead, and zinc) agency-generated data were higher than the facility's self-reported data by at least 100% and up to 230%. This suggests that perhaps different sampling strategies -- agency staff attempted to capture storm water runoff with a visible oily sheen -- could produce substantially different results, even for a same-day sampling.

One of the goals of storm water sampling at the case study facilities was to provide a well-controlled sampling environment with an adequate QA/QC necessary to generate reliable data that could be used to relate meaningfully the effects of BMPs on water quality. Two methods were used to relate BMP implementation to pollutant concentrations in storm water runoff. The first method attempted to evaluate the overall BMP implementation scores of each facility, derived based on a systematic rating system, in the context of storm water concentrations. The second method used the overall site appearance or impression as a qualitative indicator of the relative concentration of pollutants in storm water runoff.

With the first method, we tested for both linearity (r) and causality (r^2) between BMP implementation and storm water concentration by plotting for each constituent the pollutant concentration against the overall BMP score of each facility (The overall BMP scores are presented in Table 7.) The r and r^2 values were all less than 0.5 and 0.25, respectively. This implies that a mathematical relationship of the type employed in this study may not be a suitable method for relating the effects of BMPs with the runoff quality, based on the results of our case study. Possible reasons that a clear relationship between overall BMP score and the pollutant concentrations were not observed include:

- the chosen method does not take into account the degree of effectiveness of individual BMPs (this study rated the BMPs only on how completely or satisfactorily each BMP was implemented at the facilities, and summed the ratings to obtain an overall BMP score. This is essentially equivalent to assuming that all BMPs are equally effective and assigining them equal weights);

- site-specific factors, such as annual vehicle throughput; when the last batch of vehicles arrived and were dismantled; how many storm events preceded the sampling activity; and the time lapsed between the start of a rain and a sampling event, and rainfall intensity, are not considered by the above method.

It should be noted that due to the short duration of storm events and the lack of staff to cover all eight case study facilities at the same time, sampling was collected over three separate events between February and April of 1999. The inspections were performed between November of 1998 and April of 1999.

The overall site appearance or evidence of diligent implementation of good housekeeping practices seems to be a useful indicator of the relative pollutant levels between sites with similar facility size, annual throughput, and operational activities. Generally, case study facilities that were organized and clean showed relatively lower pollutant concentration levels, with the exception of one site (Facility G). Storm water samples from Facilities A and B, on average, showed much higher pollutant concentrations than those from Facilities E and F. Facilities A and B were prime examples of sites with negligent housekeeping activities, prevalent spills on the ground, and little or no coverage provided for greasy parts. Facilities E and F had a relatively organized site, had minimal spills on the ground, and appeared to segregate parts (greasy parts stored indoors or protected from rain).

Facility G was conspicuously one of the dirtier facilities with prevalent spills and greasy parts covering the facility ground. Surprisingly, the facility had relatively low pollutant concentrations in its storm water samples. The facility had the following physical characteristics that could have contributed to masking or obscuring the effects of pollution present onsite. The facility ground had many depressions, which reduced the amount of runoff and created pools of standing water. The surface grade of this facility was not uniform, resulting not in sheet flow traveling in one direction but runoff meandering and exiting the site in multiple directions. Indeed, there was some runoff from the facility, but the hydraulic gradient of the facility was such that there was no single primary discharge point. The challenge was in determining whether the samples being collected were representative of runoff from areas of principal industrial activities. The uncharacteristically low pollutant concentrations imply that the samples were probably not representative of general site conditions. To rely only on one set of perhaps not-so-representative analytical results to judge the adequacy of one's BMP performance would be a major oversight in this case because the results do not accurately reflect the site conditions.

The above example points to some of the difficulties in collecting representative samples and the importance of not only obtaining indicative samples but also being able to properly interpret analytical results in the context of conditions under which sampling was conducted. One solution is to obtain grab samples from every discharge location to obtain representative samples. Although the GISP requires facilities to obtain samples representative of the site conditions (multiple sets if necessary), self-reported data submitted as part of the Annual Reports indicate that nearly all facilities that perform any sampling at all only obtain one set of samples for each storm event (For some facilities with only one primary discharge location, one set of grab samples may suffice.)

In conclusion, there is a substantial degree of variation in the pollutant levels in storm water samples from facilities conducting similar industrial activities. The observed trend between BMP implementation and storm water quality is that a more diligent implementation of (a greater number of) BMPs is likely to result in a lower pollutant concentration. The storm water programs, as implemented by the eight case study facilities, failed to attain the USEPA benchmark levels for most constituents. It is unclear whether the benchmark levels could have been met had the facilities diligently implemented *all* the BMPs described in their SWPPPs, or if additional BMPs would have been required. A more clear standard of compliance is needed in the GISP. The GISP should either specify a measurable endpoint -- either by establishing a minimum set of baseline BMPs to be implemented or by providing numerical effluent limitations- that could be used to demonstrate whether a facility has attained the desired BAT level and has indeed achieved compliance.

Now, how does all this relate to water quality impacts on receiving waterbodies? Here we turn our attention to pollutant loads.

POLLUTANT LOADS

Load estimates are necessary to accurately assess the potential impact of various sources of pollution on receiving waterbodies. In this section we evaluated the storm water-related load contributed by auto dismantling facilities in Los Angeles County. The following mathematical equation known as the EPA Simple Method was used to estimate the range of loads generated from the auto dismantling industry in the form of storm water pollution (Chandler 1994):

$$L = 0.227*P*Pj*A*C(0.05 + 0.009*I)$$

Parameters considered in load estimates include pollutant concentrations, rainfall intensity, and other site- and or industry-specific physical parameters. Loads were estimated for individual watersheds in Los Angeles County.

For the purpose of this study, rather than calculating the load for each individual site and then adding the loads to obtain an estimate for an entire watershed, we used a simpler approach by using average values for pollutant concentration, site percent imperviousness, and facility size based on self-reported information available in the RWQCB's NOI database or in the facility's SWPPP. For area, A, area occupied per watershed by auto dismantling establishments was estimated by multiplying the following three factors: a) the total number of auto dismantlers in Los Angeles County (404) estimated earlier in this study; b) the proportion of auto dismantling facilities located in each watershed area, determined based on zip codes of all dismantlers with an active NOI; and c) the average size of auto dismantling facilities located in each watershed. Precipitation information was obtained from Los Angeles County Department of Public Works, Hydrology Division. Precipitation of 0.1 inch was considered as the threshold or the minimum rainfall needed to generate runoff. One or two reference monitoring sites were chosen per watershed to determine the annual precipitation and runoff volume specific to each watershed. Appendix E provides more details on how each parameter was derived.

Although the EPA Simple Method specifies that flow-weighted concentrations should be used, this study used the storm water analytical data for the grab samples collected by RWQCB staff from the eight case study facilities for two primary reasons. First, there are no known flow-weighted (pollutant) composite data of storm water runoff from auto dismantling sites that reflect the climatic and precipitation patterns of Southern California. Second, the agency data was generated using reliable and replicable QA/QC procedures, which makes it more useful than self-reported data submitted by facilities with unknown QA/QC.

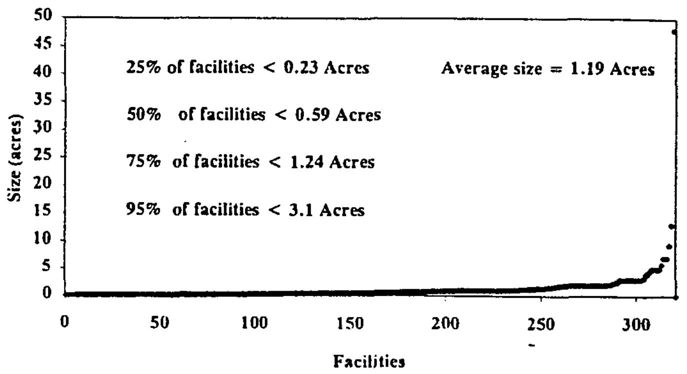
Table 10 summarizes the geographical distribution and the average size of auto dismantling facilities in Los Angeles County per watershed. As of August 1999, approximately 58% of the auto dismantlers in Los Angeles County were located in the Los Angeles River watershed; 25% in the Dominguez Channel watershed; 16% in the

Table 10. Geographical Distribution and Average Size of Auto Dismantling Facilities in Individual Watersheds in Los Angeles County.

Watershed	Estimated number of auto dismantling facilities	Average facility size (acres)	Estimated total source area (acres)
Los Angeles River	234 (57.8%)	1.215	284 (63%)
Dominguez Channel	103 (25.4%)	0937	96 (21%)
San Gabriel River	63 (15.6%)	1.06	67 (15%)
Santa Clara River	2 (0.6%)	1.31	3.2 (0.7%)
Santa Monica Bay	2 (0.6%)	0.2	0.4 (0.08%)
Total Source Area	404	1.12*	450

*county average

Figure 11. Size Distribution of Auto Dismantler Facilities in Los Angeles County



San Gabriel watershed; and 0.6% each in the Santa Clara River watershed and the Santa Monica Bay watershed. Figure 11 shows the size distribution of auto dismantling facilities in Los Angeles County. The County average is 1.2 acres, with 90% of the facilities under 3 acres.

Pollutant loads from the auto dismantling industry were estimated for the 1998 - 1999 storm year for the three watersheds with the highest number of auto dismantling facilities - Los Angeles River, San Gabriel River, and Dominguez Channel. Loads were calculated for TSS, oil & grease, copper, lead, and zinc. Table 11 presents the load estimates and information on parameters used to arrive at the estimates, such as average pollutant concentration, annual precipitation and runoff, and area within each watershed occupied by auto dismantling facilities. The total approximate loads for all of Los Angeles County contributed by the auto dismantling industry are: 22,400 lbs. of TSS, 4,650 lbs. of oil & grease, 35 lbs. of copper, 22 lbs. of lead, and 130 lbs. of zinc. These estimates may be slightly lower than for a typical wet season because the 1998/99 wet season was impacted by the La Niña phenomenon and had less-than-average

Table 11. Pollutant Load per Watershed Contributed by Auto Dismantling Industry in Los Angeles County based on the 1998/99 Wet Year (pounds/acre/year)[1]

Watershed	P[2] (in)	Pj[3]	TSS 116.3 mg/L[4]	O&G 28.4 mg/L	Cu 142 ug/L	Pb 103 ug/L	Zn 508 ug/L
Los Angeles River (284 Acres)	9.72[5]	0.72	22,950	5,600	30	20	100
Dominguez Channel (96 Acres)	4.71[6]	0.67	3,480	850	4	3	15
San Gabriel River (67 Acres)	7.48[7]	0.72	4,140	1,010	5	4	18
Total			30,570	7,460	40	30	130

[1] Based on average site imperviousness value of 43%. Rainfall data for the [illegible] wet year (Oct. - Oct.) was obtained for specific reference sites within each watershed from the Los Angeles County, Department of Public Works, Hydrology Division.
[2] P is annual precipitation in inches per year.
[3] Pj is fraction of rainfall events that produce pollutants in runoff. Pj was calculated using an assumption that the threshold rainfall greater than 0.1 inches is needed to produce runoff
[4] Average pollutant concentrations were estimated based on the storm water analytical data on the grab samples collected by RWQCB staff from the eight case study auto dismantling facilities.
[5] Rainfall data from the monitoring stations near Downtown Los Angeles and Sun Valley.
[6] Rainfall data from the monitoring station near Wilmington.
[7] Rainfall data from the monitoring station near Duarte.

precipitation On a watershed level, the Los Angeles River was the single most impacted waterbody, receiving the majority of the load. The San Gabriel River watershed, which has a smaller total "source" area than Dominguez Channel watershed, was characterized with a higher load due to the greater total precipitation and runoff experienced in the San Gabriel watershed area. Although not presented in Table 10, the loads from the auto dismantling facilities in the Santa Monica Bay watershed and the Santa Clara River watersheds are negligible given the fact that each watershed only had two known auto dismantling businesses within its respective area.

The load introduced by the auto dismantling industry to surface waters is significant. On a weight basis, the pollutant associated with the highest load by weight is TSS, followed by oil & grease, zinc, lead and copper. The estimates presented in this study may be improved by using flow-weighted composite data for pollutant concentration, accounting for the variability in the rainfall patterns within specific watersheds, and by using a more accurate estimate of the total universe of facilities that accounts for facilities that both the RWQCB and DMV failed to capture. For a more meaningful load analysis, the estimates should be evaluated in the context of loads generated from other major industrial sources, a task that lies outside the scope of this study.

Consideration of Other Approaches To Storm Water Pollution Control

The question of how compliance should be defined to protect water quality and beneficial uses of the receiving waterbody is an important one. The pollution prevention approach, as currently designed, lacks a clear, uniform standard for measuring compliance, and may require more resources than traditional (individual) NPDES to adequately monitor for compliance. An objective quantitative or measurable standard of compliance is also necessary for equitable and consistent enforcement. Two alternatives other than the current P2 approach are considered in this section. One alternative is to define compliance in terms of numerical effluent limitations. This approach is consistent with the traditional or individual NPDES permitting approach. Establishing numerical effluent limitations would help facility operators to determine whether the facility is indeed achieving the limits, and if not, how much the facility needs to ratchet down its pollutant levels to return to compliance. This simplifies compliance assessment for both regulators and the regulated community and provides a clear basis for enforcement actions. If feasible, numerical effluent limitations should be developed based on water quality criteria that are protective of beneficial uses. This would ensure that facilities, by meeting the established limitations, are not contributing to or causing exceedances of applicable water quality standards.

Another alternative is to prescribe a set of minimum, mandatory baseline BMPs for each industry. Compliance would be determined primarily by the effective and diligent implementation of these selected BMPs. To facilitate the compliance determination process, a minimum set of BMPs should consist of measures that are readily observable. This option limits the flexibility offered by the P2 approach that allows facility operators the freedom to choose from a wide range of BMPs and to tailor the BMPs to the facility's site and economic conditions. In addition to Appendix C and the sources cited for Appendix C, the list of BMPs compiled for the cooperative compliance program of Wisconsin is another comprehensive source of information on BMPs for the auto dismantling industry (KES 1999; CCP/DNR 1999)

This study recommends the following tiered approach for the auto dismantling industry that combines the core of the two alternatives outlined above: 1) a mandatory set of specific, baseline structural and non-structural BMPs for facilities with annual vehicle throughput of less than 500 (which represent "mom-and-pop" facilities); and 2) mandatory treatment of storm water for facilities with annual vehicle throughput greater than 500. Also, in lieu of requiring treatment, numerical effluent limitations could be applied to the latter group as a standard of compliance. A compliance schedule could help phase facilities into compliance over a certain specified time frame. Facilities with less than 500 annual vehicle throughput that persistently demonstrate problems in meeting certain water quality standards, for example the USEPA benchmark levels, should also be considered for mandatory storm water treatment.

Lack of sufficient resources has been identified as the primary reason for the limited compliance assurance and enforcement activities by the RWQCB. One way to help effectively implement the above recommended strategy and at the same time, reduce the workload associated with compliance assessment and assurance activities is to employ a semi-privatized certification program, such as that implemented in the State of Wisconsin, which relies on licensed, private inspectors to oversee the compliance activities of a group of facilities that voluntarily choose to participate and help fund the program. The aim of such a program is to help reduce some of the workload of the regulators and to allow facilities that diligently work toward and maintain a specified level of compliance to be certified for compliance by professional inspectors. Such certification could potentially shield them from certain regulatory responsibilities, such as monitoring activities, and indirectly from third-party lawsuits by reducing the degree of their environmental liability. (Essential to the implementation of this type of program is regular training and (re-)certification of inspectors by the regulating agency to maintain high QA/QC for the inspection procedures.)

V. CONCLUSIONS/RECOMMENDATIONS

Several conclusions can be drawn from the findings of this study. Compliance, in general, appears to be limited or low among the auto dismantling facilities in Los Angeles County, for all three tiers of the GISP requirements. Analyses based on site visits results and DMV dismantling license information showed that about one out of every five auto dismantling facilities operating in Los Angeles County are non-filers. Compliance with the annual reporting and SWPPP and written monitoring program requirements is also limited. Review of the 1997/98 Annual Reports revealed that many of the required facilities failed to conduct the key monitoring activities, such as storm water sampling and analysis, limiting the usefulness of the Annual Reports as a tool to gauge overall permittee performance. SWPPPs and written monitoring programs, due to their generally poor quality, fail to effectively guide facility operators in their P2 efforts and in proper monitoring procedures. Accelerated enforcement activities have proven to be effective for increasing the Annual Report submittal rate. Outreach to consultants is strongly recommended to upgrade or improve the quality of SWPPPs and written monitoring programs being prepared by third parties.

The GISP program has not effectively penetrated the auto dismantling industry in terms of compelling the kinds of behavioral changes needed to effectively control storm water pollution and to improve water quality. Case study investigations indicated that the selected facilities failed to select and implement appropriate BMPs to attain the USEPA benchmark levels. Pollutant load estimates based on this industry show that the magnitude of the load could be substantial. These findings imply that the current approach based on P2 and the primary reliance on facility operators to identify and implement appropriate BMPs, without establishing enforceable numerical effluent limitations, has not been shown to be effective, at least at the level currently implemented, in controlling storm water runoff from the auto dismantling industry. Past studies on other industries, including the metal plating and transportation sectors, support some of the findings and conclusions of this study (Duke and. Shaver 1999; Duke et al 1999a; Duke et al 1999b; Duke et al 1998; Duke and Bauersachs 1998; Duke et al 1998; Duke and Beswick 1997; and Duke and Chung 1996).

The lack of a clear, objective standard for compliance could pose a special challenge to dischargers when trying to determine if the existing BMPs are sufficient or need to be upgraded or supplemented with additional BMPs. The majority of the storm water analytical data from the eight case study facilities and the self-reported data provided by auto dismantling facilities in the past substantially exceeded the USEPA benchmark values. The GISP program, as currently implemented and enforced, appears to be not attaining the potential pollution reduction achievable as envisioned. For this reason, this study considered different regulatory alternatives to control industrial storm water pollution. This study recommends a tiered approach that offers different combinations of options -- including implementation of a set of minimum required BMPs, mandatory storm water treatment, or applying numerical effluent limitations -- based on each facility's annual vehicle throughput quantity.

Until now, the GISP program at the Los Angeles RWQCB has exhausted most of its resources for determining and enforcing against violators of the first and second tier compliance. In reality, it is the onsite implementation that actually achieves pollution prevention or reduction. Therefore, more resources should be allocated to assess and verify field compliance. Increase in compliance assurance activities and timely comprehensive enforcement activities would improve overall compliance. This study suggests a possible solution -- a semi-privatized compliance certification program -- that could substantially reduce regulators' workload and allow them to focus on high-risk sectors or facilities to more effectively regulate and control storm water pollution associated with industrial activities.

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Appendix A. Storm Water Pollution Prevention Plan and Monitoring Program Review Checklist

GENERAL INDUSTRIAL ACTIVITIES STORM WATER PERMIT
WATER QUALITY ORDER NO. 97-03-DWQ

FACILITY NAME ______________________________

WDID# 4 ____________________ REVIEW DATE ____________________

FACILITY CONTACT
Name ____________________
Title ____________________
Company ____________________
Street Address ____________________
City, State ____________________
Zip ____________________

CONSULTANT CONTACT
Name ____________________
Title ____________________
Company ____________________
Street Address ____________________
City, State ____________________
Zip ____________________

Indication of WDID#	☐ YES	☐ NO

STORM WATER POLLUTION PREVENTION PLAN		Not Applicable	Included	Not Included	Incomplete	Comments
Signed Certification	**(C.9 and C.10)**					
Pollution Prevention Team	**(A.3.a)**					
Existing Facility Plans	**(A.3.b)**					
Facility Site Map(s)						
Facility boundaries	(A.4.a)					
Drainage areas	(A.4.a)					
Direction of flow	(A.4.a)					
Onsite water bodies	(A.4.a)					
Areas of soil erosion	(A.4.a)					
Nearby water bodies	(A.4.a)					
Municipal storm drain inlets	(A.4.a)					
Points of discharge	(A.4.b)					
Structural control measures	(A.4.b)					
Impervious areas (paved areas, buildings, covered areas, roofed areas)	(A.4.c)					
Location of directly exposed materials	(A.4.d)					
Locations of significant spills and leaks	(A.4.d)					
Storage areas / Storage tanks	(A.4.e)					
Shipping and receiving areas	(A.4.e)					
Fueling areas	(A.4.e)					
Vehicle and equipment storage and maintenance	(A.4.e)					
Material handling / Material processing	(A.4.e)					
Waste treatment / Waste disposal	(A.4.e)					
Dust generation / Particulate generation	(A.4.e)					
Cleaning areas / Rinsing areas	(A.4.e)					
Other areas of industrial activities	(A.4.e)					

Items in parentheses refer to specific sections of the General Permit

Reviewer ____________________

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Appendix A (cont'd)

STORM WATER POLLUTION PREVENTION PLAN		Not Applicable	Included	Not Included	Incomplete	Comments
List of Significant Materials	**(A.5)**					
For each material listed:						
Storage location						
Receiving and shipping location						
Handling location						
Quantity						
Frequency						
Description of Potential Pollution Sources (A.6)						
Industrial processes	(A.6.a.i)					
Material handling and storage areas	(A.6.a.ii)					
Dust and particulate generating activities	(A.6.a.iii)					
Significant spills and leaks	(A.6.a.iv)					
Non-storm water discharges	(A.6.a.v)					
Soil erosion	(A.6.a.vi)					
Assessment of Potential Pollutant Sources (A.7)						
Areas likely to be sources of pollutants	(A.7.a.i)					
Pollutants likely to be present	(A.7.a.ii)					
Storm Water Best Management Practices (A.8)						
Existing BMPs						
Existing BMPs to be revised and/or implemented						
New BMPs to be implemented						
Non-structural BMPs	**(A.8.a)**					
Good housekeeping	(A.8.a.i)					
Preventative maintenance	(A.8.a.ii)					
Spill response	(A.8.a.iii)					
Material handling and storage	(A.8.a.iv)					
Employee training	(A.8.a.v)					
Waste handling / Waste recycling	(A.8.a.vi)					
Recordkeeping and internal reporting	(A.8.a.vii)					
Erosion control and site stabilization	(A.8.a.viii)					
Inspections	(A.8.a.ix)					
Quality assurance	(A.8.a.x)					
Structural BMPs	**(A.8.b)**					
Overhead coverage	(A.8.b.i)					
Retention ponds	(A.8.b.ii)					
Control devices	(A.8.b.iii)					
Secondary containment structures	(A.8.b.iv)					
Treatment	(A.8.b.v)					
Annual Comprehensive Site Compliance Evaluation						
Review of visual observations, inspections, and sampling analysis	(A.9.a)					
Visual inspection of potential pollution sources	(A.9.b)					
Review and evaluation of BMPs	(A.9.c)					
Evaluation report	(A.9.d)					

Appendix A (cont'd)

MONITORING PROGRAM	Not Applicable	Included	Not Included	Incomplete	Comments
Quarterly Non-Storm Water Discharge Visual Observations (B.3)					
Observations to be conducted (B.3.c) (Jan-March, April-June, July-September, October-December)					
All drainage areas (B.3.a)					
Look for presence of unauthorized NSWDs (B.3.a)					
Observe authorized NSWDs (B.3.b)					
Maintain observation records (B.3.d)					
Storm Water Discharge Visual Observations (B.4)					
Once per month during wet season (B.4.a) (October 1-May 31)					
Observe during first hour of discharge (B.4.a)					
All drainage areas (B.4.a)					
Observe stored or contained (B.4.a) storm water at time of discharge					
Preceded by three working days dry weather (B.4.c)					
Document discharge characteristics (B.4.c)					
Sampling and Analysis					
Samples to be collected during first hour of discharge (B.5.a)					
Sample from first storm of the wet season (B.5.a)					
Sample from one additional storm during wet season (B.5.a)					
Samples collected from all discharge locations (B.5.a)					
Sampling of contained storm water (B.5.a) at time of discharge					
Sampling preceded by at least (B.5.b) three working days without storm water discharges					
Sampling for pH, TSS, SC, TOC or O&G (B.5.c.i)					
Sampling for toxic chemicals and other pollutants likely present in storm water discharges in significant quantities (B.5.c.ii)					
Other analytical parameters listed in Table D (B.5.c.iii)					
Storm Water Effluent Limitation Guidelines parameters (B.6)					
Description of sampling locations (B.7)					
Description of sampling methods (B.10)					
Identification of analytical methods (B.10.b) and method detection limits					
Retention of all records for at least five years (B.13)					
Annual Report to be submitted by July 1 each year (B.14)					

General Comments: ______________________________

Appendix B. Summary of Site Inspection Results : Verification of Facility-specific Activities and BMPs

Type of Activity/ Pollutant source	Activity or pollutant sources present onsite?[1]									Applicable BMPs	BMP Indicated in Facility's SWPPP?									Level at Which BMP Implemented at Facility[2]								
	A	B	C	D	E	F	G	H	I		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Dismantling (includes fluid draining)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Conduct Activity on Impervious area	Y	Y	Y	Y	Y	Y	Y	Y	N	3	3	3	3	3	3	3	3	0
										Provide overhead cover	N	N	Y	N	N	Y	Y	N	N	1	0	2	0	0	2	0	0	0
										Use drip pan	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	2	3	N/O	N/O	3	1	0	N/O
Parts storage (batteries excluded)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Provide permanent or temporary cover	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	0	2	1	1	2	0	0	3
										Drain most fluids prior to storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	2	2	2	2	3	1	1	3
										Store parts off-ground	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	2	2	3	1	2	3
Battery storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Remove from vehicle	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	3	3	3	3	3	3	3	3
										Provide 2°containment and cover	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	1	3	3	3	2	0	3	3
Fluid management	Y	Y	Y	Y	Y	Y	Y	Y	Y	Under cover;	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	2	3	3	2	0	0	3	3
										2°containment	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	0	0	0	0	3	3	3
Parts Washing/ Cleaning	Y	Y	N/O	Y	Y	Y	Y	N	Y	Indoors or in a covered area	Y	N	N	Y	Y	Y	Y	N/A	Y	3	0	N/O	0	2	3	2	N/A	2
										Contain wash-water	Y	N/A	N/A	Y	Y	Y	Y	N/A	Y	3	0	N/O	2	2	3	2	N/A	3
Spills/leaks*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Use drip pan	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	1	2	2	2	3	1	1	3
										Maintain adequate supply of absorbent	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	0	3	2	2	3	3	2	3
Vehicle storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Close hood or cover vehicles with engine or oily parts	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	2	2	2	N/O	3	N/O	0	3
										Remove all oily/greasy parts from vehicle (esp. engine, transmission, etc.)	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	3	2	3	3	3	2	0	3
Erosion Potential	Y	N	N	N	N	N	N	N	Y	Pave entire site	N	Y	Y	Y	Y	Y	Y	Y	N	2	3	3	3	3	3	3	3	0
										Use erosion control such as bales of hay or berms (or gravel)	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Waste fluid handling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Use appropriate disposal method	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O
Auto compaction	N	N	N	N	N	N	N	Y	N	Designated area/pre-drain fluids	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A
General										Use erosion control such as bales of hay or berms (or gravel)	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
General										Good housekeeping practices	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	2	2	3	0	2	3
General										Employee training (documented)	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	0	0	0	2	2	0	3	1
General										Inspection (documented)	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	2	2	2	2	2	1	3	2
General										Recordkeeping	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	1	3	3	1	3	1
General										Storm water treatment	N	N	N	N	Y	N	N	Y	N	0	0	0	0	2	0	0	2	0

[1] Y= yes, N= no; N/A= not applicable.

[2] For BMP implementation rating, 0=Not implemented; 1= Poorly implemented; 2= Somewhat poorly implemented; 3= adequately implemented, N/A= not applicable, N/O= Not observed during site inspection.

Appendix C. Best Management Practices for Auto Dismantling Industry

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Vehicle Dismantling Dismantling Activities	Eliminate exposure	• Roof or cover to eliminate rain-in. Berm area to eliminate storm water run-on. Conduct dismantling work in this designated area. • Place a mat, plastic, or tarpaulin on the ground prior to placing parts on the ground. (Also, if no roof or cover provided over dismantling area, conduct dismantling activities on top of plastic or tarpaulin, which can be readily cleaned or replaced, and removed during storm events). • Drain all fluids (antifreeze/coolant, brake fluid, gasoline/diesel, motor oil, transmission oil) from vehicle prior to dismantling and parts removal. • Use drip pans to drain fluids. Do not overfill . • Drain oil filters before disposal/recycling. • Remove refrigerant prior to dismantling and parts removal. • Deploy airbags per guidelines or remove intact airbags for reuse and store under cover. • Dispose of greasy rags, air filters, spent coolant, and degreasers. • Remove batteries promptly after vehicle arrival. • Remove oil-bearing components prior to storage.
Fluid draining	Eliminate exposure	• Roof or cover to eliminate rain-in. Berm area to eliminate storm water run-on. Remove fluids in this designated area. • Use drip pans for draining vehicular fluid. • Use funnels, and stoppers for the containers. • Avoid discharge of vehicular fluid (as in drips or leaks) on the ground.
Parts Repair/ Wash	Eliminate exposure	• Designate contained areas for repairs and washing (curb, berm or dike area, if necessary. If not feasible, use oleophilic (oil- absorbing) boom bags to prevent washwater from running to the street / curb or other areas of facility.) • Wash parts in a wash- tray provided with secondary containment. • If area not otherwise contained, divert runoff from repair and wash areas with hydrophobic boom bags. • Transfer spent solvent or washwater into designated drums. • Recycle and reuse or release washwaters to sanitary sewer. • Use minimum amounts of solvents or detergents for parts cleaning. • Use water-based cleaning solvents and biodegradable (non-phosphate) detergents. • Wipe and sweep area regularly after activity. Dispose of greasy rags, air filters, spent coolant, and degreasers in appropriate containers.
Storage Vehicles	Eliminate exposure	• Keep vehicle engines covered with hoods or with plastic sheets secured in place. • Store vehicles on an impervious (e.g. concrete) surface (if possible). • Use drip pans under stored vehicles. • Minimize inventory during wet season. • Reduce holding time for scrap disposal.

Appendix C. Best Management Practices for Auto Dismantling Industry (Cont'd)

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Separated components	Eliminate exposure	• Confine to designated area. • Store indoors or under temporary or permanent cover (that sufficiently shields rainfall). • Curb, berm, or dike the area. (If not feasible, then: 1) store parts off-ground, for example on storage racks, with drip pans underneath to collect residual fluids; or 2) store parts in leak-free truck beds or plastic containers; or 3) place parts in auto bodies (intact), especially large-sized vans, which also provide an excellent storage places for parts; 4) divert runoff from scrap storage area with hydrophobic (water resistant) boom bags) • Place tires in semi-trailers, indoors, or covered area. Sell or recycle. • Store scrap parts/metals under cover and dispose of to scrap collector promptly • Divert runoff from scrap storage area with hydrophobic (water resistant) boom bags.
Batteries	Eliminate exposure	• Store batteries in covered storage area, on a paved surface that is bermed, or in plastic containers with lids.
Fluid	Eliminate exposure Improve materials management	• Store fluid containers (e.g. drums) on an impervious surface and under a roofed shed. • Provide secondary containment for the fluid-containing drums. • Keep separate (solvents, oils and fuel) and label accordingly.
Others Recycling	Waste minimization	• Recycle (or resell if possible) anti-freeze, fuel, waste oil, windshield washer and solvents. • Recycle usable recyclable parts. • Recycle tires and core/ scrap metals.
Spill Prevention & Clean-up	Minimize exposure Waste Minimization Contain/ cleanup pollutants	• Employee training (prepare for and clean up spills.) • Prepare a spill clean-up kit (absorbent sand, rags, adsorbent snakes, broom, etc.) and place in convenient readily accessible location. • Drain vehicular fluids at designated removal area. • Use the provided spill- kit to contain leaks or spills immediately. Dispose of properly. (Use oleophilic sands to absorb/contain small leaks, and boom bags for large spills.)
Employee Training	Waste minimization	• Train employees regularly in proper and environmentally safe practices.
Customer Education	Waste minimization	• Inform and require customers who remove parts to do so properly and appropriately dispose of waste (for example, posting signs that require the use of drip pans for parts removal and prohibit waste-generating activities in parking lot can be helpful).
Site Inspection	Good maintenance	• Inspect site regularly to ensure all appropriate BMPs are being implemented.
Preventative maintenance	Prevent pollution/ accidents	• Inspect to ensure integrity of tanks, containers, pipings and valves. Install safeguards against accidental release.

Appendix C. Best Management Practices for Auto Dismantling Industry (Cont'd)

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Site Maintenance	Minimize exposure	• Keep site clear of trash and debris. • Regularly remove and sweep sand (used to contain spills), trash or dirt from site. • Collect corrosion/ metal particles with magnet (survey the site with a forklift or small vehicle with magnet attached behind.)
Materials Inventory	Good management	• Maintain proper inventories of vehicles processed, materials stored, and wastes recycled or disposed of.
Site grading	Minimize exposure	• Repave area to direct flows to a low point (away from storage and waste areas) where leaking fluids can be collected.
Recordskeeping	Good management	• Maintain records of inspections, monitoring (including storm water sampling), Annual Reports, and training.
Storm Water Treatment Flow dissipation	Remove Pollutants	• Direct flow discharge over coarse gravel or cobblestones to facilitate settling out of particulates and sediment.
Vegetative belts	Remove Pollutants	• Direct flow discharge over vegetative belts or biofilters to enhance pollutant removal.
Sand/ gravel filters	Remove Pollutants	• Allow storm water from open parts storage areas to pass through sand-gravel filter with drain holes. Sand layer must be periodically replaced.
Detention ponds	Remove Pollutants	• Capture storm water runoff from high activity areas. Skim off surface oil and remove bottom sediment. Reuse or evaporate runoff water.
Oil-grit/ oil-water separator	Remove Pollutants	• Direct flows from high activity areas through OW separators. Off-line separators to bypass large storms are preferable. Maintain regularly.
Flotation/ coagulation	Remove Pollutants	• Store runoff flows, equalize, and provide flotation/ coagulation. High operation and maintenance costs. Inappropriate if used only intermittently.
Industrial sewer piping	Remove Pollutants offsite	• Pretreat as required and pipe to sanitary sewer if allowed (permit likely required).
Oil/grease - absorbents	Remove Pollutants	• Provide oleophilic booms or excelsior near runoff exit. Replace as needed. Dispose of properly.

References:

1. ARA 1997
2. LADPW 1998
3. MPCA 1994.
4. Swamikannu 1994
5. USEPA 1995

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
GOOD HOUSEKEEPING								
General Practices								
Develop a storm water management policy statement for your employees. Management can provide direction and support for pollution prevention by reviewing this policy with employees and keeping it posted.		■	■	■	■	★	★	★
An in-coming vehicle inspection inventory program should include a check for fluid leaks and for unwanted material that could have been placed in the vehicles.		■	●	■	■	★	★	★
Clean up debris and trash on a regular basis.		●	■	■	■	★	●	★
Construct fences or other physical barriers to act as visual and noise barriers, help to control dust, help prevent theft, and control the direction of runoff.		■	■	■	■	■	●	●
Maintain an organized inventory of materials used at the facility.	✔	■	■	■	■	●	●	★
Consider indoor storage of vehicles, parts, and equipment, and the use of berms and/or dikes to control storm water runoff.[1]	✔	●	★	★	●	■	●	■
Vehicle Dismantling Fluid Management								
Remove fluids from vehicles brought into the facility for processing or dismantling.	✔	■	★	■	■	■	■	★
Keep used oil separate from part cleaning solvents, antifreeze, and fuel. Engine oil, transmission fluid, brake fluid, and power steering fluid can be combined and stored together.		■	●	■	●	●	★	★
Label storage containers of all fluids and waste materials.	✔	■	■	■	■	★	★	★
Drain all parts of fluids prior to disposal.	✔	■	★	■	■	●	●	★
Confine the storage of vehicles, parts, and equipment to designated areas.	✔	■	■	■	■	●	●	●

COMMENTS

1 May interfere with operation and access. Indoor storage of vehicles is not appropriate or practical for an automotive recycling facility.

KEY TO THE TABLE

	■	●	★
Ability to Control Pollution	no significant removal	slight (<25%) removal	moderate to high (25%) removal
Initial Cost	>$5,000	$1,000 - $5,000	<$1,000
Operation and Maintenance Cost	>$1,000 / year	$500 - $1,000 / year	<$500 / year
Practicality	usually not practical	sometimes practical	practical for most facilities

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Use canvas or sheets of plastic to temporarily cover storage areas.[2]	✔	●	●	■	■	●	●	●
Transmission and engine cores may be stored in plastic storage boxes with leak proof tops; lugger boxes having solid bottoms and covered by a permanent roof, lugger boxes without a solid bottom stored under a permanent roof on a concrete pad with curbing; or an enclosed trailer with a steel floor to contain fluid runoff and a drain in the floor to properly remove waste fluids.		■	★	■	■	■	●	●
Engine oil should be drained and stored in labeled, doubled-walled, above ground tanks. Used oil can either be recycled for on-site use in a waste oil heater, or sent off-site for re-refining or fuel blending.		■	★	■	■	●	●	★
Antifreeze should be reclaimed and reused or properly disposed of.[3]		■	★	■	■	●	●	★
Drain window washer fluid for reuse.		■	★	■	■	★	★	★
Remove batteries as soon as possible after vehicle enters the yard. Store good batteries inside for resale. Store dead batteries inside on pallets (if your floor is gravel or dirt, put a layer of absorbent material below the pallet) or in storage containers, or store dead batteries outside in a leak proof, covered container.		■	●	●	■	●	●	★
Parts Cleaning								
Perform all parts cleaning operations indoors or cover and berm outside cleaning areas.[4]	✔	■	●	●	★	●	●	★
Clean parts by using minimal amounts of solvents or detergents.		■	●	●	★	●	●	●
Recycle and reuse cleaning fluids where practical.		■	■	■	●	★	★	●
Spent cleaning solutions should be removed by a waste hauler or recycler.		■	■	■	■	★	★	★
Use phosphate-free biodegradable detergents. Consider using detergent-based or water-based cleaning systems in place of organic solvent degreasers.		■	■	■	★	●	●	●
Vehicle Crushing Activities								
Consider providing a containment system—such as a concrete pad with berms—for vehicle crushers. Fluids and storm water runoff from such bermed areas could be discharged into a sump, oil/water separator, sanitary sewer, or other appropriate drainage system that prevents storm water contamination.		■	★	●	■	■	■	●

COMMENTS

2 May interfere with operation and access.
3 May need to check with the state to see if additional requirements are required.
4 May not be feasible or practical for all facilities.

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Ability to Control: Vehicle and Equipment Fluids	Ability to Control: Metals	Ability to Control: Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
If a gravel/geotextile fabric foundation is provided under a crusher, install a fluid collection system to capture fluids that are released during the crushing operation.		■	★	●	■	■	■	●
Capture crusher fluids to prevent spillage. Collect this mixture of fluids in a spill-proof covered container, test the fluid, and dispose of it properly. It should not be allowed to drain onto the ground. Keep the drain within the crusher clear so that the fluids do not collect and overflow from the crusher onto the ground.		■	★	●	■	●	●	●
PREVENTIVE MAINTENANCE								
Develop a preventive maintenance program that involves timely inspections and/or maintenance of the crusher and facility equipment and vehicles. The program may include: • Service checklists and maintenance logs for each piece of equipment; • Employee education and instruction material; and • Review of manufacturer-recommended parts replacement and maintenance activities and frequencies.		■	●	■	■	★	●	★
Keep the crusher and other equipment clean by frequently wiping off accumulated oil and grease that may be exposed to storm water (except where needed for proper operation of the equipment) or that may hide equipment trouble spots.		■	●	■	■	★	★	★
Conduct scheduled maintenance of facility equipment and vehicles in a covered or bermed area, where practicable.		■	●	■	■	●	●	●
Schedule periodic inspections of equipment for leaks, spills and malfunctioning, worn, or corroded parts. Regularly inspect tanks, valves, hoses, and containers. Look for signs of wear or weakness.		■	●	■	■	■	●	★
On secondary containment structures, regularly inspect the valve, seals around the outlet pipe, the outlet pipe itself, and the dike for cracks, damage, or leaks.		■	■	■	■	★	★	★
When secondary containment reservoirs require pumping or release, a sample of collected water should be visually inspected or tested for pollutants. If pollutant levels are significant or there is contamination, pump the accumulated water into barrels or into a tanker truck and haul to a wastewater treatment facility.		■	■	■	■	★	●	★
Repair or replace parts before they wear out.		■	●	■	■	★	●	★
Repair malfunctioning equipment that is responsible for any leak or spill as soon as possible.		■	★	■	■	★	●	★

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Secure and lock above ground tank storage areas. Tanks, pumps, fittings, pipes, and containers should be inspected routinely for integrity and leaks.		■	■	■	■	★	★	★
Perform maintenance activities indoors.[5]	✔	■	●	■	■	■	●	●
Valves on secondary containment structures should be kept in the "off" position at all time, except when collected water is being removed.		■	■	■	■	★	★	★
SPILL PREVENTION AND RESPONSE								
Make available MSDS sheets and other safety materials that identify types of fluids that have the potential to spill, indicate whether these fluids are hazardous or toxic, list appropriate safety equipment to be worn, and specify correct materials and procedures to use to clean up the spill.		■	●	■	●	●	★	★
Provide spill clean-up equipment at locations where spills are most likely to occur.		■	●	■	●	●	★	★
Identify clean-up procedures, including the use of dry absorbent materials or other clean-up methods to collect, dispose of, or re-cycle spilled or leaked fluids. Maintain an adequate supply of dry absorbent material on-site. Properly dispose of used absorbent materials.		■	●	■	●	●	★	★
Contain oil or other fluids spilled during parts removal.	✔	■	●	■	■	★	★	★
Never pour liquids or dry materials down a storm drain.		■	★	■	★	★	★	★
Place drip pans, plastic sheets, or canvas tarps beneath vehicles, parts, and equipment during maintenance and dismantling activities. If any parts are removed, they should be placed in a drip pan. Drip pans should not be left unattended.	✔	■	★	■	●	★	★	★
When refueling vehicles and equipment, park as close to the pump as possible. Keep fuel nozzle upright when not in use, and replace nozzle securely in the pump.		■	●	■	■	★	★	★
Pave refueling areas to prevent contamination of the soil if a spill occurs.		■	●	■	■	■	★	●
Equip fuel pumps and tanks with overflow prevention and automatic shut-off devices.		■	★	■	■	●	★	★
Control any spills that may occur around fueling areas.		■	★	■	■	★	★	★

COMMENTS

5 May not be appropriate for certain scheduled maintenance procedures.

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Ability to Control: Vehicle and Equipment Fluids	Ability to Control: Metals	Ability to Control: Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Containers and tanks should be stored on a concrete or impermeable surface, and if feasible, under cover. All containers should be labeled according to content and hazard characteristics. Keep drums containing chemicals away from sumps and drains.[6]		■	★	■	●	■	★	●
Observed spills and leaks should be captured and cleaned up using dry absorbents, drip pans, towels, mops, pads, and booms.	✔	■	★	■	★	★	●	★
Maintain good integrity of all storage containers.		■	★	■	★	★	★	★
Install safeguards (such as diking or berming) against accidental releases at dismantling and storage areas.[7]	✔	■	★	■	■	■	■	★
EROSION AND SEDIMENT CONTROL								
Implement appropriate vegetative, structural, or stabilization measures to limit soil erosion.		★	■	■	■	●	●	●
Regularly sweep and clean paved surfaces to reduce sediment build-up. Sediment should be swept up and placed into a covered, watertight dumpster for proper disposal.[8]		★	■	■	■	●	■	★
Install filtering or diversion practices, such as filter fabric fences, sediment filter booms, earthen or gravel berms, curbing, or equivalent measures.[9]		★	■	■	■	■	●	●
Install sediment traps, vegetative buffer strips, silt fencing, or equivalent measures to remove sediment prior to discharge through an inlet or catch basin.[10]		★	■	■	■	■	●	●
Do not use vehicle fluids, oils, or fuels for dust control or weed control.		■	●	■	■	★	★	★
Establish and maintain a vegetative cover in areas not used for vehicle salvage activities.		★	■	■	■	★	★	★
RUNOFF MANAGEMENT								
Use vegetated swales and buffer strips, catch basin filters, and/or other similar measures to facilitate settling or filtering of pollutants in runoff.[10]		★	●	●	●	■	●	●

COMMENTS

6 Secondary storage inside a building is only recommended when there is a potential for a spilled liquid to flow outside and reach a waterway.

7 This may not be feasible or practical for some facilities.

8 May be labor intensive for some facilities.

9 Filtering measures may not be practical for facilities with unpaved surfaces with large sediment loadings. Filters would become clogged, possibly causing flooding. May be damaged by heavy equipment.

10 May not be practical in many industrial facilities that are storm sewered. May be damaged by heavy equipment.

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Construct grassed swales, berms, and diversions to direct water flow to a central point for better control and management.		★	●	●	●	■	■	●
Properly maintain grassed swales by keeping swales free of debris and litter, maintaining vegetation, and periodically removing accumulated sediment. Do not place material or waste in swales or in the runoff paths.		★	●	●	●	★	●	●
Divert runoff away from material storage areas through such practices as dikes, berms, containment trenches, culverts, elevated concrete pads, and/or surface grading.[11]		★	●	●	●	■	■	●
Consider installing a detention pond Monitor accumulation of sediments in the bottom of detention ponds. Remove accumulated metals and other materials from the bottom of detention ponds as needed.[12]		★	●	★	●	■	■	■
Considering installing oil-water separators to reduce the levels of petroleum-based oils in storm water runoff. Test and clean out sediments and oily deposits that have accumulated in the oil-water separator. Sediments should be tested for metals and other pollutants which may be expected to be present.		●	●	●	■	■	■	●
NON-STORM WATER DISCHARGES								
Disconnect or seal off all existing floor drains and sinks that are connected to the storm drainage system.		■	■	■	■	★	★	★
Wash vehicles and equipment in a contained area.		●	●	■	■	●	●	●
Do not steam clean parts outside without proper wastewater containment.		●	●	■	■	●	●	●
Do not discharge steam cleaned wastewater to a septic tank system because the oils may not be treated or removed in the system.		●	●	■	■	★	●	●
Do not pour liquid waste or parts wash water down storm drain inlets.		■	●	■	●	★	★	★
Do not hose down the shop floor if water would be conveyed to a storm drain.	✔	■	■	■	■	★	★	★

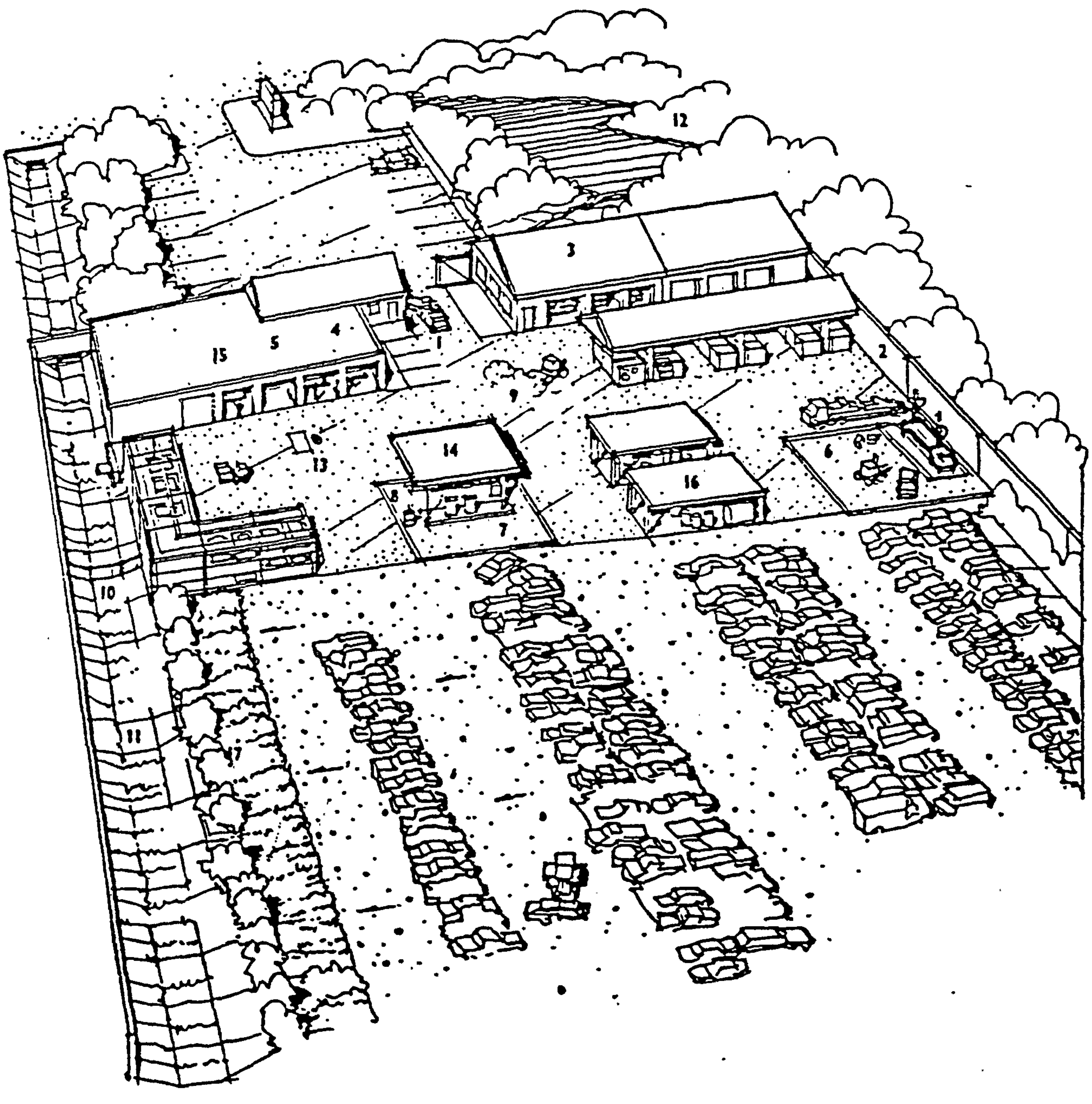
COMMENTS

11 Practices can be readily damaged by heavy equipment. Not practical in many paved facilities.

12 This BMP is not required by the U.S. EPA Multi-Sector Permit. The use of detention ponds and dikes may eliminate the need for a storm water permit if all storm water from the facility is detained and no water is discharged from the facility

Variety of BMPs at a sample automotive recycling facility. These BMPs are suggestions only. Select practices that are appropriate for your facility.

1 Inbound material control program
2 Fences and physical barriers
3 Covered transmission and engine core storage areas
4 Indoor vehicle dismantling activity
5 Covered parts cleaning operations
6 Containment system for automobile crusher
7 Signs - fuel spill prevention
8 Spill kit equipment
9 Pavement sweeping
10 Silt fences
11 Grassed swale
12 Detention pond
13 Oil-water separator
14 Fuel pump covering, containment, and automatic shut-off
15 Inspected and maintained equipment
16 Covered fluid storage
17 Vegetative buffer strip



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Appendix D. Comparison of Conventional and Toxic Pollutant Concentrations in Storm Water from Auto Dismantling Facilities in Los Angeles Region[1]

Constituents	EPA Bench-mark[2]	L.A. Regional Board[3] N=8; 1998 -1999			L.A. Regional Board[4] N=24; 1997 - 1998			L.A. Regional Board[4] N=49; 1996 - 1997			L.A. Regional Board[5] 1995 - 1996		
		Mean	Median	95ile	Mean	Median	95ile	Mean	Median	95ile	Mean	Median	95ile
pH	6-9	6.2 (min)	7.3	8.5 (max)	6.15 (min)	7	8.74 (max)	1.81 (min)	6.8	8.9 (max)	5.7 (min)	6.8	7.8 (max)
TSS	100	116	85	210	99	69	304	196	51	479	148	168	294
SC (umho/cm)	200	204	243	355	196	135	518	415	170	1530	262	160	623
O&G	15	28	18	67	N=20 8.7	6.7	20.1	11	7.7	30	39 (N=3)	15	92
TOC	110	N/A	N/A	N/A	N=7 78	110	138	N/A	N/A	N/A	45 (N=12)	32	122
Al	0.75	1.06	0.668	2.53	N=2 1.19	1.19	1.65	N/A	N/A	N/A	N/A	N/A	N/A
Cu	0.0636	0.142	0.132	0.236	0.09	0.093	0.17	0.170	0.17	.245	N/A	N/A	N/A
Fe	1	1.36	1.22	2.71	N=2 2.36	2.19	3 19	N/A	N/A	N/A	N/A	N/A	N/A
Pb	0.0816	0.103	0.083	0.210	0.06	0.035	0.2	0.304	0.267	0.682	0.174 (N=7)	0.15	0.34
Zn	0.117	0.509	0.483	0.725	0.56	0.34	1.9	1.07	0.40	2.75	N/A	N/A	N/A

[1] Data represent grab samples of storm water from auto dismantling facilities collected by facility operators as part of the annual monitoring and reporting requirement or by the Regional Board staff as part of this study.
[2] The benchmark values are from the 1995 USEPA Multi-sector Permit (USPEA 1995).
[3] Represent samples collected by staff from the eight case study facilities.
[4] Represent samples collected by facility operators.
[5] Represent samples collected by group monitoring participants.

Appendix E. Description of Load Estimate Parameters

Each of the parameters in the EPA Simple Method equation were estimated as described below:

Average pollutant concentration, C: Ideally, Flow-weighted composites should be used to estimate load. Given the lack of flow-weighted composite storm water data on the auto dismantling industry reflective of the climatic and precipitation patterns of Southern California, grab sample data generated by staff sampling at the eight case study facilities were used. At this time, the approximate margin of error or uncertainty from using grab sample data instead of flow-weighted composite data is not known.

The total site area, A: For area, A, area occupied per watershed by auto dismantling establishments were estimated by multiplying the following three factors: a) the total number of auto dismantlers in Los Angeles County (404) estimated earlier in this study; b) the proportion of auto dismantling facilities located in each watershed area, determined based on zipcodes of all dismantlers with an active NOI; and c) the average size of auto dismantling facilities located in each watershed. It was assumed that, on average, non-filers are similar to NOI filers in size and in spatial distribution.

Annual rainfall depth, P: Rainfall records for certain parts of Los Angeles County were available from the Los Angeles County Department of Public Works, Hydrology Division (the County). This study chose reference monitoring sites chosen for each watershed with a significant number of auto dismantler establishments. Rainfall pattern could vary substantially even within a watershed. Therefore, it is important to use rainfall data as specific or closest to the source area as possible. The annual rainfall depth was calculated by adding daily rainfall (in inches) reported from October 1998 to September 1999.

Fraction of rainfall events that produce a runoff, Pj: This study used 0.1 inches as the threshold volume required to generate runoff. Pj was calculated by dividing the sum of the adjusted individual rainfall volume (i.e. minus the first 0.1 inches) for the 1998/99 wet season by the annual total rainfall volume. If Pj is known for a given geographical area for a certain wet season or for an extended period (for example 100 years), one could reasonably estimate the total annual runoff (by multiplying $P*P_j$) without the individual rain records as long as the annual total precipitation is known. Since the daily rainfall data were available from the County, we calculated the product P*Pj by simply adding the individual rainfall depth after subtracting 0.1 inch from each rainfall datum.

Site Imperviousness, I: The GISP defines percent imperviousness as the portion of a facility property that is paved, roofed (including buildings), or covered. A single value for imperviousness was derived by normalizing based on area, i.e. by dividing the sum of impervious areas calculated for each facility by the sum of facility size. An average site imperviousness of 43% was estimated for the auto dismantling facilities in Los Angeles County using the self-reported information in the NOI database (This value is significantly less than the 76% imperviousness estimated for light industrial land use in the Los Angeles County's Annual Monitoring Report submitted as a requirement under the municipal storm water program.) A source of uncertainty in this estimate is that facility operators could have misinterpreted the term "imperviousness."

Governor Gray Davis

A Citizen's Guide to Planning

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INTRODUCTION

This is a citizen's guide to land use planning as it is practiced in California. Its purpose is to explain, in general terms, how local communities regulate land use and to define some commonly used planning terms. The booklet covers the following topics:

- State Law and Local Planning
- The General Plan
- Zoning
- Subdivisions
- Other Ordinances and Regulations
- Annexation and Incorporation
- The California Environmental Quality Act
- A Glossary of Planning Terms
- Bibliography

Cities and counties "plan" in order to identify important community issues (such as new growth, housing needs, and environmental protection), project future demand for services (such as sewer, water, roads, etc.), anticipate potential problems (such as overloaded sewer facilities or crowded roads), and establish goals and policies for directing and managing growth. Local governments use a variety of tools in the planning process including the general plan, specific plans, zoning, and the subdivision ordinance.

The examples discussed here represent common procedures or methods, but are by no means the only way of doing things. State law establishes a framework for local planning procedures, but cities and counties adopt their own unique responses to the issues they face. The reader is encouraged to consult the bibliography for more information on planning in general and to contact your local planning department for information on planning in your community.

STATE LAW AND LOCAL PLANNING

State law is the foundation for local planning in California. The California Government Code (Sections 65000 et seq.) contains many of the laws pertaining to the regulation of land uses by local governments including: the general plan requirement, specific plans, subdivisions, and zoning.

However, the State is seldom involved in local land use and development decisions; these have been delegated to the city councils and boards of supervisors of the individual cities and counties. Local decisionmakers adopt their own sets of land use policies and regulations based upon the state laws.

Plan and Ordinances

There are currently 533 incorporated cities and counties in California. State law requires that each of these jurisdictions adopt "a comprehensive, long-term general plan for [its] physical development." This general plan is the official city or county policy regarding the location of housing, business, industry, roads, parks, and other land uses, protection of the public from noise and other environmental hazards, and conservation of natural resources. The legislative body of each city (the city council) and each county (the board of supervisors) adopts zoning, subdivision and other ordinances to regulate land uses and to carry out the policies of its general plan.

There is no requirement that adjoining cities or cities and counties have identical, or even similar, plans and ordinances. Cities and counties are distinct and independent political units. Each city, through its council and each county, through its supervisors, adopts its own general plan and development regulations. In turn, each of these governments is responsible for the planning decisions made within its jurisdiction.

Hearing Bodies

In most communities, the city council or board of supervisors has appointed one or more hearing bodies to assist them with planning matters. The titles and responsibilities of these groups vary from place-to-place, so check with your local planning department regarding regulations in your area. Here are some of the more common types of hearing bodies and their usual responsibilities:

- **The Planning Commission:** considers general plan and specific plan amendments, zone changes, and major subdivisions.
- **The Zoning Adjustment Board:** considers conditional use permits, variances, and other minor permits.
- **Architectural Review or Design Review Board:** reviews projects to ensure that they meet community aesthetic standards.

In some cities and counties, these bodies simply advise the legislative body on the proposals that come before them, leaving actual approval to the council or board of supervisors. More commonly, these bodies have the power to approve proposals, subject to appeal to the council or board of supervisors. These hearing bodies, however, do not have final say on matters of policy such as zone changes and general or specific plan amendments.

Hearings

State law requires that local governments hold public hearings prior to most planning actions. At the hearing, the council, board, or advisory commission will explain the proposal, consider it in light of local regulations and environmental effects, and listen to testimony from interested parties. The council, board, or commission will vote on the proposal at the conclusion of the hearing.

Depending upon each jurisdiction's local ordinance, public hearings are not always required for minor land subdivisions, architectural or design review or ordinance interpretations. The method of advertising hearings may vary. At a minimum, counties and cities must publish notice of general plan adoption and amendment in the newspaper. Notice of a proposed general plan amendment affecting allowable land uses, zone change, conditional use permit, variance, and subdivision tract is published in the newpaper and mailed to nearby property owners.

THE GENERAL PLAN

The Blueprint

The local general plan can be described as the city's or county's "blueprint" for future development. It represents the community's view of its future; a constitution made up of the goals and policies upon which the city council, board of supervisors, and planning commission will base their land use decisions. To illustrate its importance, all subdivisions, public works projects, and zoning decisions (except in charter cities other than Los Angeles) must be consistent with the general plan. If inconsistent, they must not be approved.

Long-range Emphasis

The general plan is not the same as zoning. Although both designate how land may be developed, they do so in different ways. The general plan and its diagrams have a long-term outlook, identifying the types of development that will be allowed, the spatial relationships among land uses, and the general pattern of future development. Zoning regulates present development through specific standards such as lot size, building setback, and a list of allowable uses. In counties and general law cities, the land uses shown on the general plan diagrams will usually be reflected in the local zoning maps as well. Development must not only meet the specific requirements of the zoning ordinance, but also the broader policies set forth in the local general plan.

Contents

State law requires that each city and each county adopt a general plan containing the following seven components or "elements": land use, circulation, housing, conservation, open-space, noise, and safety (Government Code Sections 65300 et seq.). At the same time, each jurisdiction is free to adopt a wide variety of additional elements covering subjects of particular interest to that jurisdiction such as recreation, urban design, or public facilities.

Most general plans consist of: (1) a written text discussing the community's goals, objectives, policies, and programs for the distribution of land use; and, (2) one or more diagrams or maps illustrating the general location of existing and future land uses. Figure 1 is an example of a general plan diagram.

Each local government chooses its own general plan format. The plan may be relatively short or long, one volume or ten volumes, depending upon local needs. Some communities, such as the City of San Jose, have combined the required elements into one document and most communities have adopted plans which consolidate the elements to some extent.

State law requires that local governments make copies of their plans available to the public for reference. Copies can be sold to the public for the cost of reproduction.

Planning Issues

Although state law establishes a set of basic issues for consideration in local general plans, each city and county determines the relative importance of each issue to local planning and decides how they are to be addressed in the general plan. As a result, no two cities or counties have plans which are exactly alike in form or content. Here is a summary of the basic issues, by element:

- The **land use element** designates the general location and intensity of housing, business, industry, open space, education, public buildings and grounds, waste disposal facilities, and other land uses.

- The **circulation element** identifies the general location and extent of existing and proposed major roads, transportation routes, terminals, and public utilities and facilities. It must be correlated with the land use element.

- The **housing element** is a comprehensive assessment of current and projected housing needs for all economic segments of the community. It sets forth local housing policies and programs to implement those policies.

- The **conservation element** addresses the conservation, development, and use of natural resources including water, forests, soils, rivers, and mineral deposits.

- The **open-space element** details plans and measures for preserving open-space for natural resources, the managed production of resources, outdoor recreation, public health and safety, and the identification of agricultural land.

- The **noise element** identifies and appraises noise problems within the community and forms the basis for distributing new noise-sensitive land uses.

- The **safety element** establishes policies and programs to protect the community from risks associated with seismic, geologic, flood, and wildfire hazards.

Approving the Plan

The process of adopting or amending a general plan requires public participation. Cities and counties must hold public hearings for such proposals. Advance notice of the place and time of the hearing must be published in the newspaper or posted in the vicinity of the site proposed for change. Prior to approval, hearings will be held by the advisory body such as the planning commission. The general plan must be adopted by resolution by the legislative body of each city or county.

Community and Specific Plans

"Community plans" and "specific plans" are often used by cities and counties to plan the future of a particular area at a finer level of detail than that provided by the general plan. A community plan is a portion of the local general plan focusing on the issues pertinent to a particular area or community within the city or county. It supplements the policies of the general plan.

Specific plans describe allowable land uses, identify open space, and detail the availability of facilities and financing for a portion of the community. Specific plans must be consistent with the local general plan. A specific plan implements but is not technically a part of the general plan. In some jurisdictions, specific plans take the place of zoning. Zoning, subdivision, and public works decisions must be consistent with any applicable specific plan.

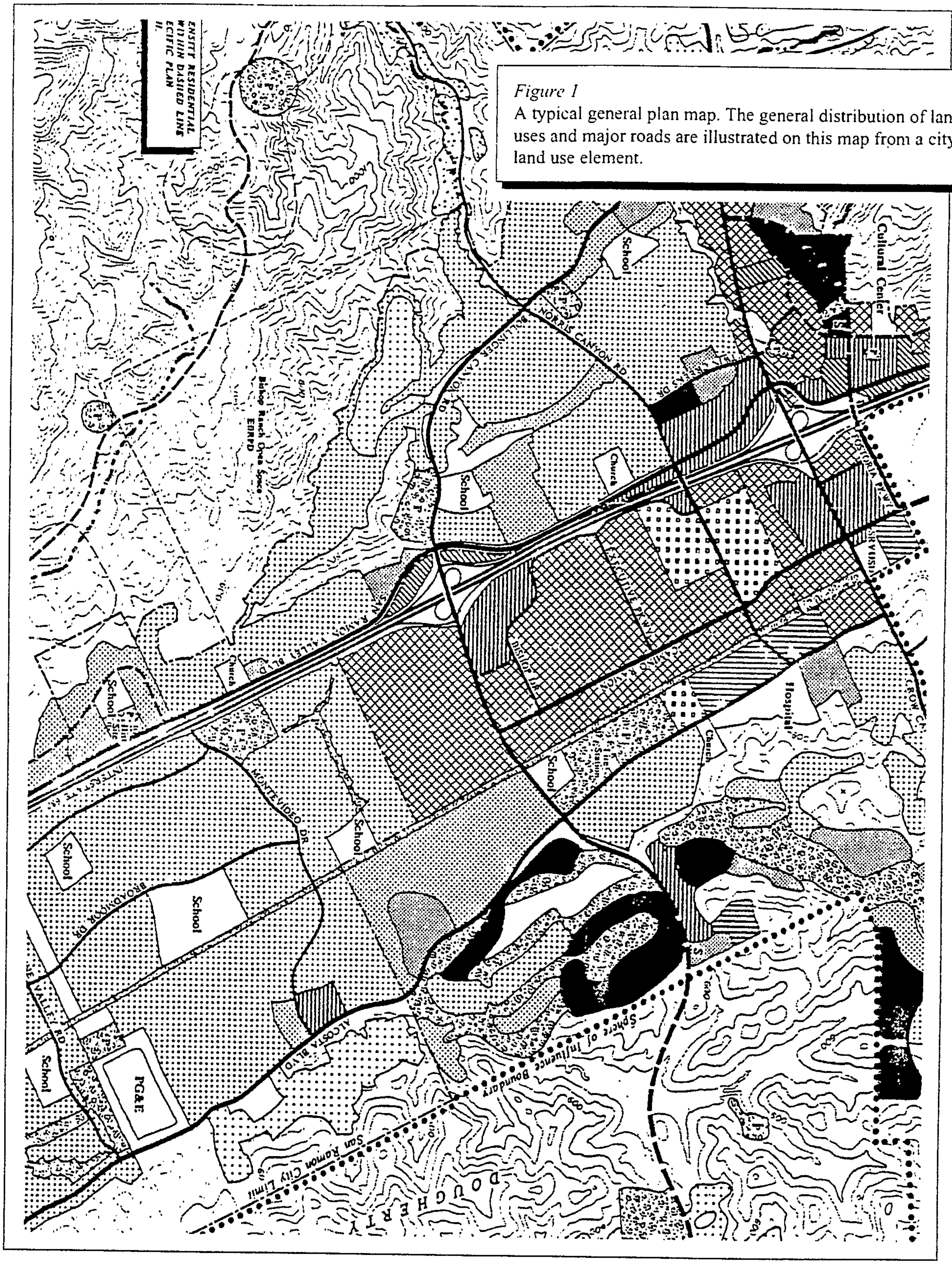

Figure 1
A typical general plan map. The general distribution of land uses and major roads are illustrated on this map from a city land use element.

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ZONING

The general plan is a long-range policy document that looks at the future of the community. A zoning ordinance is the local law that spells out the immediate, allowable uses for each piece of property within the community. In all counties, general law cities, and the city of Los Angeles, zoning must comply with the general plan. This rule does not apply to charter cities.

The purpose of zoning is to implement the policies of the general plan.

Zones

Under the concept of zoning, various kinds of land uses are grouped into general categories or "zones" such as single-family residential, multi-family residential, neighborhood commercial, light industrial, agricultural, etc. A typical zoning ordinance describes 20 or more different zones which may be applied to land within the community. Each piece of property in the community is assigned a zone listing the kinds of uses that will be allowed on that land and setting standards such as minimum lot size, maximum building height, and minimum front yard depth. The distribution of residential, commercial, industrial, and other zones will be based on the pattern of land uses established in the community's general plan. Maps are used to keep track of the zoning for each piece of land (an example of a zoning map is shown in Figure 2).

Zoning is adopted by ordinance and carries the weight of local law. Land may be put only to those uses allowed by the applicable zoning classification. For example, if a commercial zone does not allow five-story office buildings, then no such building could be built on the lands which have been assigned that zone. A zoning ordinance has two parts: (1) a precise map or maps illustrating the distribution of zones within the community; and, (2) a text which identifies the specific land uses and development standards allowed in each zone.

Rezoning

The particular zone determines the uses to which land may be put. If a landowner proposes a use that is not allowed in the zone, the city or county could approve a rezoning (change in zone) to allow that development. The local planning commission and the city council or county board of supervisors must hold public hearings before property may be rezoned. The hearings must be advertised in advance and notice mailed directly to surrounding property owners. The council or board is not obligated to approve requests for rezoning and, except in charter cities, must deny such requests when the proposed zone conflicts with the general plan.

Overlay Zones

In addition to the zoning applied to each parcel of land, many cities and counties use "overlay zones" to further regulate development in areas of special concern. Lands in historic districts, downtowns, floodplains, near earthquake faults or on steep slopes are often subject to having additional regulations "overlain" upon the basic zoning requirements. For example, a lot that is within a single-family residential zone and also subject to a steep-slope overlay zone, must meet the development requirements of both zones when it is developed.

Prezoning

Cities may "prezone" lands located within the surrounding county in the same way that they approve zoning within the city. Prezoning is done before annexation of the land to the city in order to facilitate its transition into the city boundaries. Prezoning does not change the allowable uses of the land nor the development standards until such time as the site is officially annexed to the city. Likewise, land that has been prezoned continues to be subject to county zoning regulations until annexation is completed.

Variances

A variance is a limited waiver of development standards for a use that is otherwise permitted in that zone. The city or county may grant a variance in special cases where: (1) application of the zoning regulations would deprive property of the uses enjoyed by nearby, similarly zoned lands; and (2) restrictions have been imposed to ensure that the variance will not be a grant of special privilege. A city or county may not grant a variance that would permit a use that is not otherwise allowed in that zone (for example, a commercial use could not be approved in a residential zone by variance). Typically, variances are considered when the physical characteristics of the property make it difficult to develop. For instance, in a situation where the rear half of a lot is a steep slope, a variance might be approved to allow a house to be built closer to the street than usually allowed. Variance requests require a public hearing and neighbors are given the opportunity to testify. The local hearing body then decides whether to approve or deny the variance.

Conditional Use Permits

Most zoning ordinances identify certain land uses which do not precisely fit into existing zones, but which may be allowed upon approval of a conditional use permit (sometimes called a special use permit or a CUP). These might include community facilities (such as hospitals or schools), public buildings or grounds (such as fire stations or parks), temporary or hard-to-classify uses (such as Christmas tree sales or small engine repair), or land uses with potentially significant environmental impacts (hazardous chemical storage or a house in a floodplain). The local zoning ordinance specifies those uses for which a conditional use permit may be requested, which zones they may be requested in, and the public hearing procedure.

As with rezoning and variances, a public hearing must be held to consider a CUP. If the local planning commission or zoning board approves the use, it will usually do so subject to certain conditions being met by the permit applicant. Alternatively, it may deny uses which do not meet local standards.

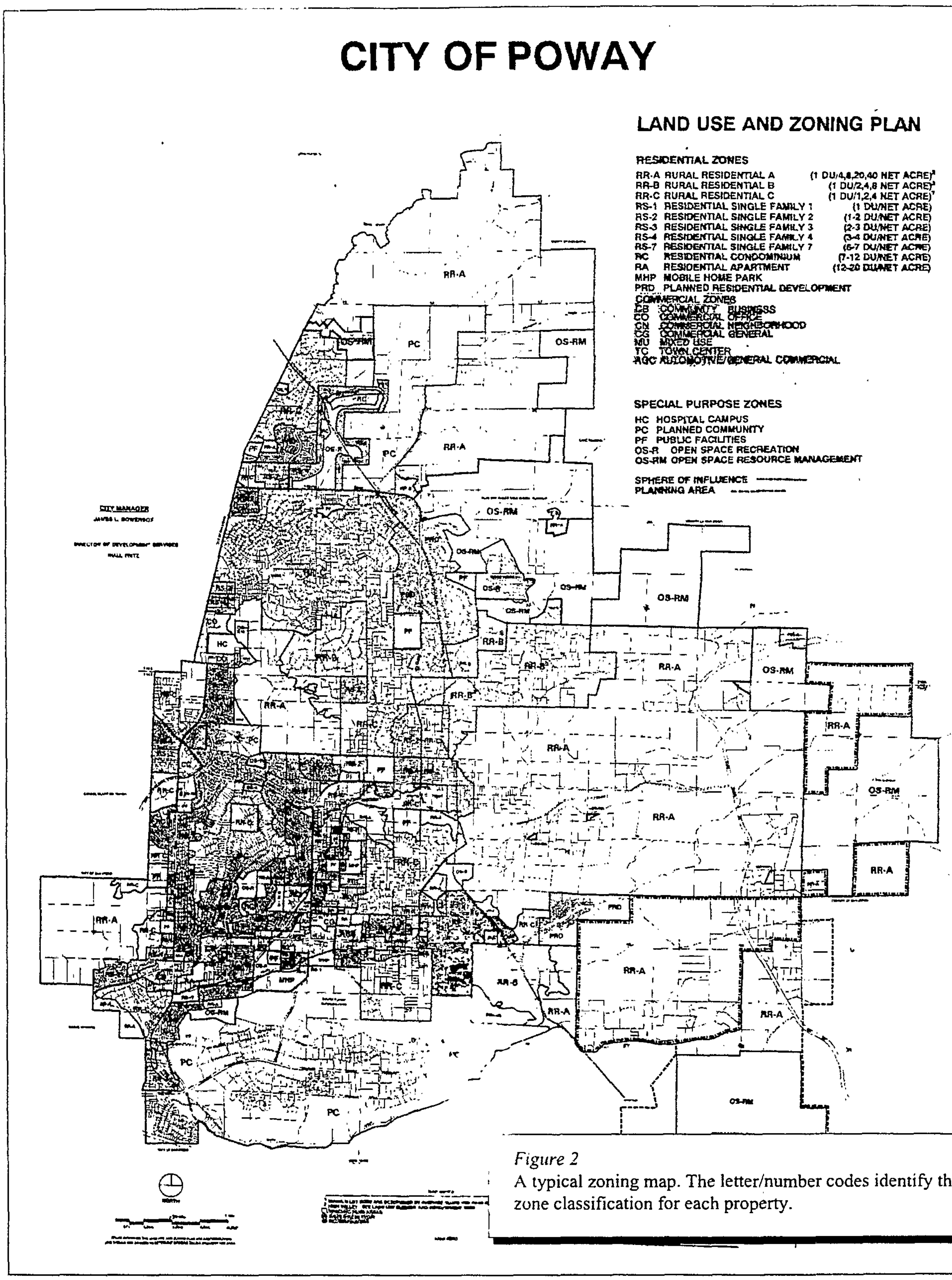

Figure 2
A typical zoning map. The letter/number codes identify the zone classification for each property.

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SUBDIVISIONS

In general, land cannot be divided in California without local government approval. Dividing land for sale, lease or financing is regulated by local ordinances based on the State Subdivision Map Act (commencing with Government Code Section 66410). The local general plan, zoning, subdivision, and other ordinances govern the design of the subdivision, the size of its lots, and the types of improvements (street construction, sewer lines, drainage facilities, etc.). In addition, the city or county may impose a variety of fees upon the subdivision, depending upon local and regional needs, such as school impact fees, park fee, etc. Contact your local planning department for information on local requirements and procedures.

Subdivision Types

There are basically two types of subdivisions: parcel maps, which are limited to divisions resulting in fewer than five lots (with certain exceptions), and subdivision maps (also called tract maps), which apply to divisions resulting in five or more lots. Applications for both types of land divisions must be submitted to the local government for consideration in accordance with the local subdivision ordinance and the Subdivision Map Act.

Processing

Upon receiving an application for a subdivision map, the city or county staff will examine the design of the subdivision to ensure that it meets the requirements of the general plan, the zoning ordinance, and the local subdivision ordinance. A public hearing must be held prior to approval of a tentative tract map. Parcel maps may also be subject to a public hearing, depending upon the requirements of the local subdivision ordinance.

Final Approval

Approval of a tentative tract map or parcel map generally means that the subdivider will be responsible for installing improvements such as streets, drainage facilities or sewer lines to serve the subdivision. These improvements must be installed or secured by bond before the city or county will grant final approval of the map and allow the subdivision to be recorded in the county recorder's office. Lots within the subdivision cannot be sold until the map has been officially recorded. The subdivider has at least two years (and depending upon local ordinance, usually more) in which to comply with the improvement requirements, gain final administrative approval, and record the final map. Parcel map requirements may vary dependent upon local ordinance requirements. Figure 3 illustrates a typical subdivision map.

OTHER ORDINANCES AND REGULATIONS

Cities and counties often adopt other ordinances besides zoning and subdivision to protect the general health, safety, and welfare of their inhabitants. Contact your local planning department for information on the particular ordinances in effect in your area. Common types include: flood protection, historic preservation, design review, hillside development control, growth management, impact fees, traffic management, and sign control.

Local ordinances may also be adopted in response to state requirements. Examples include: Local Coastal Programs (California Coastal Act); surface mining regulations (Surface Mining and Reclamation Act); earthquake hazard standards (Alquist-Priolo Special Studies Zone Act); and hazardous material disclosure requirements. These regulations are generally based on the applicable state law.

ANNEXATION AND INCORPORATION

The LAFCO

Annexation (the addition of territory to an existing city) and incorporation (creation of a new city) are controlled by the Local Agency Formation Commission (LAFCO) established in each county by the state's Cortese-Knox-Hertzberg Act (commencing with Government Code Section 56000). The commission is made up of elected officials from the county, cities, and, in some cases, special districts. LAFCO duties include: establishing the "spheres of influence" that designate the service areas of cities and special districts; studying and approving requests for city annexations; and, studying and approving proposals for city incorporations. Below is a very general discussion of annexation and incorporation procedures. For detailed information on this complex subject, contact your county LAFCO.

Annexation

When the LAFCO receives an annexation request, it will convene a hearing to determine the worthiness of the proposal and may deny or conditionally approve the request based on the policies of the LAFCO and state law. Annexation requests which

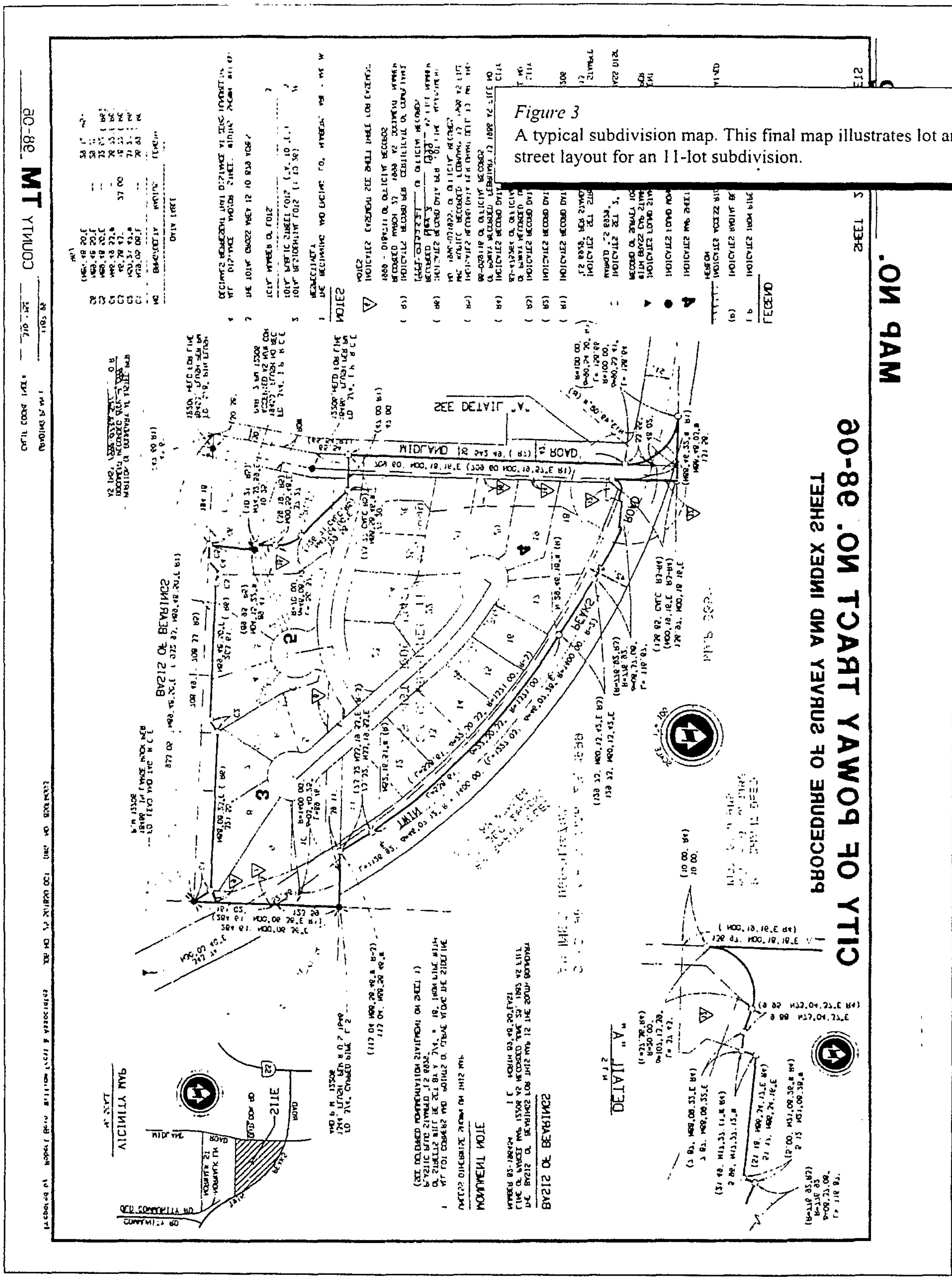

Figure 3
A typical subdivision map. This final map illustrates lot and street layout for an 11-lot subdivision.

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receive tentative LAFCO approval are delegated to the affected city for hearings and, if necessary, an election. Annexations which have been passed by vote of the inhabitants or which have not been defeated by protest (in cases where no election was required) must be certified by the LAFCO as to meeting all its conditions before they become final. It is the LAFCO, not the city, that is ultimately responsible for the annexation process.

Incorporation

When the formation of a new city is proposed, the LAFCO studies the economic feasibility of the proposed city, its impact on the county and special districts, and its ability to provide public services. A new city must be shown to be "revenue neutral" with regard to the tax revenues lost by the county as a result of incorporation and the cost of current services to the proposed city. If the feasibility of the proposed city cannot be shown, the LAFCO can terminate the proceedings. If the proposed city appears to be feasible, LAFCO will refer the proposal to the county board of supervisors for hearing along with a set of conditions to be met upon incorporation. If the supervisors do not receive protests from a majority of the involved voters, an election will be held among the voters within the proposed city boundaries to create the city. The voters elect the first council at the same election.

THE CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

The California Environmental Quality Act (commencing with Public Resources Code Section 21000) requires local and state governments to consider the potential environmental effects of a project before deciding whether to approve it. CEQA's purpose is to disclose the potential impacts of a project, suggest methods to minimize those impacts, and discuss alternatives to the project so that decision makers will have full information upon which to base their decision. The term "project" is defined broadly in CEQA. It includes all of the actions discussed in this paper—from annexations to zoning.

CEQA is a complex law with a great deal of subtlety and local variation. The following discussion is *extremely* general. The basic requirements and administrative framework for local governments' CEQA responsibilities are described in the *California Environmental Quality Act: Statutes and Guidelines*. For more information, readers should contact their local planning department or refer to the CEQA listings in the bibliography.

Lead Agency

The "lead agency" is responsible for seeing that environmental review is done in accordance with CEQA and that environmental analyses are prepared when necessary. The agency with the principal responsibility for issuing permits to a project (or for carrying out the project) is deemed to be the "lead agency." As lead agency, it may prepare the environmental analysis itself or it may contract for the work to be done under its direction. In practically all local planning matters (such as rezoning, conditional use permits, and specific plans) the planning department is the lead agency.

Preliminary Review

Analyzing a project's potential environmental effect is a multistep process. Many minor projects are exempt from the CEQA requirements. Typically, these include single-family homes, remodeling, accessory structures, and minor lot divisions (for a complete list refer to *California Environmental Quality Act: Statutes and Guidelines*). No environmental review is required when a project is exempt from CEQA.

When a project is subject to review under CEQA, the lead agency prepares an "initial study" to assess the potential adverse physical impacts of the proposal.

Negative Declarations and EIRs

If the initial study shows that the project will not cause a "significant" impact on the environment or when it has been revised to eliminate all such impacts, a "negative declaration" is prepared. The negative declaration describes why the project will not have a significant impact and may require that the project incorporate a number of measures (called "mitigation measures") ensuring that there will be no such impact.

If significant environmental effects are identified, then an Environmental Impact Report (EIR) must be written before the project can be considered by decision makers. An EIR discusses the proposed project, its environmental setting, its probable impacts, realistic means of reducing or eliminating those impacts, its cumulative effects, and alternatives to the project. CEQA requires that draft Negative Declarations and EIRs be made available for review by the public and other agencies prior to consideration of the project. The review period allows concerned citizens and agencies to comment on the completeness and adequacy of the environmental review prior to its completion.

When the decision making body (the city council, board of supervisors, or other board or commission) approves a project, it must certify the adequacy of the environmental review. If its decision to approve a project will result in unavoidable significant impacts, the decision making body must not only certify the EIR, but also state, in writing, its overriding reasons for granting the approval and how the impacts are to be addressed.

A Negative Declaration or an EIR is an informational document. It does not, in itself, approve or deny a project. Environmental analysis must be done as early as possible in the process of considering a project and must address the entire project. There are several different types of EIRs that may be prepared, depending upon the project. They are described in the *California Environmental Quality Act: Statutes and Guidelines*.

GLOSSARY

These are some commonly used planning terms. This list includes several terms that are not discussed in this booklet.

Board of Supervisors
A county's legislative body. Board members are elected by popular vote and are responsible for enacting ordinances, imposing taxes, making appropriations, and establishing county policy. The board adopts the general plan, zoning, and subdivision regulations.

The "Brown Act"
The Ralph M. Brown Open Meeting Act (commencing with Government Code Section 54950) requires cities and counties to provide advance public notice of hearings and meetings of their councils, boards, and other bodies. Meetings and hearings with some exceptions must be open to the public.

CEQA
The California Environmental Quality Act (commencing with Public Resources Code Section 21000). In general, CEQA requires that all private and public projects be reviewed prior to approval for their potential adverse effects upon the environment.

Charter City
A city which has been incorporated under its own charter rather than under the general laws of the state. Charter cities have broader powers to enact land use regulations than do general law cities. All of California's largest cities are charter cities.

City Council
A city's legislative body. The popularly elected city council is responsible for enacting ordinances, imposing taxes, making appropriations, establishing policy, and hiring some city officials. The council adopts the local general plan, zoning, and subdivision ordinance.

COG
Council of Governments. There are 25 COGs in California made up of elected officials from member cities and counties. COGs are regional agencies concerned primarily with transportation planning and housing; they do not directly regulate land use.

Community Plan
A portion of the local general plan that focuses on a particular area or community within the city or county. Community plans supplement the policies of the general plan.

Conditional Use Permit
Pursuant to the zoning ordinance, a conditional use permit (CUP) may authorize uses not routinely allowed on a particular site. CUPs require a public hearing and if approval is granted, are usually subject to the fulfillment of certain conditions by the developer. Approval of a CUP is not a change in zoning.

Density Bonus
An increase in the allowable number of dwelling units granted by the city or county in return for the project's providing low- or moderate-income housing (see Government Code Section 65915).

Design Review Committee
A group appointed by the city council to consider the design and aesthetics of development within design review zoning districts.

Development Fees
Fees charged to developers or builders as a prerequisite to construction or development approval. The most common are: (1) impact fees (such as parkland acquisition fees, school facilities fees, or street construction fees) related to funding public improvements which are necessitated in part or in whole by the development; (2) connection fees (such as water line fees) to cover the cost of installing public services to the development; (3) permit fees (such as building permits, grading permits, sign permits) for the administrative costs of processing development plans; and, (4) application fees (rezoning, CUP, variance, etc.) for the administrative costs of reviewing and hearing development proposals.

Downzone
This term refers to the rezoning of land to a more restrictive or less intensive zone (for example, from multi-family residential to single-family residential or from residential to agricultural).

EIR
Environmental Impact Report. A detailed review of a proposed project, its potential adverse impacts upon the environment, measures that may avoid or reduce those impacts, and alternatives to the project.

Final Map Subdivision
Final map subdivisions (also called tract maps or major subdivisions) are land divisions which create five or more lots. They must be consistent with the general plan and are generally subject to stricter requirements than parcel maps. Such requirements may include installing road improvements, the construction of drainage and sewer facilities, parkland dedications, and more.

Floor Area Ratio
Abbreviated as FAR, this is a measure of development intensity. FAR is the ratio of the amount of floor area of a building to the amount of area of its site. For instance, a one-story building that covers an entire lot has an FAR of 1. Similarly, a one-story building that covers 1/2 of a lot has an FAR of 0.5.

General Law City
A city incorporated under and administered in accordance with the general laws of the state.

General Plan
A statement of policies, including text and diagrams setting forth objectives, principles, standards, and plan proposals, for the future physical development of the city or county (see Government Code Sections 65300 et seq.).

"Granny" Housing
Typically, this refers to a second dwelling attached to or separate from the main residence that houses one or more elderly persons. California Government Code 65852.1 enables cities and counties to approve such units in single-family neighborhoods.

Impact Fees
See Development Fees.

Infrastructure
A general term describing public and quasi-public utilities and facilities such as roads, bridges, sewers and sewer plants, water lines, power lines, fire stations, etc.

Initial Study
Pursuant to CEQA, an analysis of a project's potential environmental effects and their relative significance. An initial study is preliminary to deciding whether to prepare a negative declaration or an EIR.

Initiative
A legislative measure which has been placed on the election ballot as a result of voter signatures. At the local level, initiatives usually propose changes or additions to the general plan and zoning ordinance. The right to initiative is guaranteed by the California Constitution.

LAFCO
Local Agency Formation Commission. The Cortese-Knox Act (commencing with Government Code Section 56000) establishes a LAFCO made up of elected officials of the county, cities, and, in some cases, special districts in each county. The 57 LAFCOs establish spheres of influence for all the cities and special districts within the county. They also consider incorporation and annexation proposals.

Mitigation Measure
The California Environmental Quality Act requires that when an adverse environmental impact or potential impact is identified, measures must be proposed that will eliminate, avoid, rectify, compensate for or reduce those environmental effects.

Negative Declaration
When a project is not exempt from CEQA and will not have a significant adverse effect upon the environment a negative declaration must be prepared. The negative declaration is an informational document that describes the reasons why the project will not have a significant effect and proposes measures to completely mitigate or avoid any possible effects.

Overlay Zone
A set of zoning requirements that is superimposed upon a base zone. Overlay zones are generally used when a particular area requires special protection (as in a historic preservation district) or has a special problem (such as steep slopes, flooding or earthquake faults). Development of land subject to overlay zoning requires compliance with the regulations of both the base and overlay zones.

Parcel Map
A minor subdivision resulting in fewer than five lots. The city or county may approve a parcel map when it meets the requirements of the general plan and all applicable ordinances. The regulations governing the filing and processing of parcel maps are found in the state Subdivision Map Act and the local subdivision ordinance.

Planned Unit Development (PUD)
Land use zoning which allows the adoption of a set of development standards that are specific to the particular project being proposed. PUD zones usually do not contain detailed development standards; these are established during the process of considering the proposals and adopted by ordinance if the project is approved.

Planning Commission
A group of residents appointed by the city council or board of supervisors to consider land use planning matters. The commission's duties and powers are established by the local legislative body and might include hearing proposals to amend the general plan or rezone land, initiating planning studies (road alignments, identification of seismic hazards, etc.), and taking action on proposed subdivisions.

Referendum
A ballot measure challenging a legislative action by the city council or county board of supervisors. When sufficient voter signatures are filed before the council or board action becomes final, the council or board must either set aside its action or call an election on the matter. Use permits, variances, and subdivisions cannot be challenged by referendum.

School Impact Fees
Proposition 13 put a limit on property taxes and thereby limited the main source of funding for new school facilities. California law allows school districts to impose fees on new developments to offset their impacts on area schools.

Setback
A minimum distance required by zoning to be maintained between two structures or between a structure and property lines.

Specific Plan
A plan addressing land use distribution, open space availability, infrastructure, and infrastructure financing for a portion of the community. Specific plans put the provisions of the local general plan into action (see Government Code Sections 65450 et seq.).

Tentative Map
The map or drawing illustrating a subdivision proposal. The city or county will approve or deny the proposed subdivision based upon the design depicted by the tentative map. A subdivision is not complete until the conditions of approval imposed upon the tentative map have been satisfied and a final map has been certified by the city or county and recorded with the county recorder.

Tract Map
See final map subdivision.

Variance
A limited waiver from the property developement standards of the zoning ordinance. Variance requests are subject to public hearing, usually before a zoning administrator or board of zoning adjustment. Variances do not allow a change in land use.

Zoning
Local codes regulating the use and development of property. The zoning ordinance divides the city or county into land use districts or "zones", represented on zoning maps, and specifies the allowable uses within each of those zones. It establishes development standards for each zone, such as minimum lot size, maximum height of structures, building setbacks, and yard size.

Zoning Adjustment Board
A group appointed by the local legislative body to consider minor zoning adjustments such as conditional use permits and variances. It is empowered to conduct public hearings and to impose conditions of approval. Its decisions may be appealed to the local legislative body.

Zoning Administrator
A planning department staff member responsible for hearing minor zoning permits. Typically, the zoning administrator considers variances and conditional use permits and may interpret the provisions of the zoning ordinance when questions arise. His/her decision may be appealed to the local legislative body.

BIBLIOGRAPHY: A FEW GOOD BOOKS

The reader is encouraged to refer to the following books for a better understanding of planning in California.

California Environmental Quality Act: Statutes and Guidelines (Governor's Office of Planning and Research, Sacramento, California). *The* CEQA Guidelines *describe the requirements for evaluating environmental impacts. Out of print; check in the government documents section of your local library, or CERES website at ceres.ca.gov/ceqa.*

California Land Use and Planning Law, by Daniel J. Curtin Jr., (Solano Press, Pt. Arena, California), revised annually. *A look at the planning, zoning, subdivision, and environmental quality laws that is illustrated by references to numerous court cases.*

The General Plan Guidelines (Governor's Office of Planning and Research, Sacramento, California). *The Guidelines discuss local planning activities and how to write or revise a general plan.*

Growth Within Bounds: Report of the Commission on Local Governance for the 21st Century, 2000. *Recommendations on future local governance options, including LAFCO reform. Out of print; check in the government documents section of your local library, or the Commission website at www.clg21.ca.gov.*

A Guide to Planning in California, (League of Women Voters of California, Sacramento, California). *An excellent summary of the processes of local and state government.*

Guide to California Planning, by William J. Fulton (Solano Press, Point Arena, California). *A lively, well-written discussion of nearly every aspect of planning in the State.*

Open and Public: A User's Guide to The Ralph M. Brown Act, by the League of California Cities (League of California Cities, Sacramento, California), 1994. *An easy to read explanation of the state's open meeting laws and the responsibilities of local government with regard to public meetings.*

Subdivision Map Act Manual, by Daniel J. Curtin, Jr., (Solano Press, Pt. Arena, California), revised annually. *A practitioner's guide to the Map Act, including pertinent legal precedents.*

Illicit Discharge Detection and Elimination

Presentation at the EPA *National Storm Water Coordinator's Meeting*, Orlando, FL. May 1-3, 2001

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Abstract
This paper describes procedures that have been used to identify sources of inappropriate ("illicit") discharges in storm drainage systems. Also included is a review of emerging techniques that may also be useful, especially in future years as they become more accessible and become proven technologies. This paper also describes a series of tests where the original methods developed previously for EPA (Pitt, *et al.* 1993), along with selected new procedures, were examined using almost 700 stormwater samples collected from telecommunication manholes from throughout the U.S. About ten percent of the samples were estimated to be contaminated with sanitary sewage using these methods, similar to what is expected for most stormwater systems. The original methods are still recommended as the most useful procedure for identifying contamination of storm drainage systems, with the possible addition of specific tests for *E. coli* and enterococci and UV absorbance at 228 nm. Most newly emerging methods require exotic equipment and unusual expertise and are therefore not very available, especially at low cost and with fast turn-around times for the analyses. These emerging methods may therefore be more useful for special research projects than for routine screening of storm drainage systems.

The Center for Watershed Protection (CWP) and Dr. Robert Pitt with the University of Alabama are currently being funded by EPA to complete a technical assessment of techniques and methods for identifying and correcting illicit and inappropriate discharges geared towards NPDES Phase II communities. The project has a two year duration. In the first year, most of our effort will be directed to collecting data. The most cost effective and efficient techniques will also be identified during this initial project period. In the second project year, the project team will develop draft guidance on methods and techniques to identify and correct illicit connections, test the efficacy of the draft guidance in four communities, complete a final "User's Manual for Identifying and Correcting Illicit and Inappropriate Discharges," and conduct training and dissemination. This project is expected to start in the summer of 2001.

Introduction
Urban stormwater runoff includes waters from many other sources which find their way into storm drainage systems, besides from precipitation. There are cases where pollutant levels in storm drainage are much higher than they would otherwise be because of excessive amounts of contaminants that are introduced into the storm drainage system by various non-stormwater discharges. Additionally, baseflows (during dry weather) are also common in storm drainage systems. Dry-weather flows and wet-weather flows have been monitored during numerous urban runoff studies. These studies have found that discharges observed at outfalls during dry weather were significantly different from wet-weather discharges and may account for the majority of the annual discharges for some pollutants of concern from the storm drainage system.

There have been numerous methods used to investigate inappropriate discharges to storm drainage systems. Pitt, *et al.* (1993) and Lalor (1994) reviewed many of these procedures and developed a system that municipalities could use for screening outfalls in residential and commercial areas. In these areas, sewage contamination, along with low rate discharges from small businesses (especially laundries, vehicle repair shops, plating shops, etc.) are of primary concern. One of the earliest methods used to identify sewage contamination utilized the ratio of fecal coliform to fecal strep. bacteria. This method is still in use, but unfortunately has proven inaccurate in most urban stormwater

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applications. The fol[illegible] methodology developed by Pitt, *et al.* (1993) and [illegible] and some new approaches [illegible] investigated.

Use of Tracers to Identify Sources of Contamination in Urban Drainage Systems

Investigations designed to determine the contribution of urban stormwater runoff to receiving water quality problems have led to a continuing interest in inappropriate connections to storm drainage systems. Urban stormwater runoff is traditionally defined as that portion of precipitation which drains from city surfaces and flows via natural or man-made drainage systems into receiving waters. In fact, urban stormwater runoff also includes waters from many other sources which find their way into storm drainage systems. Sources of some of this water can be identified and accounted for by examining current National Pollutant Discharge Elimination System (NPDES) permit records for permitted industrial wastewaters that can be legally discharged to the storm drainage system. However, most of the water comes from other sources, including illicit and/or inappropriate entries to the storm drainage system. These entries can account for a significant amount of the pollutants discharged from storm sewerage systems (Pitt and McLean 1986).

Permits for municipal separate storm sewers include a requirement to effectively prohibit problematic non-stormwater discharges, thereby placing emphasis on the elimination of inappropriate connections to urban storm drains. Section 122.26 (d)(1)(iv)(D) of the rule specifically requires an initial screening program to provide means for detecting high levels of pollutants in dry weather flows which should serve as indicators of illicit connections to the storm sewers. To facilitate the application of this rule, the EPA's Office of Research and Development's Storm and Combined Sewer Pollution Control Program and the Environmental Engineering & Technology Demonstration Branch, along with the Office of Water's Nonpoint Source Branch, supported research for the investigation of inappropriate entries to storm drainage systems (Pitt, *et al.* 1993). The approach presented in this research was based on the identification and quantification of clean baseflow and the contaminated components during dry weather. If the relative amounts of potential components are known, then the importance of the dry weather discharge can be determined.

The ideal tracer to identify major flow sources should have the following characteristics:

- Significant difference in concentrations between possible pollutant sources;
- Small variations in concentrations within each likely pollutant source category;
- A conservative behavior (i.e., no significant concentration change due to physical, chemical or biological processes); and,
- Ease of measurement with adequate detection limits, good sensitivity and repeatability.

In order to identify tracers meeting the above criteria, literature characterizing potential inappropriate entries into storm drainage systems was examined. Several case studies which identified procedures used by individual municipalities or regional agencies were also examined.

Selection of Parameters for Identifying Inappropriate Discharge Sources. Table 1 is an assessment of the usefulness of candidate field survey parameters in identifying different potential non-stormwater flow sources. Natural and domestic waters should be uncontaminated (except in the presence of contaminated groundwaters entering the drainage system, for example). Sanitary sewage, septage, and industrial waters can produce toxic or pathogenic conditions. The other source flows (wash and rinse waters and irrigation return flows) may cause nuisance conditions, or degrade the ecosystem. The parameters marked with a plus sign can probably be used to identify the specific source flows by their presence. Negative signs indicate that the potential source flow probably does not contain the listed parameter in adverse or obvious amounts, and may help confirm the presence of the source by its absence. Parameters with both positive and negative signs for a specific source category would not likely be very helpful due to likely wide variations expected.

TABLE 1 Candidate Field Survey Parameters and Associated Non-Stormwater Flow Sources

Parameter	[illegible] Water	Potable Water	Sanitary Sewage	Septage Water	Indus Water	Wash Water	Rinse Water	Irrig Water
Fluoride	-	+	+	+	+/-	+	+	+
Hardness change	-	+/-	+	+	+/-	+	+	-
Surfactants	-	-	+	-	-	+	+	-
Florescence	-	-	+	+	-	+	+	-
Potassium	-	-	+	+	-	-	-	-
Ammonia	-	-	+	+	-	-	-	+/-
Odor	-	-	+	+	+	+/-	-	-
Color	-	-	-	-	+	-	-	-
Clarity	-	-	+	+	+	+	+/-	-
Floatables	-	-	+	-	+	+/-	+/-	-
Deposits and stains	-	-	+	-	+	+/-	+/-	-
Vegetation change	-	-	+	+	+	+/-	-	+
Structural damage	-	-	-	-	+	-	-	-
Conductivity	-	-	+	+	+	+/-	+	+
Temperature change	-	-	+/-	-	+	+/-	+/-	-
pH	-	-	-	-	+	-	-	-

Note: - implies relatively low concentration
\+ implies relatively high concentration
+/- implies variable conditions

Parameters Suitable for Indicators of Contamination by Sanitary Sewage
Tracer Characteristics of Local Source Flows. Table 2 is a summary of tracer parameter measurements for Birmingham, AL. This table is a summary of the "library" that describes the tracer conditions for each potential source category. The important information shown on this table includes the median and coefficient of variation (COV) values for each tracer parameter for each source category. Appropriate tracers are characterized by having significantly different concentrations in flow categories that need to be distinguished. In addition, effective tracers also need low COV values within each flow category. The study indicated that the COV values were quite low for each category, with the exception of chlorine, which had much greater COV values. Chlorine is therefore not recommended as a quantitative tracer to estimate the flow components. Similar data must be collected in each community where these procedures are to be used. Recommended field observations include color, odor, clarity, presence of floatables and deposits, and rate of flow, in addition to the selected chemical measurements.

Simple Data Evaluation Methods to Indicate Sources of Contamination
Negative Indicators Implying Contamination. Indicators of contamination (negative indicators) are clearly apparent visual or physical parameters indicating obvious problems and are readily observable at the outfall during the field screening activities. These observations are very important during the field survey because they are the simplest method of identifying grossly contaminated dry-weather outfall flows. The direct examination of outfall characteristics for unusual conditions of flow, odor, color, turbidity, floatables, deposits/stains, vegetation conditions, and damage to drainage structures is therefore an important part of these investigations. Table 3 presents a summary of these indicators, along with narratives of the descriptors to be selected in the field.

Correlation tests were conducted to identify relationships between outfalls that were known to have severe contamination problems and the negative indicators (Lalor 1994). Pearson correlation tests indicated that high turbidity and obvious odors appeared to be the most useful physical indicators of contamination when contamination was defined by toxicity and the presence of detergents. High turbidity was noted in 74% of the contaminated source flow samples. This represented a 26% false negative rate (indication of no contamination when contamination actually exists), if one relied on turbidity alone as an indicator of contamination. High turbidity was noted in only 5% of the uncontaminated source flow samples. This represents the rate of false positives (indication of contamination when none actually exists) when relying on turbidity alone. Noticeable odor was indicated in 67% of flow samples from contaminated sources, but in none of the flow samples from uncontaminated sources. This [illegible] identified include gasoline, oil, [illegible] industrial chemicals or [illegible] compounds [illegible]

False negatives are more of a concern than a reasonable number of false positives when working with a screening methodology. Screening methodologies are used to direct further, more detailed investigations. False positives would be discarded after further investigation. However, a false negative during a screening investigation results in the dismissal of a problem outfall for at least the near future. Missed contributors to stream contamination may result in unsatisfactory in-stream results following the application of costly corrective measures elsewhere.

The method of using physical characteristics to indicate contamination in outfall flows does not allow quantifiable estimates of the flow components and, if used alone, will likely result in many incorrect determinations, especially false negatives. These simple characteristics are most useful for identifying gross contamination, only the most significantly contaminated outfalls and drainage areas would therefore be recognized using this method.

Detergents as Indicators of Contamination. Results from the Mann-Whitney U tests (Lalor 1994) indicated that samples from any of the dry-weather flow sources could be correctly classified as clean or contaminated based only on the measured value of any one of the following parameters, detergents, color, or conductivity. Color and high conductivity were present in samples from clean sources as well as contaminated sources, but their levels of occurrence were significantly different between the two groups. If samples from only one source were expected to make up outfall flows, the level of color or conductivity could be used to distinguish contaminated outfalls from clean outfalls. However, since multi-source flows occur, measured levels of color or conductivity could fall within acceptable levels because of dilution, even though a contaminating source was contributing to the flow. Detergents, on the other hand, can be used to distinguish between clean and contaminated outfalls simply by their presence or absence, using a detection limit of 0.06 mg/L. All samples analyzed from contaminated sources contained detergents in excess of this amount (with the exception of three septage samples collected from homes discharging only toilet flushing water). No clean source samples were found to contain detergents. Contaminated sources would be detected in mixtures with uncontaminated waters if they made up at least 10% of the mixture.

Flow Chart for Most Significant Flow Component Identification. A further refinement is the flow chart shown on Figure 1. This flow chart describes an analysis strategy which may be used to identify the major component of dry-weather flow samples in residential and commercial areas. This method does not attempt to distinguish among all potential sources of dry-weather flows identified earlier, but rather the following four major groups of flow are identified: (1) tap waters (including domestic tap water, irrigation water and rinse water), (2) natural waters (spring water and shallow ground water), (3) sanitary wastewaters (sanitary sewage and septic tank discharge), and (4) wash waters (commercial laundry waters, commercial car wash waters, radiator flushing wastes, and plating bath wastewaters). The use of this method would not only allow outfall flows to be categorized as contaminated or uncontaminated, but would allow outfalls carrying sanitary wastewaters to be identified. These outfalls could then receive highest priority for further investigation leading to source control. This flow chart (Lalor 1994) was designed for use in residential and/or commercial areas only.

Table 2. Tracer Concentrations found in Birmingham, AL, Waters (mean, standard deviation, and coefficient of Variation, COV) (Pitt, *et al.* 1993 and Lalor 1994)

	Spring water	Treated potable water	Laundry wastewater	Sanitary wastewater	Septic tank effluent	Car wash water	Radiator flush water
Fluorescence	6.8	4.6	1020	250	430	1200	22,000
(% scale)	2.9	0.35	125	50	100	130	950
	0.43	0.08	0.12	0.20	0.23	0.11	0.04
Potassium	0.73	1.6	3.5	6.0	20	43	2800
(mg/L)	0.070	0.059	0.38	1.4	9.5	16	375
	0.10	0.04	0.11	0.23	0.47	0.37	0.13
Ammonia	0.009	0.028	0.82	10	90	0.24	0.03
(mg/L)	0.016	0.006	0.12	3.3	40	0.066	0.01
	1.7	0.23	0.14	0.34	0.44	0.28	0.3
Ammonia/Potassium	0.011	0.018	0.24	1.7	5.2	0.006	0.011
(ratio)	0.022	0.006	0.050	0.52	3.7	0.005	0.011
	2.0	0.35	0.21	0.31	0.71	0.86	1.0
Fluoride	0.031	0.97	33	0.77	0.99	12	150
(mg/L)	0.027	0.014	13	0.17	0.33	2.4	24
	0.87	0.02	0.38	0.23	0.33	0.20	0.16
Toxicity	<5	47	99.9	43	99.9	99.9	99.9
(% light decrease after 25	n/a	20	<1	26	<1	<1	<1
minutes, I_{25})	n/a	0.44	n/a	0.59	n/a	n/a	n/a
Surfactants	<0.5	<0.5	27	1.5	3.1	49	15
(mg/L as MBAS)	n/a	n/a	6.7	1.2	4.8	5.1	1.6
	n/a	n/a	0.25	0.82	1.5	0.11	0.11
Hardness	240	49	14	140	235	160	50
(mg/L)	7.8	1.4	8.0	15	150	9.2	1.5
	0.03	0.03	0.57	0.11	0.64	0.06	0.03
pH	7.0	6.9	9.1	7.1	6.8	6.7	7.0
(pH units)	0.05	0.29	0.35	0.13	0.34	0.22	0.39
	0.01	0.04	0.04	0.02	0.05	0.03	0.06
Color	<1	<1	47	38	59	220	3000
(color units)	n/a	n/a	12	21	25	78	44
	n/a	n/a	0.27	0.55	0.41	0.35	0.02
Chlorine	0.003	0.88	0.40	0.014	0.013	0.070	0.03
(mg/L)	0.005	0.60	0.10	0.020	0.013	0.080	0.016
	1.6	0.68	0.26	1.4	1.0	1.1	0.52
Specific conductivity	300	110	560	420	430	485	3300
(μS/cm)	12	1.1	120	55	311	29	700
	0.04	0.01	0.21	0.13	0.72	0.06	0.22
Number of samples	10	10	10	[illegible]	9	10	10

Table 3. Interpretations of Physical Observation Parameters and Likely Associated Flow Sources (Pitt, *et al.* 1993)

Odor - Most strong odors, especially gasoline, oils, and solvents, are likely associated with high responses on the toxicity screening test. Typical obvious odors include: gasoline, oil, sanitary wastewater, industrial chemicals, decomposing organic wastes, etc.

sewage: smell associated with stale sanitary wastewater, especially in pools near outfall.
sulfur ("rotten eggs"): industries that discharge sulfide compounds or organics (meat packers, canneries, dairies, etc.).
oil and gas: petroleum refineries or many facilities associated with vehicle maintenance or petroleum product storage.
rancid-sour: food preparation facilities (restaurants, hotels, etc.).

Color - Important indicator of inappropriate industrial sources. Industrial dry-weather discharges may be of any color, but dark colors, such as brown, gray, or black, are most common.

yellow: chemical plants, textile and tanning plants.
brown: meat packers, printing plants, metal works, stone and concrete, fertilizers, and petroleum refining facilities.
green: chemical plants, textile facilities.
red: meat packers.
gray: dairies, sewage.

Turbidity - Often affected by the degree of gross contamination. Dry-weather industrial flows with moderate turbidity can be cloudy, while highly turbid flows can be opaque. High turbidity is often a characteristic of undiluted dry-weather industrial discharges.

cloudy: sanitary wastewater, concrete or stone operations, fertilizer facilities, automotive dealers.
opaque: food processors, lumber mills, metal operations, pigment plants.

Floatable Matter - A contaminated flow may contain floating solids or liquids directly related to industrial or sanitary wastewater pollution. Floatables of industrial origin may include animal fats, spoiled food, oils, solvents, sawdust, foams, packing materials, or fuel.

oil sheen: petroleum refineries or storage facilities and vehicle service facilities.
sewage: sanitary wastewater.

Deposits and Stains - Refers to any type of coating near the outfall and are usually of a dark color. Deposits and stains often will contain fragments of floatable substances. These situations are illustrated by the grayish-black deposits that contain fragments of animal flesh and hair which often are produced by leather tanneries, or the white crystalline powder which commonly coats outfalls due to nitrogenous fertilizer wastes.

sediment: construction site erosion.
oily: petroleum refineries or storage facilities and vehicle service facilities.

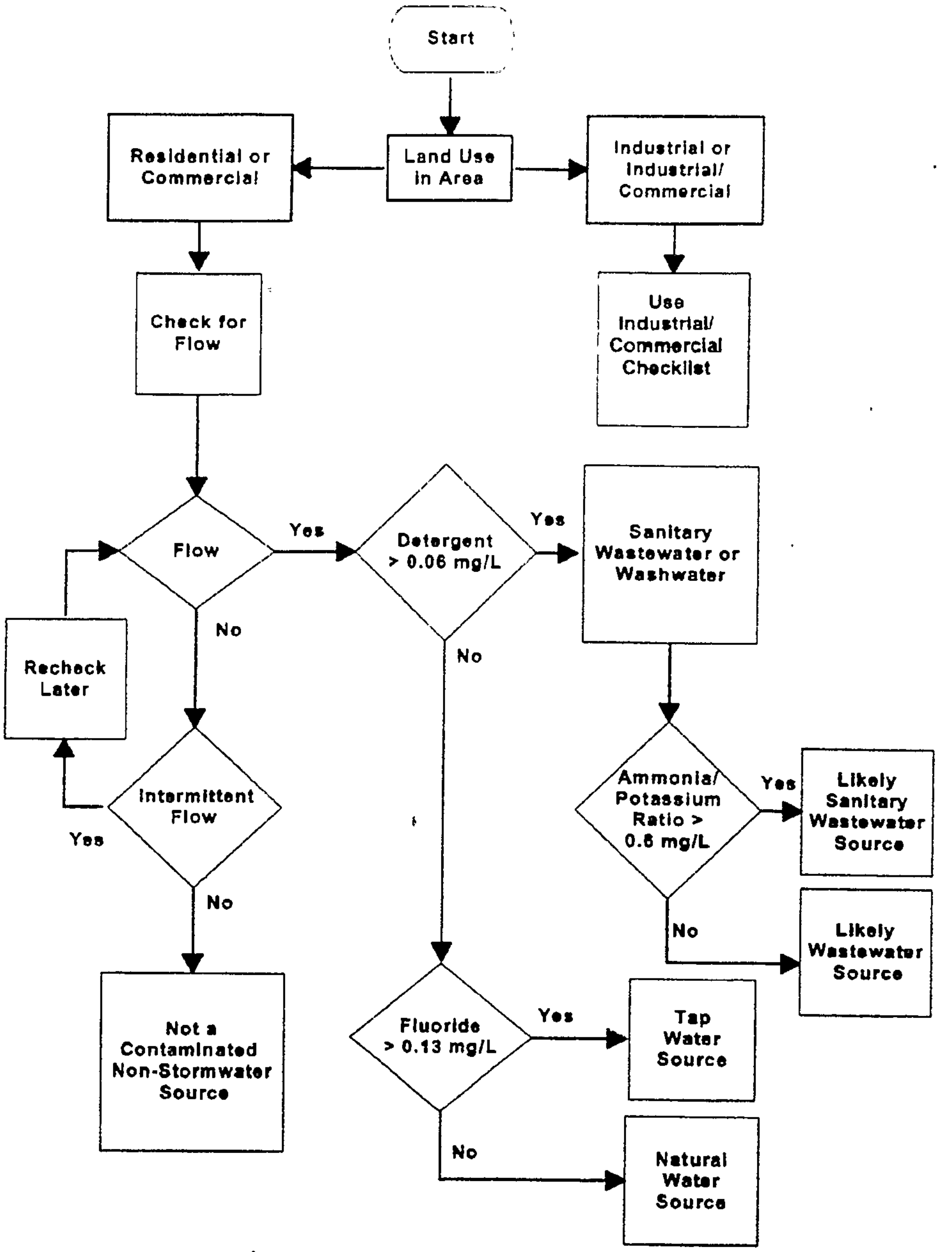
Vegetation - Vegetation surrounding an outfall may show the effects of industrial pollutants. Decaying organic materials coming from various food product wastes would cause an increase in plant life, while the discharge of chemical dyes and inorganic pigments from textile mills could noticeably decrease vegetation. It is important not to confuse the adverse effects of high stormwater flows on vegetation with highly toxic dry-weather intermittent flows.

excessive growth: food product facilities.
inhibited growth: high stormwater flows, beverage facilities, printing plants, metal product facilities, drug manufacturing, petroleum facilities, vehicle service facilities and automobile dealers.

Damage to Outfall Structures - Another readily visible indication of industrial contamination. Cracking, deterioration, and spalling of concrete or peeling of surface paint, occurring at an outfall are usually caused by severely contaminated discharges, usually of industrial origin. These contaminants are usually very acidic or basic in nature. Primary metal industries have a strong potential for causing outfall structural damage because their batch dumps are highly acidic. Poor construction, hydraulic scour, and old age may also adversely affect the condition of the outfall structure.

concrete cracking: industrial flows
concrete spalling: industrial flows
peeling paint: industrial flows
metal corrosion: industrial flows

Figure 1 Simple flow chart method to identify significant contaminating sources (Lalor 1994).



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In residential and or commercial areas, all outfalls should be located and examined. The first indicator is the presence or absence of dry-weather flow. If no dry-weather flow exists at an outfall, then indications of intermittent flows must be investigated. Specifically, stains, deposits, odors, unusual stream-side vegetation conditions, and damage to outfall structures can all indicate intermittent non-stormwater flows. However, frequent visits to outfalls over long time periods, or the use of other monitoring techniques, may be needed to confirm that only stormwater flows occur. If intermittent flow is not indicated, then the outfall probably does not have a contaminated non-stormwater source. The other points on the flow chart serve to indicate if a major contaminating source is present, or if the water is uncontaminated. Component contributions cannot be quantified using this method, and only the "most contaminated" type of source present will be identified.

If dry-weather flow exists at an outfall, then the flow should be sampled and tested for detergents. If detergents are not present, the flow is probably from a non-contaminated non-stormwater source. The lower limit of detection for detergent should be about 0.06 mg L.

If detergents are not present, fluoride levels can be used to distinguish between flows with treated water sources and flows with natural sources in communities where water supplies are fluoridated and natural fluoride levels are low. In the absence of detergents, high fluoride levels would indicate a potable water line leak, irrigation water, or wash rinse water. Low fluoride levels would indicate waters originating from springs or shallow groundwater. Based on the flow source samples tested in this research (Table 2), fluoride levels above 0.13 mg/L would most likely indicate that a tap water source was contributing to the dry-weather flow in the Birmingham, Alabama, study area.

If detergents are present, the flow is probably from a contaminated non-stormwater source, as indicated on Table 2. The ratio of ammonia to potassium can be used to indicate whether or not the source is sanitary wastewater. Ammonia/potassium ratios greater than 0.60 would indicate likely sanitary wastewater contamination. Ammonia/potassium ratios were above 0.9 for all septage and sewage samples collected in Birmingham (values ranged from 0.97 to 15.37, averaging 2.55). Ammonia/potassium ratios for all other samples containing detergents were below 0.7, ranging from 0.00 to 0.65, averaging 0.11. One radiator waste sample had an ammonia/potassium ratio of 0.65.

Non-contaminated samples collected in Birmingham had ammonia/potassium ratios ranging from 0.00 to 0.41, with a mean value of 0.06 and a median value of 0.03. Using the mean values for non-contaminated samples (0.06) and sanitary wastewaters (2.55), flows comprised of mixtures containing at least 25% sanitary wastes with the remainder of the flow from uncontaminated sources would likely be identified as sanitary wastewaters using this method. Flows containing smaller percent contributions from sanitary wastewaters might be identified as having a wash water source, but would not be identified as uncontaminated.

General Matrix Algebra Methods to Indicate Sources of Contamination Through Fingerprinting

Other approaches can also be used to calculate the source components of mixed outfall flows. One approach is the use of matrix algebra to simultaneously solve a series of chemical mass balance equations. This method can be used to predict the most likely flow source, or sources, making up an outfall sample. It is possible to estimate the outfall source flow components using a set of simultaneous equations. The number of unknowns should equal the number of equations available, resulting in a square matrix. If there are seven likely source categories, then there should be seven tracer parameters used. If there are only four possible sources, then only the four most efficient tracer parameters should be used. Only tracers that are linearly related to mixture components can be used. As an example, pH cannot be used in these equations, because it is not additive.

This method estimates flow contributions from various sources using a "receptor model", based on a set of chemical mass balance equations. Such models, which assess the contributions from various sources based on observations at sampling sites (the receptors), have been applied to the investigation of air pollutant sources for many years (Scheff and Wadden 1993; Cooper and Watson 1980). The characteristic "signatures" of the different types of sources, as identified in the library of source flow data, allows the development of a set of mass balance equations. These equations describe the measured concentrations in an outfall's flow as a linear combination of the contributions from the different potential so[illegible] requirement for this method is the physical and chemical characterization of waters collected directly from potential sources of dry-weather flows (the "library"). This allows concentration patterns (fingerprints) for the parameters of interest to be established for each type of source. Theoretically, if these patterns are different for each source, the observed concentrations at the outfall would be a linear combination of the concentration patterns from the different component sources, each weighted by a source strength term (m_n). This source strength term would indicate the fraction of outfall flow originating from each likely source. By measuring a number of parameters equal to, or greater than, the number of potential source types, the source strength term could be obtained by solving a set of chemical mass balance equations of the type:

$$C_p = \sum_n m_n x_{pn}$$

where C_p is the concentration of parameter p in the outfall flow and x_{pn} is the concentration of parameter p in source type n.

As an example of this method, consider 8 possible flow sources and 8 parameters, as presented in Table 4. The number of parameters evaluated for each outfall must equal the number of probable dry-weather flow sources in the drainage area. Mathematical methods are available which provide for the solution of over specified sets of equations (more equations than unknowns) but these are not addressed here.

The selection of parameters for measurement should reflect evaluated parameter usefulness. Evaluation of the Mann-Whitney U Test results (Lalor 1994) suggested the following groupings of parameters, ranked by their usefulness for distinguishing between all the types of flow sources sampled in Birmingham, AL:

- First set (most useful): potassium and hardness
- Second set: fluorescence, conductivity, fluoride, ammonia, detergents, and color
- Third set (least useful): chlorine

TABLE 4. Set of Chemical Mass Balance Equations

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	Outfall
Parameter 1:	(m1)(x11) +	(m2)(x12) +	(m3)(x13) +	(m4)(x14) +	(m5)(x15) +	(m6)(x16) +	(m7)(x17) +	(m8)(x18)	= C1
Parameter 2:	(m1)(x21) +	(m2)(x22) +	(m3)(x23) +	(m4)(x24) +	(m5)(x25) +	(m6)(x26) +	(m7)(x27) +	(m8)(x28)	= C2
Parameter 3:	(m1)(x31) +	(m2)(x32) +	(m3)(x33) +	(m4)(x34) +	(m5)(x35) +	(m6)(x36) +	(m7)(x37) +	(m8)(x38)	= C3
Parameter 4:	(m1)(x41) +	(m2)(x42) +	(m3)(x43) +	(m4)(x44) +	(m5)(x45) +	(m6)(x46) +	(m7)(x47) +	(m8)(x48)	= C4
Parameter 5:	(m1)(x51) +	(m2)(x52) +	(m3)(x53) +	(m4)(x54) +	(m5)(x55) +	(m6)(x56) +	(m7)(x57) +	(m8)(x58)	= C5
Parameter 6:	(m1)(x61) +	(m2)(x62) +	(m3)(x63) +	(m4)(x64) +	(m5)(x65) +	(m6)(x66) +	(m7)(x67) +	(m8)(x68)	= C6
Parameter 7	(m1)(x71) +	(m2)(x72) +	(m3)(x73) +	(m4)(x74) +	(m5)(x75) +	(m6)(x76) +	(m7)(x77) +	(m8)(x78)	= C7
Parameter 8	(m1)(x81) +	(m2)(x82) +	(m3)(x83) +	(m4)(x84) +	(m5)(x85) +	(m6)(x86) +	(m7)(x87) +	(m8)(x88)	= C8

Equations of the Form $C_p = \sum_n m_n x_{pn}$

where: C_p = the concentration of parameter p in the outfall flow

m_n = the fraction of flow from source type n

x_{pn} = the mean concentration of parameter p in source type n

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Emerging Tools for Identifying Sources of Discharges

Coprostanol and Other Fecal Sterol Compounds Utilized as Tracers of Contamination by Sanitary Sewage. A more likely indicator of human wastes than fecal coliforms and other "indicator" bacteria may be the use of certain molecular markers, specifically the fecal sterols such as coprostanol and epicoprostanol (Eaganhouse, *et al.* 1988). However, these compounds are also discharged by other carnivores in a drainage (especially dogs). A number of research projects have used these compounds to investigate the presence of sanitary sewage contamination. The most successful application may be associated with sediment analyses instead of water analyses. As an example, water analyses of coprostanol are difficult due to the typically very low concentrations found, although the concentrations in many sediments are quite high and much easier to quantify. Unfortunately, the long persistence of these compounds in the environment easily confuses recent contamination with historical or intermittent contamination.

Particulates and sediments collected from coastal areas in Spain and Cuba receiving municipal sewage loads were analyzed by Grimalt, *et al.* (1990) to determine the utility of coprostanol as a chemical marker of sewage contamination. Coprostanol can not by itself be attributed to fecal matter inputs. However, relative contributions of steroid components can be a useful indicator. When the relative concentrations of coprostanol and coprostanone are higher than their 5α epimers, or more realistically, other sterol components of background or natural occurrence, it can provide useful information.

Sediment cores from Santa Monica Basin, CA, and effluent from two local municipal wastewater discharges were analyzed by Venkatesan and Kaplan (1990) for coprostanol to determine the degree of sewage addition to sediment. Coprostanols were distributed throughout the basin sediments in association with fine particles. Some stations contained elevated levels, either due to their proximity to outfalls or because of preferential advection of fine-grained sediments. A noted decline of coprostanols relative to total sterols from outfalls seaward indicated dilution of sewage by biogenic sterols.

Other chemical compounds have been utilized for sewage tracer work. Saturated hydrocarbons with 16-18 carbons, and saturated hydrocarbons with 16-21 carbons, in addition to coprostanol, were chosen as markers for sewage in water, particulate, and sediment samples near the Cocoa, FL, domestic wastewater treatment plant (Holm, *et al.* 1990). The concentration of the markers was highest at points close to the outfall pipe and diminished with distance. However the concentration of C16-C21 compounds was high at a site 800 m from the outfall indicating that these compounds were unsuitable markers for locating areas exposed to the sewage plume. The concentrations for the other markers were very low at this station.

The range of concentrations of coprostanol found in sediments and mussels of Venice, Italy, were reported by Sherwin, *et al.* (1993). Raw sewage is still discharged directly into the Venice lagoon. Coprostanol concentrations were determined in sediment and mussel samples from the lagoon using gas chromatography/mass spectroscopy. Samples were collected in interior canals and compared to open-bay concentrations. Sediment concentrations ranged from 0.2-41.0 μg/g (dry weight). Interior canal sediment samples averaged 16 μg/g compared to 2 μg/g found in open bay sediment samples. Total coprostanol concentrations in mussels ranged from 80 to 620 ng/g (wet weight). No mussels were found in the four most polluted interior canal sites.

Nichols, *et al.* (1996) also examined coprostanol in stormwater and the sea-surface microlayer to distinguish human versus nonhuman sources of contamination. Other steroid compounds in sewage effluent were investigated by Routledge, *et al.* (1998) and Desbrow, *et al.* (1998) who both examined estrogenic chemicals. The most common found were 17β-Estradiol and estrone which were detected at concentrations in the tens of nanograms per liter range. These were identified as estrogenic through a toxicity identification and evaluation approach, where sequential separations and analyses identified the sample fractions causing estrogenic activity using a yeast-based estrogen screen. GC/MS was then used to identify the specific compounds.

Estimating Potential Sanitary Sewage Discharges into Storm Drainage and Receiving Waters using Detergent Tracer Compounds. As described above, detergent measurements (using methylene blue active substance, MBAS, test methods) were the most successful individual tracer to indicate contaminated water in storm sewerage dry-weather flows. Unfortunately, the MBAS method uses hazardous chloroform for an extraction step. Different detergent components, especially linear alkylbenzene sulphonates (LAS) and linear alkylbenzenes (LAB), have also been tried to indicate sewage dispersal patterns in receiving waters. Boron, a major historical ingredient of laundry chemicals, can also potentially be used. Boron has the great advantage of being relatively easy to analyze using portable field test kits, while LAS requires chromatographic equipment. LAS can be measured using HPLC with fluorescent detection, after solid phase extraction, to very low levels. Fujita, *et al.* (1998) developed an efficient enzyme-linked immunosorbent assay (ELISA) for detecting LAS at levels from 20 to 500 µg/L.

LAS from synthetic surfactants (Terzic and Ahel 1993) which degrade rapidly, as well as nonionic detergents (Terzic and Ahel 1993) which do not degrade rapidly, have been utilized as sanitary sewage markers. LAS was quickly dispersed from wastewater outfalls except in areas where wind was calm. In these areas LAS concentrations increased in freshwater but were unaffected in saline water. After time, the lower alkyl groups were mostly found, possibly as a result of degradation or settling of longer alkyl chain compounds with sediments. Chung, *et al.* (1995) also describe the distribution and fate of LAS in an urban stream in Korea. They examined different LAS compounds having carbon ratios of C12 and C13 compared to C10 and C11, plus ratios of phosphates to MBAS and the internal to external isomer ratio (I/E) as part of their research. Gonález-Mazo, *et al.* (1998) examined LAS in the Bay of Cádiz off the southwest of Spain. They found that LAS degrades rapidly (Fujita, *et al.*, 1998, found that complete biodegradation of LAS requires several days), and is also strongly sorbed to particulates. In areas close to shore and near the untreated wastewater discharges, there as significant vertical stratification of LAS: the top 3 to 5 mm of water had LAS concentrations about 100 times greater than found at 0.5 m.

Zeng and Vista (1997) and Zeng, *et al.* (1997) describe a study off of San Diego where LAB was measured, along with polycyclic aromatic hydrocarbons (PAHs) and aliphatic hydrocarbons (AHs) to indicate the relative pollutant contributions of wastewater from sanitary sewage, nonpoint sources, and hydrocarbon combustion sources. They developed and tested several indicator ratios (alkyl homologue distributions and parent compound distributions) and examined the ratio of various PAHs (such as phenanthrene to anthracene, methylphenanthrene to phenanthrene, fluoranthene to pyrene, and benzo(a)anthracene to chrysene) as tools for distinguishing these sources. They concluded that LABs are useful tracers of domestic waste inputs to the environment due to their limited sources. They also describe the use of the internal to external isomer ratio (I/E) to indicate the amount of biodegradation that may have occurred to the LABs. They observed concentrations of total LABs in sewage effluent of about 3 µg/L, although previous researchers have seen concentrations of about 150 µg/L in sewage effluent from the same area.

The fluorescent properties of detergents have also been used as a tracer by investigating the fluorescent whitening agents (FWAs), as described by Poiger, *et al.* (1996) and Kramer, *et al.* (1996). HPLC with fluorescence detection was used in these studies to quantify very low concentrations of FWAs. The two most frequently used FWAs in household detergents (DSBP and DAS 1) were found at 7 to 21 µg/L in primary sewage effluent and at 3 to 9 µg/L in secondary effluent. Raw sewage contains about 10 to 20 µg/L FWAs. The removal mechanisms in sewage treatment processes is by adsorption to activated sludge. The type of FWAs varies from laundry applications to textile finishing and paper production, making it possible to identify sewage sources. The FWAs were found in river water at 0.04 to 0.6 µg/L. The FWAs are not easily biodegradable but they are readily photodegraded. Photodegradation rates have been reported to be about 7% for DSBP and 71% for DAS 1 in river water exposed to natural sunlight, after one hour exposure. Subsequent photodegradation is quite slow.

Other Compounds Found in Sanitary Sewage that may be used for Identifying Contamination by Sewage. Halling-Sørensen, *et al.* (1998) detected numerous pharmaceutical substances in sewage effluents and in receiving waters. Their work addressed human health concerns of these low level compounds that can enter downstream drinking water supplies. However, the information can also be possibly used to help identify sewage contamination. Most of the research has focused on clofibric acid, a chemical used in cholesterol lowering drugs. It has been found in concentrations ranging from 10 to 165 ng/L in Berlin drinking water sampler. Other drugs commonly found include aspirin, caffeine, and ibuprofen. Current FDA guidance mandates that the maximum concentration of a substance or its active metabolites at the point of entry into the aquatic environment be less than 1 µg/L (Hun 1998).

Caffeine has been used as an indicator of sewage contamination by several investigators (Shuman and Strand 1996). The King County, WA, Water Quality Assessment Project is examining the impacts of CSOs on the Duwamish

River and Elliott Bay. [illegible] caffeine (representing dissolved CSO constituents) and coprostanol (representing particulate-bound CSO constituents) in connection with heavy metals and conventional analyses, to help determine the contribution of CSOs to the river. The caffeine is unique to sewage, while coprostanol is from both humans and carnivorous animals and is therefore also in stormwater. They sampled upstream of all CSOs, but with some stormwater influences, 100 m upstream of the primary CSO discharge (but downstream of other CSOs), within the primary CSO discharge line, and 100 m downriver of the CSO discharge location. The relationship between caffeine and coprostanol was fairly consistent for the four sites (coprostanol was about 0.5 to 1.5 μg/L higher than caffeine). Similar patterns were found between the three metals, chromium was always the lowest and zinc was the highest. King Co. is also using clean transported mussels placed in the Duwamish River to measure the bioconcentration potential of metal and organic toxicants and the effects of the CSOs on mussel growth rates (after 6 week exposure periods). Paired reference locations are available near the areas of deployment, but outside the areas of immediate CSO influence. *US Water News* (1998) also described a study in Boston Harbor that found caffeine at levels of about 7 μg/L in the harbor water. The caffeine content of regular coffee is about 700 mg/L, in contrast.

DNA Profiling to Measure Impacts on Receiving Water Organisms and to Identify Sources of Microorganisms in Stormwater. This rapidly emerging technique seems to have great promise in addressing a number of nonpoint source water pollution issues. Kratch (1997) summarized several investigations on cataloging the DNA of *E. coli* to identify their source in water. This rapidly emerging technique seems to have great promise in addressing a number of nonpoint source water pollution issues. The procedure, developed at the Virginia Polytechnic Institute and State University, has been used in Chesapeake Bay. In one example, it was possible to identify a large wild animal population as the source of fecal coliform contamination of a shellfish bed, instead of suspected failing septic tanks. DNA patterns in fecal coliforms vary among animals and birds, and it is relatively easy to distinguish between human and non-human sources of the bacteria. However, some wild animals have DNA patterns that are not easily distinguishable. Some researchers question the value of *E. coli* DNA fingerprinting believing that there is little direct relationship between *E. coli* and human pathogens. However, this method should be useful to identify the presence of sewage contamination in stormwater or in a receiving water.

One application of the technique, as described by Krane, *et al.* (1999) of Wright State University, used randomly amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) generated profiles of naturally occurring crayfish. They found that changes in the underlying genetic diversity of these populations were significantly correlated with the extent to which they have been exposed to anthropogenic stressors. They concluded that this rapid and relatively simple technique can be used to develop a sensitive means of directly assessing the impact of stressors upon ecosystems. These Wright State University researchers have also used the RAPD-PCR techniques on populations of snails, pill bugs, violets, spiders, earthworms, herring, and some benthic macroinvertebrates, finding relatively few obstacles in its use for different organisms. As noted above, other researchers have used DNA profiling techniques to identify sources of *E. coli* bacteria found in coastal waterways. It is possible that these techniques can be expanded to enable rapid detection of many different types of pathogens in receiving waters, and the most likely sources of these pathogens.

Stable Isotope Methods for Identifying Sources of Water. Stable isotopes had been recommended as an efficient method to identify illicit connections to storm sewerage. A demonstration was conducted in Detroit as part of the Rouge River project to identify sources of dry weather flows in storm sewerage (Sangal, *et al.* 1996). Naturally occurring stable isotopes of oxygen and hydrogen can be used to identify waters originating from different geographical sources (especially along a north-south gradient). Ma and Spalding (1996) discuss this approach by using stable isotopes to investigate recharge of groundwaters by surface waters. During water vapor transport from equatorial source regions to higher latitudes, depletion of heavy isotopes occurs with rain. Deviation from a standard relationship between deuterium and ^{18}O for a specific area indicates that the water has undergone additional evaporation. The ratio is also affected by seasonal changes. As discussed by Ma and Spalding (1996), the Platte River water is normally derived in part from snowmelt from the Rocky Mountains, while the groundwater in parts of Nebraska is mainly contributed from the Gulf air stream. The origins of these waters are sufficiently different and allow good measurements of the recharge rate of the surface water to the groundwater. In Detroit, Sangal, *et al.* (1996) used differences in origin between the domestic water supply, local surface waters, and the local groundwater to identify potential sanitary sewage contributions to the separate storm sewerage. Rieley, *et al.* (1997) used stable isotopes of carbon in mar[illegible] to distinguish the primary source of carbon being consumed (sewage sludge vs. natural carbon sources) in two deep sea sewage sludge disposal areas.

Stable isotope analyses would not be able to distinguish between sanitary sewage, industrial discharges, washwaters, and domestic water, as they all have the same origin, nor would it be possible to distinguish sewage from local groundwaters if the domestic water supply was from the same local aquifer. This method works best for situations where the water supply is from a distant source and where separation of waters into separate flow components is not needed. It may be an excellent tool to study the effects of deep well injection of stormwater on deep aquifers having distant recharge sources (such as in the Phoenix area). Few laboratories can analyze for these stable isotopes, requiring shipping and a long wait for the analytical results. Sangal, *et al.* (1995) used Geochron Laboratories, in Cambridge, Massachusetts.

Dating of sediments using ^{137}Cs was described by Ma and Spalding (1996). Arsenic contaminated sediments in the Hylebos Waterway in Tacoma, WA, could have originated from numerous sources, including a pesticide manufacturing facility, a rock-wool plant, steel slags, powdered metal plant, shipbuilding facilities, marinas and arsenic boat paints, and the Tacoma Smelter. Dating the sediments, combined with knowing the history of potential discharges and conducting optical and electron microscopic studies of the sediments, was found to be a powerful tool to differentiate between the different metal sources to the sediments.

Conclusions

In almost all cases, a suite of analyses is most suitable for effective identification of inappropriate discharges. A recent example was reported by Standley, *et al.* (2000), where fecal steroids (including coprostanol), caffeine, consumer product fragrance materials, and petroleum and combustion byproducts were used to identify wastewater treatment plant effluent, agricultural and feedlot runoff, urban runoff, and wildlife sources. They studied numerous individual sources of these wastes from throughout the US. A research grade mass sperctrophotometer was used for the majority of the analyses in order to achieve the needed sensitivities, although much variability was found when using the methods in actual receiving waters affected by wastewater effluent. This sophisticated suite of analyses did yield much useful information, but the analyses are difficult to conduct and costly and may be suitable for special situations, but not for routine survey work.

Another recent series of tests examined several of these potential emerging tracer parameters, in conjunction with the previously identified parameters, during a project characterizing stormwater that had collected in telecommunication manholes, funded by Tecordia (previously Bellcore), AT&T, and eight regional telephone companies throughout the country (Pitt and Clark 1999). Numerous conventional constituents, plus major ions, and toxicants were measured, along with candidate tracers to indicate sewage contamination of this water. Boron, caffeine, coprostanol, *E. coli*, enterococci, fluorescence (using specific wavelengths for detergents), and a simpler test for detergents were evaluated, along with the use of fluoride, ammonia, potassium, and obvious odors and color. About 700 water samples were evaluated for all of these parameters, with the exception of bacteria and boron (about 250 samples), and only infrequent samples were analyzed for fluorescence. Coprostanol was found in about 25 percent of the water samples (and in about 75% of the 350 sediment samples analyzed). Caffeine was only found in very few samples, while elevated *E. coli* and enterococci (using IDEXX tests) were observed in about 10% of the samples. Strong sewage odors in water and sediment samples were also detected in about 10% of the samples. Detergents and fluoride (at >0.3 mg/L) were found in about 40% of the samples and are expected to have been contaminated with industrial activities (lubricants and cleansers) and not sewerage. Overall, about 10% of the samples were therefore expected to have been contaminated with sanitary sewage, about the same rate previously estimated for stormwater systems.

Additional related laboratory tests, funded by the University of New Orleans and the EPA (Barbe', *et al.* 2000), were conducted using many sewage and laundry detergent samples and found that the boron test was a poor indicator of sewage, possibly due to changes in formulations in modern laundry detergents. Laboratory tests did find that fluorescence was an excellent indicator of sewage, especially when using specialized "detergent whitener" filter sets, but was not very repeatable. We also examined several UV absorbance wavelengths as sewage indicators and found excellent correlations with 228 nm, a wavelength having very little background absorbance in local spring waters, but with a strong response factor with increasing strengths of sewage.

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Table 5 summarizes the different measurement parameters discussed above. We recommend that our originally developed and tested protocol, as reported by Pitt *et al.* (1993), still be used as the most efficient routine indicator of sewage contamination of stormwater drainage systems, with the possible addition of specific *E. coli* and enterococci measurements and UV absorbance at 228 nm. The numerous exotic tests requiring specialized instrumentation and expertise do not appear to warrant their expense and long analytical turn-around times, except in specialized research situations, or when special confirmation is economically justified (such as when examining sewer replacement or major repair options).

Table 5. Comparison of Measurement Parameters used for Identifying Inappropriate Discharges into Storm Drainage

Parameter Group	Comments	Recommendation
Fecal coliform bacteria and/or use of fecal coliform to fecal strep. ratio	Commonly used to indicate presence of sanitary sewage.	Not very useful as many other sources of fecal coliforms are present, and ratio not accurate for old or mixed wastes.
Physical observations (odor, color, turbidity, floatables, deposits, stains, vegetation changes, damage to outfalls)	Commonly used to indicate presence of sanitary and industrial wastewater.	Recommended due to easy public understanding and easy to evaluate, but only indicative of gross contamination, with excessive false negatives (and some false positives). Use in conjunction with chemical tracers for greater sensitivity and accuracy.
Detergents presence (anionic surfactant extractions)	Used to indicate presence of wash waters and sanitary sewage.	Recommended, but care needed during hazardous analyses (only for well-trained personnel). Accurate indicator of contamination during field tests.
Fluoride, ammonia and potassium measurements	Used to identify and distinguish between wash waters and sanitary sewage.	Recommended, especially in conjunction with detergent analyses. Accurate indicator of major contamination sources and their relative contributions.
TV surveys and source investigations	Used to identify specific locations of inappropriate discharges, especially in industrial areas.	Recommended after outfall surveys indicate contamination in drainage system.
Coprostanol and other fecal sterol compounds	Used to indicate presence of sanitary sewage.	Possibly useful. Expensive analysis with GC/MSD. Not specific to human wastes or recent contamination. Most useful when analyzing particulate fractions of wastewaters or sediments.
Specific detergent compounds (LAS, fabric whiteners, and perfumes)	Used to indicate presence of sanitary sewage.	Possibly useful. Expensive analyses with HPLC. A good and sensitive confirmatory method.
Fluorescence	Used to indicate presence of sanitary sewage and wash waters.	Likely useful, but expensive instrumentation. Rapid and easy analysis. Very sensitive.
Boron	Used to indicate presence of sanitary sewage and wash waters.	Not very useful. Easy and inexpensive analysis, but recent laundry formulations in US have minimal boron components.
Pharmaceuticals (colfibric acid, aspirin, ibuprofen, steroids, illegal drugs, etc.)	Used to indicate presence of sanitary sewage.	Possibly useful. Expensive analyses with HPLC. A good and sensitive confirmatory method.
Caffeine	Used to indicate presence of sanitary sewage.	Not very useful. Expensive analyses with GC/MSD. Numerous false negatives, as typical analytical methods not suitably sensitive.
DNA profiling of microorganisms	Used to identify sources of microorganisms	Likely useful, but currently requires extensive background information on likely sources in drainage. Could be very useful if method can be simplified, but with less specific results.
UV absorbance at 228 nm	Used to identify presence of sanitary sewage.	Possibly useful, if UV spectrophotometer available. Simple and direct analyses. Sensitive to varying levels of sanitary sewage, but may not be useful with dilute solutions. Further testing needed to investigate sensitivity in field trials.
Stable isotopes of oxygen	Used to identify major sources of water.	May be useful in area having distant domestic water sources and distant groundwater recharge areas. Expensive and time consuming procedure. Can not distinguish between wastewaters if all have common source.
E. coli and enterococci bacteria	More specific indicators of sanitary sewage than coliform tests.	Recommended in conjunction with chemical tests. Relatively inexpensive and easy analyses, especially if using the simple IDEXX methods.

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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

Compliance Assessment of the Auto Dismantling Industry:

Evaluation of the California General Industrial Storm Water Permit

March 2001

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INTRODUCTION

Urban storm water is considered as one of the largest sources of pollution to the coastal waters of the United States. Storm drains convey runoff from streets, urban centers, industrial sites, and open spaces into streams, creeks, rivers, beaches, and the ocean. Industrial operations represent one contributor to storm water pollution, but they are known to be a major source of heavy metals, oily waste, and other substances. Many industrial operations involve manufacturing, storage, and shipping activities which, when conducted outside and are exposed to storm water, can be sources of pollutants in storm water.

Federal regulations issued pursuant to the 1987 amendments to the Clean Water Act mandate the regulation of point source discharges of storm water from industry and from municipal separate storm sewer systems serving 100,000 or more people. California, one of 44 states with delegated authority from the United States Environmental Protection Agency (EPA), implements its own storm water program. The State Water Resources Control Board (State Board) and the nine Regional Water Quality Control Boards (RWQCBs) are the state agencies charged with the primary responsibility for overseeing the implementation of storm water regulations in California. In 1991, State Board issued the Industrial Activities Storm Water General Permit (General Permit No. CAS000001; hereafter, GISP), subsequently reissued in 1997, to control pollutants associated with storm water runoff from industrial sources (GISP 1997). As of August 2000, approximately 9,200 industrial facilities in California were covered under the GISP, with nearly one-third of the facilities located in the Los Angeles region.

The overall goal of this study was to assess the effectiveness of the GISP program for one industrial sector, as implemented in the Los Angeles region, in reducing water quality impacts due to storm water pollution. This executive summary is divided into five sections: introduction, background, methodology, key findings, and conclusions. The background provides a general description of the objectives of the study. The methodology summarizes the approaches used in the study to fulfill the objectives. The key findings present highlights on important results. And the conclusions provide synthesis and recommendations based on the key findings.

BACKGROUND

The Los Angeles Regional Water Quality Control Board (the Los Angeles RWQCB) initiated this compliance assessment project in 1998, recognizing the need to adequately characterize the effectiveness of its industrial storm water program, as implemented at the facility level. The specific objectives of this study were: 1) to evaluate the state of compliance of one industrial sector, the auto dismantling industry, with the GISP requirements and associated water quality implications; 2) to identify limitations of the GISP program in effectively controlling pollutants in storm water runoff; and 3) to provide specific recommendations and regulatory alternatives to help guide management actions to improve water quality. This study is one of the few *comprehensive* assessments investigating the state of compliance of a particular industrial sector with storm water regulatory requirements.

This study chose to focus on the auto dismantling industry because the typical operational and material handling practices conducted by the facilities of this industry represent a potential significant source of conventional and toxic pollutants, including heavy metals and certain hydrocarbons, in storm water. Also, the industry represents a significant portion (about 15 percent) of the facilities covered in the Los Angeles RWQCB's GISP program.

For the purpose of evaluating compliance, this study categorized the GISP requirements into the following three tiers:

Initiation (Tier 1)
Facilities subject to coverage under the GISP, based on their standard industrial classification (SIC) codes or other specific conditions stated in the GISP, must file a Notice of Intent (NOI) with the State Board. (The auto dismantling industry with SIC code of 5015 has been mandated for coverage);

Documentation/Reporting (Tier 2)
Facilities must report their self-monitoring activities and results by submitting an Annual Monitoring Report by July 1st of each year. In addition, facilities must prepare an appropriate storm water document, known as Storm Water Pollution Prevention Plan (SWPPP), along with a written monitoring program to help guide their efforts in implementing appropriate storm water control measures and monitoring the quality of storm water runoff from their facilities.

On-site Implementation (Tier 3)
Facilities must implement appropriate storm water control measures known as Best Management Practices (BMPs) described in their SWPPPs and perform the required monitoring activities.

METHODOLOGY

The methods used to conduct this assessment include database analysis, in-depth document review, and onsite case study investigations.

Non-filer Identification
Auto dismantling facilities in Los Angeles County that have failed to apply for coverage under the GISP program by filing a NOI, also known as "non-filer", were characterized using the following sources of information: 1) a list obtained from the California Department of Motor Vehicles, Occupational Licensing Division (DMV) of auto dismantling facilities in Los Angeles County that maintain a current dismantling license issued from the DMV, and 2) results from the door-to-door site visits conducted

by the City of Los Angeles inspectors from January 1999 to May 2000, specifically aimed at identifying non-filers in parts of Los Angeles city. Facility names and addresses were screened using the Los Angeles RWQCB's NOI database to verify their status of coverage under the GISP.

Document review

A detailed review of SWPPPs and written Monitoring Programs was completed for a study pool of 52 auto dismantling facilities. The purpose of the review was to assess the effectiveness of these storm water documents in guiding facility operators into compliance. The 52 facilities were selected randomly from the NOI database using a systematic, replicable process and are considered to be representative of the industry.

Case study investigations

Site inspections and storm water sampling were performed on the nine selected auto dismantling facilities located in San Gabriel River and Los Angeles River watersheds. The nine facilities were selected out of the study pool of 52 facilities, based on their proximity to the San Gabriel River watershed, the Los Angeles RWQCB's priority watershed for the 1999/00 fiscal year.

The purpose of these site-specific investigations was to take a hard look at the onsite component of compliance that may not be readily observable from document review alone. Storm water analytical data were used to evaluate the quality of storm water runoff generated, impact of the BMPs implemented on water quality, and a simple load calculation for the industry. The EPA Simple Method was used to estimate load.

KEY FINDINGS

The following highlights the important findings of this study:

Initiation (Tier 1)

Non-filer Identification

The problem of non-filers among auto dismantling facilities is significant. An assessment based on the DMV list revealed that one out of every five facilities with a valid DMV license was operating as a non-filer. The site visit results indicated a more serious degree of non-compliance for certain parts of Los Angeles city, with more than one-third (37%) of the auto dismantling establishments visited operating without a NOI.

A possible explanation for such a high ratio of non-filers observed from the site visit results- almost twice as that predicted by the DMV analysis- is that some areas of Los Angeles County, including the locations targeted by the City inspectors, potentially have a disproportionately high percentage of non-filers. Also, site visits can account for non-filers that may be operating without a valid dismantling license, thus not included in the DMV database. The actual number of non-filers in Los Angeles County could be somewhat or considerably higher than that predicted by the DMV/NOI analysis (perhaps somewhere between 19% and 37%), considering an unknown number of delinquent facilities operating with neither a dismantling license nor a NOI.

Documentation/Reporting (Tier 2)

Annual (Monitoring) Reports

Since the 1995/96 permit year, the proportion of the 52 selected facilities submitting Annual Reports has been steadily rising, with a peak submittal rate of 96% observed for the two most recent years considered by this study- 1997/98 and 1998/99. This is a significant increase in compliance, considering that less than half complied with the annual reporting requirement in some of the earlier years. Accelerated efforts expended by the Los Angeles RWQCB in outreach and enforcement activities, fueled by legislation such as Assembly Bill 2019 that mandates timely enforcement actions against violators of the GISP requirements, appear to have significantly contributed to an increased compliance.

SWPPPs/Written Monitoring Program

Initially when the Los Angeles RWQCB issued letters requesting for SWPPPs, nearly a quarter of the facility operators responded with phone calls, displaying little or no knowledge of the SWPPP requirement. Following the initial responses, most facilities (50 out of the 52 requested) did submit their SWPPPs and their written monitoring programs to the RWQCB (Formal enforcement actions were taken against the two delinquent facilities for their failure to submit the requested SWPPPs and past Annual Reports.)

This study found nearly all of the SWPPPs to be deficient in more than one area. The majority were boiler-plate documents prepared by consultants that lacked sufficient site-specific and/or procedural details crucial for proper implementation of BMPs. Many SWPPPs provided sets of "ideal" or "proposed" BMPs but were vague about specifying the measures that were chosen for implementation by the facility operator. BMPs considered universally applicable and important for pollution prevention, such as employee training, site inspection, and good housekeeping programs, were missing from a considerable number of the SWPPPs reviewed.

The majority of the written monitoring programs were prepared by consultants and contained many of the deficiencies found in the SWPPPs. Most documents failed to provide sufficient procedural details necessary to ensure proper quality assurance and quality control (QA/QC), especially regarding sample collection, storage, handling, and transport procedures.

On-site Implementation

BMPs

Staff inspections of the nine case study facilities revealed that the facilities were not fully implementing the BMPs outlined in their SWPPPs, especially measures that are more cost- and/or effort– intensive. Judging from the extent of spills and leaks observed on facility ground, it was evident that the existing BMPs, at the level implemented at most of the facilities, were not adequately controlling the pollutant sources present onsite. Some BMPs such as providing an overhead coverage for dismantling areas or storing motor parts in an enclosed area were limited in their effectiveness because dismantling and storing activities were commonly conducted outside of the designated areas due to inadequate workspace or other physical constraints. One facility eliminated the exposure of vehicle parts to storm water by storing them in large autobodies. An example of an innovative, cost-effective BMP that was implemented unsuccessfully at many of the selected facilities was using truckbeds to store vehicle parts. The facilities that used truckbeds for parts storage had failed to seal the cracks in the truckbeds to prevent potential leaks.

One factor that could potentially obscure a facility operator's assessment of compliance is the lack of a clear standard of compliance in the permit; GISP specifies neither a specific set of required BMPs nor a quantifiable performance or pollutant level to be achieved. (Many of the RWQCBs' staff members use and encourage the permittees to use a set of parameter benchmark values from the USEPA's "Final National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities" (most recently reissued in 2000) for the purpose of gauging potential harm or impact on water quality. However, these benchmarks are not specified in the GISP and are typically not used for gauging compliance or for enforcement purposes.)

Facility Self-monitoring

Review of the Annual Reports submitted by 50 of the 52 selected facilities indicated that the degree of compliance with the monitoring requirements did not match the success observed with submitting the monitoring reports. Based on our review of the 1997/98 Annual Reports, less than 20% of those required successfully completed the sampling & analysis requirement. Not all facilities that collected samples analyzed for the required toxic constituents (lead, zinc, and copper). Less than half conducted the monthly visual observation of storm water runoff. Despite the deficiencies in their monitoring activities, many facility operators still self-certified their Annual Reports for compliance.

Water Quality Impacts

Storm Water Sampling and Analysis

There was a wide range in the concentrations of pollutants in storm water samples obtained from the eight (out of the nine) case study facilities. The majority of the storm water analytical data exceeded the USEPA benchmark levels, in particular, for metals and oil & grease. The general trend identified in this study is that facilities that diligently implemented BMPs, especially good housekeeping practices, and had an overall neat and organized site appearance generally had lower pollutant concentrations in their storm water samples, as expected.

Load

A simple load calculation for 1998/99 suggested the following range for pollutant loads in storm water runoff from the auto dismantling industry in Los Angeles County: 30,570 lbs. of total suspended solids, 7,460 lbs. of oil & grease, 40 lbs. of copper, 30 lbs. of lead, and 130 lbs. of zinc.

CONCLUSIONS/RECOMMENDATIONS

- There is still a substantial number of auto dismantling facilities that need to be identified and permitted under the GISP program. A combined approach using currently available databases supplemented by site visits appears to be an effective method for capturing non-filers. The existing agreement between DMV and the State Board offers a good example of interagency cooperation that helps to elucidate the non-filer identification process-- a model that could be applied to other industrial sectors, including but not limited to the transportation and recycling industries. At this time, additional information is needed to evaluate if the quality of storm water from the non-filers is significantly different, on average, from the permitted facilities.

- In general, the level of understanding among the auto dismantling facility operators of the intent and the significance of the GISP program and its requirements appeared to be low when this study was conducted.

- Compliance among many auto dismantling facilities was achieved mostly on paper, primarily reflected in the quantity of the required documents or reports submitted to the agency and perhaps less in terms of the quality. Site inspections revealed that the degree of field compliance achieved through proper implementation of appropriate BMPs is low and trails behind paper compliance.

- In light of the fact that it is only the field implementation component that substantively contributes to pollution reduction and given the high levels of oil & grease and metals found in storm water runoff from auto dismantling facilities, it may be concluded that the GISP program, as currently implemented by many auto dismantling facilities, does not appear effective in controlling storm water pollution.

- Despite an increase in compliance with the annual reporting requirement, incomplete monitoring results, especially the analytical data, limit the usefulness of the Annual Reports in developing a comprehensive data inventory needed to: fully assess the quality of runoff from regulated facilities; measure progress in pollution prevention efforts over the years; assess water quality impacts from industrial storm water runoff based on load estimates; and develop water quality standards, including total daily maximum loads (TMDLs). To improve both the compliance with monitoring requirements and the quality of the Annual Reports being submitted, the RWQCB must step up its efforts to provide timely responses, for compliance assistance and enforcement purposes, when deficiencies are noted.

- Many of the storm water documents - SWPPPs and written monitoring programs- failed to serve as useful guides for facility operators in the selection and implementation of appropriate BMPs and in monitoring activities due to the absence of sufficient procedural and site-specific details. A time-efficient solution recommended by this study is to target those the consultants (who work closely with the industry as a group monitoring leader or prepare storm water documents on behalf of the facilities) for regular training, education, and certification to ensure that SWPPPs and written monitoring programs prepared by third parties are up to par with the GISP requirements.

- One factor that potentially obscures the efforts of facility operators and regulators in assessing compliance is the lack of explicit, quantifiable standards that facilities must attain in order to demonstrate compliance with the GSIP requirements and with applicable water quality standards. Determination of compliance should not be left up to the subjective interpretation of uninformed permittees or regulators. Thus, the GISP program needs a more clear-cut standard of compliance based on a combination of a minimum set of specific BMPs and/or numerical effluent limitations. The following tiered approach is recommended for the auto dismantling industry: 1) a mandatory set of specific, baseline structural (excluding treatment) and non-structural BMPs for facilities with annual vehicle throughput less than 500 (which includes mom-and-pop and medium-sized facilities); and 2) mandatory treatment of storm water for facilities with annual vehicle throughput greater than 500. (Note: The annual volume of vehicles processed at many of the mom-and-pop facilities, which make up over three-quarters of the industry in the Los Angeles Region, is less than 300 vehicles. The threshold of 500 vehicles was chosen to include typical mom-and-pop and medium-sized facilities in the Region). Also, in lieu of requiring treatment, numerical effluent limitations could be applied to the latter group as a standard of compliance. A compliance schedule could help phase facilities into compliance over a certain specified timeframe. Facilities with less than 500 annual vehicle throughput that persistently demonstrate problems with meeting a certain water quality standard, e.g. the USEPA benchmark levels, should also be considered for inclusion in the mandatory storm water treatment category.

- The lack of sufficient resources was identified as the primary reason for the limited compliance assurance and enforcement activities performed by the RWQCB in the past and when this study was being conducted. One way to reduce the workload associated with assessing compliance of industries subject to the GISP requirements is to employ a semi-privatized certification program, such as that implemented in the State of Wisconsin, that relies on licensed, private inspectors to oversee the compliance activities of a group of facilities that voluntarily choose to participate and help fund the program. The aim of such a program is to help reduce some of the workload of the regulators and to allow facilities that diligently work toward and maintain a specified level of compliance to be certified for compliance by professional inspectors. Such certification could (partially) exempt them from certain regulatory responsibilities, such as monitoring activities, and indirectly shield them from third-party lawsuits by reducing the degree of their environmental liability. (Essential to the implementation of this type of program is regular training and (re-)certification of inspectors by the regulating agency to ensure quality assurance and quality control)

II. BACKGROUND

Storm water pollution has received steadily increasing attention from regulating agencies as well as environmental groups in the past decades. In California, efforts to better control industrial storm water pollution have resulted in legislation specifically aimed to improve the efficacy of the GISP program. Examples include Assembly Bill 2019, which mandates aggressive, mandatory enforcement actions to increase compliance with the NOI and annual reporting requirements, and Assembly Bill 1186, designed to substantially increase the funding available for the GISP program (AB 2019; AB 1186). Third-party lawsuits triggered by non-profit environmental organizations have contributed to raising the public's awareness of storm water pollution and of the importance of pollution prevention (P2).

There exist several known evaluations or reports, which have assessed the effectiveness of industrial storm water program, on both the regional and national levels. The Water Environment Federation, under a cooperative agreement with the EPA in 1994, conducted a nationwide assessment of the federal industrial storm water program implemented by USEPA (WEF 1996). The study presented the permittees' perceptions of how effective they thought the individual components of the federal industrial storm water program were in controlling and reducing storm water pollution. Two of the key findings from the study were that 1) of those companies regulated by the storm water permit program, 12.5% appeared to be out of compliance with the requirement to develop and maintain a SWPPP onsite; and that 2) small businesses spend less money on compliance and are more likely to be out of compliance because they lack environmental staff and a clear understanding of the requirements.

On a regional level, a 1998 report by Heal the Bay, a non-profit environmental organization with a primary focus on the protection of Santa Monica Bay in Southern California, criticized the lack of accomplishments of the industrial storm water program implemented by the Los Angeles Regional Water Quality Control Board (Los Angeles RWQCB), in areas of compliance assurance and enforcement activities conducted since the adoption of the GISP in 1991 (HTB 1998). In 1998 a Los Angeles RWQCB staff generated and submitted a draft report to the State Board titled, "Analysis of the Sampling Results: 1996-1997 Annual Report for Storm Water Industrial Activities General Permit". The draft document showed that a substantial fraction of the storm water data submitted for the 1992/93 and 1996/97 years exceeded the USEPA benchmark levels (RWQCB 1998). In February 2000, the National Resources Defense Council, a non-profit organization of attorneys working for environmental causes, submitted a formal written petition to EPA asking it to correct deficiencies or to withdraw from the State of California the delegated authority to implement its own storm water program, *specifically in the Los Angeles Region*. The petition documented the failure of the Los Angeles RWQCB to fully implement its storm water programs and cited the lack of sufficient funding and resources as the primary reason for the noted deficiencies (NRDC 2000). USEPA also cited similar findings in several of its annual audit summaries of the Los Angeles RWQCB's storm water programs and strongly recommended a significant augmentation in the available funding to provide the resources needed to fully implement the program (USEPA 1998; USEPA 2000a).

USEPA recognized that the RWQCB staff had achieved significant accomplishments given severely constrained resources (USEPA 1998).

Whereas many of the cited studies and analyses primarily focused on the deficiencies in the overall programmatic implementation at the RWQCB level, this study shifts the focus of its evaluation to the facility level where pollution control occurs. And by assessing the permittees' performances and compliance with the GISP requirements, this study attempts to shed light on the drawbacks and the barriers associated with the GISP program that must be addressed in order to improve the program's efficacy in controlling industrial storm water pollution. In addition, this study takes a hard look at whether the GISP requirements and its terms of compliance have been defined in such a way as to ensure adequate protection of water quality and beneficial uses of receiving waterbodies. Lastly, this study provides specific recommendations to remedy the deficiencies noted in its evaluation. To fully characterize the state of compliance achieved by the target industry, this study employed a multi-tiered assessment approach looking at the full spectrum of requirements, from initiation of coverage to field implementation.

AUTO DISMANTLING INDUSTRY

Auto dismantling industry was targeted for compliance assessment for the following reasons:

- Auto dismantling facilities, also known as auto salvage yards or auto recycling facilities, represent a significant portion (about 15%) of facilities covered in the Los Angeles RWQCB's GISP program;

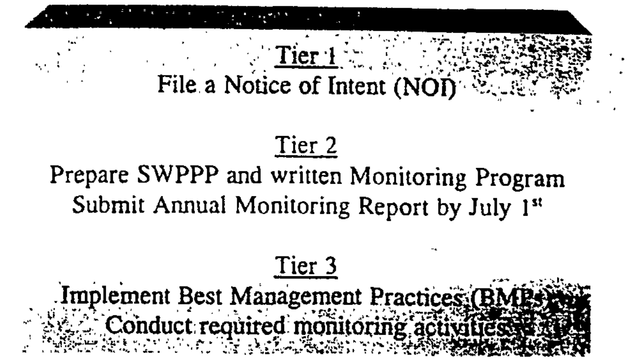
- Many of the typical operational and material handling practices conducted at auto dismantling facilities are performed outside and thus are exposed to storm water. Typical activities include dismantling vehicles and automotive parts; draining automotive fluids; storing auto parts, auto bodies and waste fluids, washing and rinsing of parts, and shipping and receiving activities;

- Spills and leaks of waste fluids and waste oil, which are common occurrences at auto dismantling facilities, contribute conventional and toxic pollutants, in particular, heavy metals and certain hydrocarbons, to storm water runoff (Swamikannu 1994); and

- The auto dismantling industry is difficult to regulate because the majority of businesses are small, mom-and-pop facilities that tend to change ownership rather quickly, posing a special challenge in outreach and compliance assurance activities for the regulating agency (approximately 70% of all auto dismantling facilities in Los Angeles County covered under the GISP are 1 acre or smaller). Economic and personnel constraints impact the ability of smaller facilities to fully comply with the GISP requirements.

MULTI-TIERED ANALYSIS

For purposes of evaluation, compliance was divided into three tiers:



Tier 1 (Initiation)

Facilities classified under certain standard industrial classification (SIC) codes specified in the GISP for coverage (including the auto dismantling industry whose SIC code is 5015) must file a NOI to apply for permit coverage. Facilities that are required but fail to file a NOI are referred to as 'non-filers'.

Tier 2 (Reporting/Documentation)

After submitting a NOI, facilities must submit an Annual Monitoring Report by July 1st of each year that summarizes both the qualitative and quantitative results from their monitoring activities. In addition to the annual reporting requirement, facilities must prepare appropriate storm water documents known as a Storm Water Pollution Prevention Plan (SWPPP) and a written Monitoring Program (MP) necessary to guide them in their P2 efforts. The purpose of a SWPPP is to serve as a "blueprint" for achieving compliance by specifying specific BMPs and a schedule of BMP implementation. Written monitoring programs must contain adequate procedural details to ensure that proper monitoring of facility condition and its storm water is provided.

Tier 3 (Implementation):

Facilities must implement BMPs provided in their SWPPP and conduct monitoring activities required by the GISP. BMPs include both non-structural and structural controls that can reduce the level of pollutants in storm water. Monitoring requirements may be broadly grouped into visual observations, storm water sampling and analysis, site inspection, and SWPPP review and update. Storm water sampling and analysis, along with the other monitoring activities, help evaluate the quality of the storm water runoff generated from the facilities and gauge the effectiveness of the facility's efforts to control storm water pollution.

The state of compliance achieved by the permittees is a reflection of how diligently facilities have been implementing the GISP requirements. Knowledge of the current state of compliance achieved and an estimate of associated load can serve many useful purposes. For example, such an understanding could help gauge if an existing program, such as the GISP, has the potential to attain further pollutant load reduction if required, for example, as part of the implementation of a Total Maximum Daily Load (TMDL). TMDL is the "amount of a specific pollutant that a waterbody can receive and still maintain water quality standard" (TWA 2000). If the majority of dischargers permitted under a given regulatory program are shown to be at the high end of a compliance curve, this implies that the program has nearly reached its maximum attainable pollutant reduction. Under such a scenario, opportunities for significant additional reduction in load would be slim. Conversely, if most dischargers are found to be at the bottom of a compliance curve, then there may be opportunities for substantial pollution reduction to be achieved through increased compliance activities.

If the GISP requirements are implemented to their maximum at the facility level, and facilities are still unable to attain the assigned load, then perhaps the standard of compliance defined in the GISP or the existing approach used to implement the GISP program may need to be re-evaluated. California has yet to allocate load associated with industrial storm water pollution. Nevertheless, an understanding of the current state of compliance under the GISP program and getting a good sense of the magnitude of load generated by industrial sectors will no doubt be useful for making critical management decisions. Also, this type of assessment will help to identify priority or high-risk industrial sectors - e.g. those with low compliance and high load contribution - to direct limited resources to the most critical areas.

LACK OF NUMERICAL EFFLUENT LIMITATIONS IN GISP

Standards for compliance can be expressed in various ways. NPDES permits may contain both qualitative and quantitative effluent limitations with which permittees must comply. Numerical effluent limitations may consist of technology- and water quality-based limits. The GISP, which falls under the NPDES framework, does not contain numerical effluent limitations for the majority of dischargers permitted under the program (Facilities among the ten industrial categories listed in USEPA regulations (40 CFR Subchapter N) must comply with the technology-based limits established by USEPA for specific pollutants. These Subchapter N facilities represent only a small portion of the facilities under the RWQCB's GISP program.)

In the absence of numerical effluent limitations, BMPs form the pillar of the GISP program. This is consistent with the "Interim Permitting Approach for Water Quality-based Effluent Limitations in Storm Water Permits" (USEPA 1996). The interim permitting approach uses BMPs in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. While it is recognized that numeric water quality-based effluent limitations could potentially provide a greater degree of confidence that a discharger will not cause or contribute to an exceedance of the water quality standards, the variable nature of storm water discharges and the lack of information on which to base numeric water quality-based effluent limitations are the main reasons that EPA developed the interim permitting approach.

There are several standards or conditions specified in the GISP that dischargers must attain including the Best Available Technology Economically Achievable (BAT) and Best Conventional Pollutant Control Technology (BCT) levels. In addition, one of the prohibitions in the GISP states that storm water discharge shall not cause or contribute to a violation of applicable water quality standards. Specifically, the achievement of BAT and BCT levels must be demonstrated by fulfilling the requirements of the GISP, which states "compliance with the terms and conditions of this General Permit constitutes compliance with BAT/BCT requirements and with requirements to achieve water quality standards." However, as discussed in the preceding section, determining compliance based on BMP implementation and performance is complicated by the absence of clear, uniform standards for measuring compliance, and because each assessment requires site-specific considerations. Prerequisites for successful attainment or measurement of progress toward desired goals are clear and adequate definitions of expectations or goals to be achieved. The lack of quantitative or numerical targets in the GISP inevitably generates questions and confusion as to whether a facility has indeed successfully achieved compliance. And herein lies one of the major handicaps of the GISP program.

A comparison of analytical monitoring data between facilities could shed light on the relative overall effectiveness of BMPs implemented at different sites. However, the bottom-line question is "how effective is effective?" Therefore, quantitative standards of some sort must be provided in order to determine the adequacy of storm water measures provided by facilities. One set of standards that has been used by RWQCBs in California and USEPA for its national storm water program is the USEPA benchmark values provided in the Final National Pollutant Discharge Elimination System Storm Water Multi-sector General Permit for Industrial Activities (hereafter USEPA Multi-sector Permit; USEPA 1995, USEPA 2000b). The benchmarks are indicators of potential impact of discharge but are not enforceable as numerical effluent criteria through the GISP program. These benchmark values are based on several sources of information, including fresh water criteria based on the effects on aquatic species, median concentrations from the National Urban Runoff Program, and minimum levels based on detection limit. However, for these numeric water quality standards to become enforceable through the NPDES framework, they must be translated into appropriate (numeric) *effluent limitations* that typically must be met "end-of-pipe". The Discussions section, under "Case study investigations: storm water analysis," explores the situation in greater depth and recommends some specific means to address this issue of whether compliance can be adequately defined to protect water quality in the absence of numeric effluent limitations.

III. METHODS

This study used database analysis, document review, and case study evaluations consisting of site inspections and storm water sampling and analysis to assess compliance of the selected auto dismantling facilities with the requirements of the GISP program. A mathematical equation, known as the EPA Simple Method, was used to quantify pollutant load in storm water runoff from the auto dismantling industry.

NON-FILER IDENTIFICATION (TIER 1 ANALYSIS)

To assess the non-filer situation, this study used two sources of data as presented in Table 1. First, to perform a county-wide evaluation, staff enlisted the cooperation of the California Department of Motor Vehicles, Occupational License Division (DMV) to obtain a list of auto dismantlers in Los Angeles County who had applied for and maintain a current dismantling license (DMV 1999). Each facility name and address on the DMV list was queried and checked using the RWQCB's NOI database to determine if the facility had filed a NOI. Facilities on the DMV list missing from the NOI database were contacted by phone to verify their operating status and the accuracy of the facility-specific information.

The second analysis focused on a four square-mile area within the County known to have high population of auto dismantling facilities. The data used in this study has been compiled by the City of Los Angeles inspectors who conducted door-to-door site visits between December 1998 and May 2000, specifically to identify non-filers in areas within the City of Los Angeles. The site visits were conducted as a Supplemental Environmental Project (SEP) that the City undertook, as part of its penalty under an Administrative Civil Liability issued by the RWQCB for City's past sewage spill incidents. A group of University of California at Los Angeles (UCLA) professor and students led the efforts to provide data QA/QC and data analysis.

TABLE 1. Data Source and Analytical Procedures for Non-filer Assessment

	Analysis I	Analysis II
Type	Auto Dismantling License Information	Door-to-door Site-visits
Source	California DMV Occupational License Division	RWQCB (City of Los Angeles' Supplemental Environmental Project)
Target area	Los Angeles County	City of Los Angeles (four square-mile area)
Analytical Procedures	1. Cross-check information on DMV list with NOI database 2. Perform over-the-phone verification of operating status and other information 3. Compile and analyze data	1. Query site visit results for auto dismantling facilities (conducted by UCLA) 2. Confirm NOI status (City of LA/ UCLA) 3. Analyze results by area (UCLA)

DETAILED STORM WATER DOCUMENT REVIEW (TIER 2 ANALYSIS)

The next level of evaluation focused on the facilities' compliance with the reporting and documentation requirement. To obtain a smaller pool of facilities for an in-depth review of storm water documents, this study selected 52 facilities from a total of 349 auto dismantling facilities from the NOI database. To ensure a representative pool, the facilities were chosen by first alphabetically sorting the 349 facilities by business name and choosing every sixth facility (A small number of the chosen facilities were located in Ventura County. These facilities were eliminated to limit the focus to Los Angeles County.)

To evaluate permittee compliance with the annual reporting requirement, this study chose to concentrate on trends observed in Annual Report submittal rates over times, based on the 52 selected auto dismantling facilities and on the quality of the Annual Reports submitted for the 1997/98 permit year. The proportion of facilities submitting the Annual Reports, among the 52 selected facilities, was determined by electronically querying the Annual Report databases maintained at the RWQCB. Similarly, the 1997/98 Annual Report database was queried for summaries of monitoring activities conducted by facilities. In addition, Annual Reports were reviewed for more detailed information not electronically available.

SWPPPs and written Monitoring Programs were requested from the selected 52 facilities through a formal letter issued by the RWQCB to each facility operator. An in-depth review of the SWPPPs and the written Monitoring Programs was provided using a checklist (see Appendix A) outlining the requirements specified in Sections A and B of the GISP.

CASE STUDY INVESTIGATIONS (TIER 3 ANALYSIS)

To investigate the onsite component of compliance, this study selected nine out of the 52 facilities for site-specific evaluation. These nine facilities were clustered in the San Gabriel River and Los Angeles River watersheds. Staff inspected all nine sites and collected storm water samples from the eight sites that produced sufficient volume of runoff to enable sample collection. Storm water samples were collected from primary discharge locations that conveyed runoff from the areas where principal industrial activities were conducted. The purpose was to assess the extent to which facilities implemented the BMPs indicated in their SWPPPs and to study the overall effect of the BMPs implemented based on the storm water analytical data. Storm water sampling activity and analysis were carried out under conditions consistent with the requirements in the GISP. Only fully-trained staff and interns participated in the storm water sample collection, handling, storage, and transport activities to ensure adequate QA/QC. Chain of custody forms were completed for all samples. Samples were analyzed by the California Department of Health Services laboratory.

WATER QUALITY IMPACT ASSESSMENT

EPA Simple Method

To provide a perspective on the potential water quality impact(s) associated with storm water runoff generated from the auto dismantling industry, pollutant load was estimated using storm water analytical data from the case study investigations. This study used the EPA Simple Method equation for load assessment:

$$L = 0.227*P*Pj*A*C(0.05 + 0.009*I)$$

where

L = pollutant load (pounds/ per year);
C = average flow-weighted concentration of the pollutant in runoff (mg/L or ppm);

P_j = fraction of rainfall events that produce runoff;
P = annual precipitation in inches per year (inches per year);
A = area of the site (acres);
I = the percent of the site's imperviousness; and,
0.227 = conversion factor (inches/foot)* (acre-feet-ppm/pounds).

IV. DISCUSSION OF RESULTS

This chapter presents key findings on the degree of compliance achieved by auto dismantling facilities; evaluates the quality of storm water runoff generated from selected facilities; estimates the load contributed by the industry in the form of storm water pollution; and discusses water quality implications associated with the key findings of this study.

NON-FILERS

Applying for coverage under the GISP does not guarantee that a facility will actually achieve pollution abatement, but it is an important first step. Also, from the perspective of "leveling the playing field," it is necessary for regulators to characterize the extent of non-compliance with the NOI requirement and take aggressive, timely actions once non-filers are identified to bring them into compliance. Auto dismantling facilities, due to the nature of the industrial activities conducted onsite, are subject to the GISP requirements. Facilities of this industry are informed about the GISP requirements through two main channels. First, auto dismantling facilities are notified about the NOI requirement by the California DMV when they apply for a dismantling license from the DMV's Occupational License Division. The DMV auto dismantling license application includes a questionnaire about whether the facility operator has filed a NOI with the State Board. (The DMV forwards a copy of the completed application to the State Board per pre-established interagency agreement/cooperation between the two state agencies.) The second channel of information regarding the industry's duty to comply is the mass-mailing that the State Board periodically conducts as part of its effort to reach potential non-filers.

Table 2 describes the results of non-filer identification using the DMV dismantling license list. Of the 463 facilities on the list that were checked against the RWQCB's NOI database, 147 were identified as potential non-filers. Phone verification identified 77 of the 147 facilities to be actually operating without a NOI. In other words, approximately one-fifth of the facilities on the DMV list comprised of non-filers. The rest of the 147 facilities had either terminated operation or could not be reached after multiple phone attempts.

Essential to obtaining an accurate estimate of non-filers is an understanding of the total universe of facilities regulated. In screening the DMV list against the NOI database for non-filers, this study assumed that the DMV list represented a relatively thorough estimate of the total universe of auto dismantlers in Los Angeles County. To test this assumption, staff screened to see whether the auto dismantlers in the NOI database appeared on the DMV list. This screening effort yielded 72 facilities that could potentially be operating without a dismantling license. Phone verifications confirmed 35 of these to be in operation. This effort yielded a conservative estimate of 404 for the total universe of auto dismantling facilities operating in Los Angeles County, as of August 1999, when this analysis was conducted. This estimate includes facilities operating with either or both a NOI or a dismantling license. The number of facilities operating with neither a NOI nor a dismantling license is unknown and is needed to

TABLE 2. Non-filers Among Auto Dismantling Facilities, Los Angeles County: DMV Licenses vs. NOIs Filed[1]

DMV COVERAGE[3]	NOI STATUS[2]					
	Active NOI[4]	Suspended NOI	Terminated NOI	No NOI[5] (Potential Non-filers = 147): Verified Non-filers	Out of Operation	Unverifiable
DMV Licensed	292	1	23	**77**	25	45 (21)[6]
No DMV License (72)						
Verified Non-licensed[3]	**35**	-[7]	-	Unknown	-	-
Out of Operation	34	-	-	-	-	-
Unverifiable	3	-	-	-	-	-

The proportion of non-filers among auto dismantling facilities operating in Los Angeles County is estimated at 19% (77 out of 404). The total universe of auto dismantlers in Los Angeles County exceeds 400, based on the number of active NOIs and verified non-filers. For a more accurate characterization, those operating with neither a NOI nor a DMV license need to be accounted for in the total universe of facilities.

[1] Table 2 originally appeared in a doctoral dissertation (*Chang 2001*).
[2] A RWQCB's NOI database contains information on facilities with NOIs.
[3] In California, auto dismantlers are required to obtain a dismantling license from the Department of Motor Vehicles (DMV), Occupational Licensing Department prior to operation. The list of facilities in Los Angeles County with auto dismantling license was obtained from the California DMV in August 1999.
[4] Note that the total number of auto dismantlers in the NOI database with active status is 364, slightly higher than the total number (349) that was used to select the study pool of 52 facilities. The pool of facilities with active NOIs changes over time as facilities begin and terminate coverage.
[5] Facilities that did not appear on both the DMV list and the NOI database were contacted by phone to confirm their operating status. The facilities were categorized as: "verified" non-licensed (DMV); non-filers; out of operation; and unverifiable if they could not be reached by phone after numerous attempts.
[6] Of the 45 facilities in the unverifiable category, 21 did not have phone numbers listed on the DMV list nor with directory assistance. Therefore, the operating status of these facilities could not be verified. The rest did have phone numbers listed but could not be reached.
[7] Dashes mean not applicable.

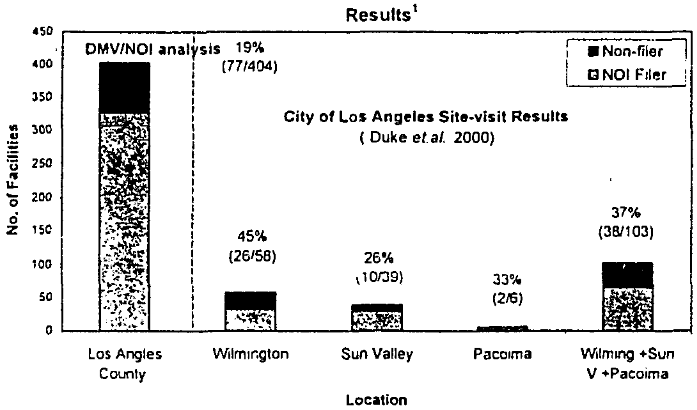
accurately characterize the total universe of facilities, is not known at this time. This estimate lies outside the realm of the objectives and methodology of this study. However, considering the potential severe consequences of violations under both regulatory requirements, the actual number of facilities in this category is probably a small percentage of the total number of auto dismantling facilities in operation.

This study further investigated the 10% (35 of the 364) of auto dismantling facilities with an active NOI that were verified to be operating without a dismantling license. The purpose was to shed some light on reasons that some facilities have apparently chosen to comply with one type of regulatory requirement over another. Each of these facilities were contacted by phone for explanations as to why the facility appeared to be in violation with a regulatory requirement so essential to its operational activities (a valid dismantling license is required for transactions at used auto auctions). It turned out that a small fraction of these facilities (less than 10% of those contacted) actually had a dismantling license, either under a slightly different address or business name, or under the name of the facility's headquarters. Facilities that knew they were in compliance cooperatively shared their dismantling license information with the

RWQCB staff. The remaining facilities, however, refrained from revealing their dismantling license number or from discussing possible reasons why the facility is not represented in the DMV dismantling license database, even after repeated assurances from staff that the information was for research purposes only and not for enforcement activities. It is highly likely that these facilities were operating without a valid dismantling license.

Figure 1 illustrates the outcome of the two non-filer analyses, showing the percentages of non-filers for the overall County and at the sub-city level. Presented to the left of the dotted line is DMV/NOI analysis, and to the right are the site visit results. The site visits performed by the City inspectors targeted three areas within the City of Los Angeles boundary-- Wilmington, Sun Valley, and Pacoima-- with the first two areas accounting for over 40% of all auto dismantlers in Los Angeles County with an active NOI. A total of six auto dismantling facilities were identified and visited in Pacoima. Overall, non-filers accounted for 37% of the auto dismantling facilities identified in the three areas. The area with the highest ratio of non-filers was Wilmington (45%), followed by Pacoima (33%) and Sun Valley (26%). Only six auto dismantling facilities were identified in Pacoima.

Figure 1. Non-filers Among Auto Dismantling Facilities in Los Angeles County, CA.: Identified from Database Analysis and Site-visit Results[1]



[1] Figure 1 originally appeared in Chang 2001.

Because the site visits did not cover all of Los Angeles County, the results obtained from the site visits cannot be directly compared with the findings from the DMV license analysis. The site visit results, though, indicate that the proportion of non-filers among auto dismantling facilities in some areas of Los Angeles County could be twice as high as the average estimated by the DMV/NOI analysis for the entire County. Three reasons potentially account for the substantial difference between the ratio of non-filers estimated for the County and at the sub-County levels. First, Wilmington and Pacoima may have disproportionately high percentages of non-filers compared to the rest of Los Angeles County (Sun Valley had a similar percentage of non-filers as estimated by the DMV/NOI analysis). Second, the number of facilities delinquent with both the NOI and the dismantling license requirements could be significant. These facilities may be reflected in the site visit results but not in the DMV database. Another possible explanation is that the areas visited by the inspectors had both disproportionately high percentages of non-filers and non-DMV-licensed facilities. (Note: The RWQCB has started to follow up with facilities, across all industries, which were identified as potential non-filers by the City inspectors. Out of about 430 facilities fully inspected, approximately 200 facilities were identified as potential non-filers and are subject to follow-up activities, including a letter notifying their potential to file a NOI and an inspection, if necessary.)

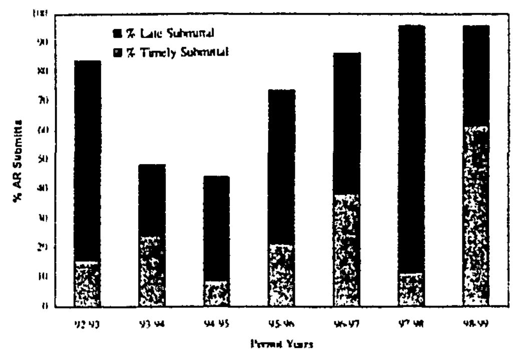
As demonstrated by the statistics, the non-filer problem is significant for the auto dismantling industry. However, to place the non-filer situation in the context of other industries, this study also looked at the City's site visit results for two other major industries mandated for coverage under the GISP- recycling and transportation sectors. Of the three sectors, the auto dismantling industry had the highest compliance rate with the NOI requirement of 63%, followed by transportation with 38%, and recycling with 13% (Duke et al 2000). The higher compliance by the auto dismantling industry could be attributed to the successful interagency coordination between the State Board and the DMV. As a way to effectively identify and reach out to potential non-filers, this study recommends that the State Board actively solicit the cooperation of other state/local agencies to enhance information sharing and to incorporate the NOI requirement by reference into other regulatory requirements, similar to the DMV dismantling application procedures. Auto dismantling licenses and construction grading permits (under the Municipal storm water requirements) are two examples where filing a storm water NOI has become a pre-requisite for license/permit issuance.

In conclusion, full compliance with the NOI requirement has not been attained by the auto dismantling industry. The DMV dismantling license analysis, which probably underestimates the number of non-filers for reasons explained revealed that, at minimum, one out of every five auto dismantling facilities in Los Angeles County is a non-filer. In some areas of Los Angeles County, such as Wilmington, the non-filer problem appears exacerbated, with approximately one out of every two facilities operating without a NOI. The recommended approach for identifying non-filers is to utilize interagency coordination and employ available databases, such as the DMV dismantling license and NOI information supplemented by site visits. Agency-generated data probably offers a higher degree of accuracy than commercially available databases. At this time, it is difficult to draw any quantifiable conclusions about the water quality implications associated with "non-filer" sites, including whether the quality of runoff from non-filers, on average, is expected to differ significantly from runoff from permitted facilities. because there are no known studies or data that specifically target the quality of storm water runoff from non-filer sites.

ANNUAL REPORTS

This sub-section describes the trend in compliance achieved by the 52 selected auto dismantling facilities with the requirement to submit Annual Reports by July 1st of each year. Also characterized are the facilities' performances in implementing the required monitoring activities for the 97-98 permit year. Both qualitative and quantitative monitoring data serve as an indicator of each facility's overall performance with BMP implementation, help build a comprehensive inventory of essential water quality data, assist in developing water quality standards, and more. For instance, analytical monitoring data provided in the Annual Reports present a potential source of information necessary to support the quantification of loads associated with storm water runoff from industrial sources, a step necessary to develop TMDLs. The types of monitoring summaries contained in the Annual Reports, if completed properly by facility operators, could reveal important facility-specific and compliance-related information such as how diligently a facility implemented the required monitoring activities, the quality of the storm water runoff generated from the facility, and whether the facility operator has reviewed and updated the facility's SWPPP, and reassessed the adequacy of existing BMPs in controlling storm water pollution.

Figure 2. Compliance with Annual Reporting Requirement among Selected Auto Dismantlers in Los Angeles County



[1] Figure 2 originally appeared in Chang 2001.

Figure 2 illustrates the trend in facilities' submittal of Annual Reports from 1992 to 1999. The overall height of a bar indicates the total percentage of Annual Reports submitted for a given permit year. The lower, lighter portion of bar indicates the proportion of facilities that submitted Annual Reports on or before July 1st. The upper, darker portion represents late submittals. Compliance is represented in percentages rather than actual number of reports submitted because the number of facilities *required* to submit Annual Reports varied over time because the facilities' coverage under the GISP program was initiated at different times (by 1996, all of the 52 selected facilities had filed a NOI).

As illustrated in Figure 2, compliance was low in the early years, with the majority of the facilities failing to submit the required Annual Reports for the 1993/94 and 1994/95 permit years, and with the majority of the reports arriving late. The lack of sound monitoring data, as a result of deficient reporting, would leave both the regulators and the dischargers in the dark about critical questions such as how successful an individual or a group of facilities' efforts have been in controlling storm water pollution at their site and their progress over the years. In addition, not having adequate analytical data substantially limits regulatory efforts to characterize the quantity of load associated with the storm water runoff from regulated communities. Without the data necessary to self-diagnose their facility's performance and a chance to address the deficiencies in a timely manner, facility operators are really placing themselves in jeopardy of increasing their environmental liability and the chances of regulatory enforcement actions and third-party lawsuits. Therefore, both the dischargers and the regulators are negatively impacted when facilities fail to monitor and report their monitoring results to the appropriate regulating agency.

Observations based on the 52 selected auto dismantling facilities revealed that starting in 1995/96, two-thirds or more of the required facilities submitted their Annual Reports. The highest Annual Report submittal rate (96%) achieved in 1997/98 and 1998/99 is an outcome of increased enforcement activities launched by the RWQCB in recent years and demonstrate the importance of and the need for aggressive, timely regulatory follow-up activities.

Several hundred enforcement letters were issued in 1997/98 to facilities across all industrial sectors that failed to submit Annual Reports on time. As apparent from Figure 2, the majority of the 1997/98 Annual Reports were received late, with most of them probably in response to the enforcement letters. The subsequent permit year had even greater success. While maintaining the Annual Report submittal rate at 96%, there was a substantial increase in the number of reports being submitted on time.

Evidently, the large-scale enforcement activities, including the issuance of formal violation letters and mandatory penalties for recalcitrant
violators, have resulted in tangible results and have demonstrated to be an effective tool for communicating to the regulated community the potential severe consequences of violating storm water regulations.

The usefulness of the Annual Reports to regulators and dischargers alike depends on the accuracy and the completeness of the reports being submitted. In the Los Angeles Region, much of the agency's limited resources have been dedicated in the past to identifying and following up with facilities that have failed to submit Annual Reports. Constrained by resources, limited regulatory attention was focused on the quality of the Annual Reports received or the monitoring results reported in the Annual Reports. This study conducted detailed reviews of the 1997/98 Annual Reports submitted by 50 of the 52 selected facilities to contribute to an increased understanding of the quality of Annual Reports and the monitoring data submitted by auto dismantling facilities.

Figure 3. Storm Water Monitoring Activities Conducted by 52 Selected Auto Dismantling Facilities (1997/98 Annual Reports)

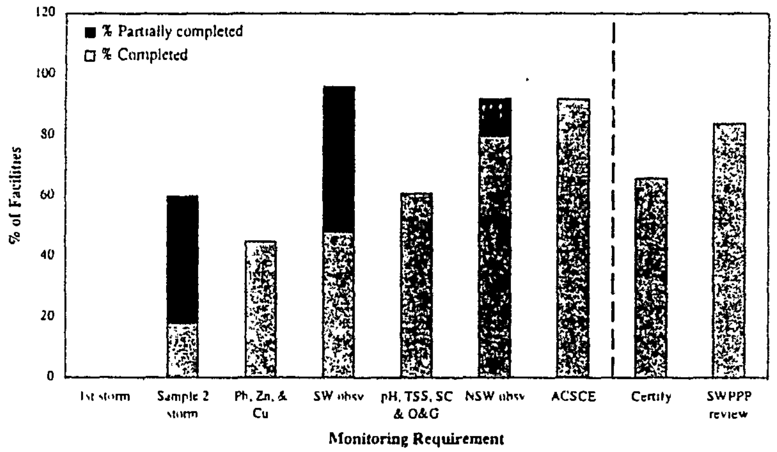


Figure 3 illustrates how successfully the 50 facilities that had submitted the Annual Reports fulfilled their required monitoring activities (two of the 52 facilities did not submit their Annual Reports). Results are presented in the order of low to high compliance, in terms of facilities that fully satisfied a monitoring requirement, as indicated by the bottom, lighter portion of a bar. The upper, darker portion represents facilities that partially completed a required monitoring activity. Bars to the left of the dashed line indicate monitoring activities and to the right are administrative requirements associated with the monitoring program. Monitoring requirements include: visual observations of storm water and non-storm water runoff, storm water sampling and analysis, and an annual comprehensive site evaluation that includes a full-scale site inspection and a SWPPP review and update. Table 3 augments the findings on the monitoring activities with detailed narrative description.

None of the individual categories of monitoring activities were completed by all 50 selected facilities. Overall, facilities were less likely to perform monitoring activities that are more cost- and effort-intensive, such as storm water sampling and analysis, than activities that are simple to perform and involve little or no cost, such as visual observations. This trend was observed even among activities such as visual observations that require minimal resources to perform. Approximately 80% of the facilities fully complied with the quarterly observation of non-storm water (a total of four observations required to be conducted under *dry* weather conditions). A

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Table 3. Summary of Monitoring Activities Reported by for 50 Selected Auto Dismantling Facilities (1997/98 Annual Reports)

MONITORING REQUIREMENT	FACILITY COMPLIANCE						COMMENTS
	Completed		Partially Completed		Did Not Attempt		
1. Submit Annual Report by July 1st deadline	31	62%	19	38%	N/A	N/A	• "Completed" means facility submitted the Annual Report before or on 7/1/98. • "Partially Completed" means facility submitted Annual Report after 7/1/98. • "Did Not Attempt" means facility did not submit Annual Report.
2. Sample from two storm events	7	18%	16	42%	15	40%	• "Completed" means facility collected and analyzed sample(s) from two qualifying storm events. • "Partially Completed" means facility collected and analyzed sample(s) from one storm events. • "Did Not Attempt" means facility did not collect or analyze any sample. • Twelve out of the 50 facilities belonged to a Group Monitoring Program and were exempt from sampling during the 97-98 year. Therefore, statistics for Requirements #2-#4 reflect results for 38 facilities. • Most facilities that failed to collect samples from two storm events did not have adequate explanations. The 97-98 wet year is marked by unusually plentiful rainfall due to the El Niño phenomena.
3. Sample from the first storm	0	0%	N/A	N/A	38	100%	• The first flush occurred on a weekend. GISP does not mandate facility operators to collect storm water samples outside of their typical operating hours or under hazardous conditions. • 19 out of the 38 facilities provided inadequate reasons for not sampling from first storm; four out of the 38 facilities that failed to sample from first storm did not provide any explanation.
4. Analyze samples for pH, TSS, SC, and O&G	23	61%	0	0%	15	39%	• About 39% of the facilities failed to collect any samples • All 23 who sampled from at least one storm tested for these basic constituents.
5. Analyze samples for Cu, Pb, and Zn	17	45%	N/A	N/A	21	55%	• Seventeen facilities tested at least one set of samples for Pb, Cu, and Zn. • About 55% of the facilities either failed to sample at all or sampled from at least one storm but failed to analyze for metal.

Table 3. Summary of Monitoring Activities Reported by for 50 Selected Auto Dismantling Facilities in 1997/98 Annual Reports

(Continued)

MONITORING REQUIREMENT	FACILITY COMPLIANCE						COMMENTS
	Completed		Partially Completed		Did Not Attempt		
6. Conduct quarterly non-storm water visual observations	40	80%	6	12%	4	8%	• "Completed" means facility conducted four quarterly observations. • "Partially Completed" means facility conducted at least one but less than four quarterly observations. • Two facilities attached a narrative description of the type of authorized non-storm water discharges observed from their site. However, when asked in the Annual Report whether the facility ever had authorized non-storm water discharges, both facility operators answered negative.
7. Conduct monthly storm water visual observations during the wet season (Oct. 1st - May 30th)	24	48%	24	48%	2	4%	• "Completed" means facility conducted eight monthly observations during the wet season (October to May). • "Partially Completed" means facility conducted at least one but less than eight monthly observations during the wet season. • If a month had no storm, the facility operator must report so.
8. Conduct annual site evaluation	46	92%	N/A	N/A	4	8%	• Four facilities that failed to conduct Annual Comprehensive Site Compliance Evaluation (ACSCE) provided no explanation.
9. Review SWPPP for BMPs and compliance	42	84%	N/A	N/A	8	16%	• Eight facilities that failed to review SWPPP provided no explanation.
10. Certify for compliance	33	66%	N/A	N/A	17	34%	• Of the 17 facilities that did not certify for compliance, 16 facilities cited their failure to meet one or more of the monitoring requirements as the reason for not certifying. • One facility did not provide any explanation for not certifying for compliance.

substantially smaller proportion of facilities (less than half) completed the storm water runoff observations (a total of eight monthly observations activities during *rain* event).

None of the facilities were able to collect samples from the first storm event because the first storm event of the 1997/98 wet season occurred on a Sunday for most of the Los Angeles region (Facilities are not required to sample outside of their normal business hours or under dangerous conditions). Some facilities did not provide a valid explanation for their failure to sample from the first storm event. Less than 20% of those *required* actually sampled from two storms events, as required by the GISP (note: Some facilities that belong to a group monitoring program are subject to less frequent sampling. This study appropriately accounted for those facilities in its analysis). The 1997/98 wet season was impacted by El Niño and had unusually frequent and intense storm events, therefore ruling out the lack of sufficient rain as one of the valid excuses for not sampling. Less than half of those required actually analyzed for copper, lead, and zinc. And among the facilities that sampled from at least one storm, about a quarter did not analyze for the required metals. Failure of facilities to analyze for the designated constituents --i.e. specific pollutants determined by regulators to be of concern for a particular industry -- really hinders efforts to quantitatively evaluate a facility's performance and to gauge potential water quality impact.

Inherent to self-reported information without QA/QC procedures is the uncertainty in the accuracy of the data provided. Annual Reports are subject to similar deficiencies. Each Annual Report must contain a self-certification of compliance signed by the facility operator or equivalent. Whether self-certifications are a reliable gauge for measuring facility compliance depends on several factors including a facility operators' level of understanding and informed interpretation of the GISP requirements and their ability to appropriately assess and accurately report the facility's compliance status. To evaluate how accurately the Annual Reports reflect facility compliance, this study compared the number of Annual Reports self-certified for compliance against the number of facilities reported to have successfully complied with a particular category of monitoring requirement. We considered a monitoring activity that is required of *all* facilities- monthly visual observation of storm water discharges. According to Table 4, less than half, 48%, completed all eight monthly visual observations of storm water, which implies that an equal or smaller number should have certified for compliance, considering the fact that a facility must also satisfy all the other GISP requirements before certifying for compliance. About two-thirds of the Annual Reports were self-certified, pointing to a discrepancy of at least about 20% between those certifying for compliance and those actually complying. It should be noted that only one monitoring activity was considered here. In reality, the actual gap between the number that self-certified and the number that fully completed all required monitoring activities or all GISP requirements is expected to be considerably larger.

Whether this discrepancy is due to a flawed interpretation of compliance criteria, mere carelessness on the part of the facility operator, or unwillingness to openly expose or admit one's deficiency for fear of potential enforcement, one conclusion that can be drawn is that self-certification is not a perfect indicator of facility compliance and should be used with caution when used to estimate permittee compliance.

Storm Water Pollution Prevention Plan

A hallmark of the P2 approach, which drives the GISP program, is the reliance on the facility operators to identify potential pollutant sources and appropriate site-specific BMPs to achieve P2 at their facility. The underlying assumption is that facility operators are the ones most familiar with the facility operations and other site-specific conditions. Therefore, facility operators are considered the ideal candidates for identifying site-specific solutions for their facility.

The GISP requires each facility operator to develop a SWPPP, which is a site-specific document that lays out exactly how a facility will control storm water pollution associated with its industrial activities. Compliance with the SWPPP requirement has not been well characterized because, unlike Annual Reports, SWPPPs are not required to be submitted to the RWQCB. An in-depth review of SWPPPs that considers the site-specific nature of each facility requires a substantial amount of time. This study is one of the first attempts in California and perhaps in the nation to characterize, on a large scale, the quality of the SWPPPs prepared by and for a specific industrial sector. A detailed review was provided for the 50 SWPPPs received based on specific SWPPP-related requirements outlined in Section A of the GISP. A summary of the deficiencies found in the SWPPPs are described in Table 4.

One major deficiency noted in many of the SWPPPs was that they were boiler-plate documents that lacked specific details on the actual BMPs chosen for implementation by the facility operator. Also missing were procedural details about how the BMPs would be implemented. About 90% of the SWPPPs reviewed were prepared by one of four consulting companies. Many of the SWPPPs were written in a vague manner that made it difficult to determine exactly which measure, among a set of "ideal" or "proposed" BMPs described in the document, was chosen for implementation by the facility operator.

As indicated in italics in Table 4, these SWPPPs provided no or limited information on: 1) the name(s) of individual(s) responsible for the implementation of various monitoring activities; 2) a detailed, comprehensive site map that describes the locations of pollutant sources and where industrial activities are conducted; and 3) BMPs that are fundamental to the P2 efforts, such as employee training, site inspection, and good housekeeping programs. In essence, a SWPPP is a "blue-print" that describes specific measures and a schedule of implementation a facility will employ to achieve P2 and regulatory compliance. The SWPPP should be a "living" document that is regularly updated and reflects the actual site conditions. Given their generally poor quality, the majority of the SWPPPs reviewed fail to effectively guide facility operators in the field implementation phase. From verbal communication with facility operators, it appeared that many SWPPPs were being developed by a third party with little involvement or input from the facility operators or key personnel. About a quarter of the 52 facility operators who had called after receiving the RWQCB's formal request for SWPPPs demonstrated little or no knowledge of the SWPPP requirement, indicating

Table 4. Review of SWPPPs and Written Monitoring Programs Submitted by about[1] 50 Selected Auto Dismantling Facility Operators (Los Angeles County, 1999)

Element Specified in General Permit	Missing	Inadequate Description
A. Storm Water Pollution Prevention Plan		
Pollution Prevention Team	0	31
Site map	2	35
List of significant materials handled or stored on site (describe type, location, and quantity)	5	26
Description of industrial activities and potential pollutant sources	2	16
Assessment of potential pollutant sources, pollutants and locations.	2	9
Spill history	5	0
Investigation of Non-storm water discharges	12	2
Non-structural Best Management Practices	0	18
Good housekeeping program	13	3
Preventive maintenance program	8	6
Spill prevention and response program	8	6
Material handling and storage procedures	8	3
Waste handling & recycling	9	5
Erosion and sediment control	9	1
Employee training program	9	10
Site inspection program	6	3
Recordkeeping and internal reporting	6	6
Quality assurance	5	0
Structural BMPs	2	N/A[2]
Annual Comprehensive Site Compliance Evaluation	2	18
B. Storm Water Monitoring Program		
Quarterly non-storm water visual observations	3	5
Storm water visual observations (monthly from October and May)	0	27
Field sampling procedures	0	12
Sampling program specifying locations and times	0	5
Sample preservation procedures	0	34
Analysis methods	7	11
Specification of constituents mandated for sample analysis	0	37
Retention of all records for at least 5 years	0	11
Submission of Annual Report by July 1st of each year	5	0
C. Standard Provisions		
Certification and signature of facility operator	3	0

[1] SWPPPs and written monitoring programs were received from 50 and 47 of the 52 selected facilities, respectively.
[2] GISP encourages facility operators to consider structural BMPs *if* the non-structural BMPs chosen are considered insufficient to adequately address the pollutants present. Therefore, the review of structural BMPs was limited to evaluating whether the facility had considered any of the five categories of structural BMPs described in the GISP. For example, it was considered adequate for the purpose of this study if a SWPPP cited that structural BMPs were reviewed and considered but not chosen for implementation because the non-structural BMPs were considered sufficient.

how closely they were involved with preparing their facility's SWPPP. Also, discussions with facility operators during the case study investigations indicated that the facility operators were either unfamiliar or unsure about many BMPs described in their SWPPP. Some facility operators admitted to not fully understanding all aspects of the SWPPP, including the BMPs described, and expressed reservations about their ability to implement certain structural BMPs described in the SWPPP, when it was explained to them what those measures were and the potential consequences for failing to fully implement the SWPPP which they had certified to implement. The lack of or limited facility operator involvement in preparing the facility's SWPPP and in selecting the appropriate BMPs for the facility appears to be one of the main reasons for the disconnect observed between the descriptions provided in a facility's SWPPP and what is actually being implemented in the field.

WRITTEN MONITORING PROGRAMS

How does a facility measure its performance or progress in P2 efforts or gauge the effectiveness of the BMPs implemented? By monitoring. As a requirement of the GISP, facilities must prepare a written monitoring program. The purpose of a written monitoring program is to ensure that proper methods are provided so that facility operators may employ these methods consistently in monitoring their site conditions and the storm water runoff generated from their site. In turn, this would generate monitoring results - both qualitative and quantitative - that are representative of the facility's site conditions and which could provide useful information on a facility's progress over the years.

Out of the 52 requested, 47 auto dismantling facilities submitted their written monitoring programs. The majority of the monitoring programs were prepared by consultants, and had characteristically similar problems as the SWPPPs. Table 4 summarizes some of the deficiencies found in the written monitoring programs per requirements outlined in Section B of the GISP. The documents generally lacked in procedural details explaining how each monitoring activity would be performed. For example, sections on sampling and analysis requirements did not describe the type of sampling equipment to be used, QA/QC procedures, or special precautions needed to provide a well-controlled environment for collecting, storing, and transporting the samples to certified laboratories for analysis. The lack of sufficient procedural details in the written monitoring programs raises questions about the QA/QC procedures used by facilities for their monitoring activities, especially during sample collection, storage, and transport. And this deficiency limits the reliability and the credibility of the storm water analytical data reported in the Annual Reports. Thus, regulators should use the monitoring results provided in the Annual Reports with caution, keeping in mind some of the limitations discussed above. Another flaw observed in a significant number of the monitoring programs is outdated information that fails to reflect the changes included in the 1997 reissued permit. For example, the minimum period required for retaining records increased from 3 years to 5 years in the 1997 permit. However, many monitoring programs still specified 3 years for the minimum required record retention period. Also, many still used the old definition of a wet season (September to April) instead of October through May, as defined in the 1997 permit. Failure to update the SWPPP per new permit conditions affects a facility's ability to comply with the regulatory requirements.

Many of the nine case study facilities that hired consultants to prepare their storm water documents also depended entirely on them to conduct many, if not all, of their monitoring activities. It appears, from discussions with facility operators, that some consultants perform the required monitoring activities alone, unaccompanied by any facility personnel, and provide a written report, summarizing qualitative and/or quantitative monitoring results, to the facility operator at a later time. Although this type of monitoring may technically meet certain regulatory requirement(s), it tends to remove from the facility operator or other key facility personnel the opportunity to fully assess and understand the site conditions first-hand and to seek out the additional steps that may be necessary to make further progress.

Increased compliance assurance activities by regulators, including random audits and formal request of SWPPPs and monitoring programs for review, as well as timely follow-up responses, are some ways to enhance the quality of these storm water documents. In addition, since some of the major problems, including the lack of site-specificity of the documents, are due to the consultants working on these documents, a time-efficient and effective approach would be for the regulating agency to target those few consultants who prepare the documents for the majority in the industry for regular education and training them so that the SWPPPs and the monitoring programs they prepare are up to speed with the GISP requirements. Another recommendation is for the regulating agency to consider the option of requiring all SWPPPs prepared by a third party to be certified to ensure that the details of the monitoring programs selected for implementation have been fully discussed, understood, and agreed upon by facility operators, and that a key facility personnel will conduct or personally accompany the consultant(s) on all of the monitoring activities.

CASE STUDY INVESTIGATIONS: SITE INSPECTIONS

The first and second tiers of compliance establish the foundation for achieving pollution reduction and/or prevention. However, it is only the compliance with the third tier requirements, the onsite implementation, that results in actual pollution abatement and directly impacts water quality. Staff conducted field investigations of nine selected auto dismantling facilities to study their onsite performance.

The field compliance component of the industrial storm water program has generally not been well characterized for the Los Angeles region due to lack of resources available for the GISP program in the past and other competing priorities. However, the general perception is that field compliance is low especially among small facilities. Substantial staff time is required to complete a comprehensive site inspection, which includes pre-inspection preparation, the actual inspection, and post-inspection follow-up activities including completing an inspection report.

Table 5 summarizes some characteristics of the nine case study facilities, including their property size, percent of imperviousness, and the estimated annual vehicle throughput or the number of vehicles processed yearly. Percent imperviousness refers to the portion of a facility property that is paved, roofed (including buildings), or covered. As shown in Table 5, the case study facilities span a wide spectrum in terms of their annual vehicle throughput, property size, and percent imperviousness. One facility

Facility	Property Size (Acres)	Percent Imperviousness (% Paved, Roofed or Inside Building)	Annual Vehicle Throughput
A	2	60	175 - 250
B	0.7	100	80 - 120
C	2	100	180
D	1	100	50
E	1.5	100	75 - 200 (trucks)
F	0.7	100	120
G	1.5	100	150 (trucks)
H	13	100	16,800
I	0.6	32	110

Table 5. Characterization of Nine Case Study Auto Dismantling Facilities

(Facility H) offered "self-service"- i.e. it allows customers to dismantle desired parts directly from the vehicles. The rest of the Facilities, A through G and I, offered retail, "over-the-counter" service and sold already dismantled parts to customers.

Table 6 summarizes some key findings on facility BMP implementation based on staff site inspections. A more complete assessment is presented in Table 7, which provides numerical ratings (from 0 to 3) on how well individual case study facilities implemented the BMPs described in the facility's SWPPPs and other BMPs considered either universally applicable or especially effective for the auto dismantling industry. A facility's overall BMP implementation score -- the sum of individual BMP ratings -- was used to evaluate a possible correlation between a facility's performance and water quality impacts, which is presented in a subsequent section (Appendix B augments Table 7 with the information on the kinds of pollutant sources or activities conducted at each facility and the BMPs that were cited in the facility's SWPPP). The SWPPPs prepared for the nine case study facilities included very similar, overlapping BMPs, primarily consisting of non-structural measures. In general, the findings of this study concur with the trend analyzed in a previous study on the transportation industry by Duke and Chung (1996) that concluded that storm water control measures described similarly in SWPPPs at a number of case study facilities were not uniformly implemented and unequally effective at managing storm water pollutants. As shown in Table 6, some BMPs were more frequently implemented than others.

Table 6. Evaluation of BMPs Implemented at the Nine Case Study Auto Dismantling Facilities

BMP Types	Fully	Partially
Overhead cover for dismantling area	0	3
Cover parts	1	7
2° Containment for fluid-storing container	3	2
Overhead cover for fluid storage	4	3
Pave entire site	7	1
Conduct dismantling on impervious area	8	0

This study also found that BMPs that are more resource-intensive or pose physical constraints on daily operational activities are less likely to be implemented. The structural BMPs cited in the case study facilities' SWPPPs were often missing or if provided at all, were not fully implemented. The first four BMPs that appear in Table 6 (overhead coverage for dismantling and fluid storage areas, coverage for stored part, and secondary containment for fluid storage area) are examples of measures specifically designed to help eliminate or reduce the exposure of pollutant sources to storm water, but yield little apparent tangible benefits for daily operational activities. Only a few facilities successfully implemented these BMPs. More often than not, dismantling activities were conducted outside in an open space, even when a designated roofed area (with three-sided walls) was provided. Staff noticed that one deterrent was the

Table 7. BMP Performance Observed at the Nine Case Study Auto Dismantling Facilities

Activity/ Pollutant Source	Applicable BMPs	BMP Rating[a]								
		A	B	C	D	E	F	G	H	I
Dismantling (includes fluid draining)	Conduct Activity on Impervious area	3	3	3	3	3	3	3	3	0
	Provide overhead cover	1	0	2	0	0	2	0	0	0
	Use drip pan	2	2	3	N/O	N/O	3	1	0	N/O
Parts storage (batteries excluded)	Provide permanent or temporary cover	1	0	2	1	1	2	0	0	3
	Drain most fluids prior to storage	1	2	2	2	2	3	1	1	3
	Store parts off-ground	1	1	2	2	2	3	1	2	3
Battery storage	Remove from vehicle	2	3	3	3	3	3	3	3	3
	Provide 2°containment and cover	2	1	3	3	3	2	0	3	3
Fluid management	Under cover;	1	2	3	3	2	0	0	3	3
	2°containment	1	1	0	0	0	0	3	3	3
Parts Washing/ Cleaning	Indoors or in a covered area	3	0	N/O	0	2	3	2	N/A	2
	Contain wash-water	3	0	N/O	2	2	3	2	N/A	3
Spills/leaks	Use drip pan	2	1	2	2	2	3	1	1	3
	Maintain adequate supply of absorbent	0	0	3	2	2	3	3	2	3
Vehicle storage	Close hood or cover vehicles with engine or oily parts	0	2	2	2	N/O	3	N/O	0	3
	Remove all oily/greasy parts from vehicle (esp. engine, transmission, etc.)	2	3	2	3	3	3	2	0	3
Erosion Potential	Pave entire site	2	3	3	3	3	3	3	3	0
	Use erosion control such as bales of hay or berms (or gravel)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Waste fluid handling	Use appropriate disposal method	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O
Auto compaction	Designated area/pre-drain fluids	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A
General	Good housekeeping practices	1	1	2	2	2	3	0	2	3
General	Employee training (documented)	0	0	0	0	2	2	0	3	1
General	Inspection (documented)	2	2	2	2	2	2	1	3	2
General	Recordkeeping (copy of GISP, SWPPP, MP, Annual Reports, monitoring records)	1	1	2	1	3	3	1	3	1
General	Storm water treatment	0	0	0	0	2	0	0	2	0
Overall BMP Score		31	27	39	35	38	48	26	34	46

[a] For BMP implementation rating, 0=Not implemented; 1= Poorly implemented; 2= Somewhat poorly implemented; 3= adequately implemented, N/A= not applicable, N/O= Not observed during site inspection.
[b] An overall BMP score is the sum of individual BMP ratings. Two BMPs that were excluded when calculating an overall BMP rating scores. The two BMPs are related to auto compaction activities and recordkeeping activities. Auto compaction-related BMP was left out because eight out of the nine case study facilities did not perform auto compaction and to consider this BMP would necessarily bias the results against the eight facilities. Recordkeeping has a definite indirect contribution toward the successful implementation of a facility's storm water program, but was not included because it is an administrative procedure and in itself does not result in pollution prevention.

insufficient overhead and work space that restricted the movement or the maneuvering of employees during dismantling activities or imposed limitations in forklift-aided transfer of vehicles to and from the designated area. These limitations could have been avoided with a more careful strategic planning of the BMP, that considers adequate work space.

Some BMPs were not implemented by many facilities because of the effort involved in consistently implementing the BMP and other factors. These BMPs include covering parts during storm events and the use of absorbents to control spills. For example, most facilities cited in their SWPPPs that plastic sheets, tarpaulins, or other types of temporary covers would be used to shield vehicle parts from rain. The use of plastic sheets or tarpaulins involves minimal cost for material acquisition but is beset by the following difficulties: (1) unless secured appropriately, tarps or plastic sheets tend to be blown away by wind and provide minimal protection from rain, if any; (2) providing temporary covers depends entirely on the effort of facility employees and are less likely to be implemented consistently and completely, especially under severe storm conditions or if a storm event starts before or after normal business hours; and (3) some facility operators cited other factors, such as tarps placed over the parts storage areas disappearing over night, most likely claimed by itinerant individuals or children in the neighborhood. Given these limitations associated with using temporary covers, facility operators should be strongly encouraged to install permanent roofs or an overhead coverage to effectively reduce exposure of stored parts to precipitation. Another BMP shown to be inconsistently implemented is the use of absorbents to control spills and leaks. Supply maintenance and timely responses are especially crucial for spill-related BMPs. Many case study facilities were deficient in implementing their spill control measures, judging by the degree of spills, leaks, and stains from past spills present on the facility ground. Failure to maintain an adequate supply of spill absorbents on site, the diligent effort required to address small frequent spills, and the lack of urgency that small spills pose compared to large-scale spills are some reasons cited by facility employees for their failure to provide spill control and response measures mentioned in the facility's SWPPPs. Instead of providing immediate attention, many facility employees delayed spill clean-up activities until the end of the business day.

Several major sources contributing oil and grease in storm water runoff were visually identified during the site inspections. Qualitatively judging from the rainbow-colored sheen floating on top of the storm water runoff, failing secondary containment, such as leaky truckbeds used to store incompletely drained parts, fluid-storage areas missing adequate secondary containment or overhead covers, unprotected dismantling areas, and auto compaction location appeared to be the principal sources introducing high levels of oil and grease into storm water from the case study facilities. All of these sources represent areas associated with principal industrial activities.

A recommendation based on these site inspection observations is to provide both an overhead coverage and an adequate (secondary) containment for areas associated with principal industrial activities. Conducting all activities inside a building or roofed, bermed (or curbed) areas would really help minimize or eliminate the introduction of pollutants into storm water runoff. To maximize the usefulness of these structural BMPs, adequate working space and overhead room are two critical factors that need to be considered in the planning stage of these BMPs. There are BMPs such as storing well-drained parts in large autobodies (as observed at Facility I) that allows facility operators to use materials readily available onsite and does not necessitate building a structure. However, this type of BMP, to be effectively implemented, requires extra effort and vigilance on the part of the facility staff (and are thus less likely to be implemented successfully) since parts must be thoroughly drained prior to being placed inside the autobodies, as opposed to parts stored in bermed areas which prevent runoff of residual fluids. Some specific measures to protect the fluid storage areas that have been shown to be effective in the field include a combination of providing an overhead roof or a clean solid board (placed on top of fluid-storing drums) along with the use of sealed, flat-bottom truckbeds, berms, or a secondary drum large enough to fit another drum inside. Secondary drums should preferably be filled with sand or other spill absorbent material, and sufficiently large and low enough so that the inner fluid-containing drum could easily be transported in and out using a forklift.

The primary cause of significant spills observed during auto compaction is incomplete draining of fluids from parts that remain on the vehicles. Facility H, the only case study facility that conducted auto compaction activities, removed most cores (unwanted parts) prior to vehicle compaction after customers had a chance to claim the desired parts. Based on the substantial spills observed during its auto compaction process, the facility apparently had neglected to completely drain residual fluids from the parts remaining on the vehicles, causing fluids to jet out well beyond the surrounding berm during the compaction process. Complete fluid draining upon vehicle arrival is crucial to preventing spills generated during vehicle staging or compaction process.

Many BMPs must be implemented in combination with other BMPs to be effective. A set of BMPs that appears to be especially effective when implemented together is secondary containment and overhead coverage as mentioned above. Overhead coverage helps to eliminate the exposure of pollutants to storm water runoff but not for spills traveling away from, for example, a roofed fluid-storage area. Similarly, severe storms could flood uncovered, bermed areas and introduce pollutants to storm water runoff. When combined, these BMPs could effectively reduce pollutant contact with storm water. Few facilities provided both of these BMPs for the same source area.

Other BMPs implemented by the case study facilities (storing parts off-ground or removing greasy parts from vehicles) by themselves offer minimal or limited pollution control. For example, mounting partially-drained parts or fluid-storing drums on wooden pallets could appear to reduce contact with storm water runoff; however, spills and leaks generated during parts or fluid transfer typically flow over the pallets and contaminate the site ground and make contact with storm water. Mounting fluid-storing drums on top of pallets does not help contain spills and leaks and is not a secondary containment measure, contrary to the claims of some facility operators. Even when parts are fully drained before being placed on pallets, they must be provided with adequate cover to minimize exposure to storm water. Site pavement, which is considered as a stand-alone solution to controlling sediment in storm water, could only offer some degree of control of solids in storm water when facilities have poor housekeeping practices. Facility B had the entire site paved, but the level of total suspended solids (TSS) in its storm water samples substantially exceeded the USEPA benchmark for this constituent. In fact, the facility's TSS level was comparable to other case study facilities with partial or almost no site pavement. A potential source of sediment in storm water generated from completely paved sites is soil from vehicle tires or customers' shoes.

Several factors were considered in identifying potential reasons for the varying degree of BMP implementation observed at the nine case study facilities. The number of employees, facility size, and annual vehicle throughput did not appear to correlate well with a facility's ability to effectively implement BMPs for facilities with five or less personnel, of two acres or less, or with yearly vehicle throughput of less than 300. The eight facilities that fell within this category demonstrated significant differences in their BMP implementation efforts. Facility H, with 16,800 annual vehicle throughput and a 13-acre site, provided several environmentally-trained personnel onsite, maintained efficient recordkeeping, offered regular training for all its employees, and provided storm water treatment, including an oil and water separator for a portion of the site's storm water runoff and an adequate supply of excelsior in the primary discharge location. However, because of the small study pool, with only one facility of this caliber, it is difficult to arrive at a conclusion as to whether facilities with greater resources are more likely to fully implement their BMPs and other storm water program requirements. The performance of this facility could very well have been compelled by an aggressive third-party lawsuit launched by a local non-profit environmental organization against the facility in the recent past.

Cultural or language barriers and the lack of public outreach were identified as two potential reasons for the deficient BMP implementation. The different ethnic backgrounds represented among auto dismantlers in Los Angeles County include Armenian, Mexican, Korean, Persian, and Caucasian, with the first two groups representing the dominant ethnic groups in some areas. From phone conversations and discussions from the site inspections, it became apparent that many of the ethnic minorities did not fully understand the GISP instructions and some had trouble following the verbal instructions of staff. This may partially explain the apparent disconnect between the consultant-prepared SWPPPs and the actual implementation of BMPs onsite. Many of the case study facility operators displayed complete ignorance and a sense of apathy about the significance of storm water pollution, and complained about having to pay for the discharge of naturally-occurring storm water, clearly missing the key point that it is the *pollution* in the storm water runoff that they are responsible for.

One of the key findings of this present study based on the staff's site-inspection experiences is that determining onsite compliance can be rather challenging and not very straightforward for both dischargers and regulators. This is especially true for facilities that are not grossly deficient or sloppy in their housekeeping or operational practices. More accurately, if compliance is to be defined to ensure protection of waterbodies and to prohibit contributing to possible excursion of all applicable water quality standards, as is stated in the GISP, the task of accurately assessing compliance becomes even more daunting because of the following three reasons.

First, the GISP does not specify a mandatory, minimum set of BMPs that must be implemented by all permittees or by each industry. The GISP basically states that facility operators should *consider* the different categories of BMPs outlined in the permit and then select and implement appropriate BMPs to attain the Best Available

Technology (BAT) level. However, the permit does not define what the BAT level is or how to demonstrate that the BAT level has been ascertained. Therefore, facility operators belonging to the same industry may choose from a range of different BMPs - either a single, highly effective BMP, such as treatment, or a combination of multiple BMPs whose cumulative impact may be equally effective. The P2 approach with its primary reliance on facility operators to identify and implement site-specific solutions offers flexibility and room for economic considerations. However, it also presents difficulties for those charged with the responsibility of assessing whether the BMPs provided and as implemented are sufficiently adequate to ensure that the facility's storm water discharges are not contributing to or causing exceedances of water quality standards. There is still limited information on the effectiveness of specific BMPs or the cumulative effects of combined BMPs. And to leave this task of compliance determination up to the individual operator's judgement seems to be questionable regulatory policy.

Secondly, there are no numerical effluent limitations in the GISP, with the exception of a small group of facilities specified under USEPA regulations (40 CFR Subchapter N), that could provide a clear, objective standard for compliance for all regulated facilities across industries. In the absence of a quantifiable measure of compliance, site inspections can, at most, point out whether certain BMPs in a facility's SWPPP are being implemented and identify evidence of pollution, including spills and leaks, that could visually indicate a facility's overall BMP effectiveness. However, to be able to link (visual) compliance with water quality impacts, one must come up with a quantifiable or numeric compliance standard based on water quality criteria.

Thirdly, not all BMPs are readily observable, in particular the non-structural ones when the activities targeted are not being performed. Thus, the implementation status of certain BMPs can be difficult to determine for individuals not part of the facility since site inspections provide only a snapshot in time of the facility's performance. Examples of such BMPs include preventative maintenance of equipment (unless records are maintained on file) or if special caution is employed for certain operating procedures.

Clearly, the overall success of a facility's BMP implementation efforts could qualitatively be judged based on the evidence of pollution, such as spills and stains. However, such qualitative assessment necessarily introduces the subjectivity of the observer and is prone to different interpretations about how well the facilities may be complying with the intent and the requirements of the GISP. As the saying goes, "how clean is clean?" Should facilities feel "safe" as long as they provide reasonably adequate housekeeping (but according to whose standard?) and maintain an overall neat appearance, or do they need to make sure their site is meticulous? Are facilities considered to be in compliance as long as the BMPs provided in the SWPPP are being implemented, or would they be penalized for choosing BMPs inadequate for their activities? Of course, the use of a "common sense" approach and close interaction with the regulating agency could help facilities to move forward. However, for all these efforts of the regulators and permittees to pay off or result in substantially improved water quality, there must be some type of clear quantifiable standards of compliance that could be enforced.

In conclusion, BMPs indicated in the SWPPPs were not fully implemented at the nine case study facilities. Some facilities performed their storm water control measures more diligently than others. Individual BMPs are unequally effective in controlling storm water pollution. As expected, areas associated with principal industrial activities appear to be the major contributors of oil and grease, and probably other pollutants as well, and should be provided with appropriate overhead coverage and secondary containment. Structural BMPs must be planned strategically-- taking into account the need for adequate work space and other conditions that would facilitate the daily operational activities-- to be utilized effectively by employees. Awareness of the significance of storm water pollution and the need for pollution controls appeared to be low among many of the facility operators. Language barriers and the lack of field presence of regulators and of timely enforcement actions in the past are some reasons for the lack of compliance observed among auto dismantling facilities. From a regulatory perspective, because each SWPPP is required to be certified by the facility operators under perjury of law, failure to implement the BMPs described in a facility's SWPPP automatically places a facility in violation of the GISP requirements; consequently, all nine facilities were out of compliance since they did not fully implement all the BMPs indicated in their SWPPP.

However, what is troubling is that, in addition to BMPs not being fully implemented, the list of BMPs drawn up by consultants or facility operators may not be sufficient to control the type and the level of pollutants generated from a site. Therefore, the need to provide a clear, verifiable standard for compliance in the permit, either in the form of (or a combination of) a set of minimum or baseline BMPs or numerical effluent limitations, is incumbent upon the regulators to make the compliance assessment process more understandable to both the regulating agency and the regulated community. Lastly, BMPs applicable to the auto dismantling industry that may be considered effective in the field, and BMPs cited in other storm water manuals, are summarized in Appendix C.

So far, we have focused on the compliance status of selected auto dismantling facilities. The next section explores the water quality implications associated with these findings.

CASE STUDY INVESTIGATIONS: STORM WATER SAMPLING & ANALYSIS

This section focuses on the quantitative measurement of P2 efforts - i.e. storm water analytical data. Storm water samples were collected from eight case study facilities between November 1998 and April 1999. (Due to storm water infiltration into the unpaved facility ground, Facility I did not generate any visible runoff during the several storm events that staff visited the site). Except for Facilities A and B where staff obtained samples from two separate storm events, one set of grab samples was collected from each facility. The goal of collecting samples from the case study facilities was to provide a small, well-controlled sampling program to evaluate the following: a) the range of pollutant concentrations in storm water runoff generated from the industry; b) the overall effect of BMPs implemented by different case study facilities; and c) comparison of the agency-monitored data with the self-reported data provided in the Annual Report for some facilities. Using the USEPA benchmark values as a reference, this study evaluated the levels of pollutants in storm water runoff from eight of the nine case study facilities. This section also provides a trend analysis of pollutant levels in storm water runoff reported over several years by one facility. The storm water analytical data for the eight case study facilities are presented in Table 8. The first column of Table 8 lists the constituents analyzed (auto dismantling facilities in the Los Angeles region must analyze for all constituents listed, except for iron and aluminum; facilities in most other regions in California are required to analyze for iron and aluminum and not copper and zinc.). The last column provides the USEPA benchmark values for the corresponding constituents for reference purposes.

Table 8. Storm Water Analytical Results for Eight Case Study Auto Dismantling Facilities[1]

(Los Angeles County, 1998/99)

CONSTITUENT	EPA Method	Reporting Limit	FACILITY										USEPA Benchmark Level[3]
			A1[2] 2/9/99[5]	**A[2]** 4/11/99	**B1[2]** 2/9/99	**B2[2]** 4/11/99	**C** 2/9/99	**D** 4/6/99	**E** 2/9/99	**F** 3/25/99	**G** 4/6/99	**H** 3/25/99	
pH	150.1	0.1	7.7	7.6	9	7.9	7.4	7.2	7.3	6.8	6.2	8.0	**6-9**
Total Suspended Solids (mg/L)	160.2	10	81	292	210	183	86	83	38	40	70	202	**100**
Specific Conductance (µmho/cm)	120.1	20	248	271	334	217	264	226	39	79	89	395	**200**
Oil & Grease (mg/L)	413.1	1	62	73	22	11	25	11	12	18	11	65	**15**
Copper (µg/L)	G/F[4]	10/50	259	204	134	67	157	128	106	79	92	238	**63.6**
Lead (µg/L)	G/F	10/200	70	51	284	187	104	153	96	62	35	69	**81.6**
Zinc (µg/L)	F	50	400	507	754	766	456	659	362	539	509	330	**117**
Aluminum (mg/L)	G/F	10/1000	812	< 1000	2032	< 1000	867	< 1000	837	< 1000	< 1000	3090	**750**
Iron (mg/L)	F	100	1170	1140	3440	1100	1320	890	1285	320	590	2800	**1000**

[1] Grab samples of storm water runoff were collected from eight auto dismantling facilities in the San Gabriel River and the Los Angeles River watersheds
[2] For Facilities A and B, staff collected samples from two storm events.
[3] The Parameter Benchmark Values are from the USEPA Multi-sector Permit (USEPA 1995)
[4] G= graphite method, F= flame method.
[5] Indicates sample collection date.

None of the facilities successfully met the USEPA benchmarks for all constituents analyzed. This is not surprising since the median and the mean pollutant concentrations estimated based on past monitoring data submitted by auto dismantling facilities in their Annual Reports (from 1995/96 to 1997/98) generally exceeded the benchmark values (Appendix D). Shading in Table 8 represent excursions of the benchmark levels. Except for pH, benchmark values for all the other constituents analyzed were exceeded by at least one case study facility. Two constituents that appeared to present the most challenge for the case study facilities were copper and zinc, as demonstrated by the fact that none of the facilities were able to achieve the benchmark levels specified for those constituents. Benchmark levels for specific conductance, oil & grease, aluminum, and iron were exceeded by five (not necessarily the same) facilities (aluminum and iron are not required to be monitored by this industry). Three and four excursions of the benchmark levels were noted for TSS and lead, respectively. Facilities, E and F, whose analytical data indicated relatively lower pollutant concentrations overall, are two facilities which appeared more organized and had signs of good housekeeping practices.

Storm water analytical monitoring data demonstrated a substantial degree of variability between facilities, storm events, and sampling events. For the eight case study facilities, pollutant concentrations or measurements varied by more than a factor of seven for TSS, ten for specific conductance (SC), six for oil & grease (O&G), four for copper (Cu), ten for iron (Fe), eight for lead (Pb), and two for zinc (Zn). The lows and highs in the pollutant concentration range were: 6.8 and 9.0 for pH, 38 and 292 (mg/L) for TSS, 39 and 395 (μmho/com) for specific conductance, 11 and 73 (mg/L) for oil & grease, 812 and 3090 (μg/L) for aluminum, 67 and 259 (μg/L) for copper, 320 and 1170 (μg/L) for iron, 35 and 284 (μg/L) for lead, and 330 and 766 (μg/L) for zinc (some results for aluminum reported as < 1000 μg/L could be less than 812.).

Some interesting trends were observed in the self-monitored storm water analytical data (reported by the case study facilities) for samples collected over multiple years, for a given wet season, and on the same day. Figures 4 through 10, which evaluated the data reported by Facility H for the period between 1993 to 1999, clearly demonstrate the stochastic nature of storm water runoff. No clear increasing or decreasing trend in pollutant concentrations over time is recognized.

An analysis involving five sets of data generated by Facility H for the 1998/99 wet season demonstrated that the highs and the lows in pollutant concentrations of storm water from one facility could vary substantially for a given wet season: by more than a factor of seven for TSS, two for specific conductance, five for oil & grease, three for lead, twelve for aluminum, four for iron, and two for chemical oxygen demand (Facility H had submitted five sets of data for the wet year 1998/99). Again, no consistent trend of increase or decrease was observed in the data set spanning one wet season.

Table 9. Comparison of Pollutant Concentrations in Storm Water Samples Collected on Same Day by Different Individuals for Two Case Study Auto Dismantling Facilities.

Constituents	Facility B (sampled on 2/9/99)		Facility H (sampled on 3/25/99)	
	Facility	Staff	Facility	Staff
pH	9	9	7.42	8
TSS (mg/L)	100	210	183	202
SC (μmho/cm)	160	334	487	395
O&G (mg/L)	9	22	17	65
Pb (mg/L)	0.085	0.284	0.1	0.069
Cu (mg/L)	0.44	0.134	0.21	0.238
Zn (mg/L)	0.3	0.754	0.28	0.33
Al (mg/L)	N/A	N/A	0.21	3.09
Fe (mg/L)	N/A	N/A	4.8	2.8

We evaluated two sites (Facilities B and H) where the facility operator and our staff collected the storm water samples on the same day to determine the extent of variation in pollutant concentrations for samples collected on the same day. Table 9 compares the analytical data reported by the facility versus agency staff. Analytical results on Facilities B and H demonstrated that storm water samples taken on the same day by different individuals, in this case by RWQCB staff and by facility personnel, can display quite different results. Facility H's data (where staff collected samples immediately after a facility employees completed his sampling for the facility) indicated that the reported concentration for the following five constituents (TSS, specific conductance, oil & grease, lead,

Figure 4. Total Suspended Solids in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1993 ~ 1999)

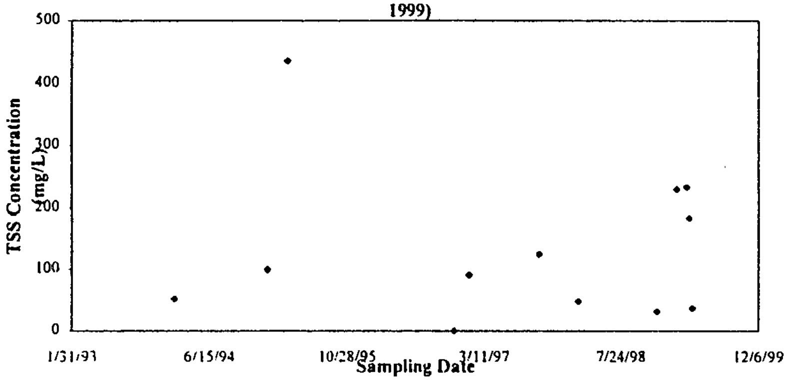

Figure 5. Specific Conductance in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park; Self-reported data for 1993 ~ 1999)

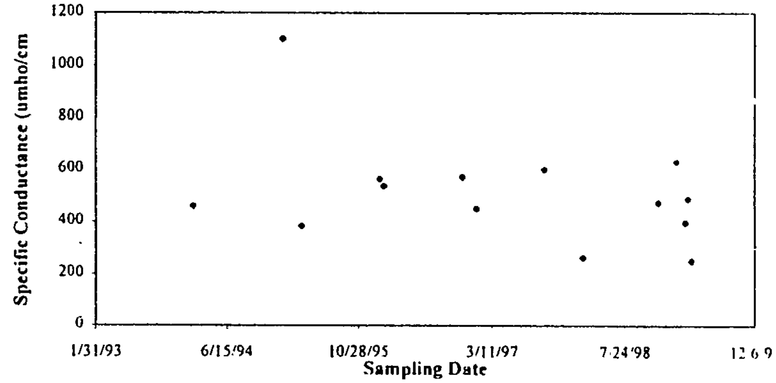

Figure 6. Oil & Grease in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1992 ~ 1999)

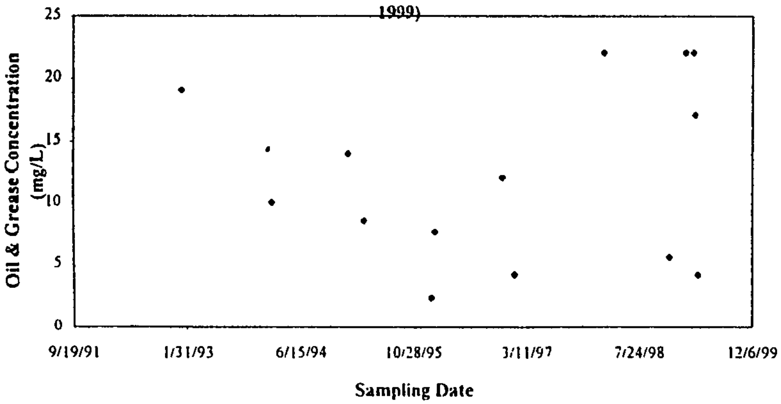

Figure 7. Lead in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

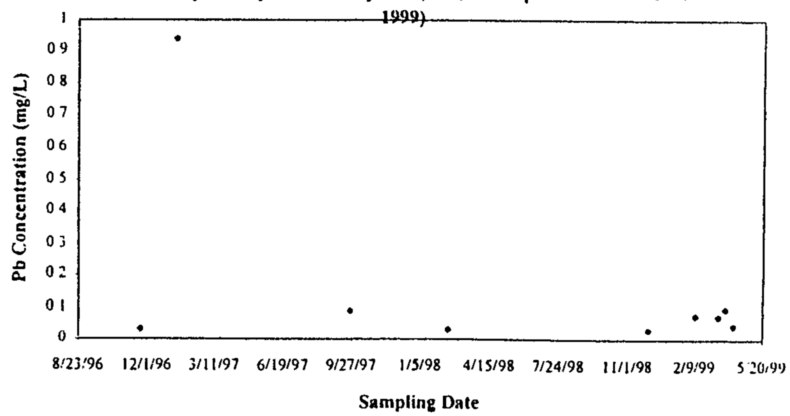

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Figure 8. Copper in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

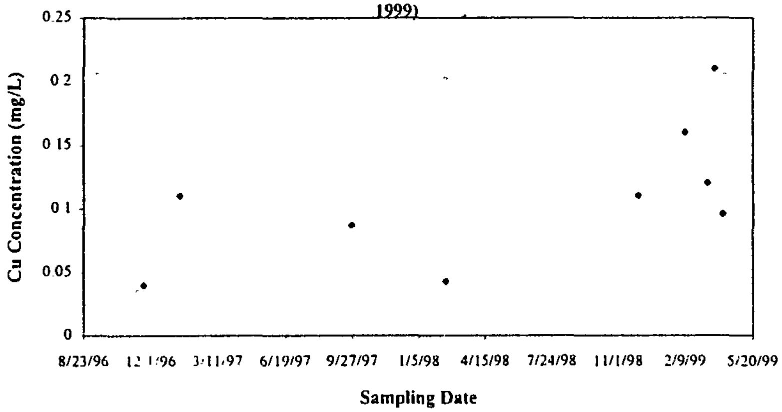


Figure 9. Zinc in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1996 ~ 1999)

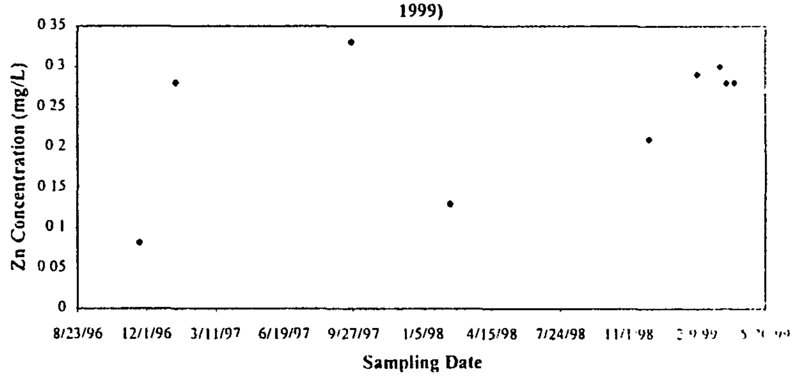
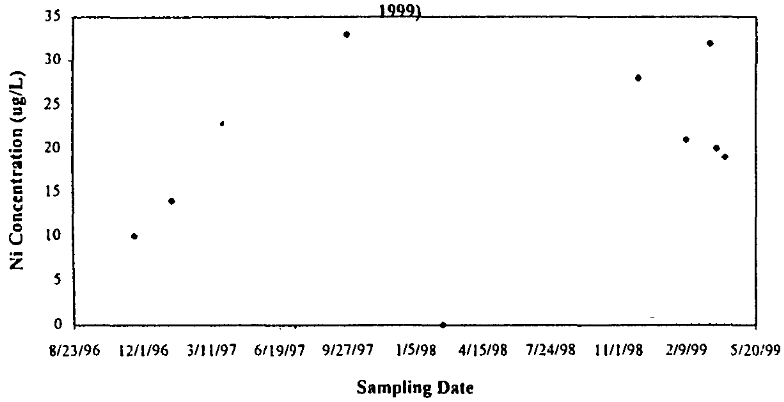


Figure 10. Nickel in Storm Water Runoff from an Auto Dismantling Facility

(Case Study Facility H; Monterey Park, CA; Self-reported data for 1993 ~ 1999)



copper, and zinc) differed by at least 20% and up to 1400% between the two sets of data, with the most significant differences observed for oil & grease (280%), and for aluminum (1400%). An interesting trend observed with Facility B's data was that for five out of the six constituents (TSS, specific conductance, oil & grease, lead, and zinc) agency-generated data were higher than the facility's self-reported data by at least 100% and up to 230%. This suggests that perhaps different sampling strategies -- agency staff attempted to capture storm water runoff with a visible oily sheen -- could produce substantially different results, even for a same-day sampling.

One of the goals of storm water sampling at the case study facilities was to provide a well-controlled sampling environment with an adequate QA/QC necessary to generate reliable data that could be used to relate meaningfully the effects of BMPs on water quality. Two methods were used to relate BMP implementation to pollutant concentrations in storm water runoff. The first method attempted to evaluate the overall BMP implementation scores of each facility, derived based on a systematic rating system, in the context of storm water concentrations. The second method used the overall site appearance or impression as a qualitative indicator of the relative concentration of pollutants in storm water runoff.

With the first method, we tested for both linearity (r) and causality (r^2) between BMP implementation and storm water concentration by plotting for each constituent the pollutant concentration against the overall BMP score of each facility (The overall BMP scores are presented in Table 7.) The r and r^2 values were all less than 0.5 and 0.25, respectively. This implies that a mathematical relationship of the type employed in this study may not be a suitable method for relating the effects of BMPs with the runoff quality, based on the results of our case study. Possible reasons that a clear relationship between overall BMP score and the pollutant concentrations were not observed include:

- the chosen method does not take into account the degree of effectiveness of individual BMPs (this study rated the BMPs only on how completely or satisfactorily each BMP was implemented at the facilities, and summed the ratings to obtain an overall BMP score. This is essentially equivalent to assuming that all BMPs are equally effective and assigining them equal weights);

- site-specific factors, such as annual vehicle throughput; when the last batch of vehicles arrived and were dismantled; how many storm events preceded the sampling activity; and the time lapsed between the start of a rain and a sampling event, and rainfall intensity, are not considered by the above method.

It should be noted that due to the short duration of storm events and the lack of staff to cover all eight case study facilities at the same time, sampling was collected over three separate events between February and April of 1999. The inspections were performed between November of 1998 and April of 1999.

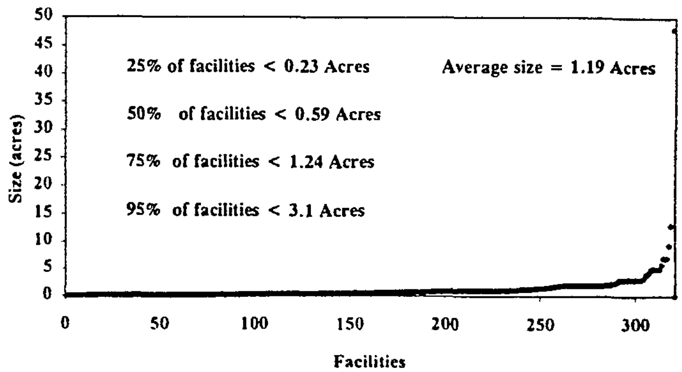
The overall site appearance or evidence of diligent implementation of good housekeeping practices seems to be a useful indicator of the relative pollutant levels between sites with similar facility size, annual throughput, and operational activities. Generally, case study facilities that were organized and clean showed relatively lower

Table 10. Geographical Distribution and Average Size of Auto Dismantling Facilities in Individual Watersheds in Los Angeles County.

Watershed	Estimated number of auto dismantling facilities	Average facility size (acres)	Estimated total source area (acres)
Los Angeles River	234 (57.8%)	1.215	284 (63%)
Dominguez Channel	103 (25.4%)	0937	96 (21%)
San Gabriel River	63 (15.6%)	1.06	67 (15%)
Santa Clara River	2 (0.6%)	1.31	3.2 (0.7%)
Santa Monica Bay	2 (0.6%)	0.2	0.4 (0.08%)
Total Source Area	404	1.12*	450

*county average

Figure 11. Size Distribution of Auto Dismantler Facilities in Los Angeles County



San Gabriel watershed; and 0.6% each in the Santa Clara River watershed and the Santa Monica Bay watershed. Figure 11 shows the size distribution of auto dismantling facilities in Los Angeles County. The County average is 1.2 acres, with 90% of the facilities under 3 acres.

Pollutant loads from the auto dismantling industry were estimated for the 1998 - 1999 storm year for the three watersheds with the highest number of auto dismantling facilities - Los Angeles River, San Gabriel River, and Dominguez Channel. Loads were calculated for TSS, oil & grease, copper, lead, and zinc. Table 11 presents the load estimates and information on parameters used to arrive at the estimates, such as average pollutant concentration, annual precipitation and runoff, and area within each watershed occupied by auto dismantling facilities. The total approximate loads for all of Los Angeles County contributed by the auto dismantling industry are: 22,400 lbs. of TSS, 4,650 lbs. of oil & grease, 35 lbs. of copper, 22 lbs. of lead, and 130 lbs. of zinc. These estimates may be slightly lower than for a typical wet season because the 1998/99 wet season was impacted by the La Niña phenomenon and had less-than-average

Table 11. Pollutant Load per Watershed Contributed by Auto Dismantling Industry in Los Angeles County based on the 1998/99 Wet Year (pounds/acre/year) [1]

Watershed	P[2] (in)	Pj[3]	TSS 116.3 mg/L[4]	O&G 28.4 mg/L	Cu 142 ug/L	Pb 103 ug/L	Zn 508 ug/L
Los Angeles River (284 Acres)	9.72[5]	0.72	22,950	5,600	30	20	100
Dominguez Channel (96 Acres)	4.71[6]	0.67	3,480	850	4	3	15
San Gabriel River (67 Acres)	7.48[7]	0.72	4,140	1,010	5	4	18
Total			30,570	7,460	40	30	130

[1] Based on average site imperviousness value of 43%. Rainfall data for the 1998/99 wet year (Oct. - Oct.) was obtained for specific reference sites within each watershed from the Los Angeles County, Department of Public Works, Hydrology Division.
[2] P is annual precipitation in inches per year.
[3] Pj is fraction of rainfall events that produce pollutants in runoff. Pj was calculated using an assumption that the threshold rainfall greater than 0.1 inches is needed to produce runoff.
[4] Average pollutant concentrations were estimated based on the storm water analytical data on the grab samples collected by RWQCB staff from the eight case study auto dismantling facilities.
[5] Rainfall data from the monitoring stations near Downtown Los Angeles and Sun Valley.
[6] Rainfall data from the monitoring station near Wilmington.
[7] Rainfall data from the monitoring station near Duarte.

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precipitation On a watershed level, the Los Angeles River was the single most impacted waterbody, receiving the majority of the load. The San Gabriel River watershed, which has a smaller total "source" area than Dominguez Channel watershed, was characterized with a higher load due to the greater total precipitation and runoff experienced in the San Gabriel watershed area. Although not presented in Table 10, the loads from the auto dismantling facilities in the Santa Monica Bay watershed and the Santa Clara River watersheds are negligible given the fact that each watershed only had two known auto dismantling businesses within its respective area.

The load introduced by the auto dismantling industry to surface waters is significant. On a weight basis, the pollutant associated with the highest load by weight is TSS, followed by oil & grease, zinc, lead and copper. The estimates presented in this study may be improved by using flow-weighted composite data for pollutant concentration, accounting for the variability in the rainfall patterns within specific watersheds, and by using a more accurate estimate of the total universe of facilities that accounts for facilities that both the RWQCB and DMV failed to capture. For a more meaningful load analysis, the estimates should be evaluated in the context of loads generated from other major industrial sources, a task that lies outside the scope of this study.

CONSIDERATION OF OTHER APPROACHES TO STORM WATER POLLUTION CONTROL

The question of how compliance should be defined to protect water quality and beneficial uses of the receiving waterbody is an important one. The pollution prevention approach, as currently designed, lacks a clear, uniform standard for measuring compliance, and may require more resources than traditional (individual) NPDES to adequately monitor for compliance. An objective quantitative or measurable standard of compliance is also necessary for equitable and consistent enforcement. Two alternatives other than the current P2 approach are considered in this section. One alternative is to define compliance in terms of numerical effluent limitations. This approach is consistent with the traditional or individual NPDES permitting approach. Establishing numerical effluent limitations would help facility operators to determine whether the facility is indeed achieving the limits, and if not, how much the facility needs to ratchet down its pollutant levels to return to compliance. This simplifies compliance assessment for both regulators and the regulated community and provides a clear basis for enforcement actions. If feasible, numerical effluent limitations should be developed based on water quality criteria that are protective of beneficial uses. This would ensure that facilities, by meeting the established limitations, are not contributing to or causing exceedances of applicable water quality standards.

Another alternative is to prescribe a set of minimum, mandatory baseline BMPs for each industry. Compliance would be determined primarily by the effective and diligent implementation of these selected BMPs. To facilitate the compliance determination process, a minimum set of BMPs should consist of measures that are readily observable. This option limits the flexibility offered by the P2 approach that allows facility operators the freedom to choose from a wide range of BMPs and to tailor the BMPs to the facility's site and economic conditions. In addition to Appendix C and the sources cited for Appendix C, the list of BMPs compiled for the cooperative compliance program of Wisconsin is another comprehensive source of information on BMPs for the auto dismantling industry (KES 1999; CCP/DNR 1999)

This study recommends the following tiered approach for the auto dismantling industry that combines the core of the two alternatives outlined above: 1) a mandatory set of specific, baseline structural and non-structural BMPs for facilities with annual vehicle throughput of less than 500 (which represent "mom-and-pop" facilities); and 2) mandatory treatment of storm water for facilities with annual vehicle throughput greater than 500. Also, in lieu of requiring treatment, numerical effluent limitations could be applied to the latter group as a standard of compliance. A compliance schedule could help phase facilities into compliance over a certain specified time frame. Facilities with less than 500 annual vehicle throughput that persistently demonstrate problems in meeting certain water quality standards, for example the USEPA benchmark levels, should also be considered for mandatory storm water treatment.

Lack of sufficient resources has been identified as the primary reason for the limited compliance assurance and enforcement activities by the RWQCB. One way to help effectively implement the above recommended strategy and at the same time, reduce the workload associated with compliance assessment and assurance activities is to employ a semi-privatized certification program, such as that implemented in the State of Wisconsin, which relies on licensed, private inspectors to oversee the compliance activities of a group of facilities that voluntarily choose to participate and help fund the program. The aim of such a program is to help reduce some of the workload of the regulators and to allow facilities that diligently work toward and maintain a specified level of compliance to be certified for compliance by professional inspectors. Such certification could potentially shield them from certain regulatory responsibilities, such as monitoring activities, and indirectly from third-party lawsuits by reducing the degree of their environmental liability. (Essential to the implementation of this type of program is regular training and (re-)certification of inspectors by the regulating agency to maintain high QA/QC for the inspection procedures.)

V. CONCLUSIONS/RECOMMENDATIONS

Several conclusions can be drawn from the findings of this study. Compliance, in general, appears to be limited or low among the auto dismantling facilities in Los Angeles County, for all three tiers of the GISP requirements. Analyses based on site visits results and DMV dismantling license information showed that about one out of every five auto dismantling facilities operating in Los Angeles County are non-filers. Compliance with the annual reporting and SWPPP and written monitoring program requirements is also limited. Review of the 1997/98 Annual Reports revealed that many of the required facilities failed to conduct the key monitoring activities, such as storm water sampling and analysis, limiting the usefulness of the Annual Reports as a tool to gauge overall permittee performance. SWPPPs and written monitoring programs, due to their generally poor quality, fail to effectively guide facility operators in their P2 efforts and in proper monitoring procedures. Accelerated enforcement activities have proven to be effective for increasing the Annual Report submittal rate. Outreach to consultants is strongly recommended to upgrade or improve the quality of SWPPPs and written monitoring programs being prepared by third parties.

The GISP program has not effectively penetrated the auto dismantling industry in terms of compelling the kinds of behavioral changes needed to effectively control storm water pollution and to improve water quality. Case study investigations indicated that the selected facilities failed to select and implement appropriate BMPs to attain the USEPA benchmark levels. Pollutant load estimates based on this industry show that the magnitude of the load could be substantial. These findings imply that the current approach based on P2 and the primary reliance on facility operators to identify and implement appropriate BMPs, without establishing enforceable numerical effluent limitations, has not been shown to be effective, at least at the level currently implemented, in controlling storm water runoff from the auto dismantling industry. Past studies on other industries, including the metal plating and transportation sectors, support some of the findings and conclusions of this study (Duke and. Shaver 1999; Duke et al 1999a; Duke et al 1999b; Duke et al 1998; Duke and Bauersachs 1998; Duke et al 1998; Duke and Beswick 1997; and Duke and Chung 1996).

The lack of a clear, objective standard for compliance could pose a special challenge to dischargers when trying to determine if the existing BMPs are sufficient or need to be upgraded or supplemented with additional BMPs. The majority of the storm water analytical data from the eight case study facilities and the self-reported data provided by auto dismantling facilities in the past substantially exceeded the USEPA benchmark values. The GISP program, as currently implemented and enforced, appears to be not attaining the potential pollution reduction achievable as envisioned. For this reason, this study considered different regulatory alternatives to control industrial storm water pollution. This study recommends a tiered approach that offers different combinations of options -- including implementation of a set of minimum required BMPs, mandatory storm water treatment, or applying numerical effluent limitations -- based on each facility's annual vehicle throughput quantity.

Until now, the GISP program at the Los Angeles RWQCB has exhausted most of its resources for determining and enforcing against violators of the first and second tier compliance. In reality, it is the onsite implementation that actually achieves pollution prevention or reduction. Therefore, more resources should be allocated to assess and verify field compliance. Increase in compliance assurance activities and timely comprehensive enforcement activities would improve overall compliance. This study suggests a possible solution -- a semi-privatized compliance certification program -- that could substantially reduce regulators' workload and allow them to focus on high-risk sectors or facilities to more effectively regulate and control storm water pollution associated with industrial activities.

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Appendix A (cont'd)

MONITORING PROGRAM	Not Applicable	Included	Not Included	Incomplete	Comments
Quarterly Non-Storm Water Discharge Visual Observations (B.3)					
Observations to be conducted (B.3.c) (Jan-March, April-June, July-September, October-December)					
All drainage areas (B.3.a)					
Look for presence of unauthorized NSWDs (B.3.a)					
Observe authorized NSWDs (B.3.b)					
Maintain observation records (B.3.d)					
Storm Water Discharge Visual Observations (B.4)					
Once per month during wet season (B.4.a) (October 1-May 31)					
Observe during first hour of discharge (B.4.a)					
All drainage areas (B.4.a)					
Observe stored or contained (B.4.a) storm water at time of discharge					
Preceded by three working days dry weather (B.4.c)					
Document discharge characteristics (B.4.c)					
Sampling and Analysis					
Samples to be collected during first hour of discharge (B.5.a)					
Sample from first storm of the wet season (B.5.a)					
Sample from one additional storm during wet season (B.5.a)					
Samples collected from all discharge locations (B.5.a)					
Sampling of contained storm water (B.5.a) at time of discharge					
Sampling preceded by at least (B.5.b) three working days without storm water discharges					
Sampling for pH, TSS, SC, TOC or O&G (B.5.c.i)					
Sampling for toxic chemicals and other pollutants likely present in storm water discharges in significant quantities (B.5.c.ii)					
Other analytical parameters listed in Table D (B.5.c.iii)					
Storm Water Effluent Limitation Guidelines parameters (B.6)					
Description of sampling locations (B.7)					
Description of sampling methods (B.10)					
Identification of analytical methods (B.10.b) and method detection limits					
Retention of all records for at least five years (B.13)					
Annual Report to be submitted by July 1 each year (B.14)					

General Comments: ______________________________

Appendix B. Summary of Site Inspection Results : Verification of Facility-specific Activities and BMPs

Type of Activity/ Pollutant source	Activity or pollutant sources present onsite?[1]									Applicable BMPs	BMP Indicated in Facility's SWPPP?									Level at Which BMP Implemented at Facility[2]								
	A	B	C	D	E	F	G	H	I		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Dismantling (includes fluid draining)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Conduct Activity on Impervious area	Y	Y	Y	Y	Y	Y	Y	Y	N	3	3	3	3	3	3	3	3	0
										Provide overhead cover	N	N	Y	N	N	Y	Y	N	N	1	0	2	0	0	2	0	0	0
										Use drip pan	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	2	3	N/O	N/O	3	1	0	N/O
Parts storage (batteries excluded)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Provide permanent or temporary cover	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	0	2	1	1	2	0	0	3
										Drain most fluids prior to storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	2	2	2	2	3	1	1	3
										Store parts off-ground	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	2	2	3	1	2	3
Battery storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Remove from vehicle	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	3	3	3	3	3	3	3	3
										Provide 2°containment and cover	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	1	3	3	3	2	0	3	3
Fluid management	Y	Y	Y	Y	Y	Y	Y	Y	Y	Under cover;	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	2	3	3	2	0	0	3	3
										2°containment	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	0	0	0	0	3	3	3
Parts Washing/ Cleaning	Y	Y	N/O	Y	Y	Y	Y	N	Y	Indoors or in a covered area	Y	N	N	Y	Y	Y	Y	N/A	Y	3	0	N/O	0	2	3	2	N/A	2
										Contain wash-water	Y	N/A	N/A	Y	Y	Y	Y	N/A	Y	3	0	N/O	2	2	3	2	N/A	3
Spills/leaks*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Use drip pan	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	1	2	2	2	3	1	1	3
										Maintain adequate supply of absorbent	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	0	3	2	2	3	3	2	3
Vehicle storage	Y	Y	Y	Y	Y	Y	Y	Y	Y	Close hood or cover vehicles with engine or oily parts	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	2	2	2	N/O	3	N/O	0	3
										Remove all oily/greasy parts from vehicle (esp. engine, transmission, etc.)	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	3	2	3	3	3	2	0	3
Erosion Potential	Y	N	N	N	N	N	N	N	Y	Pave entire site	N	Y	Y	Y	Y	Y	Y	Y	N	2	3	3	3	3	3	3	3	0
										Use erosion control such as bales of hay or berms (or gravel)	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Waste fluid handling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Use appropriate disposal method	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O
Auto compaction	N	N	N	N	N	N	N	Y	N	Designated area/pre-drain fluids	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A
General										Use erosion control such as bales of hay or berms (or gravel)	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
General										Good housekeeping practices	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	2	2	3	0	2	3
General										Employee training (documented)	Y	Y	Y	Y	Y	Y	Y	Y	Y	0	0	0	0	2	2	0	3	1
General										Inspection (documented)	Y	Y	Y	Y	Y	Y	Y	Y	Y	2	2	2	2	2	2	1	3	2
General										Recordkeeping	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	1	2	1	3	3	1	3	1
General										Storm water treatment	N	N	N	N	Y	N	N	Y	N	0	0	0	0	2	0	0	2	0

[1] Y= yes, N= no; N/A= not applicable.

[2] For BMP implementation rating, 0=Not implemented; 1= Poorly implemented; 2= Somewhat poorly implemented; 3= adequately implemented, N/A= not applicable, N/O= Not observed during site inspection.

Appendix C. Best Management Practices for Auto Dismantling Industry

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Vehicle Dismantling Dismantling Activities	Eliminate exposure	• Roof or cover to eliminate rain-in. Berm area to eliminate storm water run-on. Conduct dismantling work in this designated area. • Place a mat, plastic, or tarpaulin on the ground prior to placing parts on the ground. (Also, if no roof or cover provided over dismantling area, conduct dismantling activities on top of plastic or tarpaulin, which can be readily cleaned or replaced, and removed during storm events). • Drain all fluids (antifreeze/coolant, brake fluid, gasoline/diesel, motor oil, transmission oil) from vehicle prior to dismantling and parts removal. • Use drip pans to drain fluids. Do not overfill . • Drain oil filters before disposal/recycling. • Remove refrigerant prior to dismantling and parts removal. • Deploy airbags per guidelines or remove intact airbags for reuse and store under cover. • Dispose of greasy rags, air filters, spent coolant, and degreasers. • Remove batteries promptly after vehicle arrival. • Remove oil-bearing components prior to storage.
Fluid draining	Eliminate exposure	• Roof or cover to eliminate rain-in. Berm area to eliminate storm water run-on. Remove fluids in this designated area. • Use drip pans for draining vehicular fluid. • Use funnels, and stoppers for the containers. • Avoid discharge of vehicular fluid (as in drips or leaks) on the ground.
Parts Repair/ Wash	Eliminate exposure	• Designate contained areas for repairs and washing (curb, berm or dike area, if necessary. If not feasible, use oleophilic (oil- absorbing) boom bags to prevent washwater from running to the street / curb or other areas of facility.) • Wash parts in a wash- tray provided with secondary containment. • If area not otherwise contained, divert runoff from repair and wash areas with hydrophobic boom bags. • Transfer spent solvent or washwater into designated drums. • Recycle and reuse or release washwaters to sanitary sewer. • Use minimum amounts of solvents or detergents for parts cleaning. • Use water-based cleaning solvents and biodegradable (non-phosphate) detergents. • Wipe and sweep area regularly after activity. Dispose of greasy rags, air filters, spent coolant, and degreasers in appropriate containers.
Storage Vehicles	Eliminate exposure	• Keep vehicle engines covered with hoods or with plastic sheets secured in place. • Store vehicles on an impervious (e.g. concrete) surface (if possible). • Use drip pans under stored vehicles. • Minimize inventory during wet season. • Reduce holding time for scrap disposal.

Appendix C. Best Management Practices for Auto Dismantling Industry (Cont'd)

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Separated components	Eliminate exposure	• Confine to designated area. • Store indoors or under temporary or permanent cover (that sufficiently shields rainfall). • Curb, berm, or dike the area. (If not feasible, then: 1) store parts off-ground, for example on storage racks, with drip pans underneath to collect residual fluids; or 2) store parts in leak-free truck beds or plastic containers; or 3) place parts in auto bodies (intact), especially large-sized vans, which also provide an excellent storage places for parts; 4) divert runoff from scrap storage area with hydrophobic (water resistant) boom bags) • Place tires in semi-trailers, indoors, or covered area. Sell or recycle. • Store scrap parts/metals under cover and dispose of to scrap collector promptly • Divert runoff from scrap storage area with hydrophobic (water resistant) boom bags.
Batteries	Eliminate exposure	• Store batteries in covered storage area, on a paved surface that is bermed, or in plastic containers with lids.
Fluid	Eliminate exposure Improve materials management	• Store fluid containers (e.g. drums) on an impervious surface and under a roofed shed. • Provide secondary containment for the fluid-containing drums. • Keep separate (solvents, oils and fuel) and label accordingly.
Others Recycling	Waste minimization	• Recycle (or resell if possible) anti-freeze, fuel, waste oil, windshield washer and solvents. • Recycle usable recyclable parts. • Recycle tires and core/ scrap metals.
Spill Prevention & Clean-up	Minimize exposure Waste Minimization Contain/ cleanup pollutants	• Employee training (prepare for and clean up spills.) • Prepare a spill clean-up kit (absorbent sand, rags, adsorbent snakes, broom, etc.) and place in convenient readily accessible location. • Drain vehicular fluids at designated removal area. • Use the provided spill- kit to contain leaks or spills immediately. Dispose of properly. (Use oleophilic sands to absorb/contain small leaks, and boom bags for large spills.)
Employee Training	Waste minimization	• Train employees regularly in proper and environmentally safe practices.
Customer Education	Waste minimization	• Inform and require customers who remove parts to do so properly and appropriately dispose of waste (for example, posting signs that require the use of drip pans for parts removal and prohibit waste-generating activities in parking lot can be helpful).
Site Inspection	Good maintenance	• Inspect site regularly to ensure all appropriate BMPs are being implemented.
Preventative maintenance	Prevent pollution/ accidents	• Inspect to ensure integrity of tanks, containers, pipings and valves. Install safeguards against accidental release.

Appendix C. Best Management Practices for Auto Dismantling Industry (Cont'd)

ACTIVITY	PURPOSE	BEST MANAGEMENT PRACTICES (BMPs)
Site Maintenance	Minimize exposure	• Keep site clear of trash and debris. • Regularly remove and sweep sand (used to contain spills), trash or dirt from site. • Collect corrosion/ metal particles with magnet (survey the site with a forklift or small vehicle with magnet attached behind.)
Materials Inventory	Good management	• Maintain proper inventories of vehicles processed, materials stored, and wastes recycled or disposed of.
Site grading	Minimize exposure	• Repave area to direct flows to a low point (away from storage and waste areas) where leaking fluids can be collected.
Recordskeeping	Good management	• Maintain records of inspections, monitoring (including storm water sampling), Annual Reports, and training.
Storm Water Treatment Flow dissipation	Remove Pollutants	• Direct flow discharge over coarse gravel or cobblestones to facilitate settling out of particulates and sediment.
Vegetative belts	Remove Pollutants	• Direct flow discharge over vegetative belts or biofilters to enhance pollutant removal.
Sand/ gravel filters	Remove Pollutants	• Allow storm water from open parts storage areas to pass through sand-gravel filter with drain holes. Sand layer must be periodically replaced.
Detention ponds	Remove Pollutants	• Capture storm water runoff from high activity areas. Skim off surface oil and remove bottom sediment. Reuse or evaporate runoff water.
Oil-grit/ oil-water separator	Remove Pollutants	• Direct flows from high activity areas through OW separators. Off-line separators to bypass large storms are preferable. Maintain regularly.
Flotation/ coagulation	Remove Pollutants	• Store runoff flows, equalize, and provide flotation/ coagulation. High operation and maintenance costs. Inappropriate if used only intermittently.
Industrial sewer piping	Remove Pollutants offsite	• Pretreat as required and pipe to sanitary sewer if allowed (permit likely required).
Oil/grease - absorbents	Remove Pollutants	• Provide oleophilic booms or excelsior near runoff exit. Replace as needed. Dispose of properly.

References:

1. ARA 1997
2. LADPW 1998
3. MPCA 1994.
4. Swamikannu 1994
5. USEPA 1995

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
GOOD HOUSEKEEPING								
General Practices								
Develop a storm water management policy statement for your employees. Management can provide direction and support for pollution prevention by reviewing this policy with employees and keeping it posted.		■	■	■	■	★	★	★
An in-coming vehicle inspection inventory program should include a check for fluid leaks and for unwanted material that could have been placed in the vehicles.		■	●	■	■	★	★	★
Clean up debris and trash on a regular basis.		●	■	■	■	★	●	★
Construct fences or other physical barriers to act as visual and noise barriers, help to control dust, help prevent theft, and control the direction of runoff.		■	■	■	■	■	●	●
Maintain an organized inventory of materials used at the facility.	✔	■	■	■	■	●	●	★
Consider indoor storage of vehicles, parts, and equipment, and the use of berms and/or dikes to control storm water runoff.[1]	✔	●	★	★	●	■	●	■
Vehicle Dismantling Fluid Management								
Remove fluids from vehicles brought into the facility for processing or dismantling.	✔	■	★	■	■	■	■	★
Keep used oil separate from part cleaning solvents, antifreeze, and fuel. Engine oil, transmission fluid, brake fluid, and power steering fluid can be combined and stored together.		■	●	■	●	●	★	★
Label storage containers of all fluids and waste materials.	✔	■	■	■	■	★	★	★
Drain all parts of fluids prior to disposal.	✔	■	★	■	■	●	●	★
Confine the storage of vehicles, parts, and equipment to designated areas.	✔	■	■	■	■	●	●	●

COMMENTS

1 May interfere with operation and access. Indoor storage of vehicles is not appropriate or practical for an automotive recycling facility.

KEY TO THE TABLE

	■	●	★
Ability to Control Pollution	no significant removal	slight (<25%) removal	moderate to high (25%) removal
Initial Cost	>$5,000	$1,000 - $5,000	<$1,000
Operation and Maintenance Cost	>$1,000 / year	$500 - $1,000 / year	<$500 / year
Practicality	usually not practical	sometimes practical	practical for most facilities

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Use canvas or sheets of plastic to temporarily cover storage areas.[2]	✔	●	●	■	■	●	●	●
Transmission and engine cores may be stored in plastic storage boxes with leak proof tops; lugger boxes having solid bottoms and covered by a permanent roof, lugger boxes without a solid bottom stored under a permanent roof on a concrete pad with curbing; or an enclosed trailer with a steel floor to contain fluid runoff and a drain in the floor to properly remove waste fluids.		■	★	■	■	■	●	●
Engine oil should be drained and stored in labeled, doubled-walled, above ground tanks. Used oil can either be recycled for on-site use in a waste oil heater, or sent off-site for re-refining or fuel blending.		■	★	■	■	●	●	★
Antifreeze should be reclaimed and reused or properly disposed of.[3]		■	★	■	■	●	●	★
Drain window washer fluid for reuse.		■	★	■	■	★	★	★
Remove batteries as soon as possible after vehicle enters the yard. Store good batteries inside for resale. Store dead batteries inside on pallets (if your floor is gravel or dirt, put a layer of absorbent material below the pallet) or in storage containers, or store dead batteries outside in a leak proof, covered container.		■	●	●	■	●	●	★
Parts Cleaning								
Perform all parts cleaning operations indoors or cover and berm outside cleaning areas.[4]	✔	■	●	●	★	●	●	★
Clean parts by using minimal amounts of solvents or detergents.		■	●	●	★	●	●	●
Recycle and reuse cleaning fluids where practical.		■	■	■	●	★	★	●
Spent cleaning solutions should be removed by a waste hauler or recycler.		■	■	■	■	★	★	★
Use phosphate-free biodegradable detergents. Consider using detergent-based or water-based cleaning systems in place of organic solvent degreasers.		■	■	■	★	●	●	●
Vehicle Crushing Activities								
Consider providing a containment system—such as a concrete pad with berms—for vehicle crushers. Fluids and storm water runoff from such bermed areas could be discharged into a sump, oil/water separator, sanitary sewer, or other appropriate drainage system that prevents storm water contamination.		■	★	●	■	■	■	●

COMMENTS
2 May interfere with operation and access.
3 May need to check with the state to see if additional requirements are required.
4 May not be feasible or practical for all facilities.

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Ability to Control: Vehicle and Equipment Fluids	Ability to Control: Metals	Ability to Control: Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
If a gravel/geotextile fabric foundation is provided under a crusher, install a fluid collection system to capture fluids that are released during the crushing operation.		■	★	●	■	■	■	●
Capture crusher fluids to prevent spillage. Collect this mixture of fluids in a spill-proof covered container, test the fluid, and dispose of it properly. It should not be allowed to drain onto the ground. Keep the drain within the crusher clear so that the fluids do not collect and overflow from the crusher onto the ground.		■	★	●	■	●	●	●
PREVENTIVE MAINTENANCE								
Develop a preventive maintenance program that involves timely inspections and/or maintenance of the crusher and facility equipment and vehicles. The program may include • Service checklists and maintenance logs for each piece of equipment; • Employee education and instruction material; and • Review of manufacturer-recommended parts replacement and maintenance activities and frequencies.		■	●	■	■	★	●	★
Keep the crusher and other equipment clean by frequently wiping off accumulated oil and grease that may be exposed to storm water (except where needed for proper operation of the equipment) or that may hide equipment trouble spots.		■	●	■	■	★	★	★
Conduct scheduled maintenance of facility equipment and vehicles in a covered or bermed area, where practicable.		■	●	■	■	●	●	●
Schedule periodic inspections of equipment for leaks, spills and malfunctioning, worn, or corroded parts. Regularly inspect tanks, valves, hoses, and containers. Look for signs of wear or weakness.		■	●	■	■	■	●	★
On secondary containment structures, regularly inspect the valve, seals around the outlet pipe, the outlet pipe itself, and the dike for cracks, damage, or leaks.		■	■	■	■	★	★	★
When secondary containment reservoirs require pumping or release, a sample of collected water should be visually inspected or tested for pollutants. If pollutant levels are significant or there is contamination, pump the accumulated water into barrels or into a tanker truck and haul to a wastewater treatment facility.		■	■	■	■	★	●	★
Repair or replace parts before they wear out.		■	●	■	■	★	●	★
Repair malfunctioning equipment that is responsible for any leak or spill as soon as possible.		■	★	■	■	★	●	★

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Secure and lock above ground tank storage areas. Tanks, pumps, fittings, pipes, and containers should be inspected routinely for integrity and leaks.		■	■	■	■	★	★	★
Perform maintenance activities indoors.[5]	✔	■	●	■	■	■	●	●
Valves on secondary containment structures should be kept in the "off" position at all time, except when collected water is being removed.		■	■	■	■	★	★	★
SPILL PREVENTION AND RESPONSE								
Make available MSDS sheets and other safety materials that identify types of fluids that have the potential to spill, indicate whether these fluids are hazardous or toxic, list appropriate safety equipment to be worn, and specify correct materials and procedures to use to clean up the spill.		■	●	■	●	●	★	★
Provide spill clean-up equipment at locations where spills are most likely to occur.		■	●	■	●	●	★	★
Identify clean-up procedures, including the use of dry absorbent materials or other clean-up methods to collect, dispose of, or re-cycle spilled or leaked fluids. Maintain an adequate supply of dry absorbent material on-site. Properly dispose of used absorbent materials.		■	●	■	●	●	★	★
Contain oil or other fluids spilled during parts removal.	✔	■	●	■	■	★	★	★
Never pour liquids or dry materials down a storm drain.		■	★	■	★	★	★	★
Place drip pans, plastic sheets, or canvas tarps beneath vehicles, parts, and equipment during maintenance and dismantling activities. If any parts are removed, they should be placed in a drip pan. Drip pans should not be left unattended.	✔	■	★	■	●	★	★	★
When refueling vehicles and equipment, park as close to the pump as possible. Keep fuel nozzle upright when not in use, and replace nozzle securely in the pump.		■	●	■	■	★	★	★
Pave refueling areas to prevent contamination of the soil if a spill occurs.		■	●	■	■	■	★	●
Equip fuel pumps and tanks with overflow prevention and automatic shut-off devices.		■	★	■	■	●	★	★
Control any spills that may occur around fueling areas.		■	★	■	■	★	★	★

COMMENTS

5 May not be appropriate for certain scheduled maintenance procedures.

COMPARISON OF BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES	Multi-Sector Permit Requires Consideration of These BMPs	Ability to Control: Sediment	Vehicle and Equipment Fluids	Metals	Solvents and Cleaners	Initial Cost	Operation and Maintenance Costs	Practicality
Containers and tanks should be stored on a concrete or impermeable surface, and if feasible, under cover. All containers should be labeled according to content and hazard characteristics. Keep drums containing chemicals away from sumps and drains.[6]		■	★	■	●	■	★	●
Observed spills and leaks should be captured and cleaned up using dry absorbents, drip pans, towels, mops, pads, and booms.	✔	■	★	■	★	★	●	★
Maintain good integrity of all storage containers.		■	★	■	★	★	★	★
Install safeguards (such as diking or berming) against accidental releases at dismantling and storage areas.[7]	✔	■	★	■	■	■	■	★
EROSION AND SEDIMENT CONTROL								
Implement appropriate vegetative, structural, or stabilization measures to limit soil erosion.		★	■	■	■	●	●	●
Regularly sweep and clean paved surfaces to reduce sediment build-up. Sediment should be swept up and placed into a covered, watertight dumpster for proper disposal.[8]		★	■	■	■	●	■	★
Install filtering or diversion practices, such as filter fabric fences, sediment filter booms, earthen or gravel berms, curbing, or equivalent measures.[9]		★	■	■	■	■	●	●
Install sediment traps, vegetative buffer strips, silt fencing, or equivalent measures to remove sediment prior to discharge through an inlet or catch basin.[10]		★	■	■	■	■	●	●
Do not use vehicle fluids, oils, or fuels for dust control or weed control.		■	●	■	■	★	★	★
Establish and maintain a vegetative cover in areas not used for vehicle salvage activities.		★	■	■	■	★	★	★
RUNOFF MANAGEMENT								
Use vegetated swales and buffer strips, catch basin filters, and/or other similar measures to facilitate settling or filtering of pollutants in runoff.[10]		★	●	●	●	■	●	●

COMMENTS

6 Secondary storage inside a building is only recommended when there is a potential for a spilled liquid to flow outside and reach a waterway.

7 This may not be feasible or practical for some facilities.

8 May be labor intensive for some facilities.

9 Filtering measures may not be practical for facilities with unpaved surfaces with large sediment loadings. Filters would become clogged, possibly causing flooding. May be damaged by heavy equipment.

10 May not be practical in many industrial facilities that are storm sewered. May be damaged by heavy equipment.

Appendix D. Comparison of Conventional and Toxic Pollutant Concentrations in Storm Water from Auto Dismantling Facilities in Los Angeles Region [1]

Constituents	EPA Bench-mark[2]	L.A. Regional Board[3] N=8; 1998 -1999			L.A. Regional Board[4] N=24; 1997 - 1998			L.A. Regional Board[4] N=49; 1996 - 1997			L.A. Regional Board[5] 1995 - 1996		
		Mean	Median	95ile	Mean	Median	95ile	Mean	Median	95ile	Mean	Median	95ile
pH	6-9	6.2 (min)	7.3	8.5 (max)	6.15 (min)	7	8.74 (max)	1.81 (min)	6.8	8.9 (max)	5.7 (min)	6.8	7.8 (max)
TSS	100	116	85	210	99	69	304	196	51	479	148	168	294
SC (umho/cm)	200	204	243	355	196	135	518	415	170	1530	262	160	623
O&G	15	28	18	67	N=20 8.7	6.7	20.1	11	7.7	30	39 (N=3)	15	92
TOC	110	N/A	N/A	N/A	N=7 78	110	138	N/A	N/A	N/A	45 (N=12)	32	122
Al	0.75	1.06	0.668	2.53	N=2 1.19	1.19	1.65	N/A	N/A	N/A	N/A	N/A	N/A
Cu	0.0636	0.142	0.132	0.236	0.09	0.093	0.17	0.170	0.17	.245	N/A	N/A	N/A
Fe	1	1.36	1.22	2.71	N=2 2.36	2.19	3.19	N/A	N/A	N/A	N/A	N/A	N/A
Pb	0.0816	0.103	0.083	0.210	0.06	0.035	0.2	0.304	0.267	0.682	0.174 (N=7)	0.15	0.34
Zn	0.117	0.509	0.483	0.725	0.56	0.34	1.9	1.07	0.40	2.75	N/A	N/A	N/A

[1] Data represent grab samples of storm water from auto dismantling facilities collected by facility operators as part of the annual monitoring and reporting requirement or by the Regional Board staff as part of this study.
[2] The benchmark values are from the 1995 USEPA Multi-sector Permit (USPEA 1995).
[3] Represent samples collected by staff from the eight case study facilities.
[4] Represent samples collected by facility operators.
[5] Represent samples collected by group monitoring participants.

Appendix E. Description of Load Estimate Parameters

Each of the parameters in the EPA Simple Method equation were estimated as described below:

Average pollutant concentration, C: Ideally, Flow-weighted composites should be used to estimate load. Given the lack of flow-weighted composite storm water data on the auto dismantling industry reflective of the climatic and precipitation patterns of Southern California, grab sample data generated by staff sampling at the eight case study facilities were used. At this time, the approximate margin of error or uncertainty from using grab sample data instead of flow-weighted composite data is not known.

The total site area, A: For area, A, area occupied per watershed by auto dismantling establishments were estimated by multiplying the following three factors: a) the total number of auto dismantlers in Los Angeles County (404) estimated earlier in this study; b) the proportion of auto dismantling facilities located in each watershed area, determined based on zipcodes of all dismantlers with an active NOI; and c) the average size of auto dismantling facilities located in each watershed. It was assumed that, on average, non-filers are similar to NOI filers in size and in spatial distribution.

Annual rainfall depth, P: Rainfall records for certain parts of Los Angeles County were available from the Los Angeles County Department of Public Works, Hydrology Division (the County). This study chose reference monitoring sites chosen for each watershed with a significant number of auto dismantler establishments. Rainfall pattern could vary substantially even within a watershed. Therefore, it is important to use rainfall data as specific or closest to the source area as possible. The annual rainfall depth was calculated by adding daily rainfall (in inches) reported from October 1998 to September 1999.

Fraction of rainfall events that produce a runoff, Pj: This study used 0.1 inches as the threshold volume required to generate runoff. Pj was calculated by dividing the sum of the adjusted individual rainfall volume (i.e. minus the first 0.1 inches) for the 1998/99 wet season by the annual total rainfall volume. If Pj is known for a given geographical area for a certain wet season or for an extended period (for example 100 years), one could reasonably estimate the total annual runoff (by multiplying $P*P_j$) without the individual rain records as long as the annual total precipitation is known. Since the daily rainfall data were available from the County, we calculated the product P*Pj by simply adding the individual rainfall depth after subtracting 0.1 inch from each rainfall datum.

Site Imperviousness, I: The GISP defines percent imperviousness as the portion of a facility property that is paved, roofed (including buildings), or covered. A single value for imperviousness was derived by normalizing based on area, i.e. by dividing the sum of impervious areas calculated for each facility by the sum of facility size. An average site imperviousness of 43% was estimated for the auto dismantling facilities in Los Angeles County using the self-reported information in the NOI database (This value is significantly less than the 76% imperviousness estimated for light industrial land use in the Los Angeles County's Annual Monitoring Report submitted as a requirement under the municipal storm water program.) A source of uncertainty in this estimate is that facility operators could have misinterpreted the term "imperviousness."

Illicit Discharge Detection and Elimination

Presentation at the EPA *National Storm Water Coordinator's Meeting*, Orlando, FL, May 1-3, 2001

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Abstract

This paper describes procedures that have been used to identify sources of inappropriate ("illicit") discharges in storm drainage systems. Also included is a review of emerging techniques that may also be useful, especially in future years as they become more accessible and become proven technologies. This paper also describes a series of tests where the original methods developed previously for EPA (Pitt, *et al* 1993), along with selected new procedures, were examined using almost 700 stormwater samples collected from telecommunication manholes from throughout the U.S. About ten percent of the samples were estimated to be contaminated with sanitary sewage using these methods, similar to what is expected for most stormwater systems. The original methods are still recommended as the most useful procedure for identifying contamination of storm drainage systems, with the possible addition of specific tests for *E coli* and enterococci and UV absorbance at 228 nm. Most newly emerging methods require exotic equipment and unusual expertise and are therefore not very available, especially at low cost and with fast turn-around times for the analyses. These emerging methods may therefore be more useful for special research projects than for routine screening of storm drainage systems.

The Center for Watershed Protection (CWP) and Dr. Robert Pitt with the University of Alabama are currently being funded by EPA to complete a technical assessment of techniques and methods for identifying and correcting illicit and inappropriate discharges geared towards NPDES Phase II communities. The project has a two year duration. In the first year, most of our effort will be directed to collecting data. The most cost effective and efficient techniques will also be identified during this initial project period. In the second project year, the project team will develop draft guidance on methods and techniques to identify and correct illicit connections, test the efficacy of the draft guidance in four communities, complete a final "User's Manual for Identifying and Correcting Illicit and Inappropriate Discharges," and conduct training and dissemination. This project is expected to start in the summer of 2001.

Introduction

Urban stormwater runoff includes waters from many other sources which find their way into storm drainage systems, besides from precipitation. There are cases where pollutant levels in storm drainage are much higher than they would otherwise be because of excessive amounts of contaminants that are introduced into the storm drainage system by various non-stormwater discharges. Additionally, baseflows (during dry weather) are also common in storm drainage systems. Dry-weather flows and wet-weather flows have been monitored during numerous urban runoff studies. These studies have found that discharges observed at outfalls during dry weather were significantly different from wet-weather discharges and may account for the majority of the annual discharges for some pollutants of concern from the storm drainage system.

There have been numerous methods used to investigate inappropriate discharges to storm drainage systems. Pitt, *et al.* (1993) and Lalor (1994) reviewed many of these procedures and developed a system that municipalities could use for screening outfalls in residential and commercial areas. In these areas, sewage contamination, along with low rate discharges from small businesses (especially laundries, vehicle repair shops, plating shops, etc.) are of primary concern. One of the earliest methods used to identify sewage contamination utilized the ratio of fecal coliform to fecal strep. bacteria. This method is still in use, but unfortunately has proven inaccurate in most urban stormwater applications. The foll[illegible] [illegible] [illegible] reviews the methodology developed by Pitt, *et al.* (1993) and Lalor (1994), and some new approaches that were investigated.

Use of Tracers to Identify Sources of Contamination in Urban Drainage Systems

Investigations designed to determine the contribution of urban stormwater runoff to receiving water quality problems have led to a continuing interest in inappropriate connections to storm drainage systems. Urban stormwater runoff is traditionally defined as that portion of precipitation which drains from city surfaces and flows via natural or man-made drainage systems into receiving waters. In fact, urban stormwater runoff also includes waters from many other sources which find their way into storm drainage systems. Sources of some of this water can be identified and accounted for by examining current National Pollutant Discharge Elimination System (NPDES) permit records for permitted industrial wastewaters that can be legally discharged to the storm drainage system. However, most of the water comes from other sources, including illicit and/or inappropriate entries to the storm drainage system. These entries can account for a significant amount of the pollutants discharged from storm sewerage systems (Pitt and McLean 1986).

Permits for municipal separate storm sewers include a requirement to effectively prohibit problematic non-stormwater discharges, thereby placing emphasis on the elimination of inappropriate connections to urban storm drains. Section 122.26 (d)(1)(iv)(D) of the rule specifically requires an initial screening program to provide means for detecting high levels of pollutants in dry weather flows which should serve as indicators of illicit connections to the storm sewers. To facilitate the application of this rule, the EPA's Office of Research and Development's Storm and Combined Sewer Pollution Control Program and the Environmental Engineering & Technology Demonstration Branch, along with the Office of Water's Nonpoint Source Branch, supported research for the investigation of inappropriate entries to storm drainage systems (Pitt, *et al.* 1993). The approach presented in this research was based on the identification and quantification of clean baseflow and the contaminated components during dry weather. If the relative amounts of potential components are known, then the importance of the dry weather discharge can be determined.

The ideal tracer to identify major flow sources should have the following characteristics:

- Significant difference in concentrations between possible pollutant sources;
- Small variations in concentrations within each likely pollutant source category;
- A conservative behavior (i.e., no significant concentration change due to physical, chemical or biological processes); and,
- Ease of measurement with adequate detection limits, good sensitivity and repeatability.

In order to identify tracers meeting the above criteria, literature characterizing potential inappropriate entries into storm drainage systems was examined. Several case studies which identified procedures used by individual municipalities or regional agencies were also examined.

Selection of Parameters for Identifying Inappropriate Discharge Sources. Table 1 is an assessment of the usefulness of candidate field survey parameters in identifying different potential non-stormwater flow sources. Natural and domestic waters should be uncontaminated (except in the presence of contaminated groundwaters entering the drainage system, for example). Sanitary sewage, septage, and industrial waters can produce toxic or pathogenic conditions. The other source flows (wash and rinse waters and irrigation return flows) may cause nuisance conditions, or degrade the ecosystem. The parameters marked with a plus sign can probably be used to identify the specific source flows by their presence. Negative signs indicate that the potential source flow probably does not contain the listed parameter in adverse or obvious amounts, and may help confirm the presence of the source by its absence. Parameters with both positive and negative signs for a specific source category would not likely be very helpful due to likely wide variations expected.

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TABLE 1. Candidate Field Survey Parameters and Associated Non-Stormwater Flow Sources

Parameter	Natural Water	Potable Water	Sanitary Sewage	Septage Water	Indus Water	Wash Water	Rinse Water	Irrig Water
Fluoride	-	+	+	+	+/-	+	+	+
Hardness change	-	+/-	+	+	+/-	+	+	-
Surfactants	-	-	+	-	-	+	+	-
Florescence	-	-	+	+	-	+	+	-
Potassium	-	-	+	+	-	-	-	-
Ammonia	-	-	+	+	-	-	-	+/-
Odor	-	-	+	+	+	+/-	-	-
Color	-	-	-	-	+	-	-	-
Clarity	-	-	+	+	+	+	+/-	-
Floatables	-	-	+	-	+	+/-	+/-	-
Deposits and stains	-	-	+	-	+	+/-	+/-	-
Vegetation change	-	-	+	+	+	+/-	-	+
Structural damage	-	-	-	-	+	-	-	-
Conductivity	-	-	+	+	+	+/-	+	+
Temperature change	-	-	+/-	-	+	+/-	+/-	-
pH	-	-	-	-	+	-	-	-

Note: - implies relatively low concentration
+ implies relatively high concentration
+/- implies variable conditions

Parameters Suitable for Indicators of Contamination by Sanitary Sewage

Tracer Characteristics of Local Source Flows. Table 2 is a summary of tracer parameter measurements for Birmingham, AL. This table is a summary of the "library" that describes the tracer conditions for each potential source category. The important information shown on this table includes the median and coefficient of variation (COV) values for each tracer parameter for each source category. Appropriate tracers are characterized by having significantly different concentrations in flow categories that need to be distinguished. In addition, effective tracers also need low COV values within each flow category. The study indicated that the COV values were quite low for each category, with the exception of chlorine, which had much greater COV values. Chlorine is therefore not recommended as a quantitative tracer to estimate the flow components. Similar data must be collected in each community where these procedures are to be used. Recommended field observations include color, odor, clarity, presence of floatables and deposits, and rate of flow, in addition to the selected chemical measurements.

Simple Data Evaluation Methods to Indicate Sources of Contamination

Negative Indicators Implying Contamination. Indicators of contamination (negative indicators) are clearly apparent visual or physical parameters indicating obvious problems and are readily observable at the outfall during the field screening activities. These observations are very important during the field survey because they are the simplest method of identifying grossly contaminated dry-weather outfall flows. The direct examination of outfall characteristics for unusual conditions of flow, odor, color, turbidity, floatables, deposits/stains, vegetation conditions, and damage to drainage structures is therefore an important part of these investigations. Table 3 presents a summary of these indicators, along with narratives of the descriptors to be selected in the field.

Correlation tests were conducted to identify relationships between outfalls that were known to have severe contamination problems and the negative indicators (Lalor 1994). Pearson correlation tests indicated that high turbidity and obvious odors appeared to be the most useful physical indicators of contamination when contamination was defined by toxicity and the presence of detergents. High turbidity was noted in 74% of the contaminated source flow samples. This represented a 26% false negative rate (indication of no contamination when contamination actually exists), if one relied on turbidity alone as an indicator of contamination. High turbidity was noted in only 5% of the uncontaminated source flow samples. This represents the rate of false positives (indication of contamination when none actually exists) when relying on turbidity alone. Noticeable odor was indicated in 67% of flow samples from contaminated sources, but in none of the flow samples from uncontaminated sources. This translates to 37% false [illegible] and no false positives. Obvious odors identified included gasoline, oil, sewage, industrial chemicals or detergents, decomposing organic wastes, etc.

False negatives are more of a concern than a reasonable number of false positives when working with a screening methodology. Screening methodologies are used to direct further, more detailed investigations. False positives would be discarded after further investigation. However, a false negative during a screening investigation results in the dismissal of a problem outfall for at least the near future. Missed contributors to stream contamination may result in unsatisfactory in-stream results following the application of costly corrective measures elsewhere.

The method of using physical characteristics to indicate contamination in outfall flows does not allow quantifiable estimates of the flow components and, if used alone, will likely result in many incorrect determinations, especially false negatives. These simple characteristics are most useful for identifying gross contamination: only the most significantly contaminated outfalls and drainage areas would therefore be recognized using this method.

Detergents as Indicators of Contamination. Results from the Mann-Whitney U tests (Lalor 1994) indicated that samples from any of the dry-weather flow sources could be correctly classified as clean or contaminated based only on the measured value of any one of the following parameters: detergents, color, or conductivity. Color and high conductivity were present in samples from clean sources as well as contaminated sources, but their levels of occurrence were significantly different between the two groups. If samples from only one source were expected to make up outfall flows, the level of color or conductivity could be used to distinguish contaminated outfalls from clean outfalls. However, since multi-source flows occur, measured levels of color or conductivity could fall within acceptable levels because of dilution, even though a contaminating source was contributing to the flow. Detergents, on the other hand, can be used to distinguish between clean and contaminated outfalls simply by their presence or absence, using a detection limit of 0.06 mg/L. All samples analyzed from contaminated sources contained detergents in excess of this amount (with the exception of three septage samples collected from homes discharging only toilet flushing water). No clean source samples were found to contain detergents. Contaminated sources would be detected in mixtures with uncontaminated waters if they made up at least 10% of the mixture.

Flow Chart for Most Significant Flow Component Identification. A further refinement is the flow chart shown on Figure 1. This flow chart describes an analysis strategy which may be used to identify the major component of dry-weather flow samples in residential and commercial areas. This method does not attempt to distinguish among all potential sources of dry-weather flows identified earlier, but rather the following four major groups of flow are identified: (1) tap waters (including domestic tap water, irrigation water and rinse water), (2) natural waters (spring water and shallow ground water), (3) sanitary wastewaters (sanitary sewage and septic tank discharge), and (4) wash waters (commercial laundry waters, commercial car wash waters, radiator flushing wastes, and plating bath wastewaters). The use of this method would not only allow outfall flows to be categorized as contaminated or uncontaminated, but would allow outfalls carrying sanitary wastewaters to be identified. These outfalls could then receive highest priority for further investigation leading to source control. This flow chart (Lalor 1994) was designed for use in residential and/or commercial areas only.

Table 2. Tracer Concentrations found in Birmingham, AL, Waters (mean, standard deviation, and coefficient of Variation, COV) (Pitt, *et al.* 1993 and Lalor 1994)

	Spring water	Treated potable water	Laundry wastewater	Sanitary wastewater	Septic tank effluent	Car wash water	Radiator flush water
Fluorescence	6.8	4.6	1020	250	430	1200	22.000
(% scale)	2.9	0.35	125	50	100	130	950
	0.43	0.08	0.12	0.20	0.23	0.11	0.04
Potassium	0.73	1.6	3.5	6.0	20	43	2800
(mg/L)	0.070	0.059	0.38	1.4	9.5	16	375
	0.10	0.04	0.11	0.23	0.47	0.37	0.13
Ammonia	0.009	0.028	0.82	10	90	0.24	0.03
(mg/L)	0.016	0.006	0.12	3.3	40	0.066	0.01
	1.7	0.23	0.14	0.34	0.44	0.28	0.3
Ammonia/Potassium	0.011	0.018	0.24	1.7	5.2	0.006	0.011
(ratio)	0.022	0.006	0.050	0.52	3.7	0.005	0.011
	2.0	0.35	0.21	0.31	0.71	0.86	1.0
Fluoride	0.031	0.97	33	0.77	0.99	12	150
(mg/L)	0.027	0.014	13	0.17	0.33	2.4	24
	0.87	0.02	0.38	0.23	0.33	0.20	0.16
Toxicity	<5	47	99.9	43	99.9	99.9	99.9
(% light decrease after 25	n/a	20	<1	26	<1	<1	<1
minutes, I_{25})	n/a	0.44	n/a	0.59	n/a	n/a	n/a
Surfactants	<0.5	<0.5	27	1.5	3.1	49	15
(mg/L as MBAS)	n/a	n/a	6.7	1.2	4.8	5.1	1.6
	n/a	n/a	0.25	0.82	1.5	0.11	0.11
Hardness	240	49	14	140	235	160	50
(mg/L)	7.8	1.4	8.0	15	150	9.2	1.5
	0.03	0.03	0.57	0.11	0.64	0.06	0.03
pH	7.0	6.9	9.1	7.1	6.8	6.7	7.0
(pH units)	0.05	0.29	0.35	0.13	0.34	0.22	0.39
	0.01	0.04	0.04	0.02	0.05	0.03	0.06
Color	<1	<1	47	38	59	220	3000
(color units)	n/a	n/a	12	21	25	78	44
	n/a	n/a	0.27	0.55	0.41	0.35	0.02
Chlorine	0.003	0.88	0.40	0.014	0.013	0.070	0.03
(mg/L)	0.005	0.60	0.10	0.020	0.013	0.080	0.016
	1.6	0.68	0.26	1.4	1.0	1.1	0.52
Specific conductivity	300	110	560	420	430	485	3300
(µS/cm)	12	1.1	120	55	311	29	700
	0.04	0.01	0.21	0.13	0.72	0.06	0.22
Number of samples	10	10	10	36	9	10	10

Table 3. Interpretations of Physical Observation Parameters and Likely Associated Flow Sources (Pitt, *et al.* 1993)

Odor - Most strong odors, especially gasoline oils and solvents, are likely associated with high responses on the toxicity screening test Typical obvious odors include gasoline oil, sanitary wastewater, industrial chemicals, decomposing organic wastes, etc

sewage smell associated with stale sanitary wastewater, especially in pools near outfall.

sulfur ("rotten eggs") industries that discharge sulfide compounds or organics (meat packers, canneries, dairies, etc.)

oil and gas petroleum refineries or many facilities associated with vehicle maintenance or petroleum product storage.

rancid-sour food preparation facilities (restaurants, hotels, etc.).

Color - Important indicator of inappropriate industrial sources Industrial dry-weather discharges may be of any color, but dark colors such as brown, gray, or black, are most common

yellow chemical plants, textile and tanning plants

brown meat packers, printing plants, metal works stone and concrete, fertilizers, and petroleum refining facilities.

green: chemical plants, textile facilities.

red: meat packers

gray: dairies, sewage.

Turbidity - Often affected by the degree of gross contamination Dry-weather industrial flows with moderate turbidity can be cloudy, while highly turbid flows can be opaque. High turbidity is often a characteristic of undiluted dry-weather industrial discharges

cloudy: sanitary wastewater, concrete or stone operations, fertilizer facilities, automotive dealers.

opaque: food processors, lumber mills, metal operations, pigment plants.

Floatable Matter - A contaminated flow may contain floating solids or liquids directly related to industrial or sanitary wastewater pollution. Floatables of industrial origin may include animal fats, spoiled food, oils, solvents, sawdust, foams, packing materials, or fuel.

oil sheen: petroleum refineries or storage facilities and vehicle service facilities

sewage: sanitary wastewater.

Deposits and Stains - Refers to any type of coating near the outfall and are usually of a dark color. Deposits and stains often will contain fragments of floatable substances. These situations are illustrated by the grayish-black deposits that contain fragments of animal flesh and hair which often are produced by leather tanneries, or the white crystalline powder which commonly coats outfalls due to nitrogenous fertilizer wastes.

sediment: construction site erosion.

oily: petroleum refineries or storage facilities and vehicle service facilities.

Vegetation - Vegetation surrounding an outfall may show the effects of industrial pollutants. Decaying organic materials coming from various food product wastes would cause an increase in plant life, while the discharge of chemical dyes and inorganic pigments from textile mills could noticeably decrease vegetation. It is important not to confuse the adverse effects of high stormwater flows on vegetation with highly toxic dry-weather intermittent flows.

excessive growth: food product facilities.

inhibited growth: high stormwater flows, beverage facilities, printing plants, metal product facilities, drug manufacturing, petroleum facilities, vehicle service facilities and automobile dealers.

Damage to Outfall Structures - Another readily visible indication of industrial contamination. Cracking, deterioration, and spalling of concrete or peeling of surface paint, occurring at an outfall are usually caused by severely contaminated discharges, usually of industrial origin. These contaminants are usually very acidic or basic in nature. Primary metal industries have a strong potential for causing outfall structural damage because their batch dumps are highly acidic. Poor construction, hydraulic scour, and old age may also adversely affect the condition of the outfall structure.

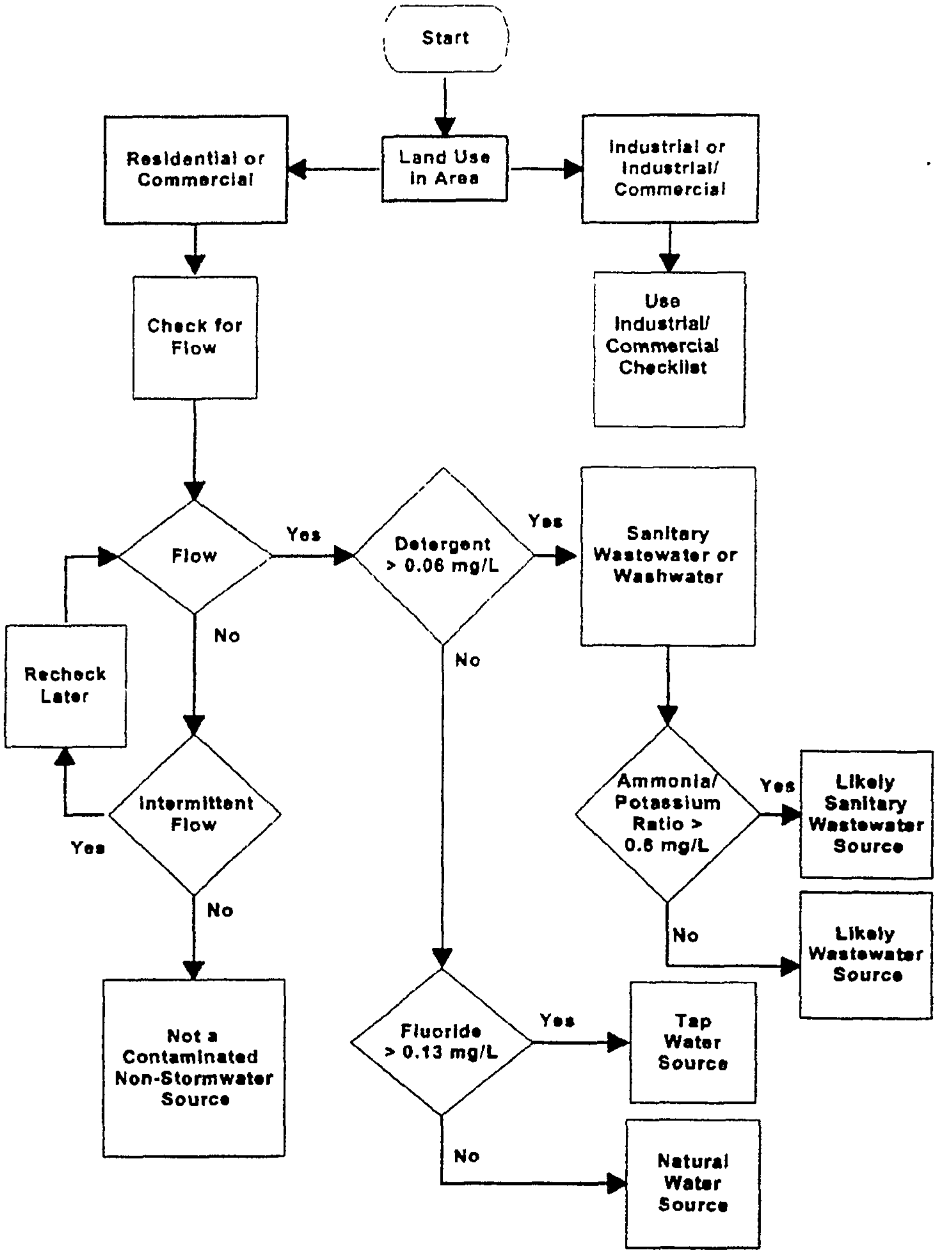
concrete cracking: industrial flows

concrete spalling: industrial flows

peeling paint: industrial flows

metal corrosion: industrial flows

Figure 1 Simple flow chart method to identify significant contaminating sources (Lalor 1994).



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In residential and/or commercial areas, all outfalls should be located and examined. The first indicator is the presence or absence of dry-weather flow. If no dry-weather flow exists at an outfall, then indications of intermittent flows must be investigated. Specifically, stains, deposits, odors, unusual stream-side vegetation conditions, and damage to outfall structures can all indicate intermittent non-stormwater flows. However, frequent visits to outfalls over long time periods, or the use of other monitoring techniques, may be needed to confirm that only stormwater flows occur. If intermittent flow is not indicated, then the outfall probably does not have a contaminated non-stormwater source. The other points on the flow chart serve to indicate if a major contaminating source is present, or if the water is uncontaminated. Component contributions cannot be quantified using this method, and only the "most contaminated" type of source present will be identified.

If dry-weather flow exists at an outfall, then the flow should be sampled and tested for detergents. If detergents are not present, the flow is probably from a non-contaminated non-stormwater source. The lower limit of detection for detergent should be about 0.06 mg/L.

If detergents are not present, fluoride levels can be used to distinguish between flows with treated water sources and flows with natural sources in communities where water supplies are fluoridated and natural fluoride levels are low. In the absence of detergents, high fluoride levels would indicate a potable water line leak, irrigation water, or wash/rinse water. Low fluoride levels would indicate waters originating from springs or shallow groundwater. Based on the flow source samples tested in this research (Table 2), fluoride levels above 0.13 mg/L would most likely indicate that a tap water source was contributing to the dry-weather flow in the Birmingham, Alabama, study area.

If detergents are present, the flow is probably from a contaminated non-stormwater source, as indicated on Table 2. The ratio of ammonia to potassium can be used to indicate whether or not the source is sanitary wastewater. Ammonia/potassium ratios greater than 0.60 would indicate likely sanitary wastewater contamination. Ammonia/potassium ratios were above 0.9 for all septage and sewage samples collected in Birmingham (values ranged from 0.97 to 15.37, averaging 2.55). Ammonia/potassium ratios for all other samples containing detergents were below 0.7, ranging from 0.00 to 0.65, averaging 0.11. One radiator waste sample had an ammonia/potassium ratio of 0.65.

Non-contaminated samples collected in Birmingham had ammonia/potassium ratios ranging from 0.00 to 0.41, with a mean value of 0.06 and a median value of 0.03. Using the mean values for non-contaminated samples (0.06) and sanitary wastewaters (2.55), flows comprised of mixtures containing at least 25% sanitary wastes with the remainder of the flow from uncontaminated sources would likely be identified as sanitary wastewaters using this method. Flows containing smaller percent contributions from sanitary wastewaters might be identified as having a wash water source, but would not be identified as uncontaminated.

General Matrix Algebra Methods to Indicate Sources of Contamination Through Fingerprinting

Other approaches can also be used to calculate the source components of mixed outfall flows. One approach is the use of matrix algebra to simultaneously solve a series of chemical mass balance equations. This method can be used to predict the most likely flow source, or sources, making up an outfall sample. It is possible to estimate the outfall source flow components using a set of simultaneous equations. The number of unknowns should equal the number of equations available, resulting in a square matrix. If there are seven likely source categories, then there should be seven tracer parameters used. If there are only four possible sources, then only the four most efficient tracer parameters should be used. Only tracers that are linearly related to mixture components can be used. As an example, pH cannot be used in these equations, because it is not additive.

This method estimates flow contributions from various sources using a "receptor model", based on a set of chemical mass balance equations. Such models, which assess the contributions from various sources based on observations at sampling sites (the receptors), have been applied to the investigation of air pollutant sources for many years (Scheff and Wadden 1993; Cooper and Watson 1980). The characteristic "signatures" of the different types of sources, as identified in the library of source flow data, allows the development of a set of mass balance equations. These equations describe the measured concentrations in an outfall's flow as a linear combination of the contributions from the different potential sources. A major requirement for this method is the physical and chemical characterization of waters collected directly from potential sources of dry-weather flows (the "library"). This allows concentration patterns (fingerprints) for the parameters of interest to be established for each type of source. Theoretically, if these patterns are different for each source, the observed concentrations at the outfall would be a linear combination of the concentration patterns from the different component sources, each weighted by a source strength term (m_n). This source strength term would indicate the fraction of outfall flow originating from each likely source. By measuring a number of parameters equal to, or greater than, the number of potential source types, the source strength term could be obtained by solving a set of chemical mass balance equations of the type:

$$C_p = \sum_n m_n x_{pn}$$

where C_p is the concentration of parameter p in the outfall flow and x_{pn} is the concentration of parameter p in source type n.

As an example of this method, consider 8 possible flow sources and 8 parameters, as presented in Table 4. The number of parameters evaluated for each outfall must equal the number of probable dry-weather flow sources in the drainage area. Mathematical methods are available which provide for the solution of over specified sets of equations (more equations than unknowns) but these are not addressed here.

The selection of parameters for measurement should reflect evaluated parameter usefulness. Evaluation of the Mann-Whitney U Test results (Lalor 1994) suggested the following groupings of parameters, ranked by their usefulness for distinguishing between all the types of flow sources sampled in Birmingham, AL:

- First set (most useful): potassium and hardness
- Second set: fluorescence, conductivity, fluoride, ammonia, detergents, and color
- Third set (least useful): chlorine

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TABLE 4. Set of Chemical Mass Balance Equations

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	Outfall
Parameter 1:	(m1)(x11)	+ (m2)(x12)	+ (m3)(x13)	+ (m4)(x14)	+ (m5)(x15)	+ (m6)(x16)	+(m7)(x17)	+ (m8)(x18)	= C1
Parameter 2:	(m1)(x21)	+ (m2)(x22)	+ (m3)(x23)	+ (m4)(x24)	+ (m5)(x25)	+ (m6)(x26)	+(m7)(x27)	+ (m8)(x28)	= C2
Parameter 3:	(m1)(x31)	+ (m2)(x32)	+ (m3)(x33)	+ (m4)(x34)	+ (m5)(x35)	+ (m6)(x36)	+(m7)(x37)	+ (m8)(x38)	= C3
Parameter 4:	(m1)(x41)	+ (m2)(x42)	+ (m3)(x43)	+ (m4)(x44)	+ (m5)(x45)	+ (m6)(x46)	+(m7)(x47)	+ (m8)(x48)	= C4
Parameter 5:	(m1)(x51)	+ (m2)(x52)	+ (m3)(x53)	+ (m4)(x54)	+ (m5)(x55)	+ (m6)(x56)	+(m7)(x57)	+ (m8)(x58)	= C5
Parameter 6:	(m1)(x61)	+ (m2)(x62)	+ (m3)(x63)	+ (m4)(x64)	+ (m5)(x65)	+ (m6)(x66)	+(m7)(x67)	+ (m8)(x68)	= C6
Parameter 7	(m1)(x71)	+ (m2)(x72)	+ (m3)(x73)	+ (m4)(x74)	+ (m5)(x75)	+ (m6)(x76)	+(m7)(x77)	+ (m8)(x78)	= C7
[illegible]	(m1)(x81)	+ (m2)(x82)	+ (m3)(x83)	+ (m4)(x84)	+ (m5)(x85)	+ (m6)(x86)	+(m7)(x87)	+ (m8)(x88)	= C8

Equations of the Form $C_p = \sum_n m_n x_{pn}$

where: C_p = the concentration of parameter p in the outfall flow

m_n = the fraction of flow from source type n

x_{pn} = the mean concentration of parameter p in source type n

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Emerging Tools for Identifying Sources of Discharges

Coprostanol and Other Fecal Sterol Compounds Utilized as Tracers of Contamination by Sanitary Sewage. A more likely indicator of human wastes than fecal coliforms and other "indicator" bacteria may be the use of certain molecular markers, specifically the fecal sterols, such as coprostanol and epicoprostanol (Eaganhouse, *et al.* 1988). However, these compounds are also discharged by other carnivores in a drainage (especially dogs). A number of research projects have used these compounds to investigate the presence of sanitary sewage contamination. The most successful application may be associated with sediment analyses instead of water analyses. As an example, water analyses of coprostanol are difficult due to the typically very low concentrations found, although the concentrations in many sediments are quite high and much easier to quantify. Unfortunately, the long persistence of these compounds in the environment easily confuses recent contamination with historical or intermittent contamination

Particulates and sediments collected from coastal areas in Spain and Cuba receiving municipal sewage loads were analyzed by Grimalt, *et al.* (1990) to determine the utility of coprostanol as a chemical marker of sewage contamination. Coprostanol can not by itself be attributed to fecal matter inputs. However, relative contributions of steroid components can be a useful indicator. When the relative concentrations of coprostanol and coprostanone are higher than their 5α epimers, or more realistically, other sterol components of background or natural occurrence, it can provide useful information.

Sediment cores from Santa Monica Basin, CA, and effluent from two local municipal wastewater discharges were analyzed by Venkatesan and Kaplan (1990) for coprostanol to determine the degree of sewage addition to sediment. Coprostanols were distributed throughout the basin sediments in association with fine particles. Some stations contained elevated levels, either due to their proximity to outfalls or because of preferential advection of fine-grained sediments. A noted decline of coprostanols relative to total sterols from outfalls seaward indicated dilution of sewage by biogenic sterols.

Other chemical compounds have been utilized for sewage tracer work. Saturated hydrocarbons with 16-18 carbons, and saturated hydrocarbons with 16-21 carbons, in addition to coprostanol, were chosen as markers for sewage in water, particulate, and sediment samples near the Cocoa, FL, domestic wastewater treatment plant (Holm, *et al.* 1990). The concentration of the markers was highest at points close to the outfall pipe and diminished with distance. However the concentration of C16-C21 compounds was high at a site 800 m from the outfall indicating that these compounds were unsuitable markers for locating areas exposed to the sewage plume. The concentrations for the other markers were very low at this station.

The range of concentrations of coprostanol found in sediments and mussels of Venice, Italy, were reported by Sherwin, *et al.* (1993). Raw sewage is still discharged directly into the Venice lagoon. Coprostanol concentrations were determined in sediment and mussel samples from the lagoon using gas chromatography/mass spectroscopy. Samples were collected in interior canals and compared to open-bay concentrations. Sediment concentrations ranged from 0.2-41.0 μg/g (dry weight). Interior canal sediment samples averaged 16 μg/g compared to 2 μg/g found in open bay sediment samples. Total coprostanol concentrations in mussels ranged from 80 to 620 ng/g (wet weight). No mussels were found in the four most polluted interior canal sites.

Nichols, *et al.* (1996) also examined coprostanol in stormwater and the sea-surface microlayer to distinguish human versus nonhuman sources of contamination. Other steroid compounds in sewage effluent were investigated by Routledge, *et al* (1998) and Desbrow, *et al.* (1998) who both examined estrogenic chemicals. The most common found were 17β-Estradiol and estrone which were detected at concentrations in the tens of nanograms per liter range. These were identified as estrogenic through a toxicity identification and evaluation approach, where sequential separations and analyses identified the sample fractions causing estrogenic activity using a yeast-based estrogen screen. GC/MS was then used to identify the specific compounds.

Estimating Potential Sanitary Sewage Discharges into Storm Drainage and Receiving Waters using Detergent Tracer Compounds. As described above, detergent measurements (using methylene blue active substance, MBAS, test methods) were the most successful individual tracer to indicate contaminated water in storm sewerage dry-weather flows. Unfortunately, the MBAS method uses hazardous chloroform for an extraction step. Different detergent components, especially linear alkylbenzene sulphonates (LAS) and linear alkylbenzenes (LAB), have also been tried to indicate sewage dispersal patterns in receiving waters. Boron, a major historical ingredient of laundry chemicals, can also potentially be used. Boron has the great advantage of being relatively easy to analyze using portable field test kits, while LAS requires chromatographic equipment. LAS can be measured using HPLC with fluorescent detection, after solid phase extraction, to very low levels. Fujita, *et al.* (1998) developed an efficient enzyme-linked immunosorbent assay (ELISA) for detecting LAS at levels from 20 to 500 μg/L.

LAS from synthetic surfactants (Terzic and Ahel 1993) which degrade rapidly, as well as nonionic detergents (Terzic and Ahel 1993) which do not degrade rapidly, have been utilized as sanitary sewage markers. LAS was quickly dispersed from wastewater outfalls except in areas where wind was calm. In these areas LAS concentrations increased in freshwater but were unaffected in saline water. After time, the lower alkyl groups were mostly found, possibly as a result of degradation or settling of longer alkyl chain compounds with sediments. Chung, *et al.* (1995) also describe the distribution and fate of LAS in an urban stream in Korea. They examined different LAS compounds having carbon ratios of C12 and C13 compared to C10 and C11, plus ratios of phosphates to MBAS and the internal to external isomer ratio (I/E) as part of their research. Gonález-Mazo, *et al* (1998) examined LAS in the Bay of Cádiz off the southwest of Spain. They found that LAS degrades rapidly (Fujita, *et al.*, 1998, found that complete biodegradation of LAS requires several days), and is also strongly sorbed to particulates. In areas close to shore and near the untreated wastewater discharges, there as significant vertical stratification of LAS: the top 3 to 5 mm of water had LAS concentrations about 100 times greater than found at 0.5 m.

Zeng and Vista (1997) and Zeng, *et al.* (1997) describe a study off of San Diego where LAB was measured, along with polycyclic aromatic hydrocarbons (PAHs) and aliphatic hydrocarbons (AHs) to indicate the relative pollutant contributions of wastewater from sanitary sewage, nonpoint sources, and hydrocarbon combustion sources. They developed and tested several indicator ratios (alkyl homologue distributions and parent compound distributions) and examined the ratio of various PAHs (such as phenanthrene to anthracene, methylphenanthrene to phenanthrene, fluoranthene to pyrene, and benzo(a)anthracene to chrysene) as tools for distinguishing these sources. They concluded that LABs are useful tracers of domestic waste inputs to the environment due to their limited sources. They also describe the use of the internal to external isomer ratio (I/E) to indicate the amount of biodegradation that may have occurred to the LABs. They observed concentrations of total LABs in sewage effluent of about 3 μg/L, although previous researchers have seen concentrations of about 150 μg/L in sewage effluent from the same area.

The fluorescent properties of detergents have also been used as a tracer by investigating the fluorescent whitening agents (FWAs), as described by Poiger, *et al.* (1996) and Kramer, *et al.* (1996). HPLC with fluorescence detection was used in these studies to quantify very low concentrations of FWAs. The two most frequently used FWAs in household detergents (DSBP and DAS 1) were found at 7 to 21 μg/L in primary sewage effluent and at 3 to 9 μg/L in secondary effluent. Raw sewage contains about 10 to 20 μg/L FWAs. The removal mechanisms in sewage treatment processes is by adsorption to activated sludge. The type of FWAs varies from laundry applications to textile finishing and paper production, making it possible to identify sewage sources. The FWAs were found in river water at 0.04 to 0.6 μg/L. The FWAs are not easily biodegradable but they are readily photodegraded. Photodegradation rates have been reported to be about 7% for DSBP and 71% for DAS 1 in river water exposed to natural sunlight, after one hour exposure. Subsequent photodegradation is quite slow.

Other Compounds Found in Sanitary Sewage that may be used for Identifying Contamination by Sewage. Halling-Sørensen, *et al.* (1998) detected numerous pharmaceutical substances in sewage effluents and in receiving waters. Their work addressed human health concerns of these low level compounds that can enter downstream drinking water supplies. However, the information can also be possibly used to help identify sewage contamination. Most of the research has focused on clofibric acid, a chemical used in cholesterol lowering drugs. It has been found in concentrations ranging from 10 to 165 ng/L in Berlin drinking water sampler. Other drugs commonly found include aspirin, caffeine, and ibuprofen. Current FDA guidance mandates that the maximum concentration of a substance or its active metabolites at the point of entry into the aquatic environment be less than 1 μg/L (Hun 1998).

Caffeine has been used as an indicator of sewage contamination by several investigators (Shuman and Strand 1996). The King County, WA, Water Quality Assessment Project is examining the impacts of CSOs on the Duwamish

River and Elliott Bay. They are using both caffeine (representing dissolved CSO constituents) and coprostanol (representing particulate bound CSO constituents) in conjunction with heavy metals and conventional analyses, to help determine the contribution of CSOs to the river. The caffeine is unique to sewage, while coprostanol is from both humans and carnivorous animals and is therefore also in stormwater. They sampled upstream of all CSOs, but with some stormwater influences, 100 m upstream of the primary CSO discharge (but downstream of other CSOs), within the primary CSO discharge line, and 100 m downriver of the CSO discharge location. The relationship between caffeine and coprostanol was fairly consistent for the four sites (coprostanol was about 0.5 to 1.5 µg/L higher than caffeine). Similar patterns were found between the three metals: chromium was always the lowest and zinc was the highest. King Co. is also using clean transported mussels placed in the Duwamish River to measure the bioconcentration potential of metal and organic toxicants and the effects of the CSOs on mussel growth rates (after 6 week exposure periods). Paired reference locations are available near the areas of deployment, but outside the areas of immediate CSO influence. *US Water News* (1998) also described a study in Boston Harbor that found caffeine at levels of about 7 µg/L in the harbor water. The caffeine content of regular coffee is about 700 mg/L, in contrast.

DNA Profiling to Measure Impacts on Receiving Water Organisms and to Identify Sources of Microorganisms in Stormwater. This rapidly emerging technique seems to have great promise in addressing a number of nonpoint source water pollution issues. Kratch (1997) summarized several investigations on cataloging the DNA of *E. coli* to identify their source in water. This rapidly emerging technique seems to have great promise in addressing a number of nonpoint source water pollution issues. The procedure, developed at the Virginia Polytechnic Institute and State University, has been used in Chesapeake Bay. In one example, it was possible to identify a large wild animal population as the source of fecal coliform contamination of a shellfish bed, instead of suspected failing septic tanks. DNA patterns in fecal coliforms vary among animals and birds, and it is relatively easy to distinguish between human and non-human sources of the bacteria. However, some wild animals have DNA patterns that are not easily distinguishable. Some researchers question the value of *E. coli* DNA fingerprinting believing that there is little direct relationship between *E. coli* and human pathogens. However, this method should be useful to identify the presence of sewage contamination in stormwater or in a receiving water.

One application of the technique, as described by Krane, *et al.* (1999) of Wright State University, used randomly amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) generated profiles of naturally occurring crayfish. They found that changes in the underlying genetic diversity of these populations were significantly correlated with the extent to which they have been exposed to anthropogenic stressors. They concluded that this rapid and relatively simple technique can be used to develop a sensitive means of directly assessing the impact of stressors upon ecosystems. These Wright State University researchers have also used the RAPD-PCR techniques on populations of snails, pill bugs, violets, spiders, earthworms, herring, and some benthic macroinvertebrates, finding relatively few obstacles in its use for different organisms. As noted above, other researchers have used DNA profiling techniques to identify sources of *E. coli* bacteria found in coastal waterways. It is possible that these techniques can be expanded to enable rapid detection of many different types of pathogens in receiving waters, and the most likely sources of these pathogens.

Stable Isotope Methods for Identifying Sources of Water. Stable isotopes had been recommended as an efficient method to identify illicit connections to storm sewerage. A demonstration was conducted in Detroit as part of the Rouge River project to identify sources of dry weather flows in storm sewerage (Sangal, *et al.* 1996). Naturally occurring stable isotopes of oxygen and hydrogen can be used to identify waters originating from different geographical sources (especially along a north-south gradient). Ma and Spalding (1996) discuss this approach by using stable isotopes to investigate recharge of groundwaters by surface waters. During water vapor transport from equatorial source regions to higher latitudes, depletion of heavy isotopes occurs with rain. Deviation from a standard relationship between deuterium and ^{18}O for a specific area indicates that the water has undergone additional evaporation. The ratio is also affected by seasonal changes. As discussed by Ma and Spalding (1996), the Platte River water is normally derived in part from snowmelt from the Rocky Mountains, while the groundwater in parts of Nebraska is mainly contributed from the Gulf air stream. The origins of these waters are sufficiently different and allow good measurements of the recharge rate of the surface water to the groundwater. In Detroit, Sangal, *et al.* (1996) used differences in origin between the domestic water supply, local surface waters, and the local groundwater to identify potential sanitary sewage contributions to the separate storm sewerage. Rieley, *et al.* (1997) used stable isotopes of carbon in marine organisms to distinguish the primary source of carbon being consumed (sewage sludge vs. natural carbon sources) in two deep sea sewage sludge disposal areas.

Stable isotope analyses would not be able to distinguish between sanitary sewage, industrial discharges, washwaters, and domestic water, as they all have the same origin, nor would it be possible to distinguish sewage from local groundwaters if the domestic water supply was from the same local aquifer. This method works best for situations where the water supply is from a distant source and where separation of waters into separate flow components is not needed. It may be an excellent tool to study the effects of deep well injection of stormwater on deep aquifers having distant recharge sources (such as in the Phoenix area). Few laboratories can analyze for these stable isotopes, requiring shipping and a long wait for the analytical results. Sangal, *et al.* (1995) used Geochron Laboratories, in Cambridge, Massachusetts.

Dating of sediments using ^{137}Cs was described by Ma and Spalding (1996). Arsenic contaminated sediments in the Hylebos Waterway in Tacoma, WA, could have originated from numerous sources, including a pesticide manufacturing facility, a rock-wool plant, steel slags, powdered metal plant, shipbuilding facilities, marinas and arsenic boat paints, and the Tacoma Smelter. Dating the sediments, combined with knowing the history of potential discharges and conducting optical and electron microscopic studies of the sediments, was found to be a powerful tool to differentiate between the different metal sources to the sediments.

Conclusions

In almost all cases, a suite of analyses is most suitable for effective identification of inappropriate discharges. A recent example was reported by Standley, *et al.* (2000), where fecal steroids (including coprostanol), caffeine, consumer product fragrance materials, and petroleum and combustion byproducts were used to identify wastewater treatment plant effluent, agricultural and feedlot runoff, urban runoff, and wildlife sources. They studied numerous individual sources of these wastes from throughout the US. A research grade mass sperctrophotometer was used for the majority of the analyses in order to achieve the needed sensitivities, although much variability was found when using the methods in actual receiving waters affected by wastewater effluent. This sophisticated suite of analyses did yield much useful information, but the analyses are difficult to conduct and costly and may be suitable for special situations, but not for routine survey work.

Another recent series of tests examined several of these potential emerging tracer parameters, in conjunction with the previously identified parameters, during a project characterizing stormwater that had collected in telecommunication manholes, funded by Tecordia (previously Bellcore), AT&T, and eight regional telephone companies throughout the country (Pitt and Clark 1999). Numerous conventional constituents, plus major ions, and toxicants were measured, along with candidate tracers to indicate sewage contamination of this water. Boron, caffeine, coprostanol, *E coli*, enterococci, fluorescence (using specific wavelengths for detergents), and a simpler test for detergents were evaluated, along with the use of fluoride, ammonia, potassium, and obvious odors and color. About 700 water samples were evaluated for all of these parameters, with the exception of bacteria and boron (about 250 samples), and only infrequent samples were analyzed for fluorescence. Coprostanol was found in about 25 percent of the water samples (and in about 75% of the 350 sediment samples analyzed). Caffeine was only found in very few samples, while elevated *E. coli* and enterococci (using IDEXX tests) were observed in about 10% of the samples. Strong sewage odors in water and sediment samples were also detected in about 10% of the samples. Detergents and fluoride (at >0.3 mg/L) were found in about 40% of the samples and are expected to have been contaminated with industrial activities (lubricants and cleansers) and not sewerage. Overall, about 10% of the samples were therefore expected to have been contaminated with sanitary sewage, about the same rate previously estimated for stormwater systems.

Additional related laboratory tests, funded by the University of New Orleans and the EPA (Barbe', *et al.* 2000), were conducted using many sewage and laundry detergent samples and found that the boron test was a poor indicator of sewage, possibly due to changes in formulations in modern laundry detergents. Laboratory tests did find that fluorescence was an excellent indicator of sewage, especially when using specialized "detergent whitener" filter sets, but was not very repeatable. We also examined several UV absorbance wavelengths as sewage indicators and found excellent correlations with 228 nm, a wavelength having very little background absorbance in local spring waters, but with a strong response factor with increasing strengths of sewage.

Table 5 summarizes the different measurement parameters discussed above. We recommend that our originally developed and tested protocol, as reported by Pitt, *et al.* (1993), still be used as the most efficient routine indicator of sewage contamination of stormwater drainage systems, with the possible addition of specific *E. coli* and enterococci measurements and UV absorbance at 228 nm. The numerous exotic tests requiring specialized instrumentation and expertise do not appear to warrant their expense and long analytical turn-around times, except in specialized research situations, or when special confirmation is economically justified (such as when examining sewer replacement or major repair options).

Table 5. Comparison of Measurement Parameters used for Identifying Inappropriate Discharges into Storm Drainage

Parameter Group	Comments	Recommendation
Fecal coliform bacteria and or use of fecal coliform to fecal strep ratio	Commonly used to indicate presence of sanitary sewage	Not very useful as many other sources of fecal coliforms are present, and ratio not accurate for old or mixed wastes.
Physical observations (odor, color, turbidity, floatables, deposits, stains, vegetation changes, damage to outfalls)	Commonly used to indicate presence of sanitary and industrial wastewater	Recommended due to easy public understanding and easy to evaluate, but only indicative of gross contamination, with excessive false negatives (and some false positives). Use in conjunction with chemical tracers for greater sensitivity and accuracy
Detergents presence (anionic surfactant extractions)	Used to indicate presence of wash waters and sanitary sewage.	Recommended, but care needed during hazardous analyses (only for well-trained personnel). Accurate indicator of contamination during field tests.
Fluoride, ammonia and potassium measurements	Used to identify and distinguish between wash waters and sanitary sewage	Recommended, especially in conjunction with detergent analyses. Accurate indicator of major contamination sources and their relative contributions.
TV surveys and source investigations	Used to identify specific locations of inappropriate discharges, especially in industrial areas.	Recommended after outfall surveys indicate contamination in drainage system.
Coprostanol and other fecal sterol compounds	Used to indicate presence of sanitary sewage	Possibly useful. Expensive analysis with GC/MSD. Not specific to human wastes or recent contamination. Most useful when analyzing particulate fractions of wastewaters or sediments.
Specific detergent compounds (LAS, fabric whiteners, and perfumes)	Used to indicate presence of sanitary sewage.	Possibly useful. Expensive analyses with HPLC. A good and sensitive confirmatory method.
Fluorescence	Used to indicate presence of sanitary sewage and wash waters.	Likely useful, but expensive instrumentation. Rapid and easy analysis. Very sensitive.
Boron	Used to indicate presence of sanitary sewage and wash waters.	Not very useful. Easy and inexpensive analysis, but recent laundry formulations in US have minimal boron components.
Pharmaceuticals (colfibric acid, aspirin, ibuprofen, steroids, illegal drugs, etc.)	Used to indicate presence of sanitary sewage	Possibly useful. Expensive analyses with HPLC. A good and sensitive confirmatory method.
Caffeine	Used to indicate presence of sanitary sewage.	Not very useful. Expensive analyses with GC/MSD. Numerous false negatives, as typical analytical methods not suitably sensitive.
DNA profiling of microorganisms	Used to identify sources of microorganisms	Likely useful, but currently requires extensive background information on likely sources in drainage. Could be very useful if method can be simplified, but with less specific results.
UV absorbance at 228 nm	Used to identify presence of sanitary sewage.	Possibly useful, if UV spectrophotometer available. Simple and direct analyses. Sensitive to varying levels of sanitary sewage, but may not be useful with dilute solutions. Further testing needed to investigate sensitivity in field trials.
Stable isotopes of oxygen	Used to identify major sources of water.	May be useful in area having distant domestic water sources and distant groundwater recharge areas. Expensive and time consuming procedure. Can not distinguish between wastewaters if all have common source.
E. coli and enterococci bacteria	More specific indicators of sanitary sewage than coliform tests.	Recommended in conjunction with chemical tests. Relatively inexpensive and easy analyses, especially if using the simple IDEXX methods.

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Review of Existing Stormwater Monitoring Programs for Estimating Bight-wide Mass Emissions from Urban Runoff

By Kenneth Schiff

ABSTRACT

Urban runoff is perceived as a large source of pollutant inputs to the ocean, but no mass emission monitoring programs have been established to assess this discharge. Recently, however, National Pollutant Discharge Elimination System permits for urban runoff discharges were issued to stormwater management agencies on a regional (county-wide) basis and the 1994-95 water year represents the first period in which urban runoff water quality measurements have been monitored bight-wide. The goal of this study was to use the data generated by these monitoring programs to estimate mass emissions of pollutants to the Southern California Bight from urban runoff. After documenting the sampling design of each stormwater monitoring program, then collating information on rainfall, watershed area, runoff volume, and water quality measurements, we estimated the mass emissions of total suspended solids, nutrients (ammonia, nitrate, phosphorous), and five trace metals (chromium, copper, nickel, lead, zinc). Although the mass emissions of these constituents appeared substantial relative to other sources, there was tremendous uncertainty in the load estimates. Less than 5% of the watershed areas and less than 2% of the annual runoff volumes were actually monitored during 1994-95 water year. Extrapolation of water quality data to these unmonitored channels and flows, which is necessary to develop bight-wide emission estimates, are hampered by the tremendous vaiability in contaminant concentrations among the different watersheds and storm events. This variability in water quality measurements from urban runoff are not well understood. This lack of understanding adds to our uncertainty in the load estimates we provide.

INTRODUCTION

Rivers in southern California are amongst the most extensively modified channels in the world (Brownlie and Taylor 1981). These storm drain systems, which ultimately discharge directly to the ocean, were designed to remove stormwater from streets and low-lying areas as efficiently as possible, thus reducing flooding and minimizing property damage. Most of the modification to these channels occurred prior to an era of interest or knowledge about urban runoff water quality. As a result, accumulated debris, pollutants, and pathogens from the largest metropolitan centers on the west coast are discharged along with this urban runoff. Moreover, many urban runoff discharges are augmented by inland municipal/industrial treated wastewater discharges, potentially contaminated groundwater discharges, and at times, inputs from illegal discharges and illicit connections. There is little in the way of retention and virtually no treatment of runoff from southern California urbanized watersheds. Only relatively recently has concern regarding water quality of these urban runoff discharges been examined (SMBRP 1996, Schiff and Stevenson 1996, Bay *et al.* 1996, Suffet *et al.* 1993, Gold *et al.* 1992; SCCWRP 1980).

Although urban runoff is currently perceived as a potentially large source of contaminants to our near coastal environment (Eganhouse and Kaplan 1987, RWQCB-LA 1988, USEPA 1995), there has been little monitoring for estimating contaminant mass emissions to the Southern California Bight (SCB). One reason for the lack of quantified loadings is because sampling and characterizing runoff discharges is extremely difficult. Unlike many other point sources of pollutants to the ocean, such as treated municipal or industrial wastewaters, the ubiquitous nature of urban runoff prohibits characterization from a single location or at infrequent intervals. The unpredictable rainfall in southern California further complicates runoff monitoring since the resulting flows are discontinuous and highly variable. Historically, most runoff measurements for estimating contaminant mass loadings to the ocean have been the result of special studies (SCCWRP 1973; 1990; 1992). Re-authorization of the Clean Water Act in 1987 and associated litigation sampling methodology were identified

Estimation of Runoff Mass Emissions By Collating Monitoring Data
A simplistic, watershed-based approach was used to calculate mass emissions of contaminants from urban runoff to the SCB in 1994-95 illustrated by the following equation (1):

$$(1) \quad L_{annual} = \sum_{i=1}^{n} (EMC_{median} * Volume_i)$$

Where,

L_{annual} = Annual pollutant load;

i = Watershed listed in the NPDES permit;

Volume = Annual volume of watershed$i$; and

EMC_{median} = Bightwide median event mean concentration .

Annual runoff volume for each watershed was obtained from either the ADMR's, the United States Geological Survey (USGS 1995), LA Co. - Engineering Section, Orange Co. Environmental Management Agency, San Diego Co. Flood Control District, or the International Boundary Water Commission (IBWC). Rainfall data, summarized from the National Weather Service (Nationwide Climatic Data Center, Ashville, NC), was used to complement flow data, demonstrate part of the variability responsible in flow among regions, and assess the relative discharges this water year compared to "normal" years as determined from long-term rainfall records. Additional information collated from these sources included 15 min. average flow during storm events and total volume discharged during storm events to assess volumes representatively sampled versus discharged.

Bight-wide median event mean concentrations (EMC) were calculated from the midpoint in the distribution of all the water quality data for a particular constituent reported in the 1994-95 ADMR's. The EMC is equivalent to the concentration designated as representative of each storm event by each monitoring agency. It is defined as the sum of all volume-weighted concentrations divided by the total storm volume (USEPA 1983). The only water quality data we collated for median EMC calculations were channel sites where an entire watershed was sampled. No sub-watershed, land use sites were used to calculate median EMC's. We also compared water quality results for the different region-wide permits by calculating 1994-95 median EMC's for individual SCB watersheds where the data were available.

Our watershed-based approach required pooling data to estimate water quality for channels not sampled. Because we had to extrapolate concentrations to unsampled watersheds, which adds some uncertainty to our estimates of mass emissions, we also calculated mass emissions based upon the 10th and 90 th percentile concentrations observed among watersheds. Our intention in the calculations was to capture the uncertainty in the extrapolations we have made.

Evaluation of Monitoring Data for Calculating Bightwide Mass Emissions from Runoff
The ability to calculate bightwide mass emissions from urban runoff based upon the monitoring data from 1994-95 was judged by two factors: (1) An assessment of monitoring coverage, and (2) The commonality of methods among monitoring programs. Monitoring coverage was assessed in terms of the percent of the area monitored and the percent of runoff volume representatively sampled. Commonality among programs

assessments of urban runoff including general characteristics, inorganic analytes such as trace metals, and organic constituents such as chlorinated and petroleum hydrocarbons, toxicity tests with invertebrates or vertebrates, and fecal indicator bacteria (Table 4). Since not all constituents are measured during every storm or at every station, only those analytes and detection limits routinely listed in their respective ADMR's were reported. Thirteen analytes were measured in common between the four region-wide stormwater permits in the SCB. Some individual permittees, however, measured as many as 183 analytes for a given sample.

Collating Monitoring Data and Estimation of Mass Emissions

Rainfall. Annual rainfall varied from 44 to 73 cm throughout the coastal SCB (Figure 2). As expected, precipitation patterns across the SCB were highest in the north and steadily declined moving south. Oxnard received 66% more rainfall compared to San Diego. In 1994-95, the annual rainfall was approximately double the long-term average. Although precipitation was recorded between 9 and 10 months of the year, the majority of rain fell in the months of January and March. These two months represented 69 to 80% of the rainfall for the entire year, depending upon the gage site.

Watershed Area and Runoff Volume.

The total watershed area of the rivers and creeks named in Southern California NPDES stormwater permits was roughly 26,000 km^2 (Table 5). Approximately 90% of this area was gaged for urban runoff flows by a variety of agencies; 2.9 x 10^{12} L were measured during the 1994-95 water year (Table 5). Three rivers discharged over half of the gaged volume to the SCB. Annual discharges from the Los Angeles River, Santa Clara River, and Santa Ana River cumulatively exceeded 1.7 x 10^{12} L, but their watersheds represented only 41% of the SCB area.

When examined on a region-by-region basis, the San Diego Co. NPDES permit (10,800 km_2) encompassed nearly double the watershed area of the other three permits (4,900 to 5,500 km^2). Annual discharge volume in the Los Angeles region (1.13 x 10^{12} L), however, was between 175% and 230% greater than the other three regions (0.49 to 0.65 x 10^{12} L).

Water Quality.

Suspended solids, nutrients (nitrogen and phosphorous), and five trace metals (Cr, Cu, Pb, Ni, and Zn) were consistently analyzed and reported among the various NPDES stormwater monitoring programs of the SCB that sampled channel sites (Table 6). Other water quality parameters were measured frequently by individual agencies, but not consistently among all permits or at all sites within a permit. Organic constituents such as PAH's, DDT's, and PCB's were frequently measured, but virtually all measurements for these compounds were below reported detection limits.

No single region had all the highest or all the lowest median EMC's at channel sampling sites during 1994-95 (Table 6). The range of EMC's between regions differed by a factor of 2 to 20 among the general constituents and by a factor of 1 to 15 among the trace metals. This magnitude of variability was also observed between sites within a single region (Table 6). For example, the range of median EMC's among SCB regional permits for suspended solids was 175 to 330 mg/L. The range of EMC's between different monitoring sites within the San Diego region was 148 to 485 mg/L while the EMC's from various sites within the Orange County region ranged from 41 to 2,148 mg/L.

Mass Emission Estimates from Urban Runoff to the SCB.

Bight-wide median EMC's and mass emissions from urban runoff were estimated for the 1994-95 water year (Table 7). The total load of suspended solids was estimated to be 598 x 10^3 metric tons (mt). Using the 10^{th} and 90^{th} percentile of the distribution of EMC's within the SCB, low and high load estimates tremendous variability among watersheds. For example, suspended solids flow-weighted mean concentrations ranged from 283 to 4,313 mg/L among the eight largest rivers and creeks in southern California during 1986-88. In 1994-95, only one of these eight channels was actually monitored by the stormwater management agencies. Since the corresponding data were not available from all channels, we are unable to assess the bias associated with our extrapolation to unmonitored watersheds.

A second assumption we used was that the temporal periods sampled within a watershed were representative of other periods which were not sampled. Assumptions based upon extrapolations to unsampled storms introduces uncertainty because of flow-related variability. Studies on the Los Angeles River and other channels of the SCB observed significant correlations between flow and pollutant concentrations (SCCWRP 1990). Consequently, mass emission estimates for specific runoff events differ between large and small storms as a result of changing constituent concentrations as well as discharge volumes. Therefore, missing or capturing significant events can result in potential bias depending upon the magnitude of the storm size. Capturing the largest storm of the year may result in the largest EMC's and will likely overestimate the unsampled, but smaller-sized storms. Alternatively, capturing the smallest storms may underestimate the true annual discharge (if substantially large storms are not sampled). Moreover, 1994-95 was a very wet year. Rainfall was approximately double the long-term annual average which generated some of the largest peak flows in recent history (USGS 1995). The magnitude of bias associated with unsampled storm events cannot be assessed because none of the SCB monitoring programs have sufficient temporal sampling regimes to address this question.

Other temporal assumptions relative to this study that can introduce uncertainty are even less understood than flow-related correlations. Assumptions which are not well understood for southern California watersheds include relationships of water quality to antecedent dry periods (pollutant build-up) and rainfall intensity or duration (pollutant transport). Examples of the interactions between these two important parameters include concepts such as "first flush" (initial storm flows) or "seasonal flushing" (initial storms of the water year). Although several investigators have demonstrated portions of these concepts in other regions (Herricks 1995), they are not well-quantified in southern California. In some cases they appear significant (OCEMA 1996, RWQCB-LA 1988); in others, they do not (SCCWRP 1989).

Temporal variability within and among runoff events is compounded in the SCB by the different sampling strategies utilized by stormwater monitoring agencies. Our data set was comprised of individual grab, single and multiple weighted-composite samples. Grab and composite samples however, represent very different portions of a storm event. Grab samples represent a single snapshot of water quality during a storm event and, for the most part in 1994-95, were taken independently of flow regime or time since start of flow. Composite samples were actually multiple grab samples which, when combined together, were used to represent the mean water quality for an entire storm event. Composite samples, however, were weighted differently among the agencies. Some were weighted by storm flow (e.g., sampling every set volume interval); others were weighted by time (e.g. every hour, every 15 minutes, etc.). Flow-weighted composites sample more frequently during high flows than low flows, while time-weighted samples are distributed evenly throughout the storm event. Moreover, the number of samples per composite varied substantially among agencies (4 to 40+), or even within an agency (12 to 40+). The degree to which sampling strategies influence water quality results has not been quantified in terms of bias to the true EMC or the relative effect on seasonal loading estimates.

One reason we needed to rely on so many assumptions is that the monitoring programs are not entirely designed to estimate mass emissions to the ocean. Most monitoring programs have multiple purposes, all of which are important. Multiple information needs from urban runoff monitoring include regulatory compliance, identifying sources of pollutants and developing runoff models, as well as evaluating management actions such as effectiveness of best management practices (Dixon and Chiswell 1996). Even

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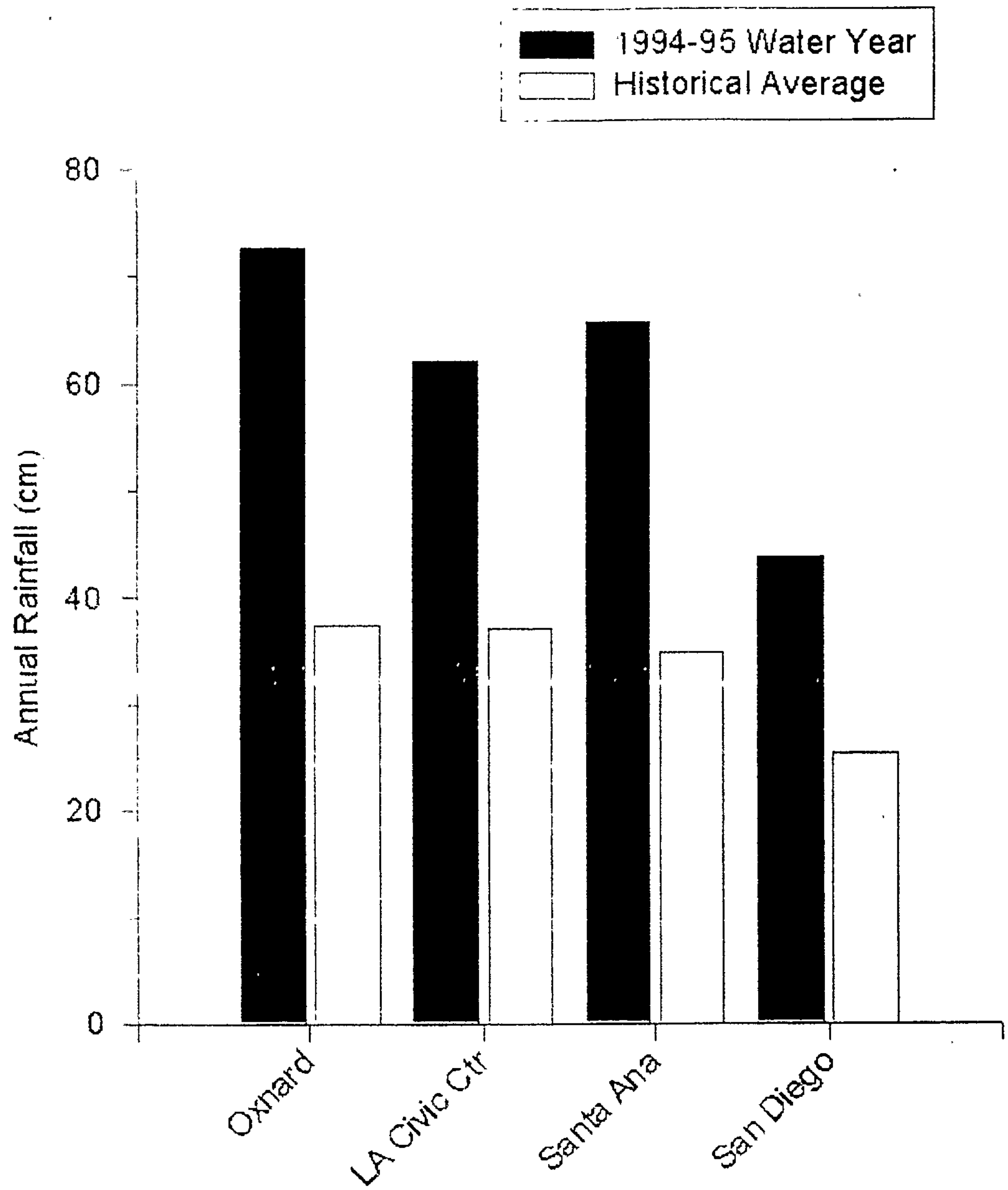
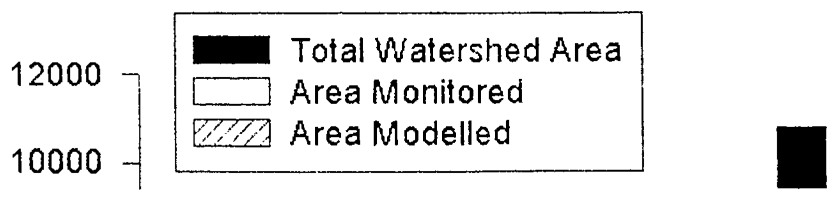


Figure 3. Total watershed area and volume discharged during the 1994-95 water year from rivers and creeks listed in NPDES stormwater permits of Southern California relative to the quantity actually monitored or estimated by permittees using stormwater management models.



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The Southern California Bight Pilot Project: Sampling Design

Mary Bergen

A general description of the Southern California Bight Pilot Project (SCBPP) is provided in the *Southern California Bight Pilot Project: An Overview* (in this annual report). It describes the justification for the Project, the basic elements of the sampling design, and the project management used to implement the program. This paper will provide a detailed description of the sampling design used for the SCBPP.

SAMPLING DESIGN

The Steering Committee used the conceptual framework of the United States Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP) (Overton *et al.* 1990, Stevens 1994) to design the SCBPP survey. EMAP sampling is based on a randomly-placed, triangular grid of points covering the contiguous United States and associated coastal waters. The interpoint distance for the EMAP grid is approximately 27 km (White *et al.* 1992); however, the grid spacing can be adjusted as needed for a particular sampling design. Use of the triangular grid ensures that sample points are well-distributed over the study area. Moreover, the explicit spatial basis of the design ensures that each sampling point represents a known area, so that it is possible to estimate the amount of area with a particular characteristic, e.g., the area with total organic carbon (TOC) greater than 2%. Random placement of the grid and random selection of sampling points provides randomness needed for statistical inference.

To assure a sufficient sample size, the Southern California Bight (SCB) was divided into subpopulations of interest (Figure 1, Table 1), including three geographic zones; three depth zones; the areas around the four largest municipal wastewater outfalls, treated cumulatively; the areas within 3 km of the 11 largest rivers (excluding the Los Angeles River which discharges into Long Beach Harbor) and stormdrains, treated cumulatively; Santa Monica Bay; and the area around the Hyperion Treatment Plant (HTP) outfall. The goal was to have at least 40 samples per subpopulation.

The areas around the municipal wastewater outfalls and the rivers and storm drains were chosen as subpopulations to allow assessment of ecological changes near point and nonpoint discharges, respectively. The geographic and depth subpopulations were chosen because nonpoint sources are more likely to affect shallow areas and point sources are more likely to affect deeper areas in the central Bight. In addition, the Steering Committee expected benthic infaunal and demersal fish assemblages to vary with latitude and depth. Santa Monica Bay and the area around the HTP 5-mile outfall were chosen to enhance sampling density so that data from the SCBPP could be compared to data collected by the City of Los Angeles in their fixed-station monitoring.

The dividing lines for the geographic and depth zones were chosen using the Committee's collective knowledge of invertebrate and fish distributions in the SCB. The circles around the rivers and storm drains were drawn using a 3-km radius. Since there is no information about the impacts of nonpoint discharges on demersal fish or benthic infaunal asssemblages in Southern California, this distance was chosen arbitrarily.

Except for the HTP outfall, the areas around the outfalls were delineated by drawing a line around the sampling grid that is currently used to monitor each outfall. Since the monitoring program includes all of Santa Monica Bay, the HTP sampling grid was not used to delineate the HTP outfall area. This was because the Steering Committee wanted to distinguish between the outfall area and the rest of Santa Monica Bay. In addition they wanted to enhance the sampling effort around the outfall to allow for a comparison between the SCBPP data and HTP monitoring data. Therefore, monitoring data was used to delineate an area that included stations that were shown to be impacted by the HTP outfall in the winter of 1989 (CLAEMD 1990).

For the assessment, the Committee chose 12 indicators of ecological health, including four measures of water quality (dissolved oxygen, temperature, salinity, and transmissivity), benthic infauna, epibenthic macroinvertebrate and demersal fish assemblages, sediment characteristics, including contamination, sediment toxicity, external fish pathology and bioaccumulation, and marine debris.

The assessment period was targeted for summer (July-August) since populations of demersal fish and benthic infauna are expected to be more stable in summer than in winter or spring, and sampling is less likely to be interrupted by bad weather. In addition summer sampling corresponds to the "index period" used in the EMAP program.

Due to financial and logistical constraints, it was not possible to collect enough samples to characterize all indicators in all subpopulations. Given available resources, it was possible to take enough trawls to characterize fish assemblages, fish pathology, and marine debris in the three geographic zones, three depth zones, and cumulative outfall areas. Sediment toxicity and fish tissue contamination were characterized for the cumulative outfall areas and for the SCB as a whole. Water quality, sediment characteristics and benthic invertebrate assemblages were characterized for all subpopulations.

STATION SELECTION

The stations to be sampled were chosen using a modification of the sampling protocol used by EMAP for estuaries in the Louisianan province (Summers *et al.* 1993). First, to have enough grid points to produce approximately 40 stations per subpopulation, the EMAP grid was enhanced 7x7x7 fold. Then, stations were selected by a process that involved (1) randomization of the grid points, (2) random selection of grid points, and (3) random placement of a sampling point around each grid point. The grid points were randomized using a process that produced an optimum spatial spread of samples, while retaining the randomness needed for statistical evaluation. To do this, each point in the grid was given a number and spatial address. The spatial address preserved information about the original location of the point. The numbering was in groups of seven and of powers of seven. Grid points were then completely randomized within the smallest group, and the groups were randomized within the next larger group. In this way the order of points was randomized but geographically adjacent points remained close to each other during randomization.

To select grid points for benthic and water quality sampling from the total population of grid points, each grid point (in random order) was assigned an inclusion probability based on the number of samples needed in the area in which the point was located. For instance, grid points in the river discharge areas were given larger inclusion probabilities than points in nondischarge areas because more samples per unit area were needed. To choose the first grid point, the inclusion probabilities were sequentially summed, starting with the first point, until the cumulative probability was greater than or equal to one. Then a point was randomly chosen from the group of points with a cumulative probability of one or less. Subsequent grid points were chosen by adding 1 to the first randomly chosen probability (= r) and the number of points selected (i.e., grid points were selected at r + 1, r + 2, etc.).

To select grid points for the trawl sampling, which would only be analyzed for depth, geographic, and outfall subpopulations, the same procedure was used; however, the selection process included only the grid points selected for benthic and water quality sampling. Finally, the stations to be sampled for sediment toxicity and tissue analysis were selected from the grid points chosen for trawling.

SAMPLING LOGISTICS

Five organizations were responsible for collecting samples: City of Los Angeles, Environmental Monitoring Division; City of San Diego, Metropolitan Wastewater Department, County Sanitation Districts

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For toxicity, the threshold can be set at the point where there is a statistically significant change in an experimental endpoint. For some sediment contaminants (e.g., silver), the thresholds can be chosen from estimates of the concentration of the compound expected to cause toxicity (Long and Morgan 1990). However, for a compound such as TOC, there is no definitive method to determine a threshold between natural and unnatural values. Regression analysis can be used to identify stations with higher than expected concentrations (Bergen *et al.* 1995, Daskalakis and O'Connor 1995). Then the sediment chemistry data along with data from other sources can be used to determine if increased concentrations are associated with anthropogenic activities. For demersal fish and benthic infaunal assemblages, the threshold will be based on an index (one for fish and one for infauna) that summarizes changes in community parameters, such as number of species and number of individuals. If the absolute value of the threshold is not clear, the Steering Committee will use all the available information to select a threshold.

SUMMARY

The SCBPP is a cooperative sampling effort intended to provide synoptic information about the ecological condition of the mainland shelf of Southern California.

The sampling design was based on a design developed by USEPA EMAP. Sampling points were chosen by random placement of a grid of points over the sampling area, followed by random selection of grid points and random placement of stations around the grid points. The grid ensured that the sampling effort was well distributed over the study area while the random placement of the grid and random selection of sampling stations provided randomness needed for statistical inference. Moreover, since the interpoint distance of the grid was known, each sampling point represents a known area so that the amount of area with a particular characteristic, e.g., the area with total organic carbon greater than 2%, can be estimated.

The sampling was designed for assessing ecological conditions in three geographic zones, three depth zones, the areas around the four largest municipal wastewater outfalls (treated cumulatively), the areas within 3 km of 11 rivers and stormdrains (treated cumulatively), Santa Monica Bay, and the area around the HTP outfall. The assessment of ecological condition will be based on measures of water quality, demersal fish and benthic infaunal assemblages, sediment characteristics, sediment toxicity, fish pathology and bioaccumulation, and marine debris.

The extent and magnitude of change between subpopulations will be measured by (1) developing a cumulative distribution function for a parameter and (2) selecting a threshold value to divide natural from changed. Then the percent area that has been changed will be estimated.

Analysis of data is in progress. Survey results will be presented in a series of reports, including an assessment of ecological conditions on the Southern California mainland shelf and an evaluation of the SCBPP survey design.

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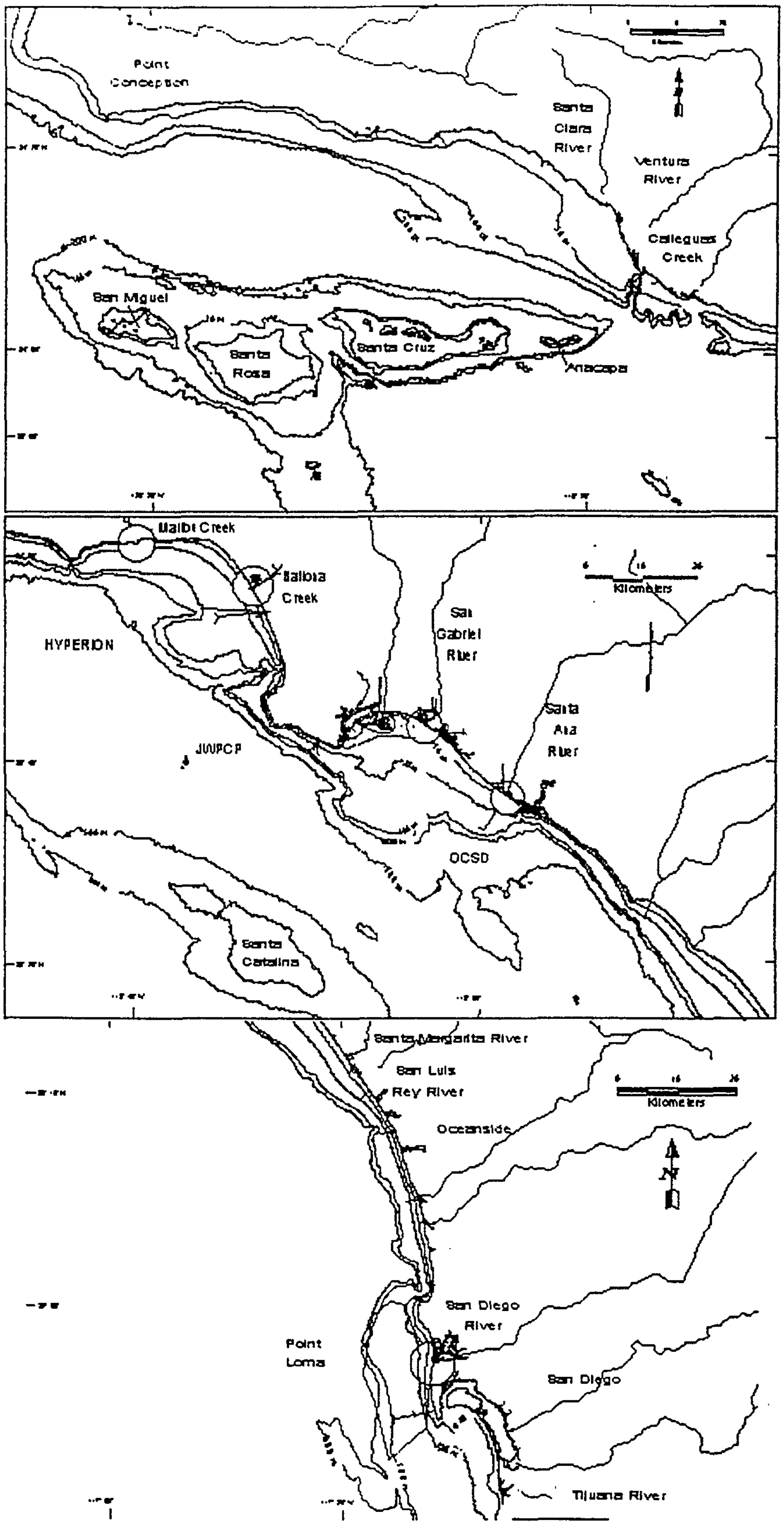

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the percent of the area of the SCB or of one of the subpopulations for the category of the variable; for instance, it is the percent of area with DDE of 10 ppb, 20 ppb, ... up to the maximum measured. The CDF shows the percent of area with DDE equal to or less than 10 ppb, 20 ppb, etc. In the SCBPP survey, because some areas (e.g., around the HTP outfall) were more intensively sampled than others, the number of points per unit area and the amount of area that the points represent varies. Therefore, the area weight, (i.e., the amount of area represented by the point) must be used to calculate the CDF. The CDF for parameter value x (e.g., DDE = 30 ppb) is the sum of the area weights for observations with values equal to or less than x divided by the sum of all the area weights in the population or:

$$cdfx = \text{Total } x\ (areawt_i) / \text{Total } (n)\ areawt_i)$$

where: *cdfx* = estimate of CDF for parameter value x
(e.g., DDE = 40 ppb)
$areawt_i$ = area weight for parameter value x
n = total number of observations
x = parameter value

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EPA Office of Water

OFFICE OF WASTEWATER MANAGEMENT

BMP MENU
LINKS
FEEDBACK

Identifying Illicit Connections

Illicit Discharge Detection and Elimination

Description

Illicit connections are defined as "illegal and/or improper connections to storm drainage systems and receiving waters" (CWP, 1998). A discharge of industrial wastewater to a storm sewer is "illicit" because it would ordinarily require a permit under the Clean Water Act. Many building owners or operators are not aware that improper connections exist in their facilities. Identifying and removing illicit connections is a measure for reducing storm water pollution. In extreme cases of illicit dumping, legal action is necessary.

One of the ways to identify illicit connections is by inspecting storm drain system using video equipment (Source: Drain Patrol, no date)

From 1987 to 1998, Wayne County, Michigan, investigated 3,851 businesses and industries for illicit connections to the county's storm sewer system. Of those investigated, about 8 percent had illicit connections, and where one illicit connection was found, there was an average of 2.4 improper connects at that business. To prioritize the investigation, the county relied on Standard Industrial Classification (SIC) codes of the businesses. The prioritization system was found to be successful in locating illicit discharges (Johnson and Tuomari, no date; Tuomari, no date). The City of Hialeah, Florida, uses its storm water management plan to emphasize illicit discharge detection and removal as part of its overall monitoring activities. There are at least 252 outfalls in the city, 72 of which drain into city rights-of-way. After considering the costs associated with removing illicit discharges, the city chose a proactive field screening program approach to remove these discharges (City of Hialeah, 1999).

Applicability

Identifying illicit and improper connections are necessary for all sewer systems, especially in areas where pollutants with unknown sources have been detected in receiving waters. The level and types of industrial activities and the surrounding land uses and ordinances will affect the methods used to identify illicit connections.

Implementation

Some practices used to discover and prevent illicit connections are

- Instituting building and plumbing codes to prevent connections of potentially hazardous pollutants to storm drains.
- Organizing structures to be inspected by building age, with older buildings identified as priorities. Buildings whose processes have the potential to affect water quality also should be given priority.
- Mapping each area to be surveyed and indicating the route of the sewer system and the locations of storm drains on the map. This enables planners to estimate the likely locations of illicit connections. A Geographic Information System (GIS) is an appropriate tool for identifying illicit discharges. The location of illicit discharges can be maintained by a geo-coded address. The attributes for illicit discharges are SIC code, owner/occupant information, inspection schedule, inspection dates, and comments (Huey, 2000).

To help municipalities detect illicit connections to storm sewers, the North Central Texas Council of Governments (NCTCOG) used GIS to develop a 1/4-mile grid cell overlay for the entire 16-county NCTCOG region. The initial report suggested that illicit connections were not as prevalent in the North Central Texas area, and sewage material was observed in about 10 percent of the sites (NCTCOG, 2000).

The City of Greensboro, North Carolina, is using GIS technology as part of its storm water management program. This GIS system is used to in conjunction with the program's monitoring aspect to identify illicit connections. More information on this program can be found at *www.ci.greensboro.nc.us/stormwater/dynamic%5Fwatershed%5F management%5Fpro.htm* (Bryant et al., 1999 and City of Greensboro, 2000).

- Survey individual buildings to discover where connections to storm drains exist.
- Inspect sewer lines with television equipment to visually identify all physical connections.
- Compare the results of the field tests and the video inspection with the known connections on the map. Suspicious areas should be further investigated.
- Institute mandatory inspections for new developments or remodeling to identify illicit connections to the storm sewer system.
- Remove and test sediment from the catch basins or equivalent structures.
- Inspect connections in question to determine whether they should be connected to the storm drain system or to the sanitary sewer. Use methods of identification such as dye testing, visual inspection, smoke testing, or flow monitoring, as described below.
  - *Dye Testing.* Flushing fluorometric dye into suspicious

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downspouts can be useful to identify illicit connections. Once the dye has been introduced into the storm system via the connection in question, the water in the collection system is monitored to determine whether an illicit connection is present.

- *Visual Inspection.* Remotely guiding television cameras through sewer lines is another way to identify physical connections.
- *Smoke Testing.* Smoke testing is another method used to discover illicit connections. Zinc chloride smoke is injected into the sewer line and emerges via vents on connected buildings or through cracks or leaks in the sewer line. Monitoring and recording where the smoke emerges, crews can identify all connections, legal and illegal, to the sewer system. Mechanisms on drains should prevent the smoke from entering buildings; however, in some instances, this will occur. It is important to notify the public that the smoke is non-toxic, though it should be avoided as it can cause irritation of the nose and throat for some people.
- *Flow Monitoring.* Monitoring increases in storm sewer flows during dry periods can also lead investigators to sources of infiltration due to improper connections.
- *Infrared, Aerial, and Thermal Photography.* Researchers are experimenting with the use of aerial, infrared, and thermal photography to locate dischargers by studying the temperature of the stream water in areas where algae might be concentrated and in soils. It also examines land surface moisture and vegetative growth. This technique assumes that a failing OSDS, for example, would have more moisture in the surface soil, the area would be warmer, and the vegetation would grow faster than in the surrounding area (Johnson and Tuomari, no date).

On November 17 and 30, 1999, the Arkansas Department of Health used infrared technology to identify illicit discharges from septic systems into Lake Conway, Arkansas. Lake Conway, located in Faulkner County, Arkansas, is a man-made lake used mostly for recreational fishing. Approximately 90 percent of the residents within 1 mile of the lakefront have onsite wastewater treatment systems. Of the 2,500 to 3,500 residents who living within 300 feet of the shoreline, only 250 are connected to the public sewer system. Most of these systems are more than 30 years old and were installed before state regulations. The inspector used a state policy helicopter that was equipped with a Forward Looking Infrared imaging system, video equipment, and a global positioning system. The results of this two-day survey indicated that there are approximately 380 malfunctioning and improperly constructed septic systems within 300 feet of the lakefront (Eddie, 2000). Facility owners should be required to correct the problem by eliminating the discharge and connecting to the sanitary sewer system

Some agencies use a priority system for identifying illicit discharges. According to the Southeast Michigan Council of Governments (1987, cited in Tuomari, no date), a priority scheme for detecting illicit discharges from businesses should be as follows:

1. Automobile-related businesses/facilities and heavy manufacturing
2. Printers, dry cleaners/laundries, photo processors, utilities, paint stores, water conditioners, chemical laboratories, construction companies, and medium light manufacturing
3. Institutional facilities, private service agencies, retail establishments, and schools

Limitations

There are several limitations to programs to detect illicit connections. First, a local ordinance is necessary to provide investigators with access to private property in order to perform field tests (Ferguson et al. 1997). Second, rain fall can hamper efforts to monitor flows and visual inspections. In addition, smoke testing and dye testing may become more difficult, depending on the severity of the storm event. Smoke testing has roughly the same efficiency as door-to-door investigation, and both smoke and dye testing are more accurate than visual inspection.

Despite the difficulty in identifying these connections due to budget and staff restraints, it is important to understand that these connections are illegal and should be identified and reported regardless of cost. Jurisdictions can offset some of these costs by encouraging the reporting of illicit discharges by employees, thereby saving expense on inspectors and directing resources more efficiently.

Maintenance Considerations

Identifying illicit discharges requires teams of at least two people (volunteers can be used), plus administrative personnel, depending on the complexity of the storm sewer system. To help identify illicit discharges, the City of Raleigh, North Carolina, has illicit discharge regulations and dry weather screening for illicit discharges and connections. By taking baseline samples throughout the city, pollution control efforts can be better established for future identification of illicit discharges. This inventory, combined with the city's mapping effort, will be added to the city's GIS to allow for improved tracking of illicit discharges and spills (City of Raleigh, 1998).

Effectiveness An illicit discharge detection program can be an effective method to reduce the quantity of industrial or commercial pollutants that enter the storm drain system. For example, the Department of Environmental Protection in Montgomery County, Maryland, has an illicit discharge detection and elimination program called "Pipe Detectives," which uses volunteer monitoring and community hotlines to identify suspicious discharges (MCDEP, 1997). When discharges are reported, DEP consults maps of the surrounding areas and targets those areas for additional monitoring to narrow the search for the illicit connection. In one instance, a "milky white" discharge was reported in an area with many small businesses and large apartment buildings. Businesses were sent informational letters advising them of the illegal discharge and requesting their assistance in identifying it by allowing DEP to survey the properties. Through this cooperative effort, three illicit connections were detected and removed, including a sink that was used to wash paintbrushes (the source of the milky white discharge).

The City of Denver Urban Drainage and Flood Control District (UDFCD) in an independent agency whose functions include master planning, design and construction, maintenance, floodplain management, and management of the South Platte River. The master planning aspect includes major drainageway master planning, outfall systems planning, preparation of drainage criteria manuals for local governments and the district, support of special projects, and wetland projects. The City of Denver has a Storm Drainage Master Plan, which identified $100 million in necessary drainage improvements. The district uses pollutants and education materials to limit illicit discharges to storm drains (City of Indianapolis and Marion County, 2000).

As part of the Rogue River National Wet Weather Demonstration Project, Wayne County, Michigan, offers training for illicit discharge elimination. Four training courses are offered: Overview, Basic Investigations, Advanced Investigations, and Prevention of Construction-Related Illicit Discharges. More information on these training opportunities can be found at *http://www.wcdoc.org/rougeriver/techtop/index.html*.

EPA's Surf Your Watershed (*http://www.epa.gov/surf*) can help citizens and business/industry owners identify into which watershed their storm drains flow.

The Conservation Technology Information Center (CTIC), a non-profit data and technology information transfer center, has created *Know Your Watershed* (*www.ctic.purdue.edu/KYW*). This web site allows individuals to learn their watershed address by entering their city, county, or river name, or their ZIP code.

Cost Considerations

The cost of smoke testing, dye testing, visual inspection, and flow monitoring can be significant and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and type of land use will determine the level of investigation necessary. Case studies in Michigan have estimated the cost of two field staff and required support at $182,000 to $187,000 annually (Ferguson et al., 1997). Wayne County's budget for illicit detection investigations was $735,151 from 1996 to 1997 and $599,041 for 1997 through 1998 (Johnson and Tuomari, no date).

Many programs offset some of their cost by encouraging the reporting of illicit discharges by employees, thereby saving expense on inspectors and directing resources more efficiently. Programs have also saved money by using student interns to locate and map dry weather flows from outfalls, or by contracting with academic institutions to perform outfall monitoring.

Some programs have used funds available from "environmental fees" or special assessment districts to fund their illicit connection elimination programs. The Huron River Pollution Abatement Project used annual assessments of the city of Ann Arbor and a per parcel basis for the rest of the district to fund the costs of illicit connection removal efforts. The project provided Washtenaw County with a total of $1.7 million over the life of the program to finance their efforts. Fort Worth, Texas, charges an "environmental fee" to local residents and businesses to fund storm water-related efforts, including illicit connection detection. Approximately $2.5 million dollars a year is raised through these fees.

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Review of Existing Stormwater Monitoring Programs for Estimating Bight-wide Mass Emissions from Urban Runoff

By Kenneth Schiff

ABSTRACT

Urban runoff is perceived as a large source of pollutant inputs to the ocean, but no mass emission monitoring programs have been established to assess this discharge. Recently, however, National Pollutant Discharge Elimination System permits for urban runoff discharges were issued to stormwater management agencies on a regional (county-wide) basis and the 1994-95 water year represents the first period in which urban runoff water quality measurements have been monitored bight-wide. The goal of this study was to use the data generated by these monitoring programs to estimate mass emissions of pollutants to the Southern California Bight from urban runoff. After documenting the sampling design of each stormwater monitoring program, then collating information on rainfall, watershed area, runoff volume, and water quality measurements, we estimated the mass emissions of total suspended solids, nutrients (ammonia, nitrate, phosphorous), and five trace metals (chromium, copper, nickel, lead, zinc). Although the mass emissions of these constituents appeared substantial relative to other sources, there was tremendous uncertainty in the load estimates. Less than 5% of the watershed areas and less than 2% of the annual runoff volumes were actually monitored during 1994-95 water year. Extrapolation of water quality data to these unmonitored channels and flows, which is necessary to develop bight-wide emission estimates, are hampered by the tremendous vaiability in contaminant concentrations among the different watersheds and storm events. This variability in water quality measurements from urban runoff are not well understood. This lack of understanding adds to our uncertainty in the load estimates we provide.

INTRODUCTION

Rivers in southern California are amongst the most extensively modified channels in the world (Brownlie and Taylor 1981). These storm drain systems, which ultimately discharge directly to the ocean, were designed to remove stormwater from streets and low-lying areas as efficiently as possible, thus reducing flooding and minimizing property damage. Most of the modification to these channels occurred prior to an era of interest or knowledge about urban runoff water quality. As a result, accumulated debris, pollutants, and pathogens from the largest metropolitan centers on the west coast are discharged along with this urban runoff. Moreover, many urban runoff discharges are augmented by inland municipal/industrial treated wastewater discharges, potentially contaminated groundwater discharges, and at times, inputs from illegal discharges and illicit connections. There is little in the way of retention and virtually no treatment of runoff from southern California urbanized watersheds. Only relatively recently has concern regarding water quality of these urban runoff discharges been examined (SMBRP 1996, Schiff and Stevenson 1996, Bay *et al.* 1996, Suffet *et al.* 1993, Gold *et al.* 1992; SCCWRP 1980).

Although urban runoff is currently perceived as a potentially large source of contaminants to our near coastal environment (Eganhouse and Kaplan 1987, RWQCB-LA 1988, USEPA 1995), there has been little monitoring for estimating contaminant mass emissions to the Southern California Bight (SCB). One reason for the lack of quantified loadings is because sampling and characterizing runoff discharges is extremely difficult. Unlike many other point sources of pollutants to the ocean, such as treated municipal or industrial wastewaters, the ubiquitous nature of urban runoff prohibits characterization from a single location or at infrequent intervals. The unpredictable rainfall in southern California further complicates runoff monitoring since the resulting flows are discontinuous and highly variable. Historically, most runoff measurements for estimating contaminant mass loadings to the ocean have been the result of special studies (SCCWRP 1973; 1990; 1992). Re-authorization of the Clean Water Act in 1987 and associated litigation have now required regulatory permitting of stormwater discharges. Most of this regulatory burden, both technical and fiscal, has been tasked to the stormwater management agencies, whose mission has traditionally been building and maintaining our flood control channels.

The State of California, through it's Regional Water Quality Control Boards, issued four region-wide National Pollutant Discharge Elimination System (NPDES) Permits between 1990 and 1993 for urban stormwater discharges to the SCB (Table 1; Figure 1). Each permit has many co-permittees including counties, incorporated cities within the counties, and special districts (e.g., Port District). The principal permittees are the Ventura County Flood Control District (Ventura Co.) for the Ventura County Region-wide Permit, Los Angeles County Department of Public Works (LA Co.) for the Los Angeles County Region-wide Permit, Orange County Flood Control District (Orange Co.) for the Orange County Region-wide Permit, and the City of San Diego (San Diego Co.) for the San Diego Region-wide Permit. All permittees are mandated to create a stormwater management plan (SWMP), part of which is water quality monitoring. Although monitoring programs are mandated by each NPDES Permit, they have not been standardized within the SCB.

The objectives of this study were three-fold. For each of the urban runoff water quality monitoring programs in the SCB during the 1994-95 water year, we attempted to:

1) Document the sampling designs of each water quality monitoring program;

2) Collate rainfall, watershed area, runoff volume, and water quality information from each of the monitoring programs and use this information to estimate bightwide mass emissions; and

3) Evaluate our ability to calculate mass emission estimates based upon the current monitoring programs.

MATERIALS AND METHODS

Each stormwater management agency's Annual Discharge Monitoring Report (ADMR) was reviewed to document sampling designs, collate data for water quality and flow measurements, and evaluate monitoring programs for estimating bight-wide mass emissions from urban runoff (VCFCD 1995; LACDPW 1996; OCEMA 1996; KLI 1995). The most recent year for which an ADMR was available for all permittees was the 1994-95 water year (October 1994 through September 1995). Each ADMR was obtained from the RWQCB files or from the permittee.

For the purposes of this article, several assumptions were required. First, only watersheds listed in the NPDES permits were considered, including areas beyond the urban limit line. Where watersheds were split between permits (i.e., Santa Clara, Santa Ana, and Santa Margarita Rivers), the region for which the discharge entered the ocean was chosen as the area encompassed in permitted discharge. Significant impoundments exist on most rivers of the SCB, but no attempt was made to remove upstream portions of watersheds from the estimated discharge area. However, only flows downstream of dams were considered for discharges to the ocean. No runoff factors were used to estimate unmonitored flows; only gaged flows to the SCB were utilized. It was assumed that flow and analytical chemistry measurements were conducted (and recorded) without error.

Documentation of Existing Monitoring Programs

Documentation of the existing monitoring programs focused on three areas: (1) Station selection, (2) Storm sampling criteria, and (3) Target analytes and detection limits. For station selection, the general strategy for site selection, the number of sites sampled, and the watershed area encompassed by that site were identified. For storm sampling criteria, the minimum storm size, total number of storms sampled, and sampling methodology were identified.

Estimation of Runoff Mass Emissions By Collating Monitoring Data
A simplistic, watershed-based approach was used to calculate mass emissions of contaminants from urban runoff to the SCB in 1994-95 illustrated by the following equation (1):

$$(1) \qquad L_{annual} = \sum_{i=1}^{n} (EMC_{median} * Volume_i)$$

Where,

L_{annual} = Annual pollutant load;

i = Watershed listed in the NPDES permit;

Volume = Annual volume of watershed i; and

EMC_{median} = Bightwide median event mean concentration .

Annual runoff volume for each watershed was obtained from either the ADMR's, the United States Geological Survey (USGS 1995), LA Co. - Engineering Section, Orange Co. Environmental Management Agency, San Diego Co. Flood Control District, or the International Boundary Water Commission (IBWC). Rainfall data, summarized from the National Weather Service (Nationwide Climatic Data Center, Ashville, NC), was used to complement flow data, demonstrate part of the variability responsible in flow among regions, and assess the relative discharges this water year compared to "normal" years as determined from long-term rainfall records. Additional information collated from these sources included 15 min. average flow during storm events and total volume discharged during storm events to assess volumes representatively sampled versus discharged.

Bight-wide median event mean concentrations (EMC) were calculated from the midpoint in the distribution of all the water quality data for a particular constituent reported in the 1994-95 ADMR's. The EMC is equivalent to the concentration designated as representative of each storm event by each monitoring agency. It is defined as the sum of all volume-weighted concentrations divided by the total storm volume (USEPA 1983). The only water quality data we collated for median EMC calculations were channel sites where an entire watershed was sampled. No sub-watershed, land use sites were used to calculate median EMC's. We also compared water quality results for the different region-wide permits by calculating 1994-95 median EMC's for individual SCB watersheds where the data were available.

Our watershed-based approach required pooling data to estimate water quality for channels not sampled. Because we had to extrapolate concentrations to unsampled watersheds, which adds some uncertainty to our estimates of mass emissions, we also calculated mass emissions based upon the 10th and 90 th percentile concentrations observed among watersheds. Our intention in the calculations was to capture the uncertainty in the extrapolations we have made.

Evaluation of Monitoring Data for Calculating Bightwide Mass Emissions from Runoff
The ability to calculate bightwide mass emissions from urban runoff based upon the monitoring data from 1994-95 was judged by two factors: (1) An assessment of monitoring coverage, and (2) The commonality of methods among monitoring programs. Monitoring coverage was assessed in terms of the percent of the area monitored and the percent of runoff volume representatively sampled. Commonality among programs

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included such factors as numbers and types of storms captured, sampling methodology and frequency, and comparability of analytical chemistry.

RESULTS

Documentation of Existing Monitoring Programs
Two general types of monitoring sites are currently being used by the stormwater management agencies in the SCB. The first type of monitoring site samples an entire watershed composed of large areas (10^1 to 10^3 km^2) and a diverse mix of land use types by sampling water quality at or near the end of a river or creek. The goal of this monitoring design is to characterize the cumulative discharges from all sources within the entire watershed. We refer to these as "channel sites";. The second type of monitoring site samples sub-watersheds composed of small areas (10^{-2} to 10^0 km^2) and a single homogeneous land use. The goal of this monitoring design is to characterize particular runoff sources (e.g. residential, commercial, industrial, etc.). We refer to these as "land use sites".

Fifteen of the 36 sites monitored by stormwater management agencies in 1994-95 were channel sites (Table 2). Orange Co. sampled channel sites exclusively (eight total, including the only unlined earthen channels). In contrast, Ventura Co. sampled only land use sites (seven total, including the only agricultural land use monitored). San Diego Co. sampled more sites in 1994-95 than any other stormwater management agency in the SCB (nine land use and three channel sites).

All of the stormwater monitoring programs in the SCB used storm mobilization criteria to trigger crews into action (Table 3). The first criterion was minimum storm size, as estimated from predicted rainfall quantities, which ranged from 0.10 to 0.25 inches among monitoring programs. The second criterion was antecedent dry period between storms, which ranged from three to four days among monitoring programs. Only the San Diego Co. NPDES permit specified the individual storms that must be captured, including the first two significant storms of the season and one late season storm (after February 1). Except for Los Angeles Co., monitoring programs in the SCB were required to sample a minimum of three storms per site each year; Los Angeles Co. was required to sample five storms per site each year.

Two types of samples were collected by the monitoring agencies (Table 3). The first type was a grab sample consisting of a bottle or bucket lowered into the channel or manhole. The second type was a composite sample, typically collected using a peristaltic pump with an intake strainer mounted in the bottom of channels or pipes. Composite samples, however, were weighted differently among agencies (Table 3). Ventura Co., Los Angeles Co., and San Diego Co. used a single composite sample per event weighted by storm flow (e.g., sampling every set volume interval). In contrast, Orange Co. measured two to three composite samples per event, each weighted by time (e.g. every hour, every 15 minutes, etc.). Although sampling frequency within a composite can vary as a result of storm duration or volume, automated samplers were programmed differently among monitoring agencies. Actual sampling frequencies varied from four to over 40 per storm event (Table 3).

Minimum flow requirements were defined by each monitoring agency to identify when to end sampling and evaluate the acceptability of a storm event (Table 3). Typically two trigger levels were used to conclude sampling. First, peak flows needed to recede to 120%, or less, of baseline pre-storm flow. Alternatively, the time since rainfall concluded needed to exceed a minimum interval (typically 96 hr.). Three of the four agencies reported the storm capture percentage which is equivalent to the volume representatively sampled compared to the total storm volume discharged. For those agencies that reported storm capture criteria, most events were greater than 75%.

Each of the stormwater management agencies analyzed a variety of constituents for their water quality assessments of urban runoff including general characteristics, inorganic analytes such as trace metals, and organic constituents such as chlorinated and petroleum hydrocarbons, toxicity tests with invertebrates or vertebrates, and fecal indicator bacteria (Table 4). Since not all constituents are measured during every storm or at every station, only those analytes and detection limits routinely listed in their respective ADMR's were reported. Thirteen analytes were measured in common between the four region-wide stormwater permits in the SCB. Some individual permittees, however, measured as many as 183 analytes for a given sample.

Collating Monitoring Data and Estimation of Mass Emissions

Rainfall. Annual rainfall varied from 44 to 73 cm throughout the coastal SCB (Figure 2). As expected, precipitation patterns across the SCB were highest in the north and steadily declined moving south. Oxnard received 66% more rainfall compared to San Diego. In 1994-95, the annual rainfall was approximately double the long-term average. Although precipitation was recorded between 9 and 10 months of the year, the majority of rain fell in the months of January and March. These two months represented 69 to 80% of the rainfall for the entire year, depending upon the gage site.

Watershed Area and Runoff Volume.

The total watershed area of the rivers and creeks named in Southern California NPDES stormwater permits was roughly 26,000 km^2 (Table 5). Approximately 90% of this area was gaged for urban runoff flows by a variety of agencies; 2.9 x 10^{12} L were measured during the 1994-95 water year (Table 5). Three rivers discharged over half of the gaged volume to the SCB. Annual discharges from the Los Angeles River, Santa Clara River, and Santa Ana River cumulatively exceeded 1.7 x 10^{12} L, but their watersheds represented only 41% of the SCB area.

When examined on a region-by-region basis, the San Diego Co. NPDES permit (10,800 km_2) encompassed nearly double the watershed area of the other three permits (4,900 to 5,500 km^2). Annual discharge volume in the Los Angeles region (1.13 x 10^{12} L), however, was between 175% and 230% greater than the other three regions (0.49 to 0.65 x 10^{12} L).

Water Quality.

Suspended solids, nutrients (nitrogen and phosphorous), and five trace metals (Cr, Cu, Pb, Ni, and Zn) were consistently analyzed and reported among the various NPDES stormwater monitoring programs of the SCB that sampled channel sites (Table 6). Other water quality parameters were measured frequently by individual agencies, but not consistently among all permits or at all sites within a permit. Organic constituents such as PAH's, DDT's, and PCB's were frequently measured, but virtually all measurements for these compounds were below reported detection limits.

No single region had all the highest or all the lowest median EMC's at channel sampling sites during 1994-95 (Table 6). The range of EMC's between regions differed by a factor of 2 to 20 among the general constituents and by a factor of 1 to 15 among the trace metals. This magnitude of variability was also observed between sites within a single region (Table 6). For example, the range of median EMC's among SCB regional permits for suspended solids was 175 to 330 mg/L. The range of EMC's between different monitoring sites within the San Diego region was 148 to 485 mg/L while the EMC's from various sites within the Orange County region ranged from 41 to 2,148 mg/L.

Mass Emission Estimates from Urban Runoff to the SCB.

Bight-wide median EMC's and mass emissions from urban runoff were estimated for the 1994-95 water year (Table 7). The total load of suspended solids was estimated to be 598 x 10^3 metric tons (mt). Using the 10^{th} and 90^{th} percentile of the distribution of EMC's within the SCB, low and high load estimates

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varied from 199 x [illegible] to 2,874 x 10^3 mt. The combined load of five trace metals (chromium, copper, lead, nickel, and zinc) was estimated to be 531 mt, although estimates varied from 236 to 1,807 mt.

Evaluation of Monitoring Data for Calculating Bightwide Mass Emissions from Runoff

Calculating mass emissions from urban runoff to the SCB from the current monitoring data was constrained by missing data from unmonitored watersheds (i.e., unsampled channels) and unmonitored flows (i.e., unsampled storms) (Figure 3). The watershed area sampled by stormwater monitoring agencies during the 1994-95 water year was approximately 1,162 km2 or 4.5% of the entire area discharging to the SCB which are listed in NPDES permits. Likewise, a very low percentage of the annual discharge volume was monitored. Approximately 0.06 x 1012 L was representatively sampled for analysis during the 1994-95 water year; Less than 2% of the annual volume. Of the SCB's largest watersheds (Los Angeles, San Gabriel, and Santa Clara Rivers), only 0.5 km^2 and 0.15 x 10^9 L was sampled.

Although the four stormwater monitoring programs targeted similar numbers, sizes, and types of storms, each sampled its storms differently. The data set used for this study consisted of grab, single and multiple-weighted composite samples. Furthermore, some agencies used time-weighted and others flow-weighted composites. Finally the sampling frequency within composites varied from 4 to 40+. Not all agencies used storm capture criteria, but those that did met expectations of $\geq$ 75% or more of the storm volume representatively sampled.

Each of the stormwater monitoring agencies analyzed at least nine constituents in common for which bight-wide mass emissions could be calculated (TSS, nutrients, and five trace metals). One agency measured as many as 183 constituents per sample. The methods cited in each of the ADMR's were comparable to Environmental Protection Agency (EPA) protocols. However, many organic compounds were non-detectable using these methods. Detection limits for trace metals were generally not problematic (i.e., usually detected), except for those agencies attempting to measure dissolved fractions.

DISCUSSION

Two approaches are generally used to calculate mass emissions from runoff to the SCB. There is a watershed-based approach which is empirical; concentrations and volumes are measured directly at the terminus of a channel prior to entering the receiving waters. The other approach employs a land use model which estimates runoff volumes based upon quantity of rainfall (from rain gages), watershed area, and coefficients of runoff (based upon imperviouseness). Typically, runoff models also rely upon representative land use sites for water quality data. The watershed-based approach was chosen for this study because channel sites required fewer assumptions to estimate mass emissions to receiving waters. A land use model was not applied because the ADMR's we reviewed lacked the water quality data for some land uses that may contribute substantial quantities of constituents to the SCB. Moreover, we lacked the necessary data to sufficiently calibrate and validate a land use model which would require a combination of both land use and channel site monitoring.

Although the watershed-based approach requires fewer assumptions than the land use model, it was not completely empirical. The watershed-based approach is most effective on a channel-by-channel and storm-by-storm basis. However, the stormwater monitoring agencies are not mandated by the RWQCB to monitor every channel or every storm. As a result, the data set was incomplete and a number of assumptions were required that introduced considerable uncertainty in the quality of our mass emissions estimates. First, it was necessary to assume that water quality measurements in monitored channels were equivalent to those from unmonitored channels. Based upon water quality results from monitored channels, 1994-95 median EMC's for channels within a county and between counties fluctuated widely, often ranging an order of magnitude or more for most constituents. Studies by SCCWRP (1992) also demonstrated tremendous variability among watersheds. For example, suspended solids flow-weighted mean concentrations ranged from 283 to 4,313 mg/L among the eight largest rivers and creeks in southern California during 1986-88. In 1994-95, only one of these eight channels was actually monitored by the stormwater management agencies. Since the corresponding data were not available from all channels, we are unable to assess the bias associated with our extrapolation to unmonitored watersheds.

A second assumption we used was that the temporal periods sampled within a watershed were representative of other periods which were not sampled. Assumptions based upon extrapolations to unsampled storms introduces uncertainty because of flow-related variability. Studies on the Los Angeles River and other channels of the SCB observed significant correlations between flow and pollutant concentrations (SCCWRP 1990). Consequently, mass emission estimates for specific runoff events differ between large and small storms as a result of changing constituent concentrations as well as discharge volumes. Therefore, missing or capturing significant events can result in potential bias depending upon the magnitude of the storm size. Capturing the largest storm of the year may result in the largest EMC's and will likely overestimate the unsampled, but smaller-sized storms. Alternatively, capturing the smallest storms may underestimate the true annual discharge (if substantially large storms are not sampled). Moreover, 1994-95 was a very wet year. Rainfall was approximately double the long-term annual average which generated some of the largest peak flows in recent history (USGS 1995). The magnitude of bias associated with unsampled storm events cannot be assessed because none of the SCB monitoring programs have sufficient temporal sampling regimes to address this question.

Other temporal assumptions relative to this study that can introduce uncertainty are even less understood than flow-related correlations. Assumptions which are not well understood for southern California watersheds include relationships of water quality to antecedent dry periods (pollutant build-up) and rainfall intensity or duration (pollutant transport). Examples of the interactions between these two important parameters include concepts such as "first flush" (initial storm flows) or "seasonal flushing" (initial storms of the water year). Although several investigators have demonstrated portions of these concepts in other regions (Herricks 1995), they are not well-quantified in southern California. In some cases they appear significant (OCEMA 1996, RWQCB-LA 1988); in others, they do not (SCCWRP 1989).

Temporal variability within and among runoff events is compounded in the SCB by the different sampling strategies utilized by stormwater monitoring agencies. Our data set was comprised of individual grab, single and multiple weighted-composite samples. Grab and composite samples however, represent very different portions of a storm event. Grab samples represent a single snapshot of water quality during a storm event and, for the most part in 1994-95, were taken independently of flow regime or time since start of flow. Composite samples were actually multiple grab samples which, when combined together, were used to represent the mean water quality for an entire storm event. Composite samples, however, were weighted differently among the agencies. Some were weighted by storm flow (e.g., sampling every set volume interval); others were weighted by time (e.g. every hour, every 15 minutes, etc.). Flow-weighted composites sample more frequently during high flows than low flows, while time-weighted samples are distributed evenly throughout the storm event. Moreover, the number of samples per composite varied substantially among agencies (4 to 40+), or even within an agency (12 to 40+). The degree to which sampling strategies influence water quality results has not been quantified in terms of bias to the true EMC or the relative effect on seasonal loading estimates.

One reason we needed to rely on so many assumptions is that the monitoring programs are not entirely designed to estimate mass emissions to the ocean. Most monitoring programs have multiple purposes, all of which are important. Multiple information needs from urban runoff monitoring include regulatory compliance, identifying sources of pollutants and developing runoff models, as well as evaluating management actions such as effectiveness of best management practices (Dixon and Chiswell 1996). Even if calculating total pollutant loads to the marine environment were not the primary goal of urban runoff monitoring, we suggest that the same assumptions we had to make will also inhibit the use of current monitoring data for other purposes. For example, evaluating the effectiveness of a specific management action, would be very difficult with the degree of variation observed. If a load reduction of 30% is targeted but variability in mass emission estimates are only accurate to within a factor of five to 10, true load reductions will be obscured and may not be detected. The effect of large variability would also hinder attempts to assess differences between sources and the variance added to a mass emissions computer modeling program would limit its utility as a management tool.

Estimating pollutant mass emissions from urban runoff discharges is the only way to gain perspective relative to the magnitude of inputs from other sources. Even when using the lower end of the mass emission estimates provided in this article, based upon monitoring data compiled from the 1994-95 NPDES permitted stormwater programs, inputs from urban runoff are substantial relative to other sources (See *Characteristics of Effluents from Power Generating Stations in 1995* and *Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1995* in this volume). Mass-based comparisons among various sources are preferred because large temporal and/or spatial changes in concentrations or flow can mislead scientists and resource managers when assessing the extent of potential impact. Of course, mass emission estimates are just one factor in the overall impact assessment process. Other important elements need to be considered including pollutant transport, contaminant fate, and biological impairment (See *Impacts of Stormwater Discharges on Santa Monica Bay* and *Toxicity of Stormwater Discharges from Ballona and Malibu Creeks* in this volume).

We suggest that estimating mass emissions is one of the greatest reasons to monitor because this is the only way in which stormwater management agencies can assess their relative contribution of pollutants to the marine environment. In southern California, marine environments are habitats of great concern since little freshwater habitat exists in our ephemeral streams and most channels are already highly modified. Currently, urban runoff is estimated to be a substantial source of pollutant inputs; However, this study has shown that mass emission calculations required numerous assumptions and the quality of load estimates are uncertain. If urban runoff is in fact a large source of pollutants, then quality load estimates will be required so that stormwater managers can leverage appropriate funding from their respective legislative bodies for controlling these inputs. If urban runoff is not a significant source of pollutant inputs, then quality load estimates will serve to alleviate the regulatory pressure and public perception that this source of inputs represents an unresolved environmental problem. At this point in time, the "true load" from creeks and rivers of the SCB is unknown. Furthermore, without adequate mass emission estimates and reliable confidence limits we will be unable to quantify with certainty whether mass emissions from urban runoff are increasing, decreasing, or staying the same with time, or whether they are changing as a result of management action.

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FIGURES

Figure 1. Map of major watercourses named in the four County-wide NPDES Municipal Stormwater Permits which discharge to the Southern California Bight. (See Table 1 for the names of individual rivers and creeks).

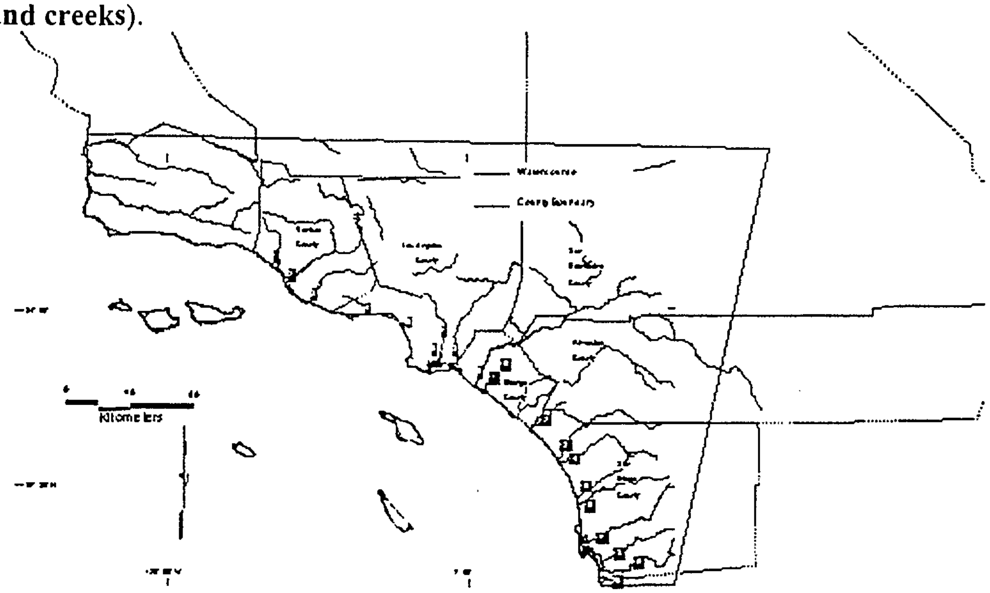


Figure 2. Annual rainfall at four locations in the Southern California Bight. (Data from the National Climatic Data Center, Ashville, NC).

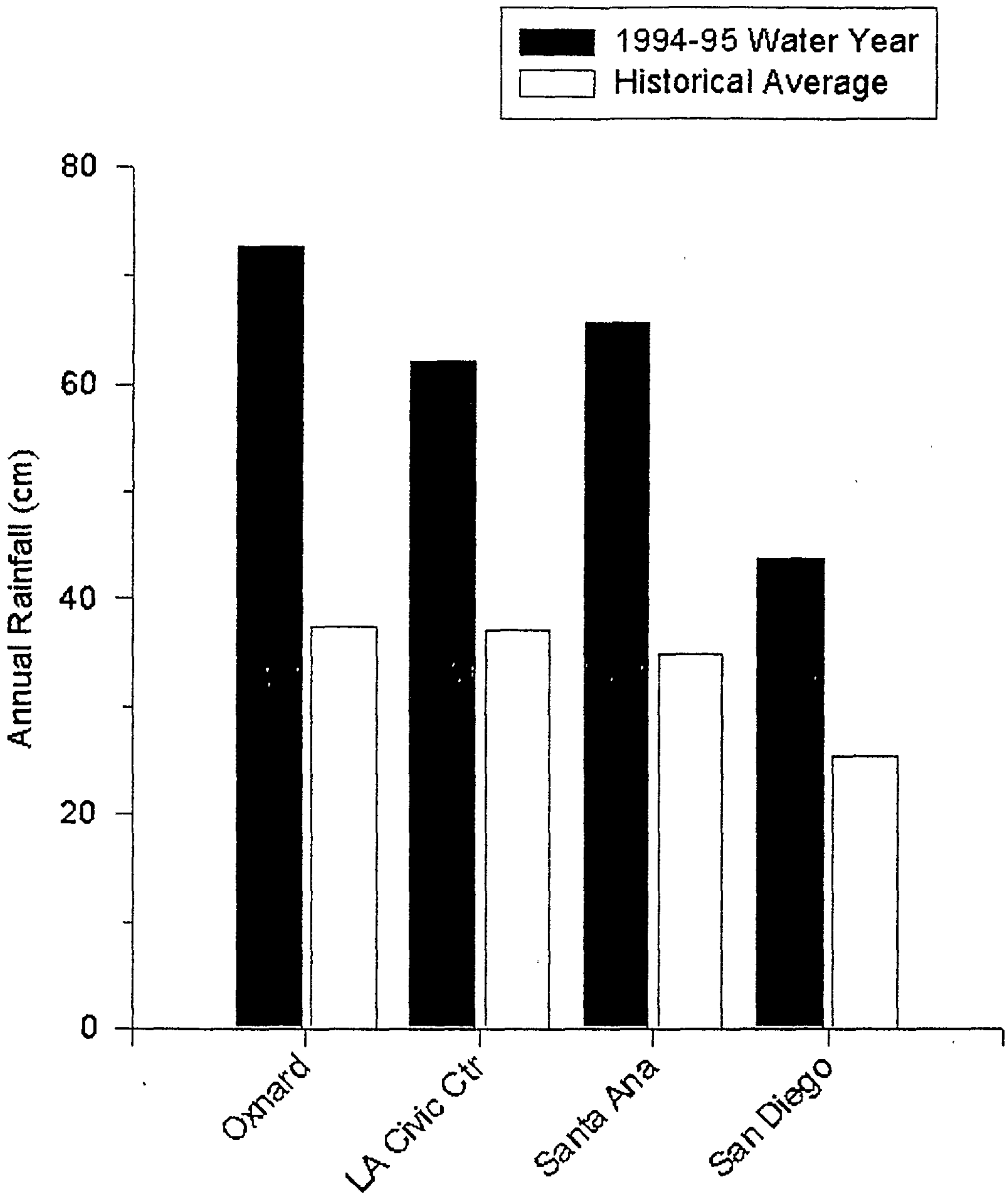
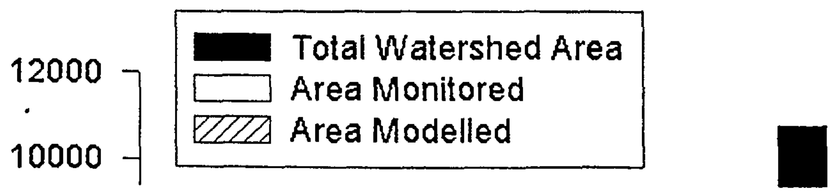


Figure 3. Total watershed area and volume discharged during the 1994-95 water year from rivers and creeks listed in NPDES stormwater permits of Southern California relative to the quantity actually monitored or estimated by permittees using stormwater management models.



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The Southern California Bight Pilot Project: Sampling Design

9 Field Manual

Mary Bergen

A general description of the Southern California Bight Pilot Project (SCBPP) is provided in the *Southern California Bight Pilot Project: An Overview* (in this annual report). It describes the justification for the Project, the basic elements of the sampling design, and the project management used to implement the program. This paper will provide a detailed description of the sampling design used for the SCBPP.

SAMPLING DESIGN

The Steering Committee used the conceptual framework of the United States Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP) (Overton *et al.* 1990, Stevens 1994) to design the SCBPP survey. EMAP sampling is based on a randomly-placed, triangular grid of points covering the contiguous United States and associated coastal waters. The interpoint distance for the EMAP grid is approximately 27 km (White *et al.* 1992); however, the grid spacing can be adjusted as needed for a particular sampling design. Use of the triangular grid ensures that sample points are well-distributed over the study area. Moreover, the explicit spatial basis of the design ensures that each sampling point represents a known area, so that it is possible to estimate the amount of area with a particular characteristic, e.g., the area with total organic carbon (TOC) greater than 2%. Random placement of the grid and random selection of sampling points provides randomness needed for statistical inference.

To assure a sufficient sample size, the Southern California Bight (SCB) was divided into subpopulations of interest (Figure 1, Table 1), including three geographic zones; three depth zones; the areas around the four largest municipal wastewater outfalls, treated cumulatively; the areas within 3 km of the 11 largest rivers (excluding the Los Angeles River which discharges into Long Beach Harbor) and stormdrains, treated cumulatively; Santa Monica Bay; and the area around the Hyperion Treatment Plant (HTP) outfall. The goal was to have at least 40 samples per subpopulation.

The areas around the municipal wastewater outfalls and the rivers and storm drains were chosen as subpopulations to allow assessment of ecological changes near point and nonpoint discharges, respectively. The geographic and depth subpopulations were chosen because nonpoint sources are more likely to affect shallow areas and point sources are more likely to affect deeper areas in the central Bight. In addition, the Steering Committee expected benthic infaunal and demersal fish assemblages to vary with latitude and depth. Santa Monica Bay and the area around the HTP 5-mile outfall were chosen to enhance sampling density so that data from the SCBPP could be compared to data collected by the City of Los Angeles in their fixed-station monitoring.

The dividing lines for the geographic and depth zones were chosen using the Committee's collective knowledge of invertebrate and fish distributions in the SCB. The circles around the rivers and storm drains were drawn using a 3-km radius. Since there is no information about the impacts of nonpoint discharges on demersal fish or benthic infaunal asssemblages in Southern California, this distance was chosen arbitrarily.

Except for the HTP outfall, the areas around the outfalls were delineated by drawing a line around the sampling grid that is currently used to monitor each outfall. Since the monitoring program includes all of Santa Monica Bay, the HTP sampling grid was not used to delineate the HTP outfall area. This was because the Steering Committee wanted to distinguish between the outfall area and the rest of Santa Monica Bay. In addition they wanted to enhance the sampling effort around the outfall to allow for a comparison between the SCBPP data and HTP monitoring data. Therefore, monitoring data was used to delineate an area that

Project Management

More than 100 people from thirteen different organizations were involved in the management of the 1994 Pilot Project. Effective management was a critical component of the success of the project since it required coordinating the efforts of many groups to produce data that are reliable and comparable. Management was based on a three-tier structure, with each tier performing a different function.

At the center of the management structure was the Steering Committee, composed of scientist/managers from each of the participating agencies. The Steering Committee was responsible for the overall planning of regional monitoring activities, focusing largely on program design. During the design process, the Steering Committee identified the questions to be addressed in the survey, selected sample sites to achieve these objectives and identified the indicators to be measured.

The Steering Committee was also responsible for project coordination among the different organizations involved. To achieve this, selected members of the Steering Committee were appointed as Quality Assurance (QA) Officer (who directed the QA components of the project), Field Coordinator (who directed the administrative and technical components of field operations), Laboratory Coordinator (who directed the administrative and technical components of laboratory analyses), and Information Management Officer (who coordinated data reporting and management).

The Steering Committee was supported by five technical subcommittees, which were responsible for addressing the technical details associated with each indicator group. These groups prepared sections of the methods and QA manuals specific to their areas of expertise. They also conducted data analysis of their indicators, with their reports subject to Steering Committee review.

The Steering Committee reported to the SCCWRP Commission, which is composed of the highest level of management from each of the largest municipal dischargers to Southern California Bight and from each of the agencies responsible for regulating discharge to the Bight. The Commission, which meets on a quarterly basis, ensured that the questions we were addressing stayed relevant to current management issues. Reporting to the Commission also ensured that the results would be used for management action.

Steering Committee Members
SCCWRP Commission

included stations that were shown to be impacted by the HTP outfall in the winter of 1989 (CLAEMD 1990).

For the assessment, the Committee chose 12 indicators of ecological health, including four measures of water quality (dissolved oxygen, temperature, salinity, and transmissivity), benthic infauna, epibenthic macroinvertebrate and demersal fish assemblages, sediment characteristics, including contamination, sediment toxicity, external fish pathology and bioaccumulation, and marine debris.

The assessment period was targeted for summer (July-August) since populations of demersal fish and benthic infauna are expected to be more stable in summer than in winter or spring, and sampling is less likely to be interrupted by bad weather. In addition summer sampling corresponds to the "index period" used in the EMAP program.

Due to financial and logistical constraints, it was not possible to collect enough samples to characterize all indicators in all subpopulations. Given available resources, it was possible to take enough trawls to characterize fish assemblages, fish pathology, and marine debris in the three geographic zones, three depth zones, and cumulative outfall areas. Sediment toxicity and fish tissue contamination were characterized for the cumulative outfall areas and for the SCB as a whole. Water quality, sediment characteristics and benthic invertebrate assemblages were characterized for all subpopulations.

STATION SELECTION

The stations to be sampled were chosen using a modification of the sampling protocol used by EMAP for estuaries in the Louisianan province (Summers *et al.* 1993). First, to have enough grid points to produce approximately 40 stations per subpopulation, the EMAP grid was enhanced 7x7x7 fold. Then, stations were selected by a process that involved (1) randomization of the grid points, (2) random selection of grid points, and (3) random placement of a sampling point around each grid point. The grid points were randomized using a process that produced an optimum spatial spread of samples, while retaining the randomness needed for statistical evaluation. To do this, each point in the grid was given a number and spatial address. The spatial address preserved information about the original location of the point. The numbering was in groups of seven and of powers of seven. Grid points were then completely randomized within the smallest group, and the groups were randomized within the next larger group. In this way the order of points was randomized but geographically adjacent points remained close to each other during randomization.

To select grid points for benthic and water quality sampling from the total population of grid points, each grid point (in random order) was assigned an inclusion probability based on the number of samples needed in the area in which the point was located. For instance, grid points in the river discharge areas were given larger inclusion probabilities than points in nondischarge areas because more samples per unit area were needed. To choose the first grid point, the inclusion probabilities were sequentially summed, starting with the first point, until the cumulative probability was greater than or equal to one. Then a point was randomly chosen from the group of points with a cumulative probability of one or less. Subsequent grid points were chosen by adding 1 to the first randomly chosen probability (= r) and the number of points selected (i.e., grid points were selected at r + 1, r + 2, etc.).

To select grid points for the trawl sampling, which would only be analyzed for depth, geographic, and outfall subpopulations, the same procedure was used; however, the selection process included only the grid points selected for benthic and water quality sampling. Finally, the stations to be sampled for sediment toxicity and tissue analysis were selected from the grid points chosen for trawling.

SAMPLING LOGISTICS

Five organizations were responsible for collecting samples: City of Los Angeles, Environmental Monitoring Division; City of San Diego, Metropolitan Wastewater Department, County Sanitation Districts of Los Angeles County, County Sanitation Districts of Orange County; and the Southern California Coastal Water Research Project (SCCWRP). The number of samples was based on the number of samples each agency collects in the summer quarter. Due to institutional restraints, such as insurance and travel restrictions, it was necessary to divide the sampling effort geographically. South of Point Dume, lines were drawn to divide the area into sample areas. Each agency sampled the geographic area that included their monitoring grid. SCCWRP, through contracts to MEC Analytical Systems, Inc., and MBC Applied Environmental Sciences, sampled the area north of Point Dume.

Between July 11 and August 22, 1994, water quality profiles were taken at 261 stations, benthic grab samples were taken at 252 stations, and trawls were taken at 114 stations. Since the participating organizations have separate field crews for each type of sampling, each station was sampled three times: once with a conductivity-temperature-depth profiler (CTD), once with a Van Veen grab sampler, and once with a otter trawl.

QUALITY ASSURANCE AND QUALITY CONTROL

Since five agencies were involved with sample collection and analysis, procedures for intercalibration and quality assurance/quality control (QA/QC) were of paramount importance. A field coordination team agreed on standard methods for collecting field samples and prepared a field operations manual for the survey (SCBPP, FCT 1994). The manual provided detailed descriptions of all procedures for sample collection and field analyses, including detailed QA/QC procedures and criteria.

Because methodologies (including instrumentation) differ widely among laboratories, the Committee opted to undertake a performance-based approach for sediment chemistry. The Committee envisioned a two-step process for implementing performance-based standards for laboratory analyses. In the first step, the laboratory would demonstrate the ability to perform the analyses by providing documentation about the procedure to be used, including documentation of the method detection limits and calibration curves, and by blind analysis of a known sample. Following successful performance in the first phase, the laboratory would continue to demonstrate performance by participation in interlaboratory intercalibration exercises, repeated analyses of Certified Reference Materials, calibration checks, and analyses of laboratory reagent blanks and fortified samples.

Intercalibration procedures for sorting and identification of specimens for benthic samples were developed by the specialty group for benthic sampling. Measurement Quality Objectives (MQOs), procedures for redressing problems, and standard reporting requirements were established for each stage of processing. Considerable effort was taken to ensure taxonomic consistency between the laboratories. Workshops under the auspices of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) were held every two to four weeks to examine infaunal specimens and discuss taxonomic problems.

DATA ANALYSIS AND INTERPRETATION

The sampling design is structured so that the extent and magnitude of change can be compared across subpopulations; that is, the areal extent of some parameter (e.g., toxicity) can be compared in the north, central, and southern zones or in outfall and nonoutfall areas. It is also possible to compare parameters, e.g., the spatial extent of toxicity and sediment with DDT higher than 3 ppb.

Determining the areal extent is a two-step process. First, the Horvitz -Thompson estimation (Cochran 1977) is used to develop a cumulative distribution function (CDF) from the area-weighted data (Appendix 1). The CDF shows the range of indicator values of an indicator as well as information about central tendency and extreme values. Then a threshold value is selected. The threshold value divides natural and changed values. Based on the threshold value, the percent area exceeding the threshold can be estimated.

The process of selecting a threshold value will be simple for some indicators and more difficult for others.

For toxicity, the threshold can be set at the point where there is a statistically significant change in an experimental endpoint. For some sediment contaminants (e.g., silver), the thresholds can be chosen from estimates of the concentration of the compound expected to cause toxicity (Long and Morgan 1990). However, for a compound such as TOC, there is no definitive method to determine a threshold between natural and unnatural values. Regression analysis can be used to identify stations with higher than expected concentrations (Bergen *et al.* 1995, Daskalakis and O'Connor 1995). Then the sediment chemistry data along with data from other sources can be used to determine if increased concentrations are associated with anthropogenic activities. For demersal fish and benthic infaunal assemblages, the threshold will be based on an index (one for fish and one for infauna) that summarizes changes in community parameters, such as number of species and number of individuals. If the absolute value of the threshold is not clear, the Steering Committee will use all the available information to select a threshold.

SUMMARY

The SCBPP is a cooperative sampling effort intended to provide synoptic information about the ecological condition of the mainland shelf of Southern California.

The sampling design was based on a design developed by USEPA EMAP. Sampling points were chosen by random placement of a grid of points over the sampling area, followed by random selection of grid points and random placement of stations around the grid points. The grid ensured that the sampling effort was well distributed over the study area while the random placement of the grid and random selection of sampling stations provided randomness needed for statistical inference. Moreover, since the interpoint distance of the grid was known, each sampling point represents a known area so that the amount of area with a particular characteristic, e.g., the area with total organic carbon greater than 2%, can be estimated.

The sampling was designed for assessing ecological conditions in three geographic zones, three depth zones, the areas around the four largest municipal wastewater outfalls (treated cumulatively), the areas within 3 km of 11 rivers and stormdrains (treated cumulatively), Santa Monica Bay, and the area around the HTP outfall. The assessment of ecological condition will be based on measures of water quality, demersal fish and benthic infaunal assemblages, sediment characteristics, sediment toxicity, fish pathology and bioaccumulation, and marine debris.

The extent and magnitude of change between subpopulations will be measured by (1) developing a cumulative distribution function for a parameter and (2) selecting a threshold value to divide natural from changed. Then the percent area that has been changed will be estimated.

Analysis of data is in progress. Survey results will be presented in a series of reports, including an assessment of ecological conditions on the Southern California mainland shelf and an evaluation of the SCBPP survey design.

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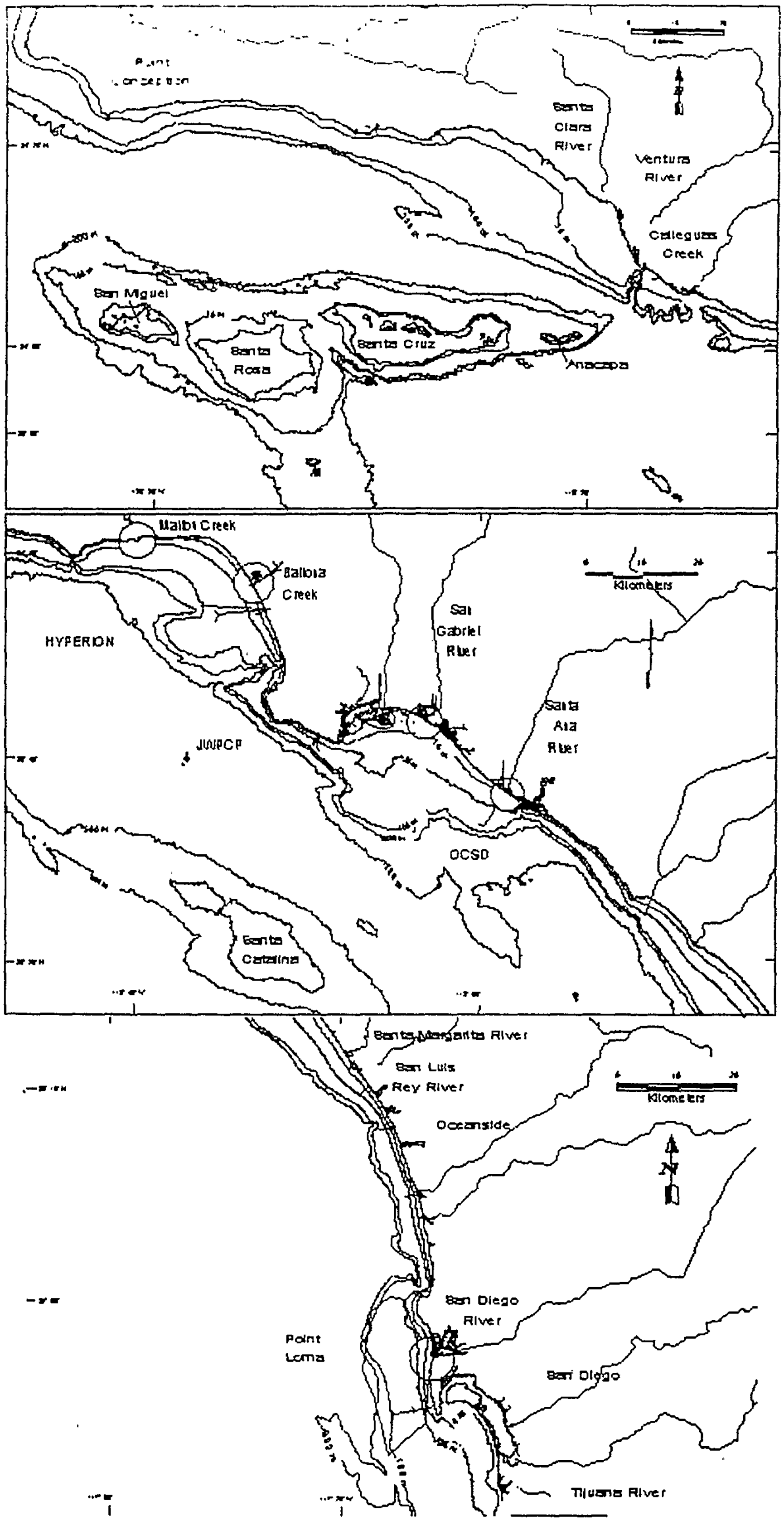
FIGURES

FIGURE 1.
River and outfall subpopulation areas for the Southern California Bight Pilot Project survey, July - August 1994.

Return to Sampling Design



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TABLES

TABLE 1.

Subpopulations of interest in the SCBPP. Subpopulations are defined in detail in the text.

Return to Sampling Design

1. Geographic zones:
Northern - Point Conception to Point Dume
Central - Point Dume to Dana Point
Southern - Dana Point to the U.S.-Mexico border
2. Depth zones:
Shallow (Inner shelf) - 10-25m
Mid-depth (Middle shelf) - 26-100m
Deep (Outer shelf) - 101-200m
3. The areas around the outfalls of the four largest municipal wastewater outfalls treated cumulatively.
4. The areas within 3 km of the following 11 largest rivers[a] and storm drains treated cumulatively:
Ventura River
Santa Clara River
Calleguas Creek
Malibu Creek
Ballona Creek
San Gabriel River
Santa Ana River
Santa Margarita River
San Luis Rey River
San Diego River
Tijuana River
5. Santa Monica Bay
6. The area around City of Los Angeles Hyperion Treatment plant 5-mile outfall.

a Los Angeles River (the largest river) was excluded because it discharged into Long Beach Harbor.

APPENDIX

APPENDIX 1.

Return to Data Analysis

The Cumulative Distribution Function A cumulative distribution function (CDF) is the progressive summation of a distribution function. A distribution function presents the amount (e.g., frequency, percent of population, percent of area) for each category of a variable. The CDF presents the cumulative total (e.g., total percent area) for each category of a variable. This allows the determination of the amount of the distribution equal to or less than the category. Sokal and Rohlf (1995) describe the distribution function and cumulative distribution function for a normal distribution. For the SCBPP, the distribution function is

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the percent of the area of the SCB or of one of the subpopulations for the category of the variable; for instance, it is the percent of area with DDE of 10 ppb, 20 ppb, ... up to the maximum measured. The CDF shows the percent of area with DDE equal to or less than 10 ppb, 20 ppb, etc. In the SCBPP survey, because some areas (e.g., around the HTP outfall) were more intensively sampled than others, the number of points per unit area and the amount of area that the points represent varies. Therefore, the area weight, (i.e., the amount of area represented by the point) must be used to calculate the CDF. The CDF for parameter value x (e.g., DDE = 30 ppb) is the sum of the area weights for observations with values equal to or less than x divided by the sum of all the area weights in the population or:

$$cdfx = \text{Total } x\ (\text{areawt}_i)/\text{Total } (n)\ \text{areawt}_i)$$

where: *cdfx* = estimate of CDF for parameter value x
(e.g., DDE = 40 ppb)
areawt_i = area weight for parameter value x
n = total number of observations
x = parameter value

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Impacts of Stormwater Discharges on the Nearshore Environment of Santa Monica Bay

Steven Bay and Kenneth Schiff

ABSTRACT

This report describes the first-year results of a three-year study to investigate the receiving water effects of stormwater discharges from Ballona and Malibu Creeks. Surface water and sediment samples were collected for analysis following four storm events in January and February, 1996. Surface water toxicity was present offshore of Ballona Creek and was proportional to the concentration of runoff in the plume. Deposition of runoff particulates offshore of both Ballona and Malibu Creeks was indicated by spatial changes in sediment characteristics, such as grain size and total organic carbon (TOC). Similar spatial patterns were present in samples collected after storms and during dry weather, indicating that the changes were persistent. Sediment contaminants, such as lead, total polychlorinated biphenyl (PCB), and total polycyclic aromatic hydrocarbon (PAH), were elevated at stations located nearest the mouth of Ballona Creek. Sediment contamination was less offshore of Malibu Creek and did not show a pattern related to stormwater discharge. The first-year results have not detected stormwater-related changes in benthic infaunal community assemblages or sediment toxicity near the discharges.

INTRODUCTION

Urban runoff has been shown to discharge large quantities of contaminants (Schiff and Stevenson 1996; SCCWRP 1990, 1993a) and can be toxic to marine organisms (Bay *et al.* 1996). Unlike municipal wastewater, stormwater runoff enters the nearshore marine environment, often through estuaries or wetlands, wholly untreated. New regulations and increased monitoring efficiency are enhancing in-channel measurements, more accurately characterizing wet weather inputs and the effectiveness of best management practices (LACDPW 1996). However, virtually no information exists on contaminant fates and their biological effects once wet weather discharges enter the marine environment.

The fates and effects of contaminants on the receiving environment cannot be predicted from in-channel measurements alone. The mixing of the freshwater plume with seawater alters the chemical state and solubility of some contaminants; particle aggregation and settling are also affected in complex ways. The nearshore environment is very dynamic, with waves and currents having strong influences on the deposition and distribution of stormwater contaminants. Much of what is known about the benthic effects of contaminants has been learned from studies of offshore ocean wastewater outfalls. These systems differ markedly from stormwater discharges in terms of discharge composition, variability, and receiving environment characteristics. Directed studies of stormwater discharge are needed to identify the contaminants of concern and their biological effects.

The research described in this report represents the initial results of a three-year program to investigate the correlation between stormwater discharge and environmental effects. This study, conducted in collaboration with the University of Southern California (USC), USC/SeaGrant, and the University of California at Santa Barbara (UCSB), has three principal objectives. The first objective is to measure the dispersion and mixing of stormwater plumes in Santa Monica Bay (this work was conducted by our collaborators and is not presented herein). The second objective is to examine the magnitude and characteristics of water column and sediment toxicity near stormwater discharges. This work element examines potential contaminant effects and provides an important link with similar data obtained from upstream measurements. The final objective of this project is to measure the impacts to benthic communities in the immediate vicinity of the discharge. This report presents the results of toxicity and benthic impact testing during the first wet season of sampling. Upon completion of the three-year study, an integration of these results with data obtained from our joint investigators will appear in a future issue of the Southern California Coastal Water Research Project (SCCWRP) Annual Report.

MATERIALS AND METHODS

The Ballona Creek and Malibu Creek watersheds were selected for evaluation in this study. Both watersheds are approximately the same size. Together, (Figure 1) they encompass over half of the entire Santa Monica Bay drainage area (Stenstrom and Strecker 1993). The Ballona Creek drainage basin is highly urbanized; 83% of the watershed is developed and comprised of predominantly residential land use. Almost the entire channel is concrete-lined. Conversely, Malibu Creek is predominantly undeveloped; 88% of the watershed is open land and the creek is in a natural state. These differences in watershed characteristics, combined with localized diversity in rainfall, lead to large variations in flow and pollutant loading to the ocean, even for the same storm event (LACDPW 1996). By comparing impacts associated with each watershed, we hope to distinguish between effects arising from urban and nonurban stormwater runoff.

Sampling and Sample Handling

The sampling program consisted of two phases. In the first phase, sediment samples were collected in November 1995 and January 1996 (Table 1) to examine the spatial extent of runoff-affected sediment offshore of each creek. These data were used to select sediment sampling stations for the second phase, consisting of sediment and water sampling during or soon after storms (wet season sampling). Wet season sampling was also coordinated with plume dispersion studies conducted by USC and UCSB. Sample dates (Table 1) and methods varied throughout the study because of the unpredictable nature of storm events, the limitations of ship availability, and the objectives of different study components. Water samples for toxicity were collected as soon as possible following a storm (8 to 48 h), while sediment samples were collected 7 to 12 d following target storms in order to allow suspended particles to settle.

The spatial survey consisted of two grids (13 to 15 stations each) surrounding the mouths of Ballona and Malibu Creeks (Figure 1). Stations were separated by approximately 2 km and extended 2 to 4 km upcoast or downcoast from each creek mouth. Sampling depths were approximately 10, 25, and 40 m. The spatial survey was completed prior to significant flow from either creek during the 1995 to 1996 wet season.

Wet season sampling was accomplished after four storm events during the 1995 to 1996 wet season (Table 1). Based upon the results of the spatial survey, four stations offshore of each creek mouth were targeted for post-storm sediment chemistry and infaunal sampling (Figure 1). Samples were taken at approximately 25 m at all eight stations to reduce any depth-related bias. One additional sediment sample was collected at each site on February 28 for sediment toxicity and chemistry testing. Continuous profiles of water column temperature, salinity, dissolved oxygen, and transmissivity were also taken at each sediment collection station (these data are not presented in this report).

Sediments were collected using a 0.1 m2 modified Van Veen grab from either the R/V LaMer or R/V Sea World. For contaminant analysis, only surficial sediments (the top 2 cm) from undisturbed grabs were collected. Sediment samples were placed in separate containers for grain size, TOC/total nitrogen(TN), trace organics, and trace metals analysis These samples were taken from the same grab but were not homogenized prior to splitting. Samples were either stored under refrigeration (grain size) or frozen until analyzed. Samples for sediment toxicity tests were taken from replicate grabs and stored under refrigeration.

For benthic invertebrate community (infaunal) analysis, entire sediment grab samples were gently washed through a 1 mm mesh stainless steel screen on the boat. The organisms retained on the screen were "relaxed" using MgSO4 (Epsom salts) in seawater. After 30 min, the sample was fixed with 10% borax-buffered formalin and returned to the laboratory. After 24 h, samples were rinsed with freshwater to remove formalin and preserved in 70% ethanol.

- Surface water samples (upper meter) were collected during each of the four storm events (Table 1). Five water samples were obtained from the Ballona Creek area during each event. Fewer samples were collected off Malibu Creek, due to difficulties in accessing the study area and the relatively small volume of runoff found in the surface water. Water sampling methods varied because of the necessity to use different boats for sampling operations. Surface water samples for January 31 and February 1 were collected by dipping into the water a glass jar attached to the end of an aluminum pole. Water samples for other storms were obtained with a submersible pump deployed off the side of the boat. Both sampling techniques may have captured portions of the sea [illegible] Both sampling techniques may have captured portions of the sea surface [illegible] no special effort was made to sample this portion of the water column. Samples were stored under refrigeration at SCCWRP and tested within 48 h.

- Locations of the water sampling stations were determined during each cruise and varied between events. Salinity measurements were used to select locations that represented a gradient of runoff concentration, usually aligned along a transect running between the creek mouth and a reference station (no apparent runoff) located up to 6 km offshore. Deviations from the general sampling plan occurred in response to available ship time, weather conditions, and the extent of the runoff plume.

Analytical Chemistry

Grain Size Analysis

Sediment grain size was measured using a Horiba Model LA-900 laser-scattering particle size distribution analyzer. The sediment sample was first homogenized, then a representative aliquot was passed through the instrument and the particle sizes were determined by detection of scattered (refracted and reflected) laser light.

Total Organic Carbon, Total Nitrogen and Total Volatile Solids Analysis

The TOC/TN measurements were conducted using a Carlo Erba 1108 CHN elemental analyzer, according to methods developed by SCCWRP (1993b). Sediment samples were homogenized, dried, and then digested with acid to remove inorganic carbon. Samples were then oxidized by combustion in the analyzer, and the evolved carbon and nitrogen were quantified using a thermal conductivity detector.

Total volatile solids (TVS) was measured using a Thermolyne Model 62700 muffle furnace. Sediments were dried at 60 C overnight, combusted at 500C, and then weighed after cooling. The TVS was determined from the net loss in weight after combustion. While not as specific a measure as TOC, TVS has been shown to be significantly correlated with TOC measurements in reference areas of the Southern California Bight (SCB) (Thompson *et al.* 1993).

Metals Analysis

Samples were prepared for metals analysis in accordance with Environmental Protection Agency (EPA) Method 3051 (EPA 1996). Dried sediment samples were digested using a nitric acid:hydrochloric acid mixture. Concentrations of aluminum, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, and zinc were determined using a Hewlett Packard Model 4500 inductively coupled plasma-mass spectrometer (ICP-MS) according to EPA Method 200.8 (EPA 1991).

Pesticides and Polychlorinated Biphenyls

Analytical methods for chlorinated pesticides (DDTs) and PCBs followed EPA protocols (EPA 1986 or EPA 1983). Six DDT isomers and metabolites (o,p'-DDT, p,p'-DDT, o,p'-DDE, p,p'-DDE, o,p'-DDD, p,p'-DDD) and 27 individual PCB congeners (Congeners 8, 18, 28, 29, 44, 50, 52, 66, 77, 87, 101, 104, 105, 118, 126, 128, 138, 153, 154, 170, 180, 187, 188, 195, 201, 206, and 209) were quantified. Samples were also examined for 12 additional chlorinated pesticides (isomers of chlordane and lindane, hexachlorobenzene, and derivatives of endosulfan), but none of these compounds were detected for any sample in this study.

Specific methodological details for the sediment analyses can be found in SCCWRP (1994) or Zeng and Khan (1995), but a general description of the procedure follows. Samples for DDT and PCB analysis were homogenized and then centrifuged to remove pore water. Following extraction by methylene chloride, samples were cleaned of interfering compounds using activated copper addition and preparative columns of alumina and silica. Extracts were concentrated to 1 mL and injected into a Hewlett Packard Model 5890 II gas chromatograph equipped with a 60m by 0.25 mm in diameter (0.25 m film thickness) DB-5 fused silica capillary column and a 63Ni electron capture detector (GC-ECD) for analyte measurement.

Polycyclic Aromatic Hydrocarbons

The PAH analyses were conducted using EPA protocols (EPA 1986 or EPA 1983), which quantify 28 different PAHs. Specific methodological details can be found in Zeng and Khan (1995) or SCCWRP (1995a). Analysis was accomplished by injecting a portion of the same solvent extract used for the chlorinated hydrocarbon measurements into a Hewlett Packard Model 5890 II gas chromatograph equipped with a DB-5 column (60m by 0.25 mm in diameter by 0.25 m film thickness) and a Hewlett Packard Model 5870 mass selective detector in electron impact ionization mode.

Quality Assurance

Each batch of samples for metals or organics analysis included blanks, spiked samples, and standard reference materials to monitor method performance and recovery. Instrument calibration was verified prior to analyzing each batch of samples, and internal standards were added to each solvent extract to correct for variations in instrument performance.

Infaunal Community Analysis

Each infaunal sample was sorted into six different taxonomic groups: annelids, molluscs, arthropods, ophiuroids, miscellaneous echinoderms, and "other phyla." A minimum of 10% of each sample was re-sorted by another person to detect missed organisms. If sorting efficiency was less than 95%, then the entire sample was re-sorted. Biomass measurements were obtained by weighing each group of organisms to the nearest 0.01 g (wet weight).

Each organism was identified to the lowest taxon possible, using standardized nomenclature developed for the SCB (SCAMIT 1996). Species-level identifications were assigned by scientists who were experts in their respective taxonomic group and were active members of the Southern California Association of Marine Invertebrate Taxonomists (an interagency quality assurance group). Ten percent of all samples were re-identified and enumerated by a second taxonomist for quality assurance. All new species encountered were maintained in a voucher collection located at SCCWRP.

Toxicity Measurement

Three types of environmental samples were tested for toxicity: surface water, sediment interstitial water, and whole sediment. Surface water samples were not filtered or centrifuged before testing. Brine (prepared by the partial freezing of seawater) was added to samples with a salinity below 30 g/kg to adjust the salinity to 34 g/kg. Each water sample was tested at a single concentration; i.e., 100% sample or the maximum concentration after salinity adjustment. Four replicates of each sample were tested. The percentage of runoff present in each toxicity test sample was calculated from the initial salinity value and included dilution resulting from salinity adjustment. This calculation assumed that the percent of runoff present in the original sample was inversely proportional to the relative salinity, expressed as a percentage of the background value (outside of plume).

Interstitial water was extracted from the sediment samples by centrifugation twice at 3,000 x g for 30 min. Laboratory seawater was added to the samples to produce three test concentrations containing 100, 50, and 25% interstitial water. Three replicates of each concentration were tested.

Water quality measurements conducted during each toxicity test consisted of salinity, dissolved oxygen, pH, and total ammonia content. Measurements were made using electrodes that were calibrated daily. Measurements were made at the start of each test and at the end of the 10-d amphipod survival test. Electronic thermometers were used to measure water temperature continuously throughout the duration of each experiment.

- *Sea Urchin Fertilization*

All samples of surface water and interstitial water were tested for toxicity using a sea urchin fertilization test (Chapman [illegible] test consisted of a 20-min exposure of sperm to the samples at 15 C. Eggs were then added and given 20 min for fertilization to occur. The eggs were preserved and examined later with a microscope to assess the percent fertilized. Toxic effects are expressed as a reduction in fertilization percentage.

Purple sea urchins (*Strongylocentrotus purpuratus*) used in the tests were collected from intertidal areas in northern Santa Monica Bay. The tests were conducted in glass vials containing 10 mL of solution.

- A negative control (0.45 m and activated carbon filtered natural seawater from Redondo Beach) and a brine control (distilled water containing 50% brine) were included in each test series for quality assurance purposes. A reference toxicant test (copper in seawater) was conducted with each batch of samples to document sea urchin health.

- *Amphipod Survival*

The toxicity of sediment samples was assessed by measuring the survival of amphipods following a 10-d exposure period. Test methods followed standard guidelines (ASTM 1991). A one-liter sediment sample was removed from storage and manually homogenized with a large plastic spoon. A 2 cm layer of sediment was added to five replicate one-quart glass canning jars for each station. Approximately 750 mL of lab seawater, adjusted to a salinity of 30 g/kg, was added to each jar. The jars were fitted with aeration tubes and allowed to equilibrate overnight before the addition of the amphipods.

Twenty amphipods (*Rhepoxynius abronius*) were added to each jar. The test animals were collected from Puget Sound, Washington. A sample of collection site sediment was also included in the test, as a negative control. The test was conducted at 15C, under constant illumination. Surviving animals were removed from the sediment at the end of the exposure by sieving and were counted to determine the percent survival. Reburial success was not determined. A concurrent reference toxicant test consisting of a four-d exposure to cadmium in seawater was conducted to document amphipod health.

Data Analysis

The sea urchin fertilization test results were normalized to the control (lab seawater) response in order to compensate for variations in response between experiments. Normalization was accomplished by dividing the mean fertilization for each sample by the control fertilization percentage, then expressing the resulting fraction as a percentage.

Sediment characteristics and infaunal community parameters at the 25 m stations were summarized by calculating the mean and 95% confidence interval of all wet weather samples for each station (n = 3 or 4 for Malibu or Ballona, respectively).

RESULTS

Surface Water Effects

Toxicity

Toxicity was present in surface water samples collected near the mouth of Ballona Creek during three of the four sampling events . No Table 2toxicity was detected in water samples collected on January 22. Samples from this event contained little runoff (<4%), whereas water samples from later storm events contained up to 44% runoff (Table 2). Toxicity was always detected in water samples containing greater than 10% runoff, with samples containing the most runoff having the greatest toxicity (Table 2). The relatively small volume of runoff present in the January 22 samples was probably due to a delay in collection following the storm.

Toxicity was usually present in water samples collected nearest the mouth of Ballona Creek (Figure 2). Toxic water samples were restricted to a relatively small zone (<2 km offshore of Ballona Creek) on January 31 and March 5. A greater area of toxicity was present on February 21, with toxic water present up to 4 km from the mouth of Ballona Creek. Too few samples were collected to examine the longshore

...samples were collected to examine the longshore ...

No toxicity was detected in water samples collected near the mouth of Malibu Lagoon during three storm events. Toxicity was not expected to be found in the Malibu samples, since they contained less than 2% runoff (Table 2).

Sediment Effects

Spatial Patterns

Sediments from the spatial survey were analyzed for indicators of grain size (percent fines) and organic material (percent TVS). These parameters were examined to identify deviations in general sediment characteristics caused by stormwater particle deposition near each creek. Since most runoff contaminants associate with stormwater organic material or silt/clay particles, stations having elevated sediment fines or TVS (relative to nearby areas) were assumed to represent locations most likely to contain the highest concentrations of stormwater-derived contaminants.

At 25 m depth, sediments directly offshore of the mouth of Ballona Creek showed a distinct increase in percent of fine-grained material, relative to sediments collected at similar depths to the north or south (Figure 3). The proportion of sediment fines doubled offshore of Ballona Creek (40%) relative to the fines measured in sediments 4 km upcoast (22% fines, Table 3). Although less pronounced, this longshore spatial pattern also reached to 40 m depth, but was not evident at a depth of 10 m. Similarly, a spatial pattern in the sediment TVS content was associated with Ballona Creek discharges. At 25 m depth, TVS was approximately 75% greater in sediments sampled directly offshore of the creek (2.5%) compared to sediments 4 km upcoast (1.4%, Figure 3).

The spatial pattern in grain size or TVS at Malibu Creek was less distinct than at Ballona Creek. Background levels of TVS and fines in the Malibu study site were higher than off Ballona Creek, potentially obscuring patterns of sediment deposition from Malibu Creek. TVS provided the strongest indication of a spatial pattern produced by Malibu Creek discharges; TVS at 25 and 40 m depth directly offshore of the creek mouth was greater than in sediments collected at similar depths to the east or west (Table 3). The spatial pattern extended 2 to 4 km upcoast and downcoast. Similar to the Ballona Creek site, data for the 10 m samples showed little evidence of discharge-related changes.

Since the spatial patterns in sediment characteristics (TVS or fine-grained sediment) were greatest at a depth of 25 m offshore of Ballona Creek, benthic sampling stations were established at this depth for the wet season (Figure 1). All stations, including Malibu Creek sites, were established at the same depth to eliminate any depth-related bias among or between creek sites.

Sediment Concentrations

Ballona and Malibu Creeks

The analytical results for the four sets of post-storm sediment samples were used to determine the wet season average concentrations of sediment characteristics and contaminants directly offshore of the mouths of Ballona and Malibu Creeks. Sediments sampled at Malibu Creek contained twice the fines, 50% more TOC, and 25% more TN than Ballona Creek (Table 4). Of the 14 different inorganic/metal constituents, 7 were substantially greater in sediments offshore of Malibu Creek (Al, Be, Cd, Cr, Fe, Ni, Se); 3 constituents were substantially greater in sediments offshore of Ballona Creek (Pb, Hg, Ag); and the remaining 3 constituents were roughly similar in the sediments offshore of the two drainages (As, Cu, Zn). Ballona Creek had significantly higher sediment concentrations of total DDT, total PCB, and total PAH than Malibu Creek.

The differences in general sediment characteristics between the two drainage areas is of fundamental importance. The sediments offshore of Malibu Creek were significantly finer than sediments offshore of Ballona Creek. Concentrations of common marine inorganic constituents such as aluminum and iron were also highest offshore of Malibu Creek. Concentrations of these metals are typically high (in the were also highest [illegible] Concentrations of these metals are typically high (in the percentage range) and are related to the degree of geological mineralization (e.g., alumina-silicate silts and clays).

Inorganic contaminants offshore of Ballona Creek followed a pattern across the gradient of stormwater influence that was similar to the pattern observed in the spatial survey. Concentrations of stormwater-associated metals such as lead, copper, and zinc were significantly higher in sediments sampled directly offshore of the creek mouth, and decreased upcoast and downcoast (Figure 4). Wet season averages at distant stations 4 km upcoast were between 41% (for copper) and 70% (for zinc) of average concentrations directly offshore of the Ballona Creek mouth.

Organic contaminants offshore of Ballona Creek also followed a similar pattern across the gradient of stormwater influence (Figure 4). Total DDT, total PCB, and total PAH were highest in sediments sampled directly offshore of the creek mouth and concentrations decreased upcoast and downcoast. Wet season averages at distant stations 4 km upcoast were between 6% (for total PAH) and 41% (for total DDT) of average concentrations directly offshore of the Ballona Creek mouth.

Inorganic contaminants offshore of Malibu Creek followed a pattern across the gradient of stormwater influence similar to the pattern described for general sediment characteristics. Figure 4 shows the pattern for copper and lead. Wet season averages at distant stations 4 km upcoast were between 58% (for copper) and 80% (for zinc) of values measured directly offshore of the Malibu Creek mouth. Except for lead, metals were highest in sediments sampled 2 km downcoast from the Malibu Creek mouth. For lead, sediment concentrations were similar between stations within 2 km of the Malibu Creek mouth. The distribution of sediment contaminants offshore of Malibu Creek was less clear than at Ballona Creek.

Organic contaminants offshore of Malibu Creek generally did not follow a pattern across the gradient of stormwater influence (Figure 4). No consistent trend was established for the data, and organic contaminant concentrations were very low overall. The highest wet season concentrations of total PCB and total PAH were not found directly offshore of Malibu Creek, but 4 km downcoast. However, the lowest values for all three organic compound classes were regularly observed 4 km upcoast from the Malibu Creek mouth.

Identification of Enriched Contaminants

Unlike synthetic organic pollutants such as DDT or PCB, which are strictly anthropogenic in origin, trace metals are naturally occurring elements that are part of the earth's crustal matrix. Most metals, including prominent stormwater constituents like copper, lead, and zinc, have native concentrations within the detectable range of measurements for this project. Natural variations in sediment metal concentrations must be accounted for before anthropogenic enrichment can be identified. To compensate for these naturally occurring concentrations, iron was used as a reference element to establish baseline conditions and to evaluate anthropogenic enrichment of sediments (see *Iron as a Reference Element for Determining Trace Metal Enrichment in California Coastal Shelf Sediments,* this report). When the 1995to 1996 wet season lead data were normalized to iron, many Ballona Creek samples contained higher-than-expected concentrations (Figure 5), indicating enrichment. Interestingly, the most enriched concentrations (between 24 and 30 g/dry g) all occurred at the site directly offshore of the Ballona Creek mouth. All lead concentrations in Malibu Creek samples fell within the expected relationship with iron, indicating that these values were probably due to natural variations in sediment composition. Copper and zinc concentrations for Malibu Creek and Ballona Creek offshore sediments fell within the baseline relationship (data not shown), indicating that anthropogenic enrichment of these metals was not present.

Toxicity

Amphipod survival was high (89 to 98%). which indicated an absence of toxicity in all sediment samples (Table.5). The concentration of ammonia in the water overlying the sediment was slightly higher for stations within 2 km of either creek, possibly reflecting the organic enrichment identified by chemical analysis. These ammonia concentrations were not toxic and were within the range typically found in sediment toxicity tests.

Interstitial water from [illegible] sediment samples was nontoxic to sea urchin sperm (Table 5). Only interstitial water sampled from one station (6 km) upcoast of Ballona Creek was toxic, reducing fertilization by about 60% (relative to the control sample).

Infaunal Community Structure

A total of 30 samples were sieved, sorted, weighed, and identified for infaunal community structure analysis. A total of 8,531 individuals were identified, comprising 389 different taxa. About 90% of the total abundance at each creek represented species common to both sites. The dominant species recorded at each creek site included the polychaetes, *Spiophanes missionensis* and *Paraprionospio pinnata*; the mollusc, *Tellina modesta*; and the amphipods, *Amphideutopus oculatus* and *Ampelisca brevisimulata*. Interestingly, the Malibu Creek site also contained some organisms (e.g., *Amphiodia urtica*), which are typical of fine-grained habitats common in deeper water (Bergen 1995).

For the entire wet season, stations directly offshore of Ballona Creek and Malibu Creek at 25 m depth had similar diversity (Shannon-Wiener H'), evenness (Pielou's J), and species richness (Table 6). Abundance was slightly reduced offshore of Ballona Creek compared to Malibu Creek.

Examination of trends across the gradient of stormwater influence did not reveal any significant relationships to stormwater discharges (Table 6). Instead, mean abundance decreased moving upcoast of both creeks. Similarly, species richness was highest downcoast and lowest upcoast of the Ballona Creek mouth. Species richness was fairly constant across the gradient of stormwater influence at Malibu Creek; however, the station 2 km downcoast showed high variability. Diversity and evenness measures showed no strong trends between stations.

DISCUSSION

Results from the first year of this study, though preliminary, provide sufficient data to address several important questions regarding runoff effects in receiving waters.

Do stormwater discharge plumes contain toxic materials?

Study results indicate that surface water toxicity in the Ballona Creek area is present when runoff concentrations are greater than 10%. This finding correlates well with the level of toxicity measured in samples of Ballona Creek stormwater collected during the same storms (see *Toxicity of Stormwater from Ballona and Malibu Creeks*, this report). The average EC50 (concentration causing 50% reduction in fertilization) of Ballona Creek stormwater samples was 16%. Stormwater composition is highly variable, however, so future results may modify estimates of in-channel and receiving water toxicity.

The area offshore of Ballona Creek receives contaminant inputs from other sources (e.g., industrial and municipal effluents, marinas, and aerial fallout) that could contribute to water column toxicity in the area. However, the spatial pattern and magnitude of toxicity between the two sites, are consistent with Ballona Creek being the dominant source of toxicity. A further correlation between receiving water and Ballona Creek stormwater toxicity has been provided by studies conducted to characterize the toxicants. Preliminary toxicity identification studies indicate that the primary toxicants in both types of samples are similar (possibly divalent trace metals).

We were unable to obtain surface water samples from the Malibu area with runoff concentrations similar to those measured near Ballona Creek. Consequently, a direct comparison of the results between study areas cannot be accomplished at this time. It is not known whether the low runoff concentrations measured are representative of the area or reflect a deficiency in sampling methodology(e.g., delays in reaching the study site after a storm). It is anticipated that this issue will be clarified during the second year of sampling. Malibu Creek stormwater appears to be less toxic that Ballona Creek stormwater, with concentrations of 25% usually needed to produce toxic effects (see *Toxicity of Stormwater Runoff from Ballona and Malibu Creeks,* this report). Extending these results to surface waters, it is likely that less toxicity will be present offshore of Malibu Creek.

Does stormwater discharge produce long-lasting alterations in Santa Monica Bay sediment characteristics?

Discharges from Ballona Creek appeared to alter offshore sediment characteristics, as shown by spatial patterns in grain size and TVS. This pattern was persistent (present in dry weather) and could be observed at least 2 km upcoast and at 40 m depth. The spatial patterns at Malibu Creek were more complicated than at Ballona Creek, probably due to differences in oceanographic processes that modify particle fate, additional sources of fine-grained and organic-rich particles, and differences in background conditions.

Enhanced local deposition of silt/clay particles may be a common feature of stormwater discharges. Increases in sediment fines were observed at distances ≥ 2 km offshore of the Santa Clara River following large winter storms (Kolpack and Drake 1985). More research is underway at SCCWRP, USC, and UCSB to define the range of influence and deposition of storm discharged particles in Santa Monica Bay.

Are sediment contaminants elevated?

Sediments offshore of Ballona Creek were higher in concentrations of organic contaminants such as total DDT, total PCB, and total PAH as well as lead, a stormwater-associated metal. This contamination covaried with sediment characteristics across the gradient of Ballona Creek stormwater influence. Sediment concentrations of organic and inorganic pollutants were highest offshore of the Ballona Creek mouth and then decreased upcoast and downcoast.

Sediments offshore of the mouth of Malibu Creek were finer, contained more organic carbon and nitrogen, and had higher concentrations of some naturally occurring inorganic constituents. No evidence was found of enrichment of inorganic or organic contaminants from Malibu Creek stormwater.

Is sediment toxicity affected by stormwater runoff?

The results available to date show no evidence of sediment or interstitial water toxicity that can be attributed to discharges from Ballona or Malibu Creeks.

Amphipod survival was not reduced by exposure to sediments from any station. These results are similar to sediment toxicity data from the Southern California Bight Pilot Project (SCBPP), a regional study of coastal sediment quality conducted in 1994 (SCCWRP 1996). Sediment from 72 stations in southern California (in depths of 10 to 200 meters), including 13 sites in Santa Monica Bay, were collected and tested for toxicity using a similar amphipod survival test. No significant amphipod mortality was found at any of the SCBPP stations.

Amphipod survival tests do not provide a sensitive measure of sediment toxicity. Recent amphipod survival tests on highly contaminated sediments located near southern California wastewater outfalls failed to detect toxicity in samples that caused sublethal effects on other toxicity test species (SCCWRP 1995b) or contained altered benthic communities (SCCWRP 1993c). The 10-d amphipod survival test was used in this program because it is a reliable method commonly used in sediment quality studies, and toxic effects observed with this test are often associated with adverse benthic community changes.

Interstitial water toxicity measurements were included in this program to provide a more sensitive measure of sediment quality. Previous studies have detected interstitial water toxicity in sediments from southern California. Sea urchin fertilization was reduced in interstitial water samples from the Palos Verdes Shelf, with the magnitude of effects corresponding to sediment contamination level (SCCWRP 1995b). Toxic effects on sea urchin embryo development was produced by interstitial water from 15 of 72 samples tested during the SCBPP (SCCWRP 1996). The sea urchin embryo development test is usually more sensitive than the fertilization test when applied to interstitial water (Carr and Chapman 1995).

The sea urchin fertilization test of interstitial water did detect toxicity in one sample off Ballona Creek.

[illegible] Ballona Creek. This station was [illegible] of Ballona Creek (Figure 1), and the sediment chemistry data indicate this station is outside the area most influenced by the Creek (Figure 4). As increased interstitial water toxicity did not directly correspond to variations in sediment contamination, it is unlikely that the toxicity at this station is directly related to stormwater from Ballona Creek. All measured interstitial water quality parameters for this station (pH, dissolved oxygen, hydrogen sulfide, salinity, and ammonia) were within nontoxic ranges, although total ammonia concentration was higher than all other samples.

A cause for the interstitial water toxicity cannot yet be identified. This toxicity may indicate the presence of unidentified contaminants from an unknown source, or it may reflect temporary variations in sediment quality caused by natural factors or sediment storage. Additional research is needed to clarify the significance of the results. Additional toxicity tests of sediments from the Ballona Creek study area are in progress to assess the sublethal effects and bioavailability of the sediment-associated contaminants.

Are infaunal communities impaired?

No dramatic biological effects in the benthic community structure were evident from the first-wet season of sampling. No indications of a strongly degraded environment were found. Differences in community composition between sites offshore of the two creeks most likely resulted from variations in sediment characteristics (e.g., grain size) rather than differences in sediment-associated contaminants.

Due to relatively small sample sizes ($n \leq 4$), it is premature to reach conclusions regarding community disturbance at this time. However, these preliminary results are similar to previous reference surveys, which reported 273 to 358 individuals and 78 to 91 species per grab at depths of 30 m during the summer months (Thompson *et al.* 1987, 1993). Completion of the second year of infaunal analysis will provide a greater ability to detect subtle differences in communities across gradients of stormwater influence and determine whether the results are consistent over time.

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FIGURES

FIGURE 1. Watershed characteristics and sediment sampling sites for the two study locations. All stations except for the toxicity station near Ballona Creek were sampled during the spatial survey. Stations along the 25 m isobath, indicated by closed symbols (), were also sampled for post-storm toxicity, chemistry, and infaunal community analyses.

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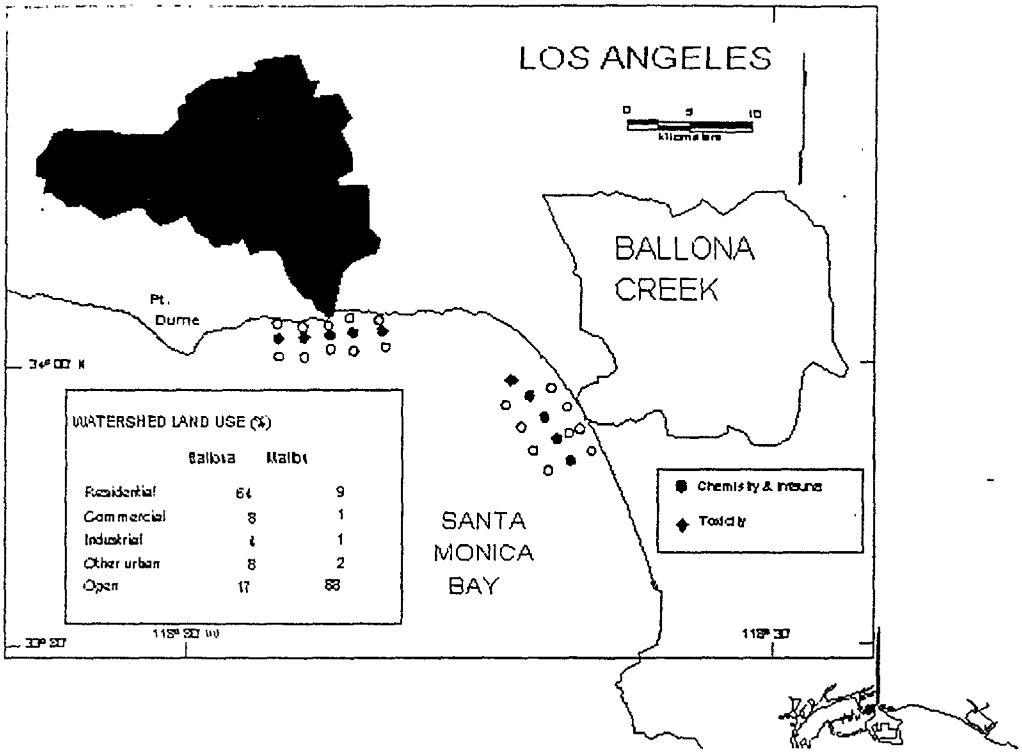

FIGURE 2. Summary of sea urchin fertilization test results for surface water samples near the mouth of Ballona Creek during three storm events in 1996. Differences in symbol size and shading indicate the magnitude of toxicity. Note that multiple samples were collected near the mouth of Ballona Creek during each storm; these samples had similar toxicity and are shown as overlapping symbols. Water samples were collected near the mouth of Malibu Creek, but no toxicity was present.

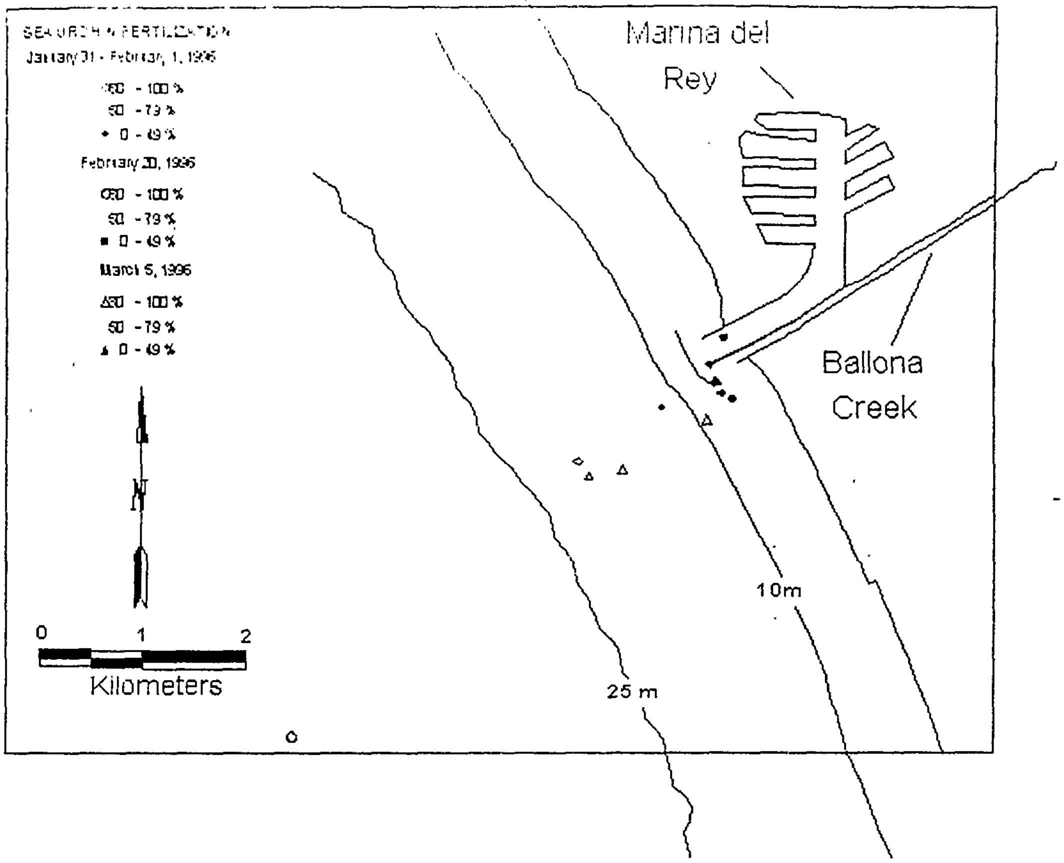

FIGURE 3. Sediment characteristics of samples collected during the dry season spatial survey for Ballona Creek. Station locations are shown in Figure 1. Distance refers to the upcoast (positive values) or downcoast (negative) direction, relative to the creek mouth.

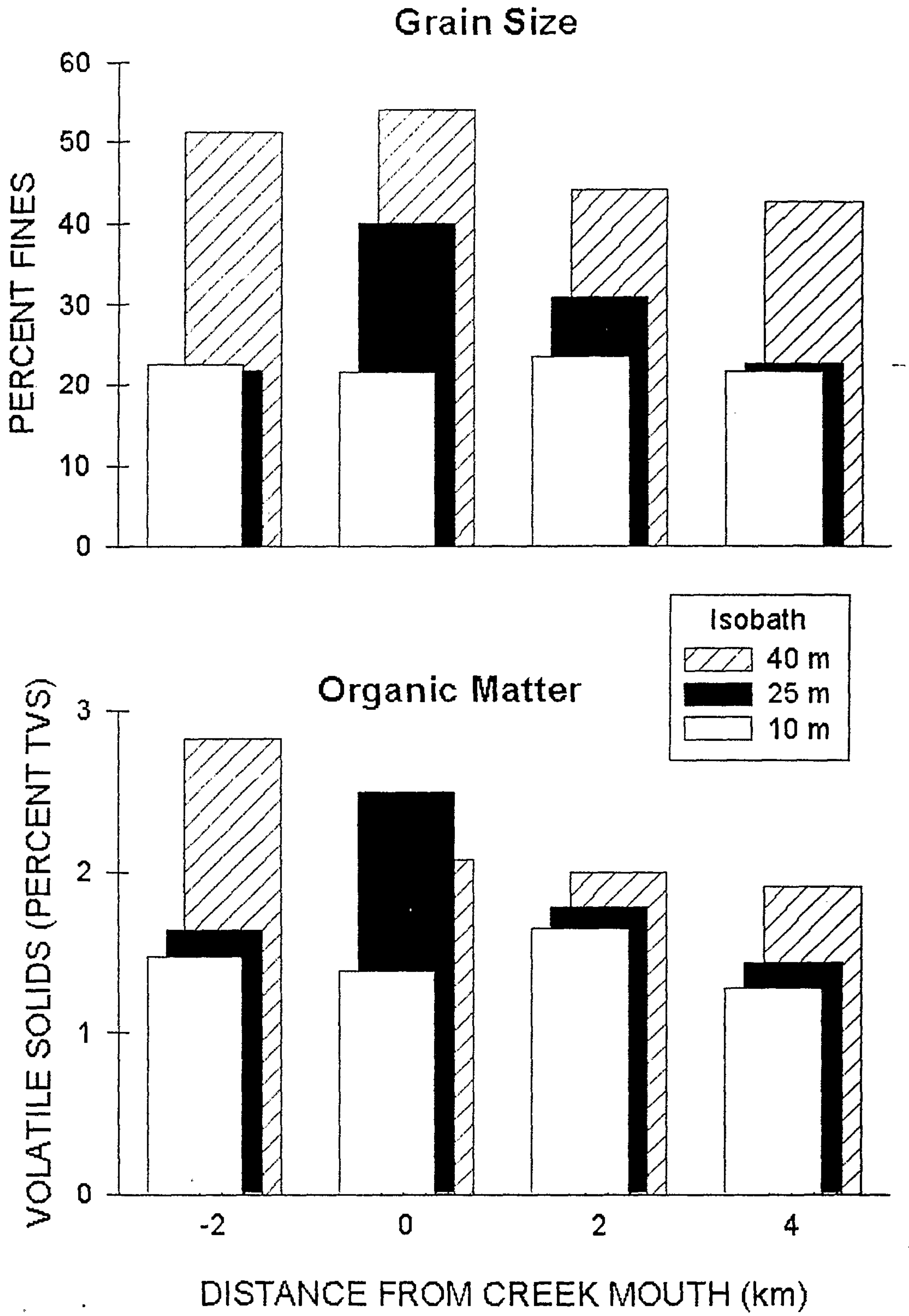
Grain Size
PERCENT FINES
60
50
40
30
20
10
0
Isobath
40 m
25 m
10 m
Organic Matter
VOLATILE SOLIDS (PERCENT TVS)
3
2
1
0
-2
0
2
4
DISTANCE FROM CREEK MOUTH (km)

FIGURE 4. Mean (95% CI) concentrations of surface sediment metals and organic contaminants offshore of Ballona and Malibu Creeks during the 1995-1996 wet season. N=3-4 except for the Ballona 6 km and Malibu 2 km stations, which represent a single sample.

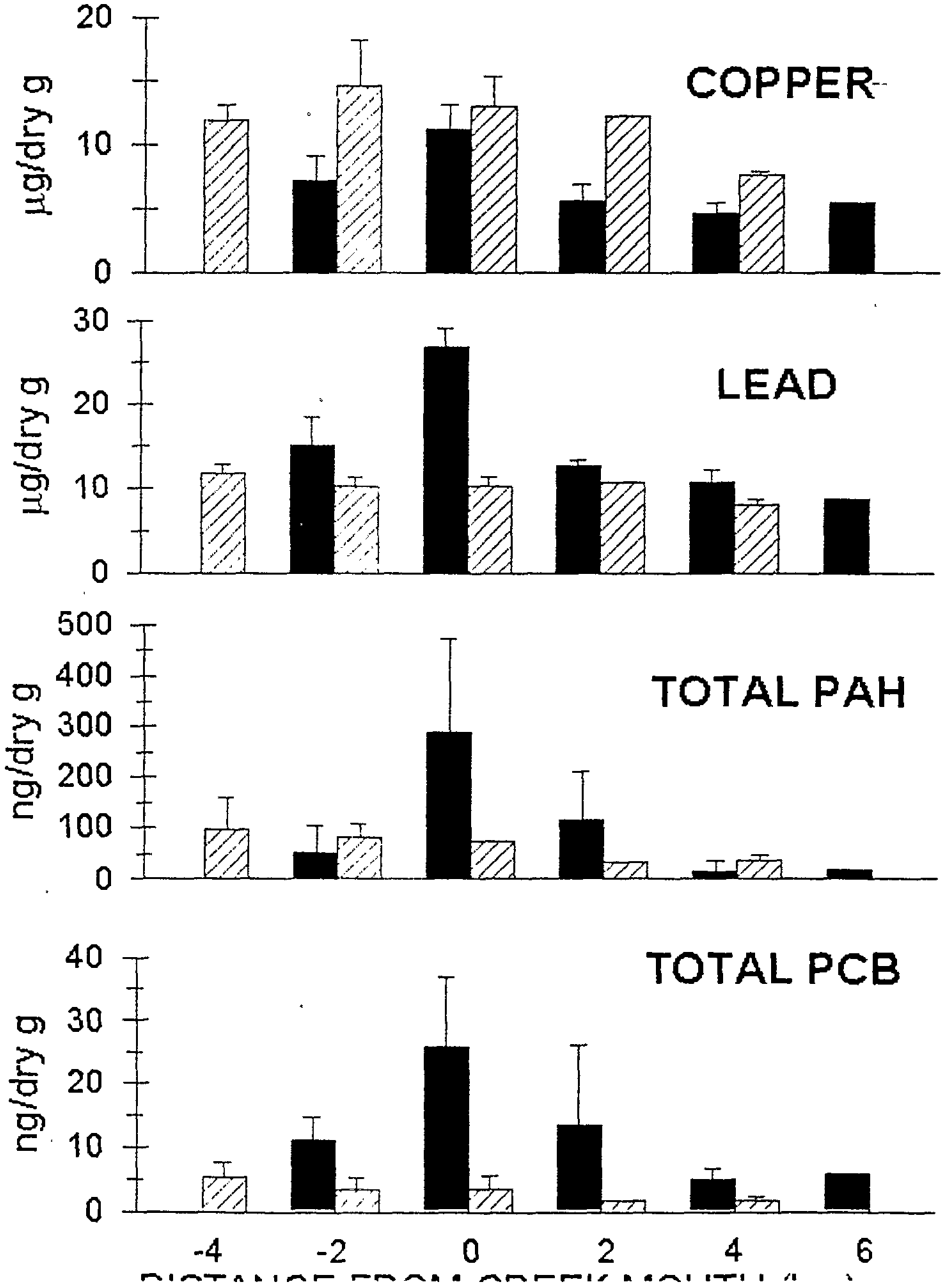

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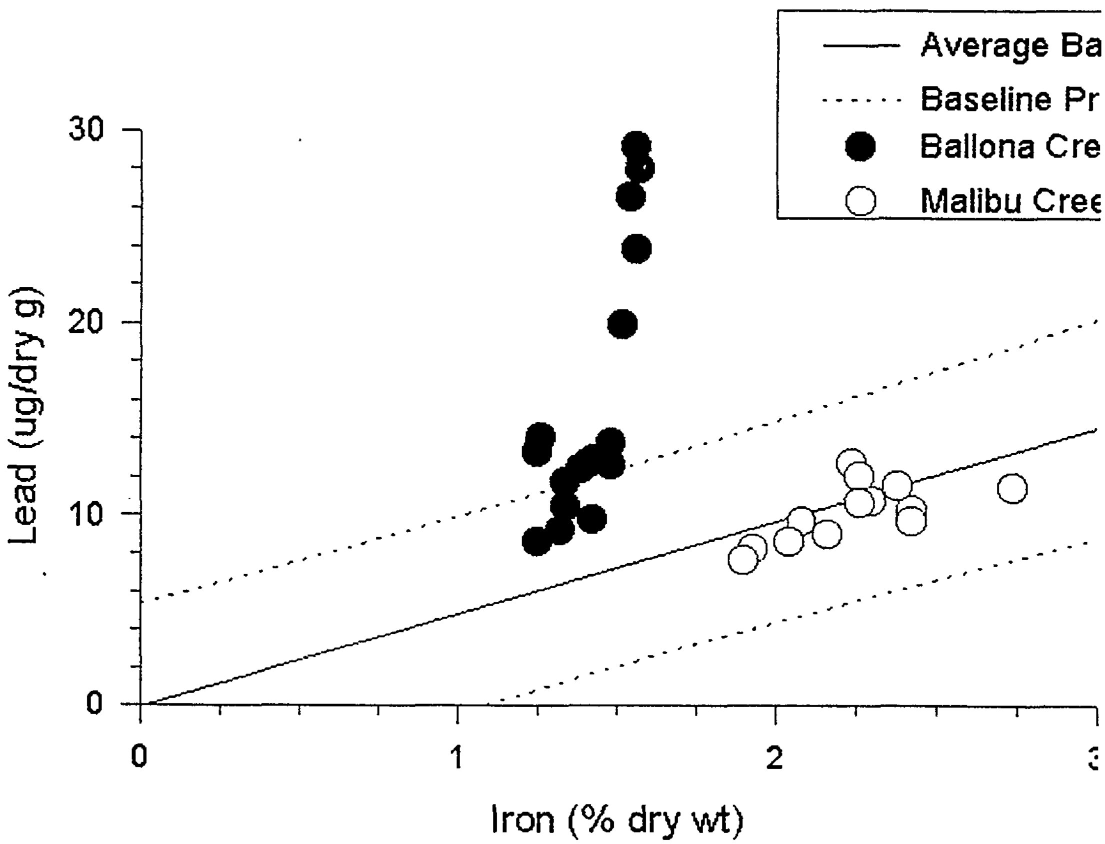
FIGURE 5. Iron normalization technique applied to sediment lead data for Ballona and Malibu Creek samples. Baseline relationship was derived using data from shallow water reference sediments throughout the Southern California Bight (see *Iron as a Reference Element for Determining Trace Metal Enrichment in California Coastal Shelf Sediments*, this report). Samples plotted above the baseline prediction interval (95% confidence limit) are enriched in lead content.



TABLES

TABLE 1 Summary of sampling dates and activities. Spatial survey samples were collected offshore of Ballona Creek (B) on November 15 and offshore of Malibu Creek (M) on January 22 and 30; all other samples were collected to examine conditions following stormwater runoff.

Sampling Date	Rainfall[a] (days)	(in)	Water Toxicity	Sediment Toxicity	Sediment Characteristics	Sediment Contamination	Biological Communities
15-Nov-95	15				B		
22-Jan-96	1	0.6	B,M		M		
30-Jan-96	3	0.6			B,M	B	B
31-Jan-96	0	0.2	B				
1-Feb-96			M				
12-Feb-96	9	0.2			B,M	B,M	B,M
21-Feb-96	0	4	B				
28-Feb-96	1	0.4		B,M	B,M	B,M	B,M
5-Mar-96	0	0.7	B, M				
13-Mar-96	1	1.4			B,M	B,M	B,M

[a]Number of days since most recent rainfall and amount as recorded at the Los Angeles Civic Center.

TABLE 2 Sea urchin fertilization test results for surface water samples. Shaded regions indicate samples from reference areas located relatively far from the creek mouth.

Date	Location	Salinity[a]	Percent Flow[b]	Percent Fertilized[c]
1/22/96				
	Ballona	32.4	3.3	98
	Ballona	33.1	1.2	100
	Ballona	33.4	0.3	99
	Ballona	33.5	0	99
	Ballona	**33.5**	**0**	**99**
	Malibu	**33.5**	**0**	**96**
1/31-2/1/96				
	Ballona	15.4	38.3	4
	Ballona	15.2	38.7	4
	Ballona	21.2	28.5	8
	Ballona	28.8	12.4	13

	Ballona	33.2	0.6	107
	Malibu	32.8	1.8	107
	Malibu	32.8	1.8	107
	Malibu	33.2	0.6	101
	Malibu	**33.4**	**0**	**107**
2/21/96				
	Ballona	15.5	37.6	8
	Ballona	11.1	43.7	8
	Ballona	26.8	15.9	22
	Ballona[d]	28.8	11.2	52
	Ballona	**32.9**	**0**	**90**
3/5/96				
	Ballona	24.4	21.6	20
	Ballona	26.6	16.7	27
	Ballona	29.9	8.6	95
	Ballona	32.2	2.4	99
	Ballona	**33**	**0**	**99**
	Malibu	32.8	0.6	98
	Malibu	**32.7**	**0.9**	**99**

[a]Initial value; salinity adjusted to 33 to 34 g/kg for toxicity test.
[b]Estimated amount of runoff in water sample during toxicity test; calculated from salinity and sample test concentration.
[c]Percent of control (laboratory seawater or brine control) fertilization.
[d]Sample from Marina del Rey Channel.

TABLE 3 Results of dry weather spatial survey. Distance refers to the upcoast (positive values) or downcoast (negative) direction, relative to the creek mouth.

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Distance from Creek (km)		Ballona Creek		Malibu Creek	
	Depth (m)	Percent TVS	Percent Fines	Percent TVS	Percent Fines
-4	10	NS[a]	NS	1.95	32.2
-2	10	1.48	22.6	1.86	44
0	10	1.39	21.5	1.67	9.8
2	10	1.66	23.5	1.4	29.5
4	10	1.28	21.5	1.49	15.6
-4	25	NS	NS	2.56	61.9
-2	25	1.65	21.8	4.14	68.6
0	25	2.5	39.9	3.29	63.3
2	25	1.79	30.8	3.81	63
4	25	1.44	22.5	2.31	67.4
-4	40	NS	NS	3.36	87.8
-2	40	2.83	51.2	4.14	92.3
0	40	2.08	54	5.16	90.1
2	40	2	44.1	4.34	88.5
4	40	1.91	42.6	3.75	85.9

[a]NS = Location not sampled in survey.

TABLE 4 Summary of sediment c>

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NOVEMBER 1999

Final Report

Investigation of Structural Control Measures for New Development

Prepared for:

Sacramento Stormwater Management Program

SACRAMENTO
STORMWATER
MANAGEMENT PROGRAM

County of Sacramento
City of Sacramento
City of Citrus Heights
City of Folsom
City of Galt

Prepared by: Larry Walker Associates, Inc.

R0011350

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INTRODUCTION

The Sacramento NPDES Stormwater Permittees include the County of Sacramento and the Cities of Folsom, Galt, and Sacramento. Under the terms of their NPDES permit, the Permittees operate a Comprehensive Stormwater Management Program, with the overall goal of reducing discharges of stormwater pollutants to the maximum extent practicable. The Comprehensive Program includes a New Development Management Program (NDMP) element, intended to improve the quality of stormwater runoff from areas of new development.

Under this program element, the Permittee agencies are responsible for approving the installation of stormwater controls in new developments within their respective jurisdictions. To help guide this approval process, the Permittees require additional information regarding specific structural control devices, especially with respect to the applicability and effectiveness of such devices for treatment of stormwater runoff in the Sacramento area. This report contains the results of research into the performance of selected on-site structural controls. Funding for this investigation was included within the 1998-99 Sacramento Stormwater Monitoring Program consultant contract.

Structural controls for improvement of stormwater quality can be considered to fall into two groups: proprietary devices that are manufactured off site and may be purchased for installation according to the manufacturer's specifications, and non-proprietary controls that can be designed and installed using information available in the public domain. The Permittees selected 14 proprietary devices and four public domain controls for this evaluation, each of which can be incorporated within a site development plan and installed on site. (Off-site or regional controls, such as detention basins, were not included in this investigation). Information was gathered for this report principally through available studies on the performance of public domain controls, and through a questionnaire requesting specific information about each product that was sent to manufacturers of proprietary devices. The information was then compiled and evaluated using a common format.

The Permittees plan to use the results of this investigation to identify stormwater controls considered acceptable for installation in new developments in Sacramento, and to identify areas where additional information is needed.

METHODS

The investigation was carried out under the direction of a working group involving representatives from the Permittee agencies and their consultants. The working group met initially in November 1998 to develop a working strategy and identify a preliminary list of controls for the investigation. In December a two-page questionnaire was prepared and mailed to manufacturers or distributors of the selected proprietary devices. The questionnaire requested specific information about applicability of the controls to the Sacramento area, existing installations, available sizes and capacities, and performance data and costs (see Appendix C for the questionnaire and cover letter). The questionnaire responses were compiled during January and February, 1999.

The investigation was originally intended to cover only proprietary structural controls thought to have potential for successful application in Sacramento. However, the working group determined that inclusion of several of the most commonly-used public domain controls would provide opportunities for appropriate comparisons of the leading available alternatives. The final list of controls established by the working group includes 16 proprietary devices and four public domain controls: grassy swales and three versions of media (sand) filtration technology.

Meanwhile, available information on the performance of the selected public domain controls was also compiled. Key sources of information (especially performance studies) on these controls included the *NDMP Stormwater Control Measure Study Literature Review Update* (LWA, 1998a), and other municipal and state agencies involved in stormwater management.

Working group members met briefly in February, 1999 to discuss the format to be used in evaluating the accumulated performance and cost data. The consultants then compiled the information in this format, and presented the preliminary results to a meeting of the full working group in March, 1999. Key issues addressed by the working group at this meeting included:

1. How to screen the results of the various available studies to determine whether there are sufficient data to demonstrate the effectiveness of the control, including whether the data should be considered to be technically valid?

2. How to "normalize" performance and cost data assembled from various disparate sources for direct comparisons of the various controls studied?

3. How to distill the normalized performance data into a "bottom line" judgement of the acceptability of each type of control for application in new developments in the Sacramento area?

The first issue, having to do with assessing data adequacy, proved to be somewhat complex. Several questions needed to be addressed in making this assessment:

- Do the study data represent hydrological conditions typical of the Sacramento area (in terms of typical storm depth, duration, etc.)?
- Does the influent quality used in the study represent typical new development runoff quality (and not, say, construction site runoff quality)?
- Were the data collected using appropriate techniques (e.g., using flow-weighted composite sampling instead of grabs, with proper attention to QA/QC issues) so as to accurately characterize influent and effluent quality?
- Are there enough data to permit conclusions to be drawn regarding performance and acceptability?
- Do the data indicate acceptable treatment performance in terms of pollutant removals?

To provide a protocol for screening data acceptability, criteria were developed to describe minimum acceptable data requirements, as follows:

- Studies to represent a minimum of two different sites, preferably a retail commercial site, a non-retail commercial site, and/or a residential site.

- Studies to represent typical new development runoff quality.

- Number of storms sampled at each site: 10
- Storm depth ranging from 0.15 to 1.5 inches
- Runoff duration ranging from 2 to 24 hours
- Average storm intensity ranging from 0.02 to 0.25 inches/hour
- Flow weight or time weight composite samples
- Analysis by a certified laboratory
- Removal efficiency with respect to TSS and zinc is reasonably equivalent to what is obtained with grass swales and sand filters. (TSS was chosen because of the preponderance of data. It is the most frequent constituent measured in all studies of stormwater treatment control measures, and serves as a surrogate for the pollutants that in stormwater tend to be primarily in the particulate form, like petroleum products, pesticides, lead, chromium, and phosphorus. Zinc was selected to represent the more soluble constituents, including itself as well as copper, cadmium, and the various nitrogen forms. Also, of the metals, zinc is typically present in runoff in concentrations sufficiently above the detection limit to allow meaningful evaluations of removal efficiency. However, the comparison of performance was limited to TSS at this time, because available data on zinc removal was limited.

The criteria for storm depth, duration, and intensity were selected by bracketing the values resulting from a first-flush design event established by the City and County for on-site control measures. The design event is a 2 year / 6 hour storm having an intensity of 0.18 inches/hour.

This protocol was then used to assess the adequacy of the available performance data for the selected controls. Most of the manufacturers of proprietary devices were able to provide some studies purporting to document the effectiveness of their products, but there were great discrepancies in the number and quality of these studies. Generally speaking, sufficient numbers of studies have been done for the public domain controls, typically by other local stormwater agencies, although the public record of studies for grassy swales is somewhat lacking.

The second issue, involving how to directly compare disparate performance and cost data for the various devices, was addressed by providing the means to "normalize" these data. Performance was assessed graphically, using a variable range of acceptable performance for TSS removal, with higher removal percentages expected at higher influent TSS concentrations. The acceptable range of TSS removal performance was derived principally from performance data produced by studies of properly functioning public domain controls. Cost was normalized to cost per unit flow treated (at approximately 0.1 cfs, 1 cfs, and 10 cfs) for each device where appropriate data were available. However, cost data were not used to assess acceptability of the products, only to provide a general comparison.

The bottom line issue of grading the products according to overall acceptability was addressed by determining the adequacy of the performance data, using the screening protocol described above, and then evaluating the valid data using the performance graph for TSS.

DESCRIPTIONS OF CONTROL MEASURES EVALUATED

Brief descriptions of the physical features, operation, application and limitations of the various proprietary and public domain control measures evaluated in this report are presented below. Summaries of product descriptions and target constituents for removal are presented in Table 1. Illustrations of each device, as available, are presented in Appendix B. For purposes of description, control measures are categorized based on principle of operation and design as follows:

- Wet Vaults
- Swirl Concentrators
- Deflection Screen
- Media Filters
- Drain Inlet Inserts
- Combined Systems
- Grass Swales
- Sand Filters (public domain)

WET VAULTS

Products in this category include the Jensen and Teichert Interceptors, Stormceptor, and Bay Saver.

Jensen and Teichert Interceptors

These two products are very similar in design, consisting of precast, rectangular concrete vaults. The units are typically multi-chambered with interior chambers separated by baffle walls. The number of vaults or vault units are increased to increase the flow capacity. The elevation of the outlet is such as to cause standing water in the vault, in the range of 4 to 4.5 feet. Total depth of the vaults, exclusive of risers, are in the range of 6 feet. Widths are on the order of 4 to 6 feet. These interceptors are essentially wet vaults or API (American Petroleum Institute) gravity separators. Hence, the units should be sized using criteria for either the settling of particles or flotation of petroleum products. Unless sized to treat the full design flow, these units require separate bypass piping to divert flows in excess of the unit flow capacity to avoid washout of material retained in the vault chambers. Oil adsorption pillows and coalescing plates can be added to the units to enhance capture of oils and grease. Both manufacturers produce several models with a range of flow capacities. Available flow capacities are listed in Table 7 in the Results section.

BaySaver and Stormceptor

Like the Jensen and Teichert Interceptors, these two products are essentially wet vaults designed to remove particulates and foatables, but they are round rather than rectangular. BaySaver and Stormceptor differ from each other in that the Stormceptor consists of one round manhole-like structure, and the BaySaver consists of two structures. The Stormceptor improves the removal of settleable solids over that of a conventional manhole by the use of a flow diverter. Up to a defined flow rate, the stormwater is diverted down and then laterally around the manhole. High flows are bypassed directly across the top of the diverter to the outlet. The diversion of high flows prevents the resuspension of previously settled material. There is some capacity at the top beneath the diverter for the accumulation of floatables.

In the BaySaver, gross settleable solids are removed in the first manhole. Like the Stormceptor, the Baysaver has a diverter, but it passes water into the second manhole where floatables are retained. Fine solids settle in both manholes. High flows are diverted through the second manhole. The purpose of the second manhole is to prevent the loss of previously accumulated floatables and fine sediments. Removal efficiency is highly affected by flow rate.

Both systems are sized for the peak of the specified design event with consideration for the total volume of the manhole or manholes. According to Stormceptor the volume also must be considered when determining efficiency. Both manufacturers produce several models with a range of flow capacities. Available flow capacities are listed in Table 7 in the Results section. The hydraulic capacity of each model offered by both manufacturers is greater than the treatment flow capacity.

Table 1. Summary of Product Descriptions

Product	Company	Product Description	Target Constituents[1]
Jensen Interceptor	Jensen Precast	A wet vault consisting of multiple chambers in series separated by baffles. Contains standing water, or dead storage, which enhances treatment.	Settleable and floatable solids, oil/grease and particulate pollutants
Teichert Interceptor	Teichert Precast	A wet vault consisting of multiple chambers in series separated by baffles. Contains standing water, or dead storage, which enhances treatment.	Settleable and floatable solids, oil/grease and particulate pollutants
BaySaver	BaySaver, Inc.	Consists of two standard manholes. The first is for removal of sediment and separation of floatables which are diverted by a special device into the second manhole for storage. Diversion device passes extreme flows through the unit.	Settleable and floatable solids, oil/grease and particulate pollutants
Stormceptor	CSR Hydro Conduit	A weir insert is placed in a round manhole vault to improve hydraulics thereby improving removal efficiency and retention of sediment. During low flows the insert directs the flow downward and then laterally towards the walls of the sump. Above the treatment flow rate, the excess flow above the design flow rate flows directly across the insert device towards the outlet.	Settleable and floatable solids, oil/grease and particulate pollutants
Downstream Defender	H.I.L. Technology, Inc.	Uses vortex separation with device installed in a round single manhole vault.	Settleable and floatable solids, oil/grease and particulate pollutants
Vortechs	Vortechnics	Vortex separation with the swirl device placed in a rectangular, shallow vault. Comes in nine standard sizes.	Settleable and floatable solids, oil/grease and particulate pollutants
V2B1	Kistner Concrete	Two manholes in series. Vortex separation removes particulates and floatables in first manhole. Floatables move to a chamber in second manhole for storage. Diverter in first manhole bypasses high flows from first to second manhole.	Settleable and floatable solids, oil/grease and particulate pollutants
CDS	CDS Technologies	Circular device; flow is directed to create circular flow like a vortex, but removal occurs as the water passes through a screen around the outer perimeter. Removal induced by countercurrent flows on opposite sides of the screen which also prevents clogging of the screen.	Settleable and floatable solids, oil/grease and particulate pollutants
StormFilter	Stormwater Management	Vertical cylinder with media of various types placed in the cylinder. Water enters laterally through the filter, enters a vertical center well which exits to an underdrain system. One standard size cylinder (15 gpm). Number of cylinders is a function of design peak flow. Pretreatment desirable under circumstances as defined by the manufacturer.	Varies with media. All reduce settleable solids. Some remove dissolved P. or dissolved metals.
Envirodrain	Envirodrain	Insert device: Rectangular unit consisting of one to three trays. Media include Absorbent W, activated carbon.	Petroleum hydrocarbons, sediment, litter
Fossil Filter	KriStar Enterprises	Insert device: Rectangular, square or circular body with an upper removable tray. Tray is trough extended around the circumference of the drain inlet. Open in the center for high flows. Activated alumina media placed in tray.	Petroleum hydrocarbons and other constituents that are not water soluble
HydroKleen	Weaver Manufacturing, LLC	Two types: box and tapering cylinder. Box: water directed to vertical chamber on one side for sediment. Water overflows to second chamber where it falls through media. Tapering unit collects sediment in perimeter trough; water overflows to center to pass downward through media.	Hydrocarbons, organically bound metals, PCBs, many pesticides, VOCs, sulfides
Ultra-Urban Filter	Abtech Industries	Insert device: Rectangular box for side curb inlet drain inlets. Media in bags attached to two sides and bottom through which water passes. Sorbent polymer for media.	Petroleum hydrocarbons, debris, suspended solids
StormTreat	Storm Treat Systems, Inc.	Circular device with two concentric chambers: closed inner chamber for settleables\floatables; open outer chamber with wetland plants in gravel. One size, about 9.5 diameter, off-line with live volume of 1400 gallons. Fills each storm, slowly drains in 5 to 10 days. Requires detention system to retain treatment volume plus several units placed together with flow manifold to match design volume. Pretreat to remove gross solids\debris.	Settleable and dissolved solids, oil/grease, particulate pollutants, and bacteria

1. As stated by each manufacturer.

SWIRL CONCENTRATORS

Products employing the swirl concentrator or vortex separation mechanism include Vortechs, V2B1, and Downstream Defender. All products are designed to remove settleable and floatable solids, oil and grease, and particulate pollutants.

Downstream Defender, Vortechs, and V2B1

The flow entry into these devices is designed so as to cause a swirling motion "around" the removal chamber. The three devices differ with regard to shape, number of units in the basic configuration, and inlet and outlet designs. Downstream Defender consists of one round manhole like structure. Water enters and passes around the outside of a circular chamber placed within the manhole. Settleable solids move to the bottom of the chamber. The Downstream Defender and the Vortechs have storage chambers below the vortex separation area. The Vortechs is rectangular, although the removal chamber that rests within the box is circular. The V2B1 consists of two manholes. The entry manhole is the vortex separator and the second, downstream manhole stores floatables within an inner chamber. Floatable pass from the first to the second chamber through a connecting pipe. High flows are bypassed through the entry manhole to the second manhole but past, rather than through, the storage chamber. Removal efficiency is highly effected by flow rate.

Each product is available in several flow capacities as reported in Table 7 in the Results section. The products are typically not sized based on flow capacity; rather they are sized to achieve an average of 80 percent removal of TSS over time. The resulting treatment flow capacity to achieve 80 percent TSS removal is approximately one quarter the maximum hydraulic flow capacity listed for the units, which the peak flow that can be safely passed through the unit. The estimated treatment flow capacities are used as the basis for comparison of these products.

DEFLECTION SCREEN

The deflection screen mechansim is employed in the CDS Continuous Deflective Separation device.

CDS

The CDS device is similar to the above swirl concentrators in two respects. The device has a circular removal chamber and flow moves in a circular motion. However, vortex separation is not induced. Rather, removal is accomplished with a screen located around the outer perimeter of the removal chamber. Water moves through the screen. The relatively high velocity of the water in the entry chamber is reduced to a very low level by the fact that the water in the outer chamber, around the screen, moves counter current to the outlet. The settleable solids "drop" down at the interface of the screen; the floatables pass upward. This hydraulic action also prevents clogging of the screen. The device, originally developed in Australia, was design to retain floatables, which has been of greater concern in Australia than the United States. The screen sizes currently offered (2400 and 4700 micron openings) are too large to effectively remove settleable solids less than 100 to 200 um, which are of concern in the United States. However, research has demonstrated that the screens are capable of removing solids much smaller than the screen opening. While the 2400 screen is still too large to effectively remove the smaller particles of interest, it is not necessary to have, for example, a screen with openings equal to the size of the particle of interest. CDS is currently experimenting with a 1200 micron screen which may prove sufficiently small to remove the particle sizes of interest.

The peak flow of the prescribed design event is used to size the unit. The manufacturer offers models having a wide range of flow capacities as indicated in Table 7 in the Results section. According to the manufacturer, performance is not affected by flow rate.

MEDIA FILTERS

Filtration through proprietary media is employed in the StormFilter device.

StormFilter

StormFilter is a vertical filter cylinder or cartridge with a unit capacity of 15 gpm. The desired total system capacity, based on the peak of the prescribed design event, is achieved by using a multiple cartridges. The cartridges are placed in a precast or cast-in-place vault. The cartridges are placed in a line. The number of lines depend on the vault capacity. Water enters radially (horizontally) through the filter media into an inner cylinder. The filtered water passes downward to an underdrain system that is contained in the bottom slab. A uniqueness of the system is the hydraulic control. To maximize the flow-through rate, each cartridge contains a simple, non-mechanical vacuum device that prevents water from flowing through the cylinder until the water has risen to the top of the cartridge. When this occurs the vacuum within the inner chamber is broken and water passes through until the water level reaches the bottom of the cartridge at which time the vacuum is reestablished. This action also apparently causes solids that have accumulated on the outer surface of the media to be released from the media to settle to the bottom of the vault, thereby extending the maintenance cycle. Several different media are offered, singly or in combination, depending on the treatment objective. Primary constituents targeted for removal include dissolved metals and nutrients. Pretreatment, which is typically provided to remove gross solids, extends the maintenance cycle period. Some pretreatment occurs in the cartridge vault, but pretreatment may also be provided in a separate smaller vault or manhole located upstream of the cartridge vault. If included, a detention facility located upstream of the StormFilter may be sufficient to provide the desired pretreatment depending on the sizing criteria for the detention facility.

DRAIN INLET INSERTS

Products installed as inserts into drain inlets or catch basins include Fossil Filter, Ultra-Urban Filter, Hydro-Kleen, and Envirodrain. The other products reviewed are considered end-of-pipe devices because they are applied after stormwater has been collected in a piped stormwater conveyance system.

Envirodrain, HydroKleen, Fossil Filter, and Ultra-Urban Filter

These four systems actually function as media filtration devices, but are grouped together because they are installed by insertion into standard drain inlet configurations. Each product is described in Table 1. They differ as to their basic configuration, boxes or trays, and the types of media. Different constituents may be targeted for removal by selecting different types of proprietary media. Each offers several different models, differing by shape, capacity, and therefore size. The issue is whether inserts can provide treatment levels equivalent to either the manufactured products presented above or the public-domain systems that are currently allowed by the Sacramento jurisdictions.

COMBINED SYSTEMS

A treatment-train approach, in which treatment processes are combined in series, is employed in the StormTreat system.

StormTreat

The StormTreat system is an off-line system consisting of two prefabricated concentric cylinders. The outer chamber has a diameter of about 9.5 feet and a height of 4 feet. Water flows directly into and around the inner chamber from either a detention facility or a pretreatment vault or manhole. Further settling of finer material occurs in this chamber. The water passes to the outer chamber, which is filled with gravel to support the growth of wetland plants. This outer chamber removes fine solids and dissolved pollutants. The capacity of the inner chamber is 1,400 gallons. This chamber fills during the storm. The release rate from the outer chamber is controlled at about 1 to 2 gpm. This slow withdrawal is necessary to obtain high levels of removal. The unit takes on the order of five to ten days to drain. Hence, to achieve treatment of the desired volume of water, detention storage must be located upstream of the StormTreat unit. This stored volume gradually flows though the unit over a period of five to ten days. Hence, it is important to recognize the inter-event time between storms when sizing the system . If the inter-event time for the Sacramento area is less than ten days, the potential exists for the unit to have residual volume of water when the next storm arrives. To avoid this problem, the volume of the detention/StormTreat system must be greater than the specified treatment volume. This can only be accomplished by incorporating the statistical nature of storms into the design process.

PUBLIC DOMAIN SYSTEMS

Grass swales and sand filters are the two public-domain treatment systems that are most commonly used at this time in the Sacramento region. The term "public-domain" is used to distinguish them from the manufactured or proprietary control measures that are evaluated in this report. Theses public domain systems are used as the basis of comparing the performances of the proprietary devices.

Grass Swales

Grass swales are gently-sloped grass-lined channels to which runoff is directed and which is used to convey runoff to a storm-drain piping system. Treatment takes place through a variety of physical, chemical and biological mechanisms as the runoff flows to and along the grass swale. Treatment efficiency is largely a function of depth of flow relative to grass height and velocity of flow.

Sand Filters

Sand filters are media filtration devices, but use sand as the filter media as opposed to a proprietary media product. With sand filters there are three configurations of interest: lineal boxes, open surface basins, and closed vaults. The three configurations are illustrated in Figure 1.

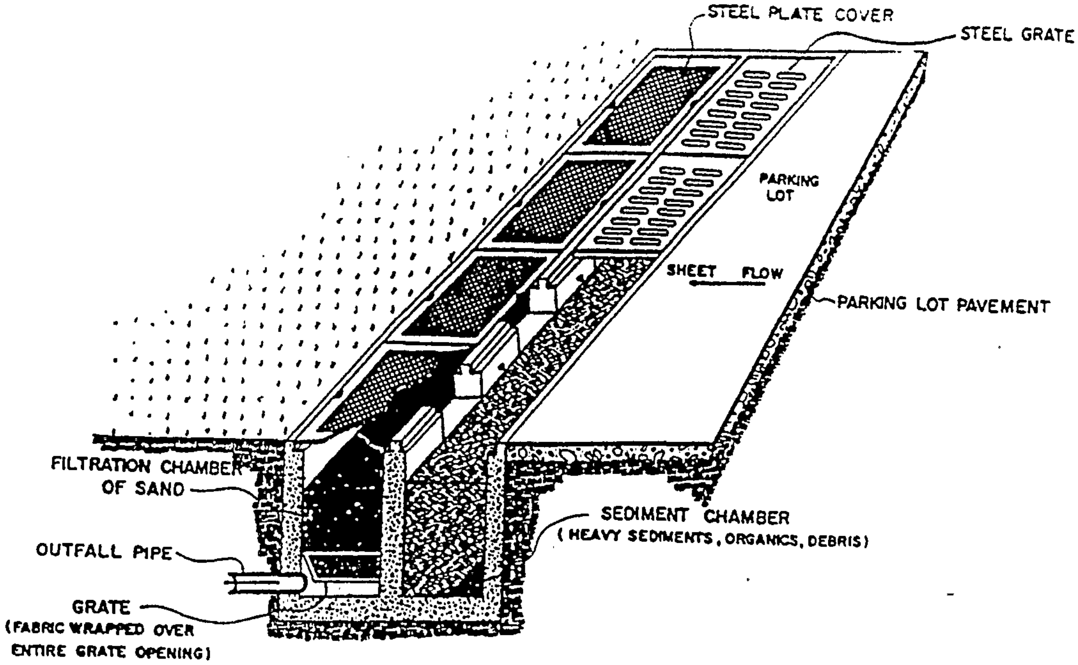

Figure 1a . Lineal Box Sand Filter

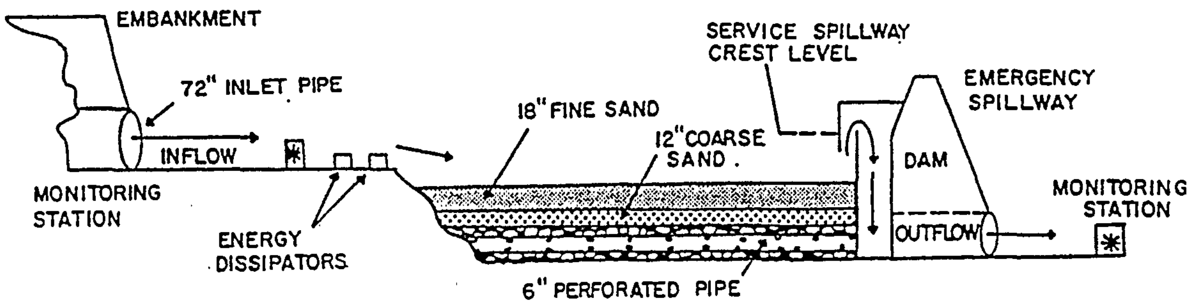

Figure 1b . Open Basin Sand Filter

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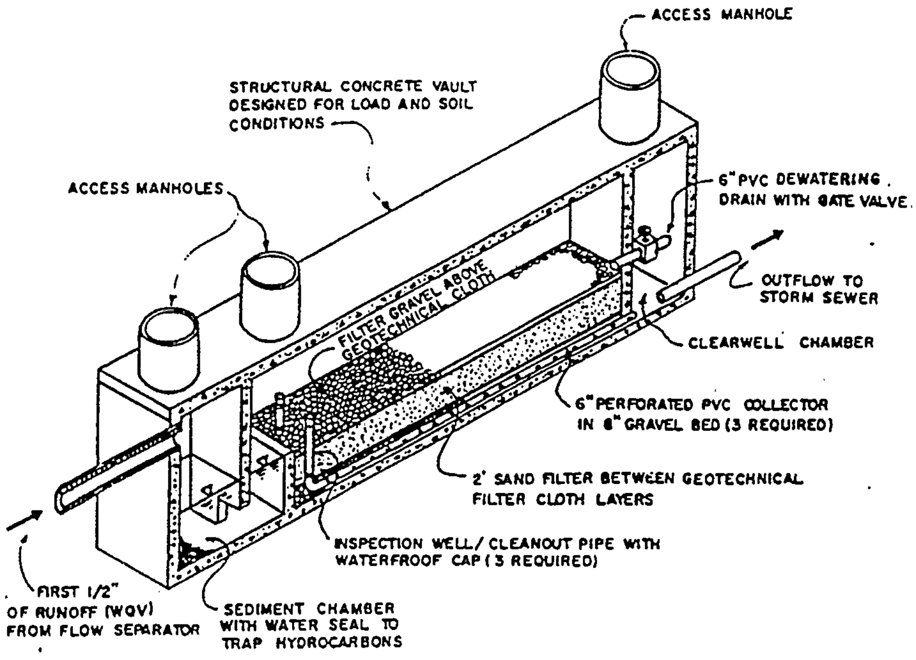

Figure 1c . Closed Vault Sand Filter

RESULTS

The results of this investigation include the following information and data:

- Summary of questionnaire responses
- Summary of performance data for proprietary control measures
- Summary of performance data for public domain control measures
- Summary of cost data for proprietary control measures
- Evaluation of proprietary control measures

QUESTIONNAIRE RESPONSES AND OTHER SOURCES OF INFORMATION

Questionnaire responses were received from manufactures or representatives of all the proprietary control measures of interest. The types of response data and information received about each product are summarized in Table 2. The information materials provided by product companies included a completed questionnaire, product brochures and technical literature, copies of available study reports, separate performance data, cost data, and design criteria. The number of product installations in California were extracted from the completed questionnaire and are listed in Table 2. Products that are no longer manufactured (Ecostar Oil/Water Separator) or are not appropriate as a stormwater control measures (Romag Stormwater Screen) were not further evaluated in this study.

In addition to the information provided by the product manufacturers, information and data from the recent literature review prepared for the Permittees (Larry Walker, 1998a) and the professional literature were used in compiling information about the various controls, particularly the public domain stormwater controls discussed latter in this section.

PERFORMANCE DATA SUMMARY — PROPRIETARY CONTROL MEASURES

Performance data supplied by the manufacturers and extracted from study reports and the professional literature are summarized in Table 3 for proprietary control measures. Performances are reported in terms of percent removal of total suspended solids (TSS), copper

(Cu), lead (Pb), zinc (Zn), and oil and grease (O&G). These constituents are typically of concern in stormwater runoff and are most often monitored. Other notable removal data are also

Table 2. Summary of Questionnaire Responses

Company Name	Product	Response			Performance Data	Cost Data	Design Criteria	California Installations	Comments
		Quest.	Brochure	Studies					
Jensen Precast	Precast Stormwater Interceptor	Y	Y	Y	Y	(Y)	Y	300+	
Teichert Precast	Precast Interceptor	Y	Y	N	N	Y	(Y)	54	
Ecostar	Oil/Water Separator	N	N	N	N	N	N	0	Out of business
Bay Saver, Inc.	Bay Saver Separation System	Y	Y	1	Y	Y	Y	0	
CSR Hydro Conduit	Stormceptor	Y	Y	Y	Y	Y	Y	52	Many studies
H.I.L. Technology, Inc.	Downstream Defender	Y	Y	Y	Y	Y	Y	0	
Vortechnics	Vortechs Stormwater Treatment System	Y	Y	Y	Y	Y	(Y)	3	
Kistner Concrete	V2B1	Y	Y	1 ongoing	(Y)	Y	(Y)	0	
CDS Technologies	Continuous Deflective Separation	Y	Y	Y	Y	Y	Y	7	Detailed information
Stormwater Management	StormFilter/CSF Treatment System	Y	Y	Y	Y	Y	(Y)	8	Independ. studies
Envirodrain	Envirodrain (Insert)	Y	Y	N	(Y)	Y	(Y)	25±	
KriStar Enterprises	Fossil Filter (Insert)	Y	Y	Y	Y	Y	(Y)	5000	
Weaver Manufacturing	Hydro Kleen (Insert)	Y	Y	1 ongoing	(Y)	Y	Y	15	
Abtech Industries	Ultra Urban Filter (Insert)	Y	Y	Y	Y	Y	(Y)	(on order)	
StormTreat Systems, Inc.	StormTreat	Y	Y	1	Y	Y	Y	0	
Waterlink - Hycore	Romag Stormwater Screen	Y	Y	1	(Y)	Y	Y	0	Combined sewer device - N/A

Y = Reponse received
(Y) = Limited reponse received
N = No reponse received
N/A = Not applicable

Table 3. Performance Comparison Summary for Proprietary Stormwater Structural Control Products (continued)

Product	*Performance Data (% Removals)*						*Data Source/* Reference	*Notes*
	TSS	Cu	Pb	Zn	O&G	Other		
Enviro-Drain						TRPH – 95 (25gpm) TRPH – 82 (60gpm)		Lab summary sheets only – no report
Fossil Filter					55	Diesel (98.6) Motor Oil (94.8)	Enetch, 1996	Lab test of absorbent exposure study
							Eagle, 1998 Sandine, 1996	Hydraulic capacity tests confirmed rating of 12 gpm /LF
					41	N&P increased slightly	Ambient, 1997	1 storm event w/ composite samples
	32/38	18	46	24/26		Diazinon (34/+4) Clorpyrifos (69/	Larry Walker, 1998b	Results from 2 storm events
Hydro-Kleen								Manufacturers field study indicates non-detect levels – no report. Study in progress by CSUC
Ultra-Urban Filter					83		AbTech , Note 1	Lab test with simulated stormwater
					91		AbTech , Note 2	Lab test repeated with unit after 2 months in field
							AbTech , Note 3	lab leaching test indicated no sheen in leachate with average concentration of 1.6 mg/L oil
StormTreat	95		65	90		TPH –90 TP – 89 TDN – 44 COD – 75 FC- 83	Allard, 1999	4 storms sampled. Types of samples or storm characteristics not indicated
	99		77	90		TPH –90 TP – 89 TDN – 44 COD – 82 FC – 97	Horsely, 1995	5 storms sampled. Types of samples or storm characteristics not indicated

Table 3. Performance Comparison Summary for Proprietary Stormwater Structural Control Products

Product	*Performance Data (% Removals)*						*Data Source/ Reference*	*Notes*
	TSS	Cu	Pb	Zn	O&G	Other		
Jensen Interceptor	24	12	13	29	38	Diesel (+16) Motor Oil (+33)	Piner, 1994	1 storm w/ in/out grab samples. (+) = increase in concentration
	63/50	33/25	47/33	26/18	Non-detect	TOC (+19/+15)	Kinnetic, 1996	6 storms monitored w/ in/out flow-weighted composite samples. Grab samples for O&G for 2 storms. Removals for intercepted flow/total flow
Teichert Interceptor								No Studies
Bay Saver Separation System	80 est.						BaySaver, 1998	Field study of 3 storms w/ auto samplers. EMC not computed. Effluent TSS at irreducible levels. Field study planned at U. of Maryland
Stormceptor	80					TKN (41)	Service, 1998	4 storms for TSS; 5 storms for TKN. No significant inlet conc. for others
	26			21		PAH (36)	Greb, 1998	45 storms monitored. Removals based on EMC and total mass
	93					TPH (82)	Environ. Sampling, 1997	3 storm events for TSS; 1 event for TPH. Removals based on EMC
	53	21	51	39	43		Labatiuk, 1997	4 storm events. Removals based on EMC
Downstream Defender								Only reliable data are for sediment analysis. 90% removal of particles > 150µ. Field study planned
Vortechs	80						Votechnics	Lab test at design operating rate of 24 gpm/ft^2
	84						Vortechnics, 1998	7 storm events. Removals based on EMC
V2B1								Only lab data on sediment removal. Field studies planned
CDS	84						Schwarz, 1999	Lab test. Percent mass capture of sand particles at 125 gpm
	70						Walker, 1999	4700 micron screen not effective for TSS < 75 mg/L
StormFilter	92	65	82	83	81	COD (70) TPH(84)	Stomwater, 1994	7 storm events. Removals based on EMC
	43	33	50	29			Lief, 1998	8 storm events
					74/69		Woodward, 1998	Lab tests with compost and Perlite filter media

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summarized in the respective tables along with notes of interest regarding the studies from which the data were obtained. For sand filters there are no performance data for closed vaults. Nonetheless, as closed vaults are essentially underground basins, the data from open basins should represent the expected performance of closed vaults.

PERFORMANCE DATA SUMMARY — PUBLIC DOMAIN CONTROL MEASURES

Performance of public domain control measures, sand filters and grass swales, is of interest, as their performance is used as a basis for comparing the performances of the proprietary devices. Performance data for public domain control measures extracted from the professional literature are summarized in Table 4. The performances of grass swales and sand filters were evaluated with respect to TSS and zinc. TSS was chosen because of the preponderance of data. It is the most frequent constituent measured in all studies of stormwater treatment control measures, and serves as a surrogate for the pollutants that in stormwater tend to be primarily in the particulate form, like petroleum products, pesticides, lead, chromium, and phosphorus. Zinc was selected to represent the more soluble constituents, including itself as well as copper, cadmium, and the various nitrogen forms. Also, of the metals, zinc is typically present in runoff in concentrations sufficiently above the detection limit to allow meaningful evaluations of removal efficiency.

Plotted in Figures 2 and 3 are the TSS and zinc removal data for grass swales, respectively. Plotted in Figures 4 and 5 are the TSS and zinc removal data for sand filters, respectively. Efficiency is plotted as a function of influent concentration. This general relationship has recently been recognized (Bell, 1995) for sand filters but appears to exist for other treatment BMPs as well, like grass swales and wet ponds. Figures 2 through 5 clearly establish this fact. Presented in each of Figures 2 through 5 are two types of data points: individual storms and the overall calculated average efficiency in each study.

Shown in Figures 2 and 4 is a line called the "Line of Comparative Performance©", developed by Dr. Gary Minton of Resource Planning Associates. The line is a reasonable first approximation of the expected performance of public domain control measures with respect to the removal of TSS. The expectation is that data points must fall above and to the left of the line: this is loosely defined as acceptable performance. The line was developed from an evaluation of the performance data of several treatment systems studied in western Washington:

Table 4. Performance Comparison Summary for Selected Public Domain Stormwater Structural Controls

Product	*Performance Data (% Removals)*						*Data Source/ Reference*	*Notes*
	TSS	**Cu**	**Pb**	**Zn**	**O&G**	**Other**		
Grass swale	83	46	67	63	75	TP-29;FC-(70)	Khan, 1992	200' swale, 6 storms, flow weight composite, aggregate removal.
	72	10	25	15	49	TP-50; FC-64	Khan, 1992	100' swale, 6 storms, flow weight composite, aggregate removal.
	68	42 (21)	62			TN-31; TP 4.5	Goldberg, 1993	8 storms, flow weight composite, aggregate removal, (dissolved).
	67	-35	6	-3		TP-39	King, 1995	15 storms, flow weight composite, aveages of storms, wetland veg
	87,85		17,41	91,75		TOC-51,53 FC-neg	Barrett, 1998	Two areas, not a swale but vegetated area between freeway lanes, infiltration significant factor.
	81	56	50	69		TN-52;TP-17 Cr-37	Schueler, 1994(a)	11 storms, swale had standing water pool
	87	89	90	90		TN-84; TP-83 Cr-88	Schueler, 1994(a)	16 storms
	65	28	41-55	49		TKN-17; TP-41 Cr, 12-16	Schueler, 1994(b)	Swale 1 (Virginia), 9 storms
	-85	14	18-92	47		TKN-9; TP-12 Cr, 22-72	Schueler, 1994(b)	Swale 2 (Maryland), 4 storms
	98	62-67	67-94	81		TKN-48; TP-18 Cr, 51-61	Schueler, 1994(b)	Swale 3 (Florida), 8 storms, high removals may be due to infiltration
	60	66 (0)	62	94(82)		TP-40	Evans, 1994	2 storms, filter swale with lime included and underdrain, (dissolved)
Sand filter basin	95	76 (38)	73	96 (77)		TN-23; TP-67	Shapiro, 1998	18 storms, data for 1997 wet season, composite samples, diverted flow only; dissolved metals in parens, efficiencies are of treated flow excluding bypass. Including bypass reduced TSS removal to 84%
	97	66	80	94			Shapiro, 1998	Data for 1996 season
	42					TP-55	King Co.	3 storms, 2 quite small, grab samples, filter follows swale instead of sed basin
	81					TP-95	Harper, 1993	6 storms
	89	72	79	76		TN-17; TP-59 BOD-51;TOC-(4) FC- neg.	Austin, 1996	7 storms

Table 4. Performance Comparison Summary for Selected Public Domain Stormwater Structural Controls (Continued)

Product	*Performance Data (% Removals)*						*Data Source/ Reference*	*Notes*
	TSS	Cu	Pb	Zn	O&G	Other		
Sand filter basin	88	29	71	50		TOC-52; TN-37 TP-21; FC-45	Austin, 1996	Highwood unit; efficiencies of all four units exclude overflows
	79	44	90	79		TOC-49; TN-34 TP-60; FC-40	Austin, 1990	BCSM unit
	87	60	81	80		TOC-62; TN-32 TP-61; FC-37	Austin, 1990	Jollyville unit
	92	80	89	91		TOC-93; TN-71 TP-80; FC-83	Austin, 1990	Brodie Oaks unit
Sand vaults	No studies							
Lineal sand filter (Delaware)	79	25		91		TOC-66; TN-47 TP-63	Bell, 1995	20 storms for most constituents, found filters can at times become anaerobic.
	83	22		33	84	TP-33	Horner, 1995	Filter 1, 14 storms
	8	31		69	69	TP-20	Horner, 1995	Filter 2, 6 storms, much lower influent TSS than Filter 1

FIGURE 2 GRASS SWALES

TSS Removal

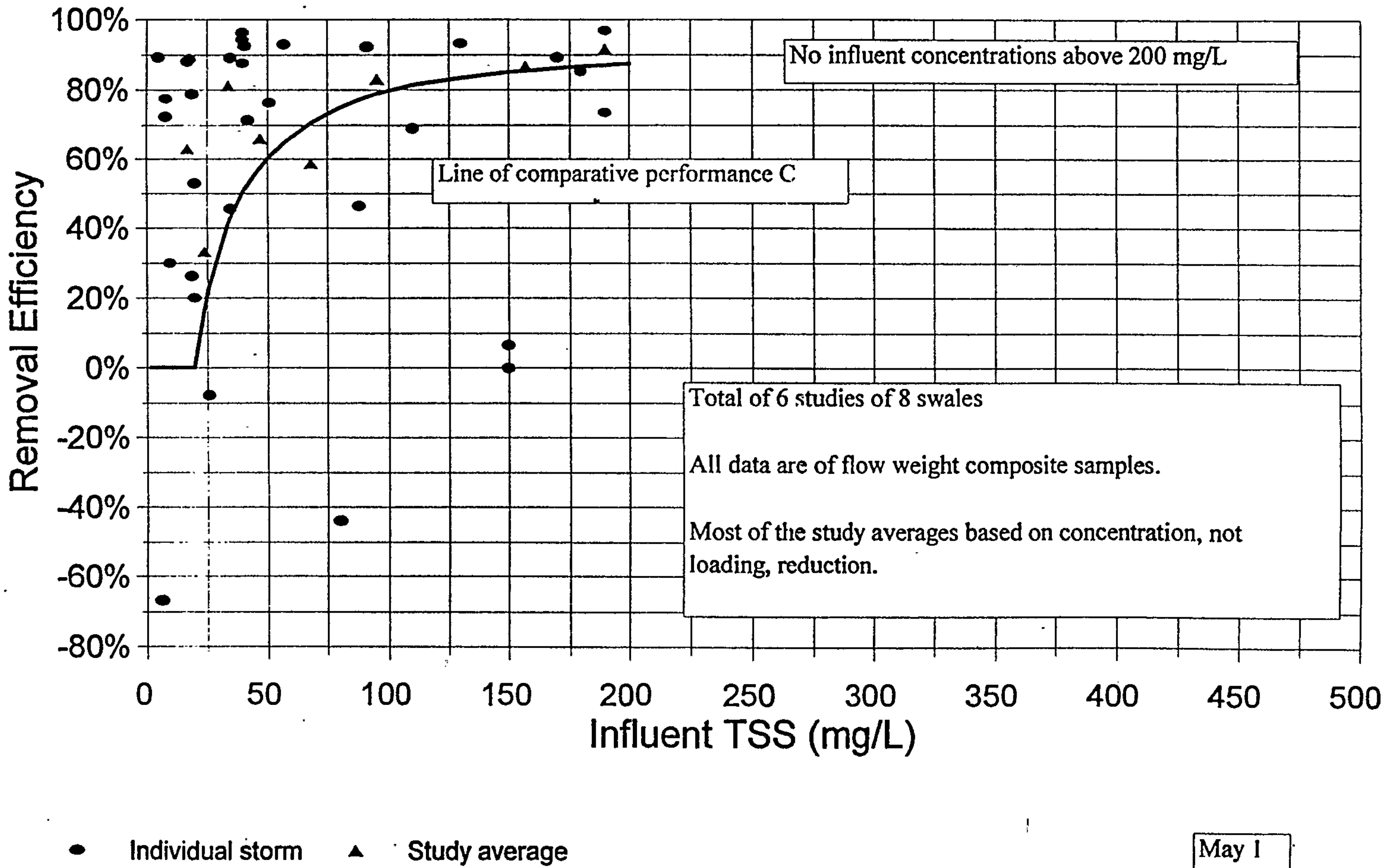

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FIGURE 3 GRASS SWALES

Zinc Removal

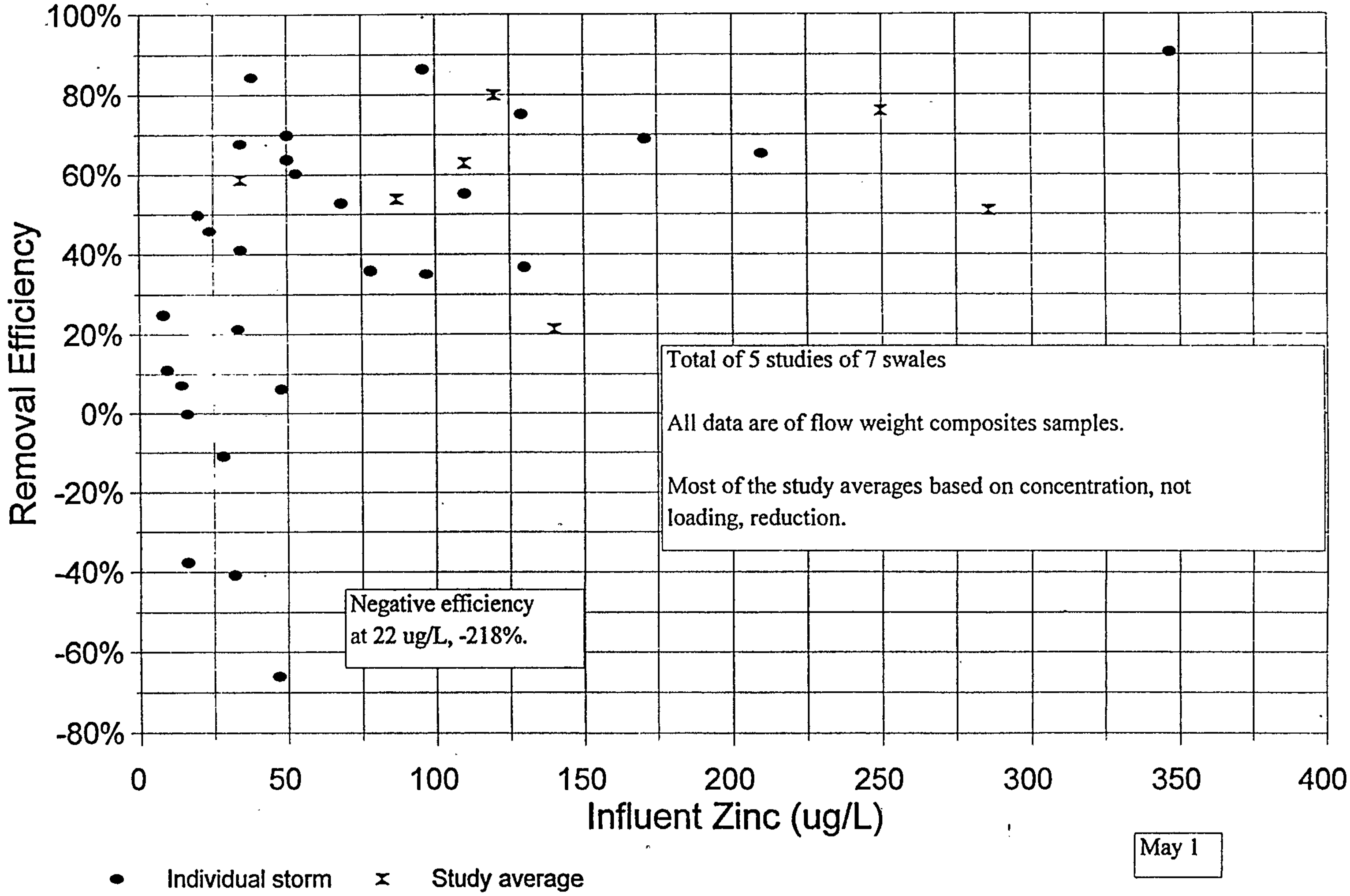

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FIGURE 4 SAND FILTERS

TSS Removal

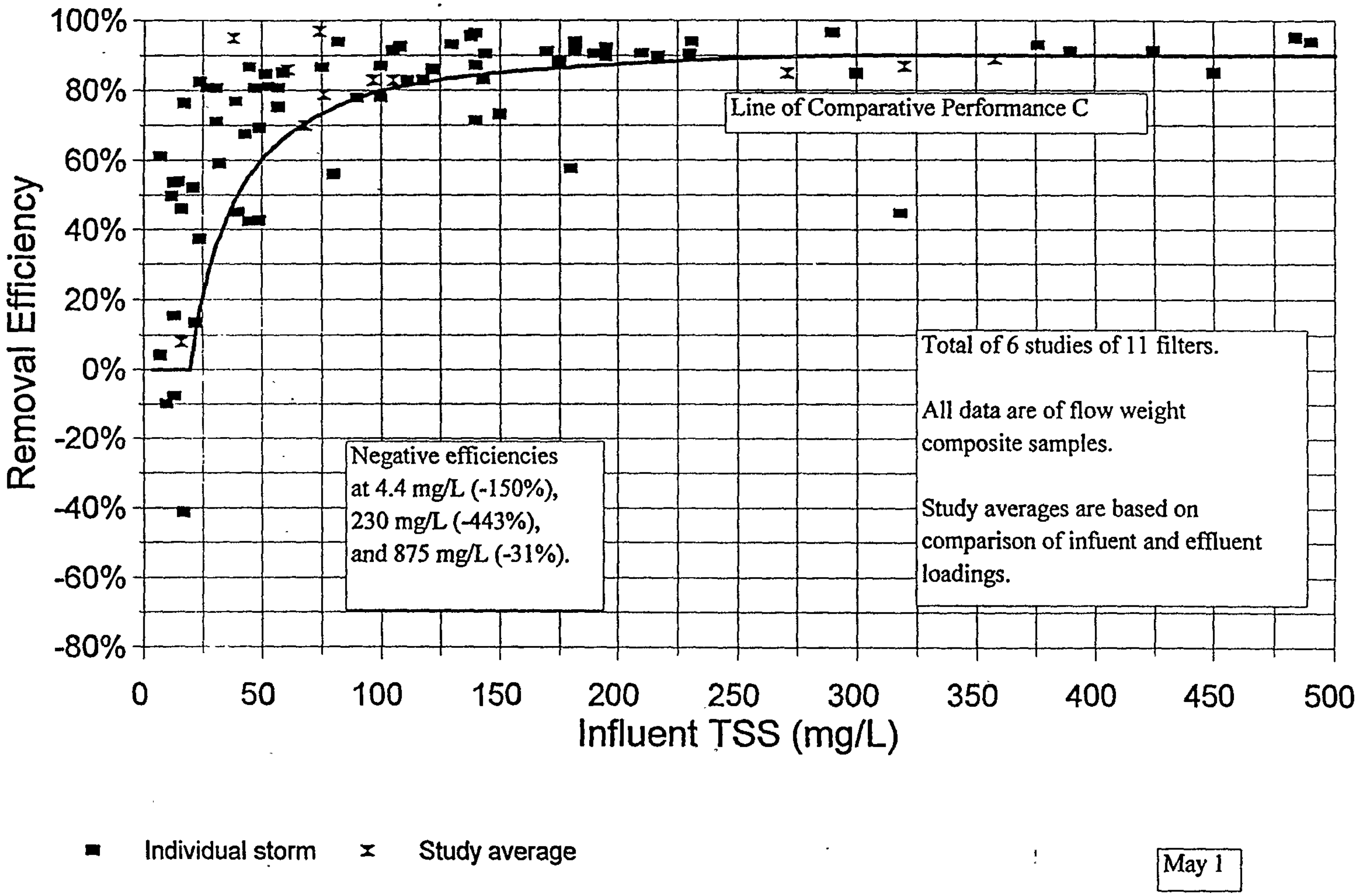

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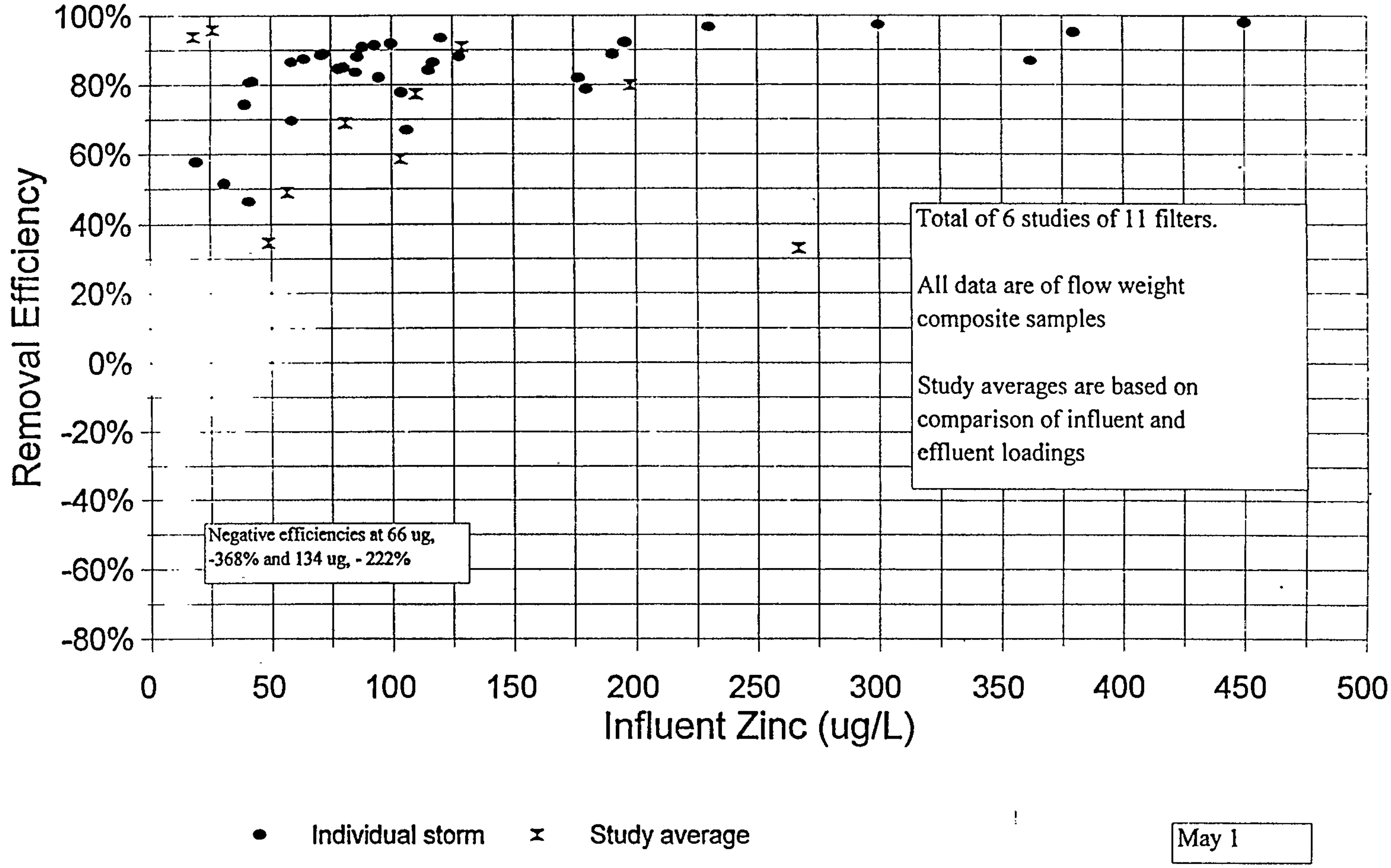
FIGURE 5 SAND FILTERS

Zinc Removal



grass swales, wet ponds\wetlands, and sand filters. These lines are useful in evaluating the performance of proprietary control measures.

The results of the analysis of data from western Washington are considered applicable to the Sacramento area because of similarities in rainfall characteristics between the two regions, in particular average rainfall intensity (0.04"/hour in Seattle; 0.05"/hour in Sacramento), which appears to be a significant determinant of the TSS concentration in untreated stormwater (Roundtree, 1995). This general observation can be seen in the comparison of data from three regions: Seattle, Los Angeles and Austin. In a recent analysis of data collected for Caltrans District 7, the mean TSS concentration was determined to be 97 mg/L (Brown and Caldwell, 1997). A similar study in the Seattle area (Merrill, et al., 1989) determined a mean concentration of 71 mg/L from highways. In contrast, stormwater from a freeway in the Austin area had a median concentration of 202 mg/L (Barrett, et. al., 1998 and pers. comm.) where the average rainfall intensity is 0.12"/hour. Median values are usually lower than mean values. Unfortunately, there are no data in California on control measure performance to compare to the data that have been generated in western Washington.

Grass swales

Data were obtained for eight swales from six studies as listed in Table 5. However, only the swales studied by Khan (1992) were specifically designed for the treatment of stormwater. Four swales treated stormwater from retail commercial or residential areas; two treated stormwater from an urban freeway, and the drainage areas of two swales was not identified. TSS data are plotted in Figure 2 and zinc data in Figure 3.

Table 5. Performance Studies of Grass Swales

STUDY	LOCATION	TYPE OF SWALE	LAND USE	STUDY PERIOD
Barrett (1995)	Austin, Texas	Wide grassed area (two) between freeway lanes	Urban freeway	1994
Goldberg (1993)	Seattle, Washington	Designed grass swale, 570 ft. length	Residential	1992
Khan (1992)	Mountlake Terrace, Washington	Designed grass swale, 200 ft length.	Residential	1991
King County (1995)	Issaquah, Washington	Designed wetland swale, 350 ft. length.	Residential	1994
Oakland (1983)	Durham, New Hampshire	Designed grass swale, 200 ft length.	Supermarket	1982
Schueler (1994)	Central Florida	Two swales of 210 ft. length, one with wet pool, one with high infiltrative bottom.	Not provided	1987

Figures 2 and 3 suggest that the performance of grass swales is less consistent than sand filters (see Figures 4 and 5). A greater percentage of the data points fall to the right of the line in Figure 2, in comparison to Figure 4. There is considerably more scatter in zinc removals in Figure 3 in comparison to Figure 5. It is likely that the greater scatter is due to the variation in the designs of the swales that were evaluated, and the condition of the vegetation. Frequently, the design procedure does not take into consideration the need to have a wide swale with a flat bottom (rather than curved). A Manning's "n" on the order of 0.20 to 0.25 should be used rather than 0.05 to 0.07, the value typically used to size grass channels (Khan, et al., 1992). Swales that are too narrow result in channelized flow with water depths that exceed the height of the grass. To be effective at pollutant removal, the depth of the stormwater must not exceed the height of the grass. These conditions were likely present with the swale that was studied by Welborn et al. (1987). The authors evaluated a large swale, in terms of both length and width, treating stormwater from a medium density residential development. Essentially no pollutant removal occurred in 19 storms. The authors provided no insights as to the reason(s) for the poor performance. However, pictures were provided in the report, which show a swale with a pronounced curved or sloped, rather than flat, bottom and grass that is closely cropped although apparently thick and in good health.

Sand Filters

Data have been obtained of 11 filters from six studies as listed in Table 6. Eight filters were of the open basin type and three were lineal filters. Nine filters treated stormwater from retail commercial or residential areas; two treated stormwater from an industrial site. TSS data are plotted in Figure 4 and zinc data in Figure 5.

The data in Figure 4 indicate that sand filters are effective in the removal of TSS and are generally consistent in their performance from storm to storm, as the vast majority of data points tend to fall on or to the left of the Line of Comparative Performance. There does not appear to be differences in performance between the three regions represented by the data (western Washington, Austin, and Washington, D.C.). However, negative efficiencies have been observed in individual storms as noted in Figure 4 (from Horner et al., 1995 and Welborn, et al., 1987). In Washington. D.C., anecdotal observations of vault filters suggests that sediments previously deposited on the filter surface are scoured during large storms (Karikari, pers. comm.). Vaults, however, do not have bypasses, nor do lineal sand filters, except to the extent that inflow is limited by the capacity of the grate. However, the sand basins in Austin are off-line, suggesting that scour should not be an issue. However, negative removals were observed by Welborn, et al. (1987) in large storms.

The pattern of removal efficiency of zinc shown in Figure 5 is similar to TSS. More scatter in the data points might be expected given that a significant fraction of zinc is in the soluble form, which presumably would not be removed by sand. However, in two studies it was found that sand does remove dissolved zinc (Shapiro, 1998; Welborn, et al, 1987). The one significant outlier in Figure 4 (study average of 31% at influent concentration of 267 μg/L) was from the study by Horner et al. (1995) of lineal filters at an industrial site. The rather low efficiency is the result of the mathematical effect of one high-flow incident with a negative efficiency. Were this one incident excluded, the zinc removal would have been 87% over the test period.

Table 6. Performance Studies of Sand Filters

STUDY	LOCATION	TYPE OF FILTER	LAND USE	STUDY PERIOD
Austin (1990)	Austin, Texas	Open filter basin preceded by dry pond.	Residential - 2 filters Shopping mall- 1 filter Roadway - 1 filter	1984-1989
Austin (1996)	Austin, Texas	Open filter basin preceded by dry pond.	Shopping mall	1993-1995
Welborn (1987)	Austin, Texas	Open filter basin preceded by dry pond.	Shopping mall	1982-1984
Bell (1995)	Alexandria, Virginia	Lineal filter which contains a lineal wet vault.	Rental car parking lot	1994
Shapiro (1998)	Seattle, Washington	Open filter basin preceded by wet vault	Residential	1995-1997
Horner (1995)	Seattle, Washington	Lineal filter which contains a lineal wet vault.	Waterfront bulk cargo yard.	1994
King County (undated)	Seattle, Washington	Open sand filter basin preceded by grass swale.	Shopping mall	1993

COST DATA SUMMARY FOR PROPRIETARY CONTROLS

Cost data provided by manufacturers of proprietary control measures, including purchase, installation and annual operation and maintenance costs are summarized in Table 7. The products are listed alphabetically by type. Many of the control measures are available in several sizes and unit flow capacities. The costs of the various sized units and their associated flow capacities are listed in Table 7. To provide a means of comparing costs, a normalized, or unit cost, in terms of dollars (purchase plus installation) per cfs of rated capacity was computed for each control measure in three flow capacity ranges (approximately 0.1, 1.0, and 10 cfs). The normalized costs are reported in Table 7 . A review of these unit costs reveals that, in general, drain inlet inserts cost in the range of $3,000 to $5,000 per cfs flow capacity, while the other end-of-pipe devices, with the exception of media filters, cost in the range of $10,000 to $20,000 per cfs flow capacity. Media filters cost in the range of $40,000 to $75,000 per cfs flow capacity, but these devices target removal of dissolved constituents and provide a higher level of treatment. The unit cost were developed only for the purpose of general comparison and were not used as a basis for determining acceptance of the products. It is recognized that product performance is not a linear function of flow. A more comprehensive cost comparison may consider cost per annual flow volume treated. Such an analysis is beyond the scope of this report.

Costs of public domain control measures were not evaluated as part of this report. In most cases the cost of grass swales will be incorporated into the cost of landscaping a particular site. Some additional engineering costs may be incurred to properly size the swales for the design flow conditions. Sand filters are installed treatment devices, similar in this respect to the proprietary devices. The cost of sand filters will vary with size and complexity of construction.

Table 7. Cost Comparison Summary for Proprietary Stormwater Structural Control Products

PRODUCT	*COMPANY NAME*	*TYPE OF DEVICE*	*APPLICATION/ LIMITATIONS*	*UNIT FLOW CAPACITIES*	*COSTS, $*			*UNIT COST*
					Purchase	Install	O&M/yr	$/cfs
Jensen Interceptor	Jensen Precast	Gravity separator	Removes particulates and floatables. Separate bypass required for flow > capacity	0.17 – 0.22 cfs	$2000 – 2750			$11,800
				0.26 – 0.33 cfs	$3300 – 4100			
				0.44 - 0.55 cfs	$55 00 – 6900			
				0.67 - 0.89 cfs	$8300 – 11,000			$12,400
				1.1 cfs	$13,7500			
Teichert Interceptor	Teichert Precast	Gravity separator	Removes particulates and floatables. Separate bypass required for flow > capacity	0.54 cfs	$3000	85%	$500 - $3000	
				0.85 cfs	$4000	85%		$8,700
				1.28 cfs	$5000	85%		
Bay Saver Separation System	Bay Saver, Inc.	Gravity separator	Removes particulates and floatables.	2.4 cfs	$6,500	25-40%	$500+	$3,700
				7.2 cfs	$10,500			
				11.0 cfs	$14,000			$1,750
Stormceptor	CSR Hydro Conduit	Gravity separator	Removes particulates and floatables	0.17 cfs	$4500	25%	$500 – 1000	$33,100
				0.635 cfs	$7830 – 11,130	25%		
				1.06 cfs	$14,390-17,200	25%		$16,700
				1.78 cfs	$22,700-26,600	25%		
				2.47 cfs	$34,570	25%		

Table 7. Cost Comparison Summary for Proprietary Stormwater Structural Control Products (continued)

PRODUCT	COMPANY NAME	TYPE OF DEVICE	APPLICATION/ LIMITATIONS	UNIT FLOW CAPACITIES	COSTS, $			UNIT COST
					Purchase	Install	O&M/yr	$/cfs
Downstream Defender	H.I.L. Technology, Inc.	Swirl concentrator	Removes particulates and floatables.	3.0 (0.8) cfs[1]	$10,300	25% (assumed)	$500+	$16,100[2]
				8.0 (2.0) cfs[1]	$13,300			
				15.0 (3.8) cfs[1]	$20,000			
				25.0 (6.2) cfs[1]	$26,000			$5,200[2]
Vortechs Stormwater Treatment System	Vortechnics	Swirl concentrator	Removes particulates and floatables	1.6 (0.4) cfs[1]	$10,500	25-50%	$400+	$36,750[2]
				2.8 (0.7) cfs[1]	$12,000			
				4.5 (1.1) cfs[1]	$14,000			$17,500[2]
				6.0 (1.5) cfs[1]	$16,000			
				8.5 (2.1) cfs[1]	$18,000			
				11.0 (2.8) cfs[1]	$20,000			
				14.0 (3.5) cfs[1]	$24,000			
				17.5 (4.4) cfs[1]	$30,000			
				25.0 (6.2) cfs[1]	$40,000			$9,000[2]
V2B1	Kistner Concrete	Swirl concentrator	Removes particulates and floatables. Head loss limitation	2.8 (0.7) cfs[1]	$8,000-11,000	25%	Variable	$17,000[2]
				4.3 (1.1) cfs[1]	$9,000-12,000			$11,900[2]
				6.2 (1.5) cfs[1]	$11,000-14,000			
				8.5 (2.1) cfs[1]	$14,000-18,000			
				11.1 (2.8) cfs[1]	$19,000-23,000			
				17.4 (4.4) cfs[1]	$25,000-30,000			
				25.2 (6.3) cfs[1]	$30,000-40,000			$6,900[2]

1. Capacities in parentheses indicate recommended design capacity for 80 percent TSS removal
2. Based on recommended design capacity for 80 percent TSS removal

Table 7. Cost Comparison Summary for Proprietary Stormwater Structural Control Products (continued)

PRODUCT	COMPANY NAME	TYPE OF DEVICE	APPLICATION/ LIMITATIONS	UNIT FLOW CAPACITIES	COSTS, $			UNIT COST
					Purchase	Install	O&M/yr	$/cfs
Continuous Deflective Separation (CDS)	CDS Technologies	Deflection screen	Removes trash, particulates and floatables	1.1 cfs	$9,600	$3,400	$400+	$11,800
				3 cfs	$15,700	$7,300	$400+	
				9-11 cfs	$34,500	$40,500	$400+	$7,500
				26 cfs	$61,800	$63,200	$525+	
				62 cfs	$121,800	$128,200	$675+	
				148 cfs	$202,600	$217,400	$1200-1450	
				270 cfs	$303,750	$293,250	$1200-1450	
				300 cfs	$332,500	$297,500	$1200-1450	
StormFilter/CSF Treatment System	Stormwater Management	Cartridge Media filter	Removes particulates, O&G, and dissolved constituents. Pretreatmentment recommended	0.13 cfs	$8,000	15-20%	$500-4500	$73,800
				0.17 cfs	$11,500			
				0.30 cfs	$15,300			
				0.60 cfs	$24,600			
				0.84 cfs	$28,000			
				1.0 cfs	$33,000			$39,600
Envirodrain	Envirodrain	Drain inlet insert media filter	Removes petroleum hydrocarbons.	0.4 cfs	$1,800	No Charge	$3/unit filter replace	$4,500
				0.6 cfs	$2,100			
				0.75 cfs	$2,300			$3,100
				Other sizes available				
Fossil Filter	KriStar Enterprises	Drain inlet insert media filter	Removes petroleum hydrocarbons. Unsuitable for large amounts of sediment or debris and snow areas	12 gpm /LF of filter		$50 – $65 /unit	$600 – $720	
				Circular units – 18" to 36" diam	$450 – 500			
				Square units – 24" x 24" to 48" x 48"	$425 – 700			$3,100

Table 7. Cost Comparison Summary for Proprietary Stormwater Structural Control Products (continued)

PRODUCT	COMPANY NAME	TYPE OF DEVICE	APPLICATION/ LIMITATIONS	UNIT FLOW CAPACITIES	COSTS, $			UNIT COST
					Purchase	Install	O&M/yr	$/cfs
Hydro-Kleen	Weaver Manufacturing, LLC	Drain inlet insert dual-media filter	Removes hydrocarbons, organics and complexed metals.	0.10 cfs	$960	Drop-in installation		$9,600
				0.17 cfs	$1120			
				0.40 cfs	$1520			
				0.50 cfs	$1920			
				0.62 cfs	$2400			$3,900
				0.9 cfs	$3500			
				High Sediment Unit				
				0.2 cfs	$2280			$11,400
				0.24 cfs	$2880			
				0.31 cfs	$3600			
				0.44 cfs	$4200			$9,550
Ultra-Urban Filter	Abtech Industries	Drain inlet insert media filter	Removes trash, particulates and floatables. Drain inlet must be larger than module size	35 gpm /module Module size: 13.75"x14"x23"	$250/module	$100+ based on multiple installation	$400+	$4,500
StormTreat	StormTreat Systems, Inc.	Gravity separator +wetland plant	Removes particulates, O&G, and dissolved constituents. Equalization required upstream	14,000 gal/unit	$5,600/unit	$750-1,500 per unit		not comparable

EVALUATION OF PROPRIETARY CONTROL MEASURES

The relevant questions are whether the available performance data for each of the proprietary control measures are acceptable in terms of collection and analytical protocols and whether the products perform as well as sand filters and grass swales, the two public domain control measures that are most commonly used at this time in the Sacramento region. Each of the proprietary control measures considered in the report was evaluated using the screening process described below. Those products that pass the screening process (i.e. provide acceptable data and are reasonably equivalent in performance to the public domain control measures) are considered acceptable for implementation as a stormwater control measure without condition and are recommended as devices to be accepted by the Permittees. Those products that do not pass the screening process are recommended as either "conditionally acceptable" or "not acceptable", depending on the deficiencies in the performance data.

Screening Criteria

Screening criteria, including sample collection and analysis protocols and data reporting protocols, were developed to determine the acceptability of each of the proprietary control measures. This comprehensive set of protocols is presented in Appendix A. These protocols are recommended as requirements to be adopted by the Permittees for acceptance of any future performance evaluation reports submitted by manufacturers of proprietary control measures seeking approval of their products for use in the Sacramento jurisdiction. Review of the studies currently available for the proprietary control measures considered in this report revealed that none of the products provided all of the requisite information listed in these comprehensive protocols. Because of the lack of this information, none of the technologies is considered acceptable at this time for placement on an "Acceptable" list. Consequently, a less-stringent set of criteria, as described in the Methods section and in Appendix A of this report, was developed to determine whether a product should be recommended as "conditionally acceptable" or "not acceptable" at this time.

The selection of the screening criteria was judgmental, based on what is reasonable given the number of studies and information about sand filters and grass swales. A review of Tables 5 and 6 suggest that the specification of two sites with 10 storms at each site is reasonable. The storm specifications outlined above are to ensure that the storms that were monitored are comparable to typical storms of the Sacramento region and that the range of storms brackets the City and County design storm for on-site control measures (2-year/6 hour storm).

Screening Results and Discussion

The available performance evaluation studies for each of the proprietary control measures were evaluated using the screening criteria described in preceding subsection. Results of this screening process are summarized in Table 8. Discussions of each of the control measures are presented below including recommendations regarding the products' current acceptability as stormwater control measures for Sacramento Stormwater Permittees. A summary of recommendations for product acceptance and follow-up is presented in Table 9.

Table 8. Summary Evaluation of Products

Product	Data Source/ Reference	TSS Removal %	Land Use	No. of Storms	Sample Type	Storm Depth Range (inches)	Storm Duration Range (hours)	Storm Intensity Range (in/hour)	Comments
Screening Criteria		See Figure 2 and 4		10	Flow wt. composites	0.15 to 1.50	2 to 24	0.05 to 0.25	See Appendix A
Jensen Interceptor	Piner, 1994	24		1					
	Kinnetic, 1996	50	Employee parking lot	6	Flow wt. composites	0.63 to 1.47	5 to 31	0.02 to 0.21	Construction impacts
Teichert Interceptor									No field studies have been done
BaySaver	BaySaver, 1998	80	School parking lot	3	Multiple grabs	0.10 to 1.25	4 to 5	0.06 to 0.10	Two storms were very small
Stormceptor	Service, 1998	80	Parking lot in a park	6	Composites	0.05 to 0.77"	8 to 14	0.01 to 0.22	Requisite number of studies have been done, although the required number of storms has been met in only one study.
	Greb, 1998	26	Maintenance shop yard	45	Flow wt composites	0.02 to 1.31"	Meets criteria	Meets criteria	
	Environmental, 1997	93	Industrial parking lot	3	Composites	0.18 to 0.25	3 to 7	0.03 to 0.06	
	Labatiuk, 1997	53	Shopping mall	5	Composites	Not in report	Not in report	Not in report	
Downstream Defender									No field studies have been done
Vortechs	Vortechnics 1998	84	Office parking lot	7	Time composites				Only one study has been conducted
V2B1									No field studies have been done
CDS	Walker, 1999	70	Mixed	15	Multiple grabs	Not in report	Not in report	Not in report	CDS model had 4700 um screen that was not effective at influent TSS<75 mg/L.
StormFilter	Stormwater 1994	92	Arterial & residential	15	Flow wt composites	0.17 to 1.47	5 to 24	Meets criteria	Study was of a flat bed system, not the cartridge.
	Lief, 1998	43	Roadway	10	Flow wt composites	Not in report	Not in report	Not in report	Study was of a flat bed system, not the cartridge. Efficiency is just the filter; excludes pretreat unit.

Table 8. Summary Evaluation of Products (continued)

Product	Data Source/ Reference	TSS Removal %	Land Use	No. of Storms	Sample Type	Storm Depth Range (inches)	Storm Duration Range (hours)	Storm Intensity Range (in/hour)	Comments
Envirodrain									No field studies have been done
Fossil filter	Ambient, 1997	0	Street	1	Composites	Not in report	Not in report	Not in report	Influent TSS was only 9 mg/L.
	Larry Walker, 1998	18	Mall	2	Flow wt. composites	0.04 to 0.40	2 to 7	0.02 to 0.06	
Hydro-Kleen									No field studies have been done
UltraUrban Filter									One field study did not include TSS test
StormTreat	Horsely, 1995	99	Parking lot	5	Single influent grab, multiple effluent grabs	Not in report	Not in report	Not in report	Only one study has been conducted.

Jensen Interceptor

This system is essentially a wet vault, where sedimentation is the dominant pollutant removal mechanism. This type of device, therefore, should be able to provide the desired level of performance, if it is sized and configured properly. Using the manufacturer's sizing guidelines, this devise is generally designed to achieve only course pollutant removal.

Of the two studies of this product reported by the manufacturer, the Piner (1994) study did not provide sufficient data to draw any conclusions. The study by Kinnetic Laboratories (1996) provided data from six storm events, but the influent TSS concentrations may have been influenced by upstream construction activities during one or more storm events. Further, the study authors reported that "bypasses of the interceptor were common during most storm events". To account for the untreated bypass flow, the overall TSS removal efficiency was adjusted from 63 to 50 percent. The relatively low observed removal efficiency (compared to the public domain control measures) and the high frequency of bypassing suggests that this device may be undersized.

An issue with the use of wet vaults is their inability to remove dissolved pollutants; further, Kinnetic (1996) found that dissolved cadmium increased significantly between the influent and the effluent. Dissolved zinc increased in five of the six storms sampled, although the differences between the influent and effluent were not found to be statistically significant. The increase in concentrations of dissolved metals may be due to release of soluble metal species under anaerobic conditions in the pooled water. This hypothesis should be studied further.

The reported studies do not meet the established criteria (see Appendix A) in terms of sampling and documentation protocols.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol.
2. Insufficient number of sites studied with proper protocol.
3. Sizing criteria questionable.

Teichert Interceptor

The above observations for the Jensen Interceptor are applicable to the Teichert Interceptor.

Recommendation: Not acceptable.
Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.
3. Sizing criteria questionable

BaySaver

Only one field study has been conducted and only three storms were sampled. Further, two of the storms were extremely small.

Recommendation: Not acceptable.
Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

Stormceptor

The manufacturer has conducted several other field studies not listed in Table 3. However, the sampling was limited to a few grab samples during each event, and therefore are not reported in Table 3. The minimum criteria are nearly met (four studies, but meeting the 10 storm criterion at only one site). However, performance is highly variable as indicated in Table 3. Two observations of significant note: in the study by Greb et al. (1998) in which 45 storms were sampled, the aggregate removal efficiency for TSS over the 45 storms was only 26%, as reported in Table 3. However, the study has been criticized by Stormceptor because it was found that salt from a salted sand pile (used for road deicing) was entering the Stormceptor, causing a dense layer of water in the lower half of the device. It therefore could be argued that this caused the low efficiency. However, at least 14 storm events occurred prior to the outset of the dense lower layer and for these 14 events the overall TSS removal efficiency was still only about 35%.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Inadequate performance

Downstream Defender

No field studies have been conducted. Performance evaluation is limited to a laboratory study in which sediment was added to potable water.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

Vortechs

Only one study has been conducted. Although the observed performance is promising. the study does not meet the 10 storm requirement.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

V2B1

No field studies have been conducted. Performance evaluation is limited to a laboratory study in which sediment was added to potable water.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

CDS

As previously indicated, CDS needs to offer a screen with much smaller openings. CDS is currently experimenting with a 1200 micron screen. CDS has conducted many studies but these have focused on the removal of gross solids. Only the study cited in Table 8 focused on the removal of pollutants, specifically TSS, phosphorus and nitrogen. Evaluation of 15 storms found that about 70% of the TSS was removed over all storms monitored. However, the CDS model, which employed a 4700 micron screen, was relatively ineffective at reducing the TSS when the influent concentration was less than 75 mg/L. Given the relatively mild storms occurring in Sacramento, and the relationship between TSS concentration and runoff rate, it is possible that for Sacramento, the TSS concentration of untreated stormwater will be frequently less than 75 mg/L.

Recommendation: Not acceptable.
Deficiencies:

1. Inadequate performance

StormFilter

Two studies are reported in Table 8, both of which meet the criteria, although not all of the rainfall information is available. Figure 6 presents a plot of the data from the two studies. The data from Stormwater Management (1994) shows satisfactory performance. The data points from Leif (1998) fall to the right side of the Line of Comparative Performance©. However, Leif (1998) evaluated the performance of only the filter unit, that is, the influent sample was taken at the entrance of the filter rather than the vault in which the filter was placed. Hence, the pretreatment efficiency of the forebay was not included. Taking this aspect into consideration, it is likely the data points would have fallen to the left of the comparative performance line.

A more significant consideration is that the two cited studies are of the flat bed system, rather than the cartridge system, which is now used. It therefore may not be appropriate to apply the findings from flat bed systems to the cartridge system as the unit flow rates (gpm/ft^2 of filter surface) may differ. The flat bed systems have 18" of media where as the thickness of media in the cartridge systems is only 7 to 9".

Stormwater Management, Inc has conducted several studies of the cartridge system, with several types of media: leaf compost, perlite, and either of these two media with a fabric. However, only grab samples, typically only one of the influent and one of the effluent, have been taken during these studies. While the two comprehensive studies have been of the flat-bed type system rather than the current cartridge system, the performance and studies are satisfactory.

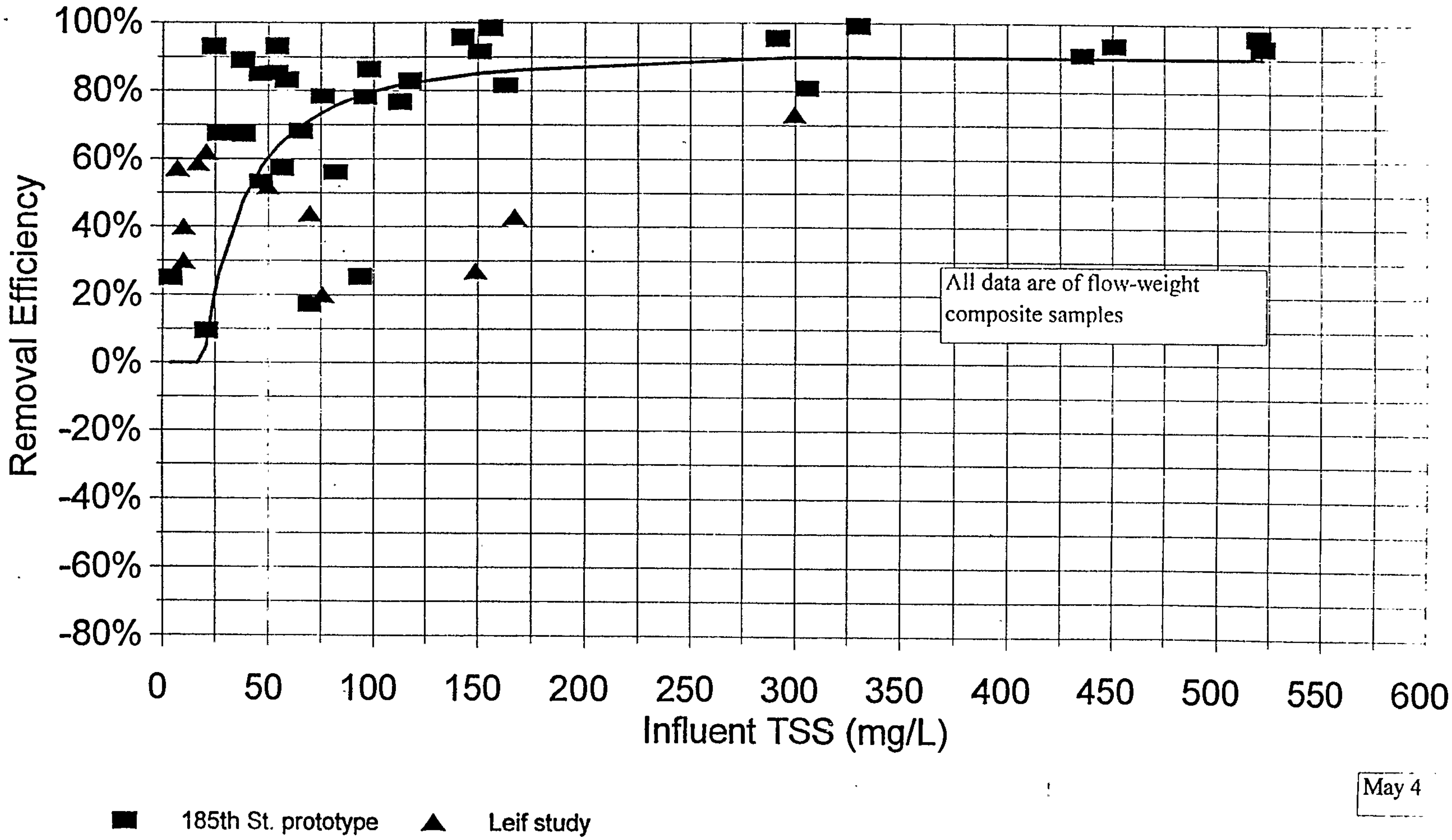
Recommendation: Conditionally acceptable.

Deficiencies:

1. Insufficient number of sites studied with proper protocol using cartridge system

FIGURE 6 STORMFILTER

TSS Removal - Flatbed System



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Envirodrain

No field studies of performance have been conducted.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

Fossil Filter

Two studies have been conducted that included consideration of the removal of TSS. With one study the removal efficiency was 0%. However, the influent TSS was only 9 mg/L and therefore further reduction would not be expected. Regardless, only one storm was sampled.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

Hydro-Kleen

No field studies of performance have been conducted.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

UltraUrban Filter

An extensive field study carried out in Santa Monica demonstrated that the filter removes litter and sediment from stormwater. However, as the influent and effluent were not sampled it is not possible to calculate efficiency. The manufacturer has conducted laboratory tests to evaluate the performance with respect to the removal of petroleum. However, the artificial stormwater that was created for the tests was not representative because sediment was not included in the stormwater. This is important because motor and diesel oil sorbs to sediment. The removal efficiency with regard to sediments is therefore important to evaluate, whether in a laboratory or field test, even if the pollutant of interest is petroleum products.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.

StormTreat

Only one field study has been conducted. Further, in this field study only one grab sample was taken of the influent during each storm. Thus, efficiency cannot be properly determined. However, effluent concentrations of TSS and other pollutants were very low, indicating high efficiencies are achievable with this system. The TSS concentration in the effluent was typically less than 3 mg/L, with a high of 11.9 mg/L. It is important to note that StormTreat gradually treats the water for several days after the storm has passed. Hence, to use StormTreat, a detention system must also be included to retain the specified volume of water that is to be treated. This need suggests that before approving or conditionally approving this product, the manufacturer should be required to provide a sizing proceedure specific to the climatic conditions of California.

Recommendation: Not acceptable.

Deficiencies:

1. Insufficient number of storms studied with proper protocol
2. Insufficient number of sites studied with proper protocol.
3. Inadequate sizing procedure

Table 9. Summary of Product Recommendations

Product	Company	Date of Most Recent Study	Approval Recommendation	Follow-up Recommendation
Jensen Interceptor	Jensen Precast	1996	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol. Review sizing guidelines
Teichert Interceptor	Teichert Precast	none	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol. . Review sizing guidelines
BaySaver	BaySaver, Inc.	1998	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
Stormceptor	CSR Hydro Conduit	1998	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
Downstream Defender	H.I.L. Technology, Inc.	none	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
Vortechs	Vortechnics	1998	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
V2B1	Kistner Concrete		Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
CDS	CDS Technologies	1999	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol. Use smaller screen
StormFilter	Stormwater Management	1998	Conditionally Acceptable	Studies at 1 site w/ 10 storms each. Follow recommended protocol w/ cartridge system
Envirodrain	Envirodrain	none	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
Fossil Filter	KriStar Enterprises	1998	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
HydroKleen	Weaver Manufacturing, LLC	none	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
Ultra-Urban Filter	Abtech Industries	none	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol
StormTreat	Storm Treat Systems, Inc.	1995	Not Acceptable	Studies at 2 sites w/ 10 storms each. Follow recommended protocol. Provide sizing procedure

CONCLUSIONS

This study has compiled the available performance data for 18 stormwater treatment control technologies (14 proprietary devices and four treatment technologies available within the public domain) and evaluated the potential of these controls to improve the quality of stormwater runoff from new developments in Sacramento, California. Cost data for the 14 proprietary devices were also compiled.

To be acceptable or conditionally acceptable by local stormwater agencies, a treatment technology should have demonstrated performance under conditions similar to those typically observed in the intended area of application. This means that adequate study data should be available to clearly demonstrate effective pollutant removals with the technology under typical Sacramento-area storm conditions, using influent quality representative of that typically found in runoff from Sacramento-area commercial and residential developments. Effective pollutant removal is considered equivalent to that provided by public domain controls – grassy swales and sand filters. The studies should be scientifically defensible and well-documented. A screening protocol was developed to evaluate whether adequate data had been produced for each of the devices studied.

The four public domain controls studied – grassy swales and three types of sand filters – have been documented to produce treatment effectiveness adequate to warrant continued recommendation for application in the Sacramento area. Furthermore, the demonstrated treatment performance of these technologies can be used as a relative measure against which to assess the acceptability of performance data from other (proprietary) treatment technologies.

Of the fourteen proprietary devices evaluated, none have adequate data at this time to recommend outright acceptance, using the screening protocol developed for this investigation. Only one device (StormFilter) is recommended as conditionally acceptable.

The inability to remove dissolved pollutants is a common problem with all of the products reviewed in this report with the possible exceptions of StormTreat and StormFilter.

RECOMMENDATIONS FOR FOLLOW-UP

1. Manufacturers of proprietary controls that are recommended as "not acceptable" at this time should be encouraged to conduct studies that can be used to demonstrate the effectiveness of their products for application in Sacramento-area new developments. A recommended data collection and documentation protocol is provided in Appendix A to this report. In general, studies that follow the recommended guidelines would be applicable to most of the western United States.

2. Product manufacturers capable of producing a report that meets the criteria for conditional acceptance should submit such reports. Conditional acceptance of a product should be determined on a case-by-case basis by the various Permittee agencies. It is further suggested that manufacturers must be required to produce a subsequent report that meets all the protocols listed in Appendix A. Failure to submit such a report in a timely manner would results in the product being removed from the "Conditionally Acceptable" list.

3. The manufacturers of the Jensen and Teichert Precast units should be encouraged to review their sizing guidelines and make corrections as needed to resolve any unnecessary treatment deficiencies.

Schueler, T., (1994a), "Runoff and Groundwater Dynamics of Two Swales in Florida, Tech Note 31, Watershed Protection Techniques, 1, 3, 120.

Schueler, T., (1994b), "Performance of Grassed Swales along East Coast Highways, Tech Note 32, Watershed Protection Techniques, 1, 3, 122.

Schwarz, T. S. and Wells, S.A. (1999) Stormwater Particle Removal Using a Cross-flow Filtration and Sedimentation Device. Presented at AFS National Conference, April , 1999.

Service Environmental & Engineering (1998) ComoPark Sampling Reports, August 1998.

Shapiro and Associates, (1998) Lakemont Stormwater Treatment Facility Monitoring Report, 197 Annual Report, April 1998.

Stormwater Mangement (1994) Technical Memorandum – Three year Performance Summary — 185th Avenue, 1994.

Vortechnics (1998), Results from the Vortechs Stormwater Treatment System Monitoring Program at Delorme Publishing Co. , Yarmouth, Maine, December 1998.

Vortechnics (undated), Laboratory Testing.

Wellborn, C.T., and J.E. Veenhule, (1987) Effects of Runoff Controls on the Quantity and Quality of Urban Runoff at Two Locations in Austin, Texas, U.S. Geological Survey, Water-Resources Investigations Report 87-4004.

Woodward-Clyde Consultants (1998) Santa Monica Bay Area Municipal Storm Water/Urban Runoff Pilot Project – Evaluation of Potential Catchbasin Retrofits, July 1998.

APPENDIX A

COMPREHENSIVE PROTOCOL FOR PERFORMANCE EVALUATION OF PROPRIETARY STORMWATER CONTROL PRODUCTS

A manufacturer who wishes to have its technology considered for placement on the "Acceptable" list must submit a report that contains performance data from studies following the requirements outlined in this protocol. A technology may be "Conditionally Acceptable" if it is demonstrated to provide effective performance but does not meet all of the Comprehensive Protocol requirements, as described below.

While it is preferred that the field studies be conducted in the Sacramento region, this is not a requirement.

NUMBER AND TYPES OF SITES EVALUATED

- Studies are to be conducted at a minimum of two sites
- Land uses: more than one of the following - retail commercial, non-retail commercial, medium density residential, high density or multi-density residential.

SAMPLING REQUIREMENTS

- Number of storms per site: 10 (may occur in two consecutive years)
- Storm depth: from 0.15 to 1.50 inches
- Runoff duration: from 2 to 24 hours
- Average storm intensity: 0.05 to 0.25 inches/hour
- Type of samples: flow-weight composite samples, except where grab sampling is required by protocol. With data collected prior to July 1, 1999, time-paced samples are satisfactory for consideration for placement of the product on the "Conditionally Acceptable" list,
- Sampling procedure: To the extent possible, sampling is to occur through the entire period of runoff. Sampling is to occur for a period that represents at least 60% of the volume of each storm with an overall average of all storms of at least 75%. A minimum of ten aliquots must be taken during each sampled storm.
- Analytes: Influent and effluent TSS, pH, total recoverable zinc, copper, cadmium, oil/grease, TPH and, TP and TKN. If the device is also intended to remove dissolved constituents, the analytes shall include the dissolved species of the targeted constituents. Chemical samples are to be preserved following analytical procedures specified by *USEPA*. protocols and are to be analyzed using USEPA protocols. Analytical analysis is to be done by a certified laboratory. To be considered for placement on the "Conditionally Acceptable" list, only TSS data need to submitted.
- At the end of the test period, the sediment shall be removed, quantified, and analyzed. The sediment will be evaluated for the following: moisture content, particle size distribution, organic content, oil/grease, and zinc. To analyze particle size distribution, both the wet and

dry sieve test procedures will be used, following ASTM. These data are not necessary for placement on the "Conditionally Acceptable" list.

DOCUMENTATION PROTOCOL

1. A description of the test site including total acreage, total impervious acreage, a description of landscaping if relevant, the acreage draining to the device if it differs from total acreage. Include a description of the drainage system. (Not required for "Conditionally Acceptable" list).
2. A description of the treatment device including the design peak capacity. (Not required for "Conditionally Acceptable" list).
3. Complete drainage calculations showing the calculations to size the treatment device for the test site.
4. All raw data including laboratory reports. All data is to be reported including rejected data with an explanation for the rejection.
5. Statement from the analytical laboratory certifying the specified analytical procedures were followed in the analysis of the samples and that the appropriate preservation methods were followed.
6. Calculation of efficiency of each storm by comparing the influent and effluent concentrations of each storm. (Not required for "Conditionally Acceptable" list).
7. Calculation of the efficiency for all storms by comparing the total aggregate inflow loading of all storms to the total aggregate outflow loading for all storms.
8. Present a plot of influent concentration versus efficiency for TSS for each storm sampled. All data is to be plotted including rejected data with an explanation for the rejection. (Not required for "Conditionally Acceptable" list).
9. Start and end times of the precipitation period. (Not required for "Conditionally Acceptable" list).
10. Start and end times of the runoff period of each sampled storm. (Not required for "Conditionally Acceptable" list).
11. Start and end times of the sampling period of each sampled storm. (Not required for "Conditionally Acceptable" list).
12. Total rainfall depth. (Not required for "Conditionally Acceptable" list).
13. Rainfall depth during the sampling period. (Not required for "Conditionally Acceptable" list).
14. Total runoff volume
15. Runoff volume that occurred during the sampling period

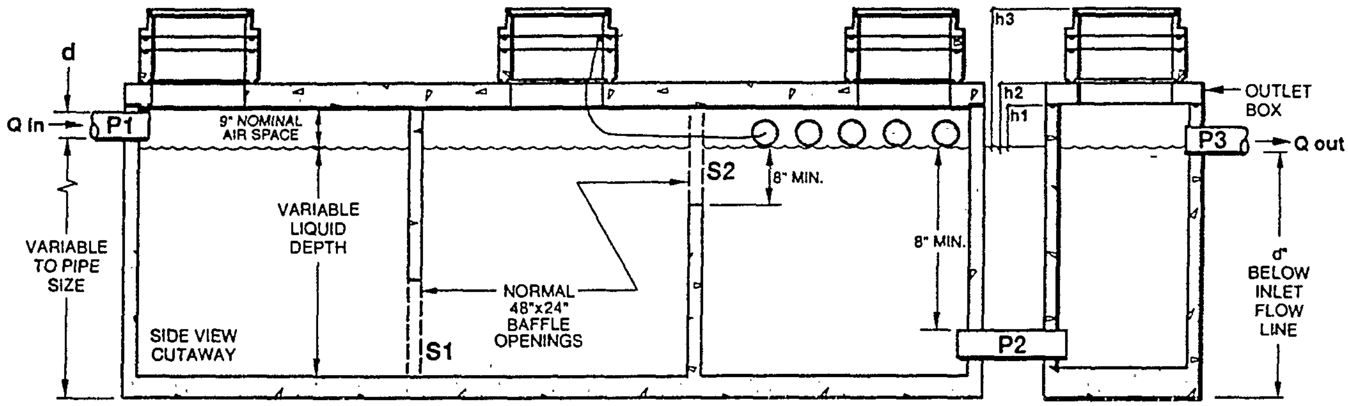
16. Statement of certification signed by an officer of the manufacturer of the product that the protocol was followed.

Appendix B

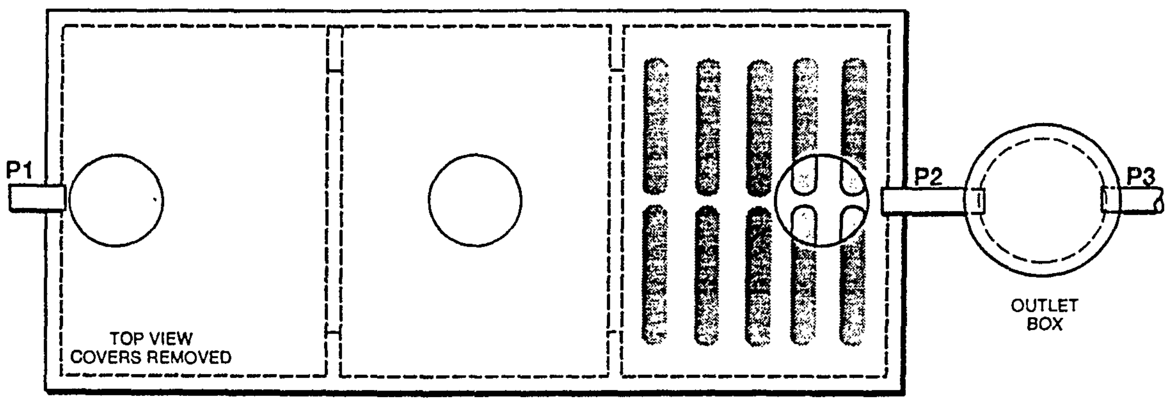
PRODUCT ILLUSTRATIONS

SIZING REQUIREMENTS

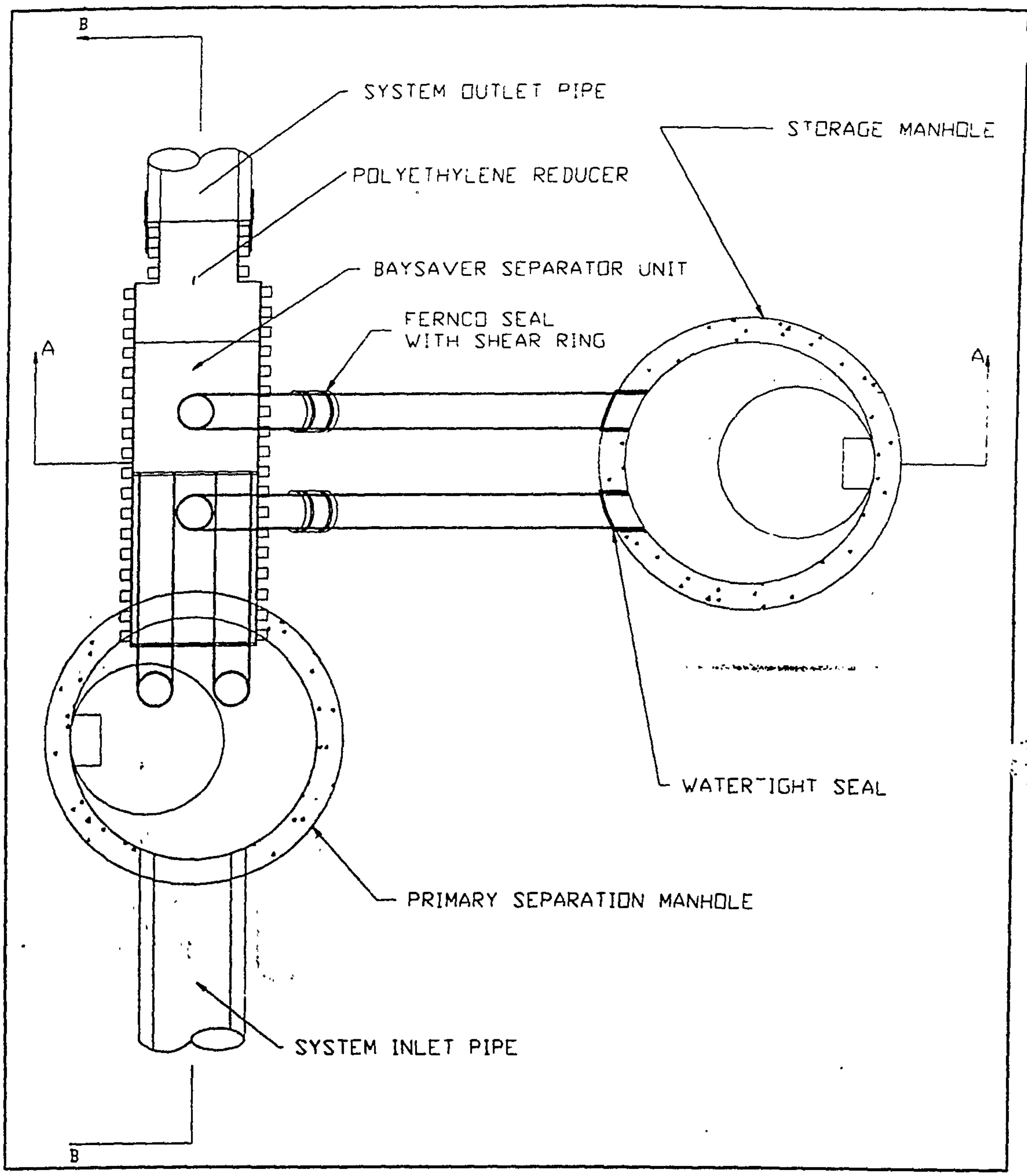
REFERENCE DRAWING



NOT TO SCALE

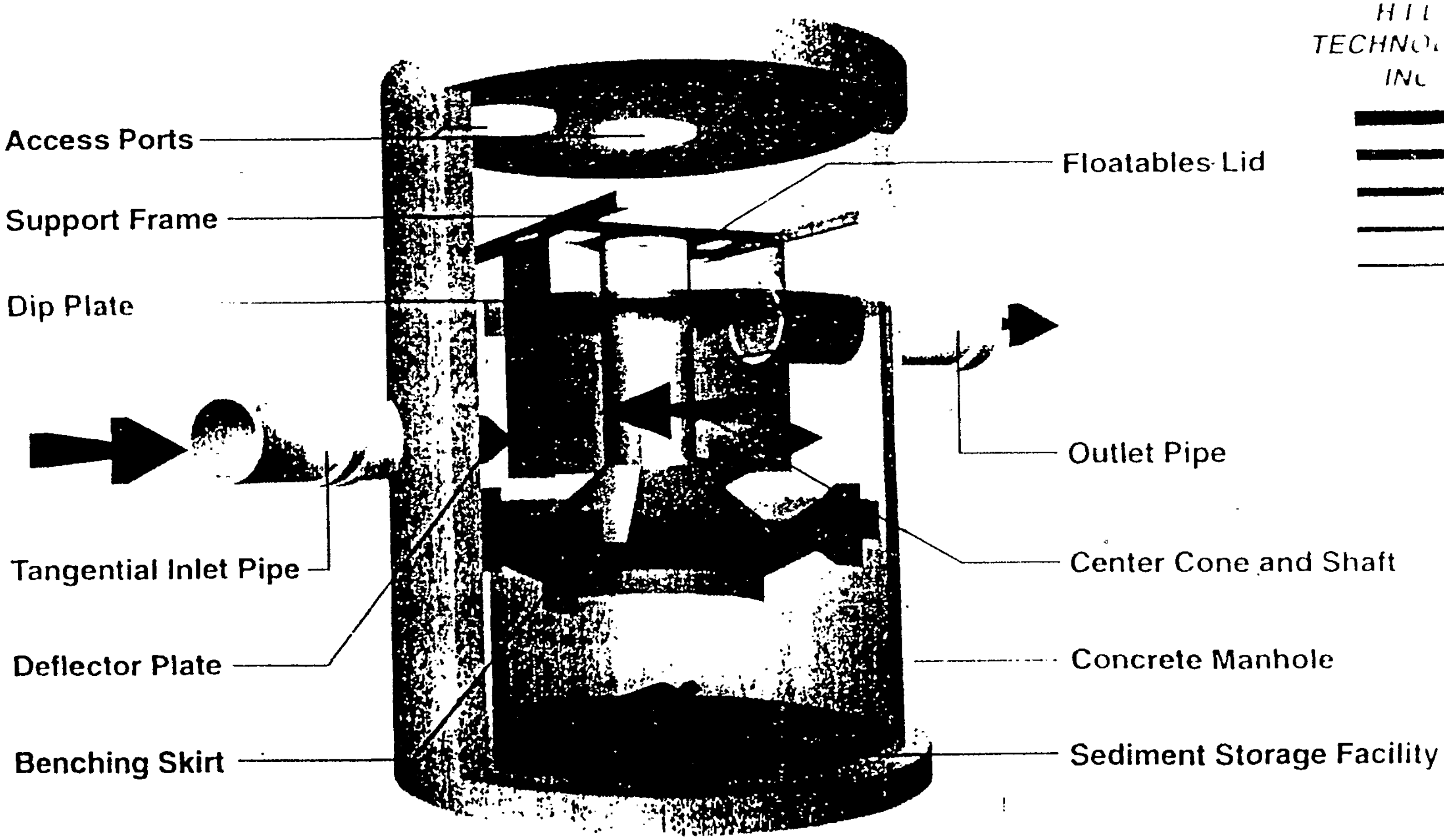


R0011410



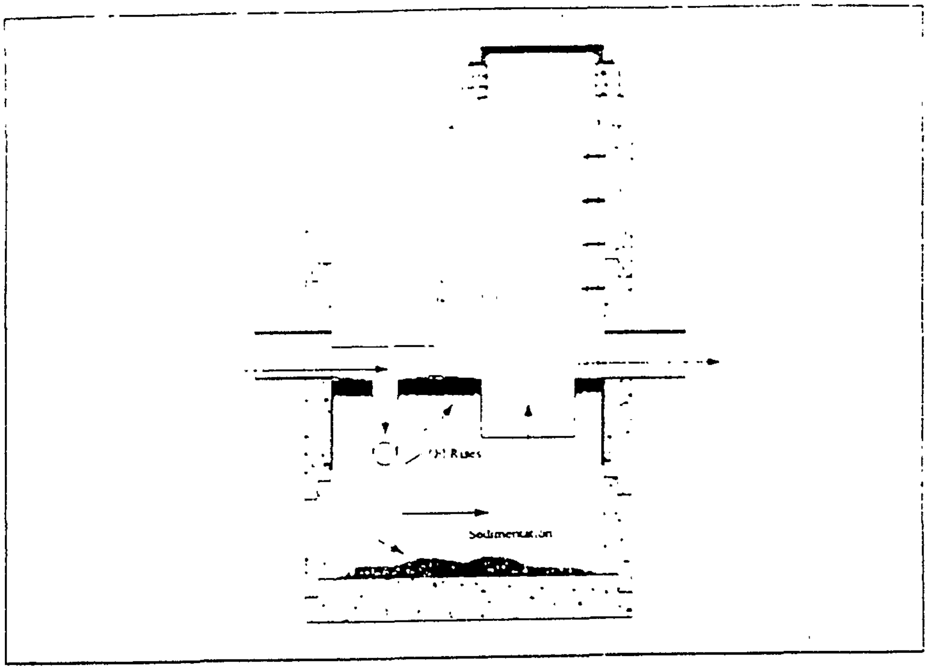
Plan View
(not to scale)

Downstream Defender Interior View



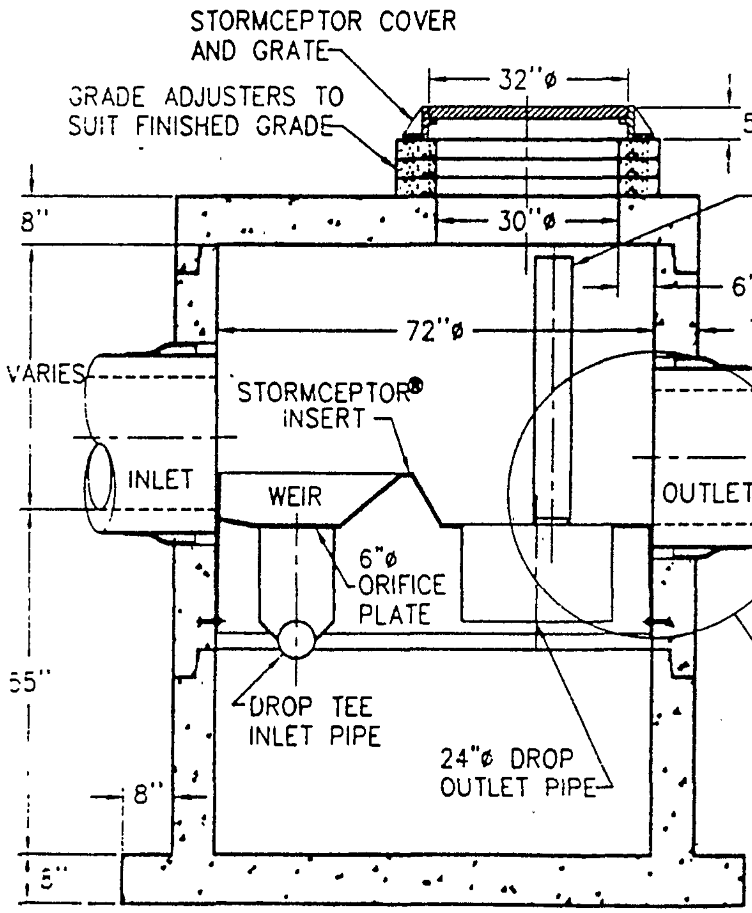
H I L
TECHNO
INC

R0011412

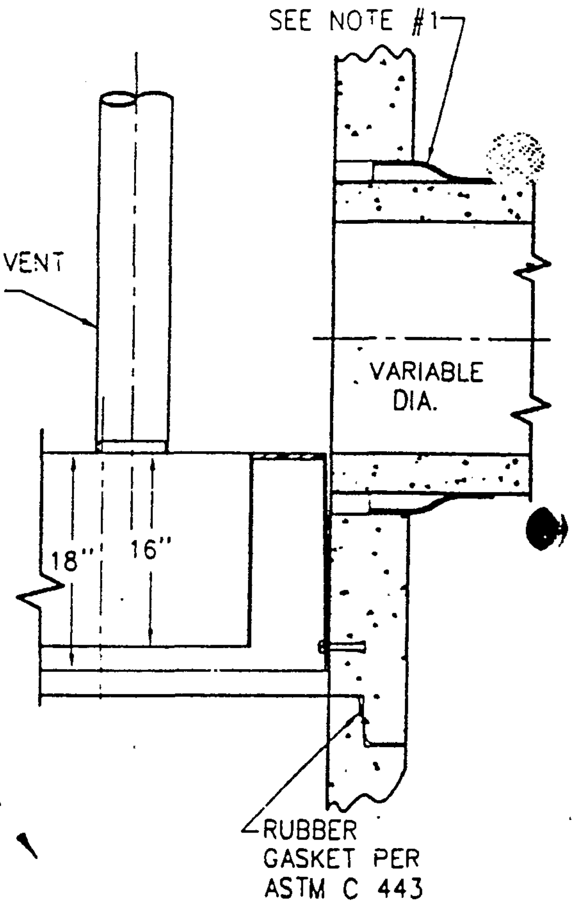


STC 900 Precast Concrete Storm*ceptor*®

(900 US Gallon Capacity)



SECTION THRU CHAMBER

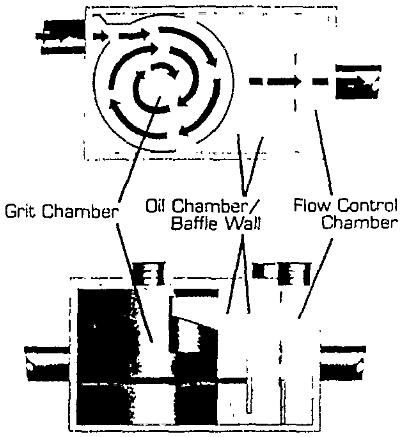


ENLARGED OUTLET CONNECTION DETAIL

R0011413

Operation

Plan View



Elevation View: Dry-Weather

Grit Chamber

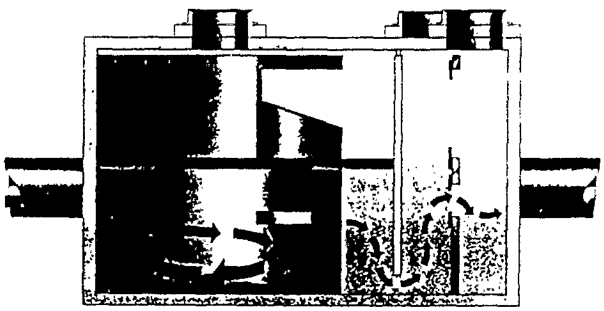
The swirling motion created by the tangential inlet directs settleable solids toward the center of this chamber. Sediment is caught in the swirling flow path and settles back onto the pile after the storm event is over.

Oil Chamber & Baffle Wall

The center baffle traps floatables in the oil chamber, even during clean-out. Highly resistant to flow surges.

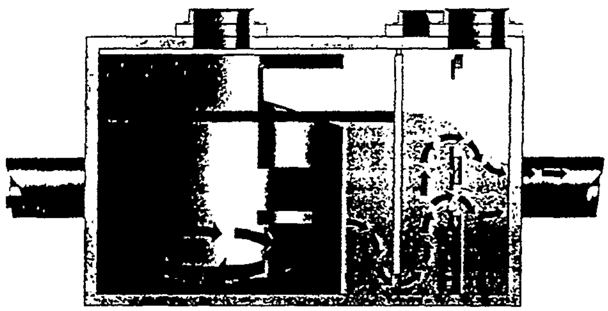
Flow Control Chamber

The weir and orifice flow controls:
1) Raise level and volume in the system as flow rate increases; and
2) gradually drain the system as flow rate subsides.



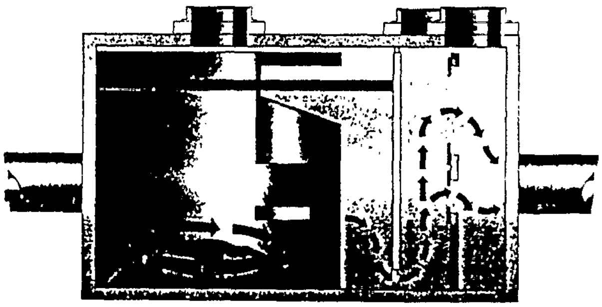
1) Initial Wet Weather Phase

During a two-month storm event the water level begins to rise above the top of the inlet pipe. This influent control feature reduces turbulence and avoids resuspension of pollutants.



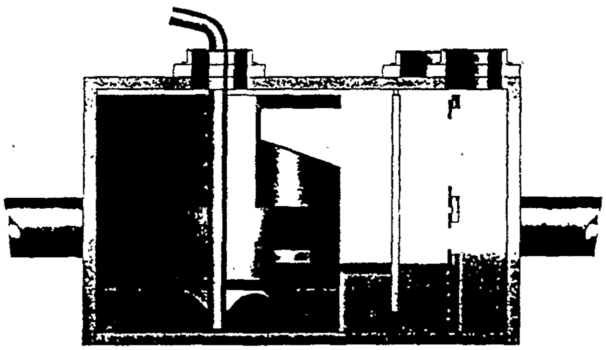
2) Transition Phase

As the inflow rate increases above the controlled outflow rate, the tank fills and the floating contaminant layer accumulated from past storms rises. Swirling action increases at this stage, while sediment pile remains stable.



3) Full Capacity Phase

When the high-flow outlet approaches full discharge, storm drains are flowing at peak capacity. The Vortechs System is designed to match your design storm flow and provide treatment throughout the range of storm events without bypassing. To accommodate very high flow rates, Vortechnics can assist designers with configuring a peak-flow bypass.



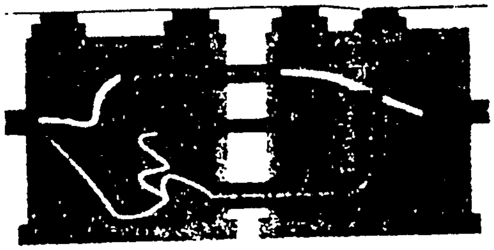
4) Storm Subsidence Phase/Cleaning

Treated runoff is decanted at a controlled rate, restoring the water level to a low dry-weather volume and revealing a conical pile of sediment. The low water level facilitates inspection and cleaning, and significantly reduces maintenance costs. The system's central baffle prevents transfer of floatables to the outlet during cleaning or during the next storm.

V2B1™

Hydro-Dynamic Stormwater Treatment System

STORMWATER TREATMENT

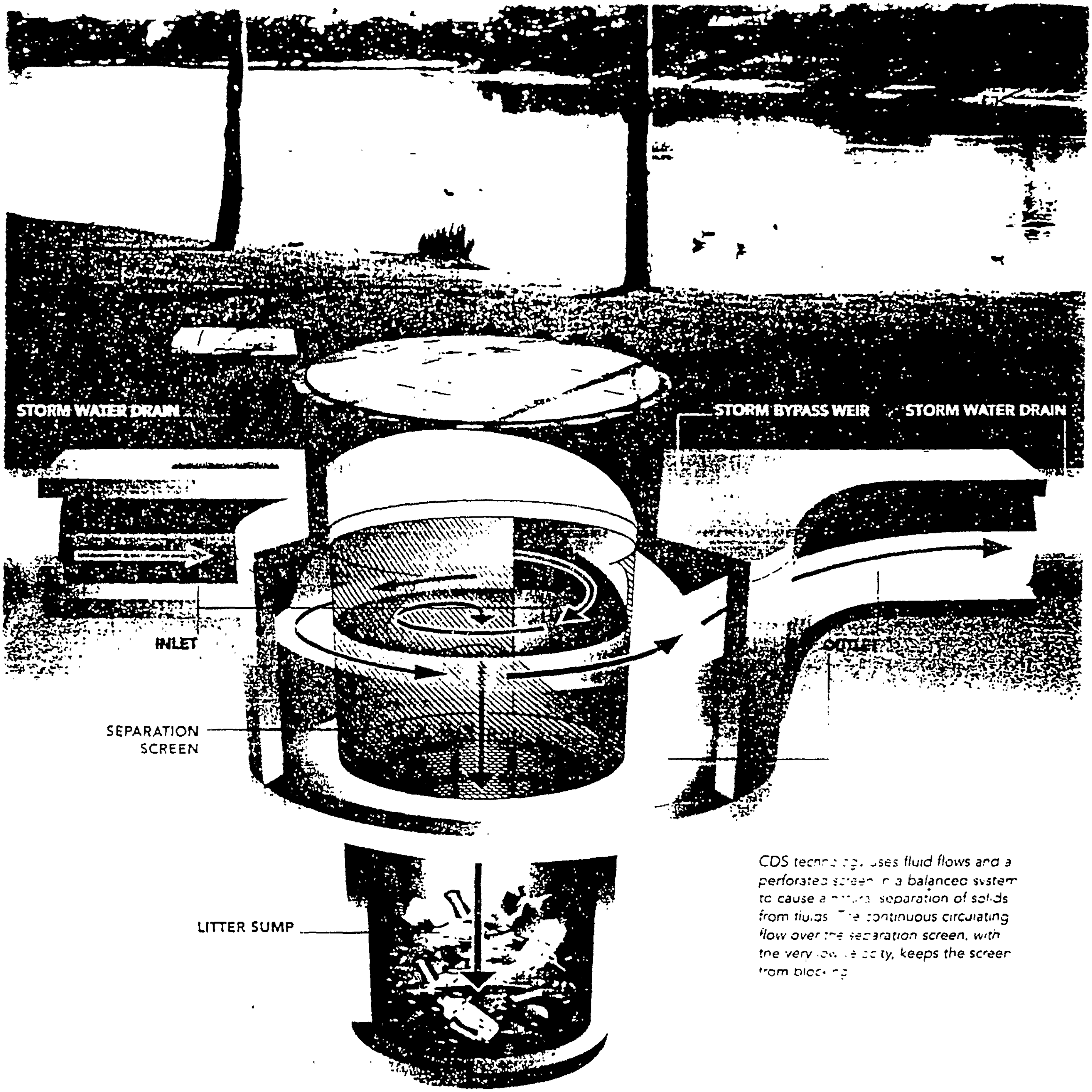


- 80% Net T.S.S. Removal Efficiencies
- 3 to 25 cfs Treatment Capabilities
- Isolates Floating Pollutants From Peak Storm Surges
- Low Maintenance Costs
- Cost Competitive

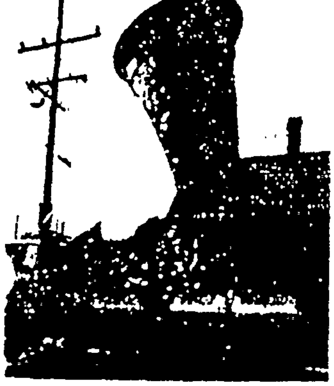
ENVIRONMENT XXI™
- P.O. Box 218, East Pembroke, New York 14056
- Phone (800) 809-2801 Fax (716) 762-8315
- www.kistner.com/envxxi/
- e-mail envxxi@iinc.com

Circle #121 on Reader Service Card

R0011415



CDS techno[illegible] uses fluid flows and a perforated screen in a balanced system to cause a [illegible] separation of solids from fluids. The continuous circulating flow over the separation screen, with the very low [illegible], keeps the screen from blocking.



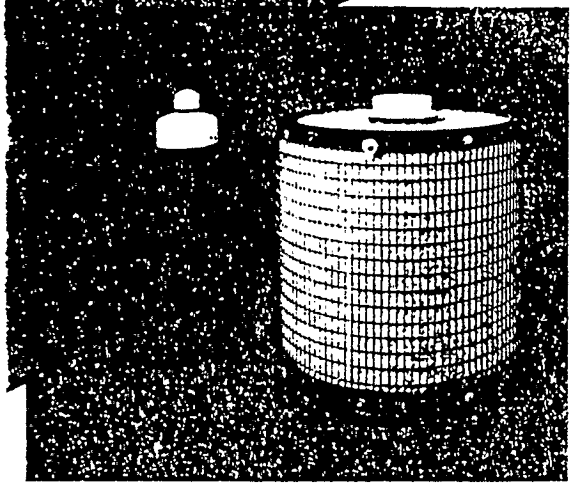
Safe Litter Removal

Removal of litter [illegible] by CDS units [illegible] low cost, safe and easy. Captured material [illegible]

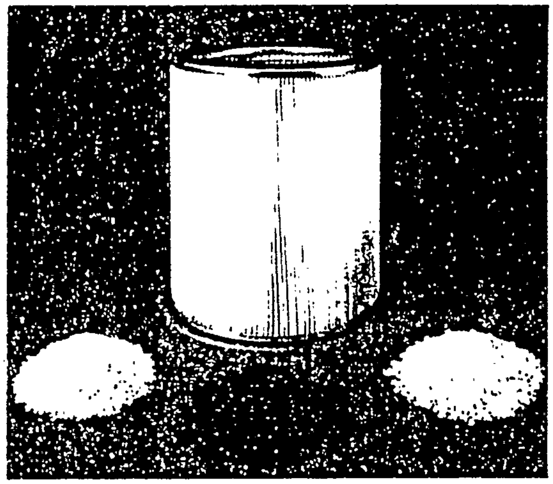
CDS Capacity & Physical Features

Model	Capacity (cfs)	Screen Dia (SD) Ft	Screen Height (Ft)	Sump Dia. x Depth (Ft)	Design Headloss (Ft)
PSW3[illegible] XX	2.7	3.0	2.[illegible]	4.5 x 2.5	0.43
PSW5[illegible] XX	[illegible]	[illegible]	[illegible]	4.0 X 4.0	0.65
PSW7[illegible] XX	26.[illegible]	[illegible]	[illegible]	5.0 X 5.0	1.10
CSW[illegible] XX	[illegible]	[illegible]	[illegible]	6.0 X 8.0	[illegible]55
CSW[illegible] XX	[illegible]	[illegible]	[illegible]	10.0 X 8.0	[illegible]
[illegible] XX	[illegible]	[illegible]	[illegible]	12.0 X 8.0	[illegible]

R0011416



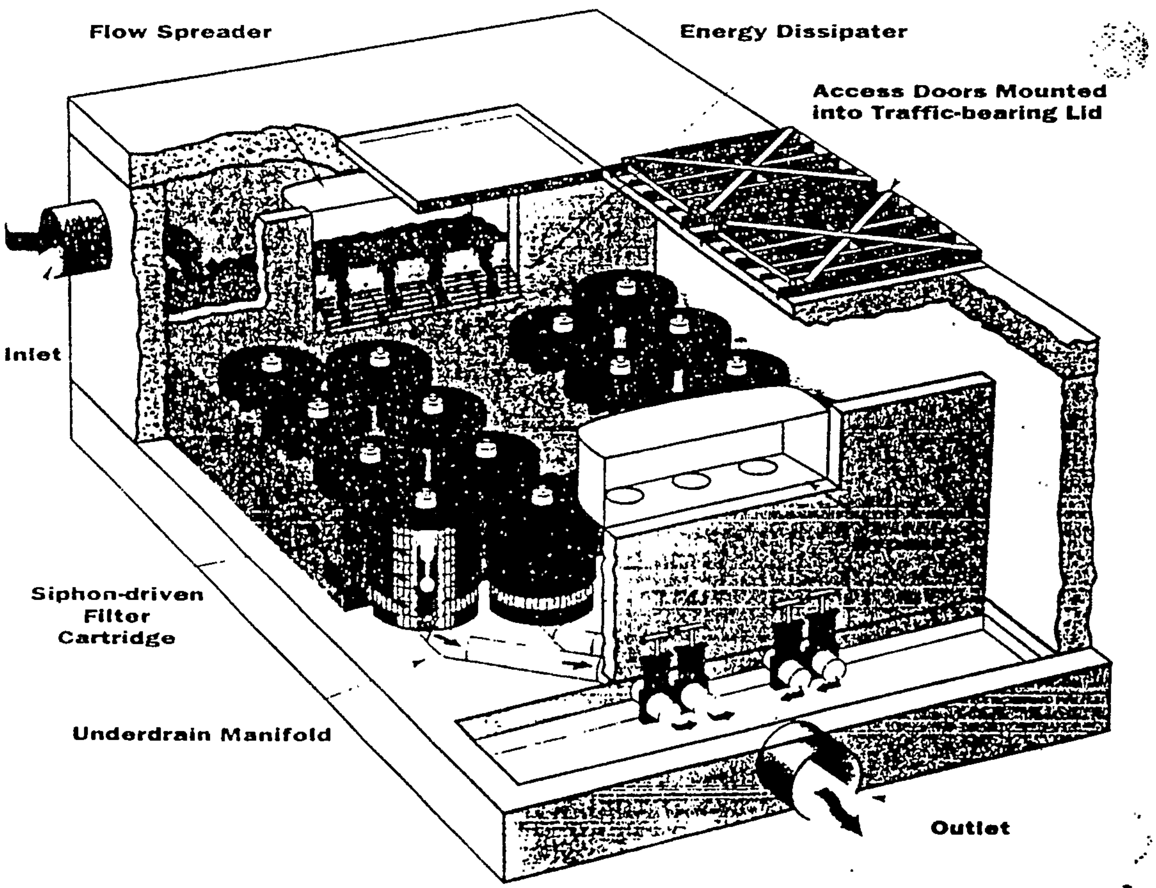
The cartridge, shown with the hood removed, employs a siphon mechanism to efficiently draw polluted runoff through the media.



From left: Zeolite, CSF leaf media, perlite, and fabric inserts can be used individually or in combination to add to the system's versatility.

The StormFilter protects our environment by removing pollutants from stormwater runoff before they enter receiving waterways.

The StormFilter incorporates rechargeable cartridges housed inside vaults that are typically ordered as precast units. The cartridges contain various types of filtration media, including perlite, zeolite, fabric inserts and the patented CSF leaf media. With the StormFilter, you have the ability to select media based on site characteristics, as well as alter the media as a site matures or land use changes.



R0011417

ENVIRO-DRAIN ™ Specifications

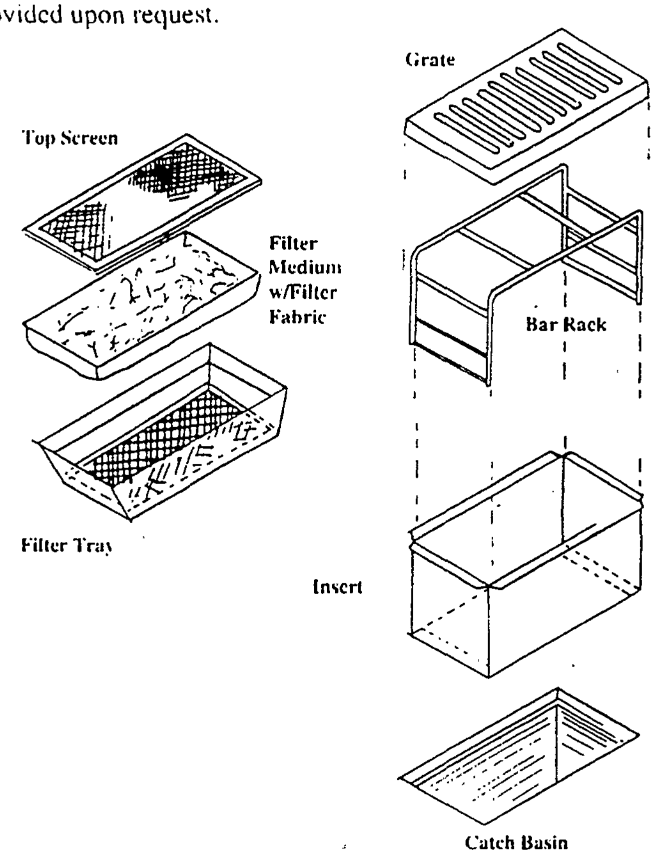
Flow Rate[1]	0-60 gpm	Filter Materials	Filter Fabric, Absorbent W™ and Activated Carbon
Nominal Flow	3-8 gpm	Mechanism	Gravity Feed Capable of All Types of Filter Medium
Electrical	None	Construction	100% Stainless Steel
Dimensions[2]	Standard/Custom Sizes		
Dry Weight	50 lbs.		

[1]Based on Filter Fabric used determines gallons per minute
[2]These measurements are based on the standard catch basin designs. Custom sizes also available

When Enviro-Drain stormwater filter is installed in catch basins, contaminated water enters through the grate and the water is diverted to enter Enviro-Drain, filtering out sediments, cigarette butts, rocks, leaves, and grass clippings in the top tray. The second tray is filled with Absorbent W™, a natural cellulose fiber that retains up to 7 times its weight in oil. The third filter is filled with activated carbon to neutralize fertilizers and pesticides. Each tray has its own characteristics and are properly spaced to eliminate clogging while providing aeration to the water which is needed to break down organic compounds and provide fish with adequate oxygen. By allowing you to use any variety or combination of filter medium Enviro-Drain stormwater filter is much more versatile and cost effective than other types of filters. Test results of Enviro-Drain stormwater filter proved to be very successful with up to 96% removal of efficiencies.* *Test results can be provided upon request.

DESCRIPTION	PART #
Storm Water Pollution Filter	
18" x 24" x 14" d Insert	100
16" x 24" x 14" d Insert	500
18" x 24" x 13" d Bar Rack	110
16" x 24" x 13" d Bar Rack	510
18" x 24" x 3" d Tray (Empty)	101
(Carbon)	102
(Wood Fiber)	103
16" x 24" x 3" d Tray (Empty)	501
(Carbon)	502
(Wood Fiber)	503
18" x 24" x .25" d Rack Screen	120
16" x 24" x .25" d Rack Screen	520
18" x 24" Diverter	200
16" x 24" Diverter	600

DESCRIPTION	PART #
Storm Water Sediment Filter	
Use same inserts, bar racks, rack screens and diverters as in 100 & 500 series filters	
18" x 24" x 15" d	300-303



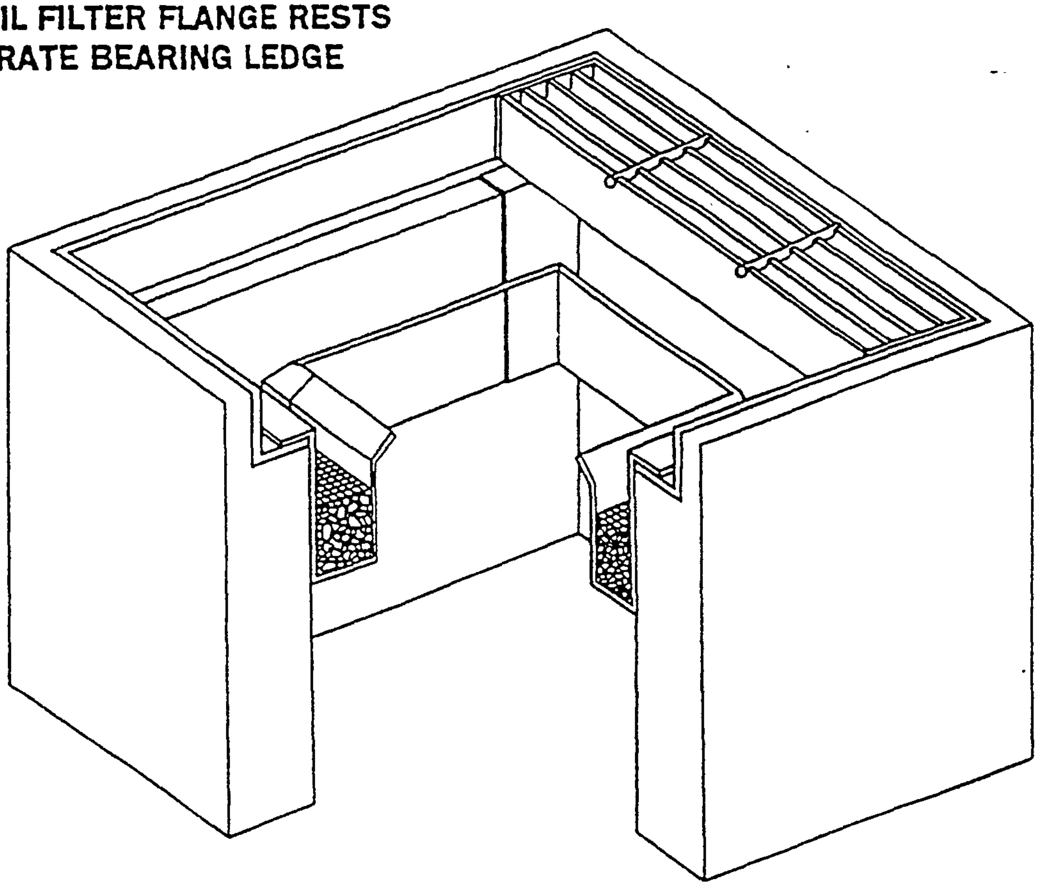
WARRANTY AND LIMITATION OF REMEDIES

1. <u>Express Warranty</u> ENVIRO-DRAIN, INC. expressly warrants this product to be free from defects in material, workmanship and title
2. <u>Disclaimer of Implied and Other Warranties</u> **THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, IMPLIED (INCLUDING WITHOUT LIMITATION A WARRANTY OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE).**
3. In the event that any product is found to be defective in workmanship or material, ENVIRO-DRAIN, INC. agrees to repair or replace such product at its option. If the product is to be repaired, Buyer will bear responsibility for returning such product to ENVIRO-DRAIN, INC. If ENVIRO-DRAIN, INC., is unable to effect such repair or replacement within 30 days (which time is agreed to be reasonable), Buyer will have the additional remedy of returning the defective product to ENVIRO-DRAIN, INC. for a full refund of the purchase price. **THESE REMEDIES ARE EXCLUSIVE, AND BUYER AGREES THIS SHALL BE THE LIMIT OF ANY LIABILITY ON THE PART OF ENVIRO-DRAIN, INC.**
4. <u>Consequential and Incidental Damages Excluded</u>. Buyer assumes all responsibility for the consequences of use of the product. ENVIRO-DRAIN, INC. assumes no liability for consequential and/or incidental damages of any kind (including without limitation injury to the person); under no circumstances will ENVIRO-

FOSSIL FILTER™

STANDARD GRATE INLET

FOSSIL FILTER FLANGE RESTS
ON GRATE BEARING LEDGE



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Weaver Manufacturing LLC
2000 Challenger A...
Oroville, CA 95965
(530) 533-8740, Fax 53...
website: http://www.weavermfg...com

Flow Rate Chart
Storm Drain Filter

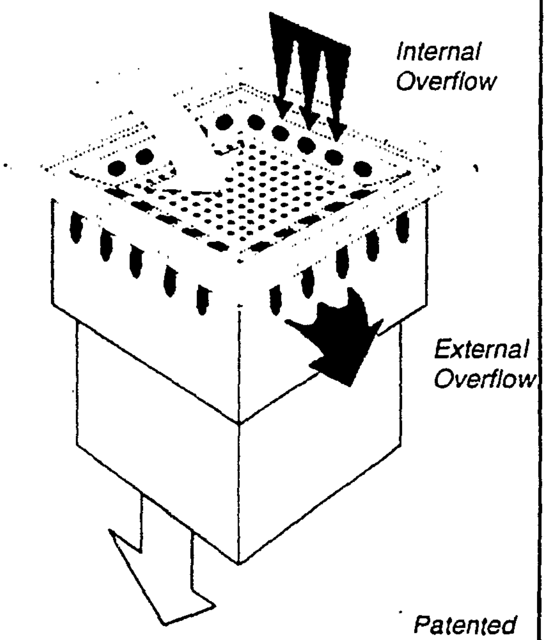
MEMBER PEI PETROLEUM EQUIPMENT INSTITUTE

Hydro-Kleen™
FILTER SYSTEMS

Drain Inlet Size	Maximum Flow Rate (Gallons per Minute)	[illegible]	[illegible]	[illegible]
12" - 15"	45	135	N/A	N/A
16" - 20"	76	196	N/A	N/A
21" - 25"	180	360	90	180
26" - 30"	225	420	110	210
31" - 35"	281	491	140	280
36" - 40"	405	675	200	400
Custom	To be Determined	To be Determined	To be Determined	To be Determined

- Flow rates are determined by the square footage of the net drain area.
- Net drain area is defined as 75% of the inlet size.
- Maximum flow rate is flow rate with straight-thru flow and media in place.
- Maximum flow rate is 60 gpm per square foot of top media as determined by actual testing.

STORM DRAIN INSET
2 Built-in Overflow Devices



Patented

R0011420

ULTRA-URBAN™ FILTER with OARS® OnBoard

Narrative Description

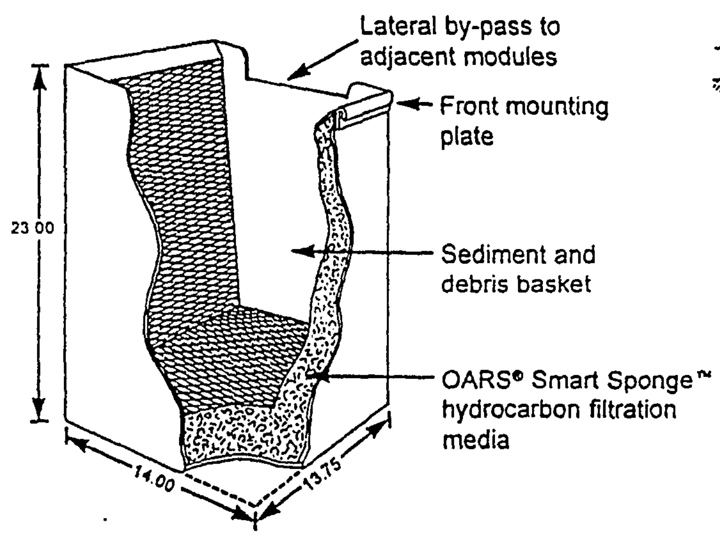
The **Ultra-Urban™ Filter with OARS® OnBoard**, developed and manufactured by AbTech Industries, is an innovative low-cost BMP to help meet NPDES requirements. The Ultra-Urban™ Filter removes oil, grease, trash and sediment from stormwater runoff before it enters the storm drain system. The Ultra-Urban™ Filter is ideal for municipal, industrial and construction applications.

The Ultra-Urban™ Filter is designed for use in storm drains that experience oil and grease pollution accompanied by low concentrations of sediment and debris. The modular design of the filters will accommodate most storm drains. Trash and sediment accumulates in the internal basket while water is filtered through the unit to remove oil and grease. The proprietary **OARS® Smart Sponge™** polymer filtration media will remove up to 80% of the oil and grease in stormwater runoff -- from low concentrations typical of residential areas to high levels associated with illegal dumping of used motor oil. Oil is permanently bonded within the polymer eliminating the possibilities of leaching.

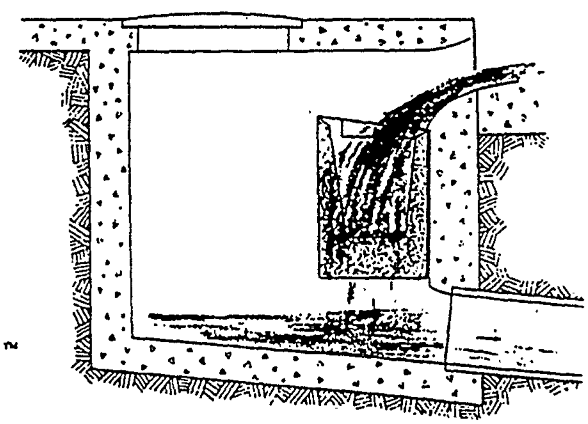
Sketch of System

Series CO2000 for Curb-Opening Storm Drains

OARS® Insert Module CO2000-R



Side view of OARS® Ultra-Urban™ Filter in catch basin.

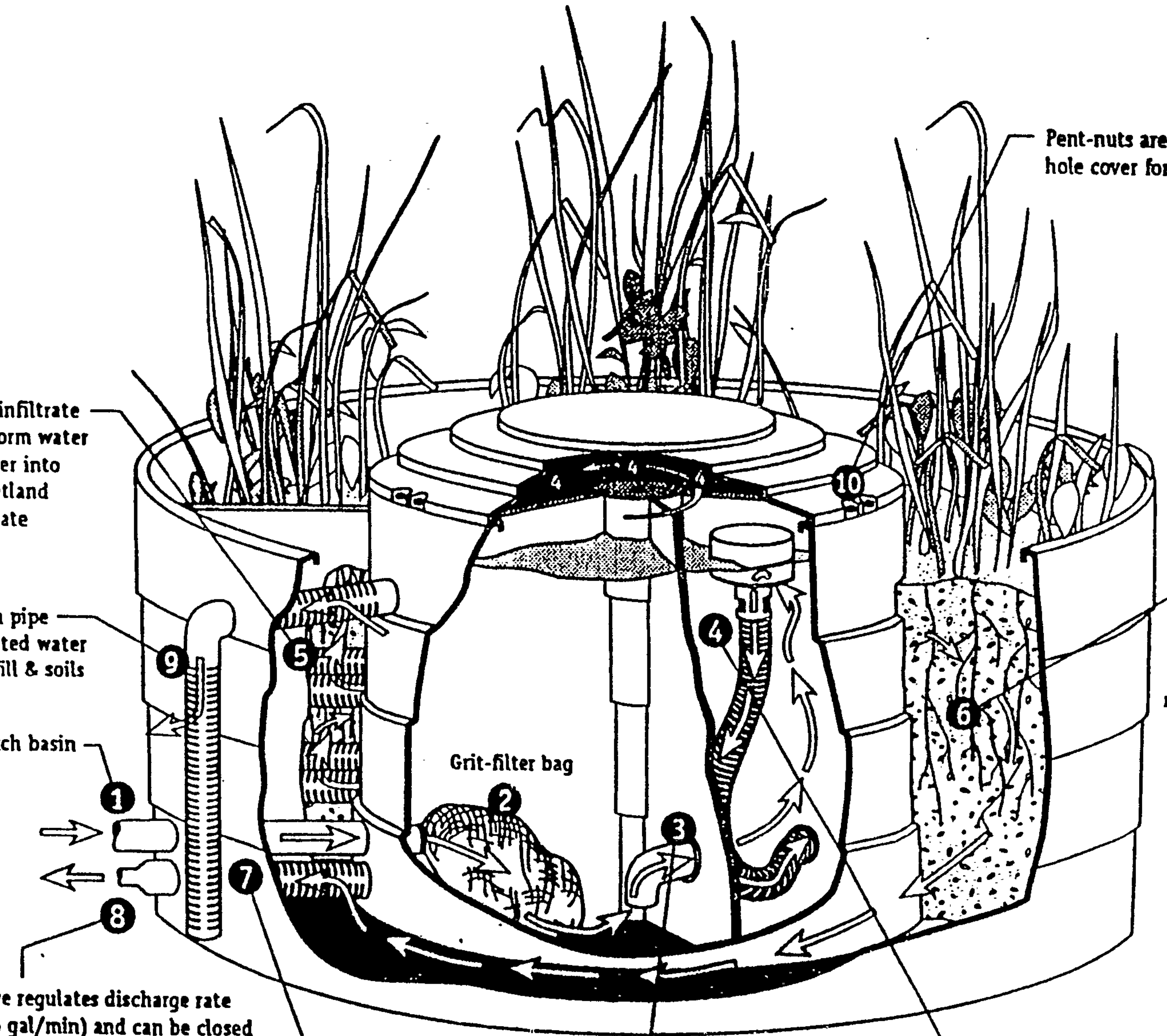


Rev 9/11/98

An environmental solution from AbTech Industries

R0011421

StormTreat™ Systems Tank



R0011422

Appendix C
QUESTIONNAIRE

STORMWATER POLLUTION SOLUTIONS

SACRAMENTO
STORMWATER
MANAGEMENT PROGRAM

December 22, 1998
980747:SH:sc

SUBJECT: PROPRIETARY STORMWATER CONTROL DEVICES, INFORMATION REQUEST

Dear Mr. ·

The Sacramento NPDES Stormwater Permittees include the City and County of Sacramento and the Cities of Folsom and Galt. The Permittees are responsibie for approving the use of stormwater controls in new developments within their respective jurisdictions, with the overriding goal of reducing discharges of stormwater pollutants to the maximum extent practicable. To help meet this goal, the Permittees are in need of additional information regarding specific proprietary structural control devices, especially with respect to the applicability and effectiveness of such devices for treatment of stormwater runoff in the Sacramento area. Your company was among those identified as a manufacturer or supplier of a proprietary device with potential application in Sacramento. The specific device identified is the Precast Interceptor.

Enclosed please find a brief questionnaire requesting specific information about your product. Please fill out the questionnaire to the best of your ability, using additional information and materials as appropriate. The information will be used to evaluate the potential usefulness of the specific device for achieving stormwater pollutant reductions in the Sacramento area.

The Permittees would greatly appreciate your timely response to this request. Please send your responses by January 11th to our consultant: Larry Walker Associates, 509 Fourth St., Davis, CA 95616, Attention: Armand Ruby. You may also contact Sherill Huun, City of Sacramento, Department of Utilities at (916) 264-1455 or Tom Garcia, County of Sacramento, Water Resources Division, (916) 874-6457 with any questions or comments you may have. Thank you for your cooperation.

Sincerely,

Larry F. Nash,
City of Sacramento

Tom W. Garcia,
County of Sacramento

cc: Bob Blaser, City of Folsom
Scott Alman, City of Galt
Armand Ruby, Larry Walker Associates

PROPRIETARY STRUCTURAL CONTROLS QUESTIONNAIRE
Sacramento Stormwater Monitoring Program

Please fill in all blanks as applicable and attach additional pages as necessary.
Use one form for each product.

Product name: ____________________

Manufacturer (company name/location): ______________________________
Manufacturer's rep for Sacramento area (name/company): ____________________
Address: ____
Telephone: ________________ Fax: ______________ e-mail address ______________

Year of first commercial application of the technology: ____________
Year of first commercial application in California: ____________

Number installed in the United States and Canada: ______________________
Number installed in California: __________ in the Sacramento area: __________

Land uses in which the technology is currently being used:

Number of standard unit sizes: ____________
(For each standard unit size please fill out the following. Costs may be approximate.)

Unit Size	Flow Capacity	Capital Cost	Installation Cost *

* Installation cost can be shown as a % range of capital cost.

Applicability/Limitations
Product description – Briefly describe components/operation (how does it work?):

Target pollutants – What pollutant(s) is this device designed to remove?

Product applicability - Describe the situations for which this technology is best suited:

Product limitations - Describe situations for which this technology may be unsuitable:

Performance
Are treatment effectiveness data available for this product? (summarize):

Have performance studies been conducted, or are any planned? ____________________
(If yes, please characterize those studies by filling out the chart below.)

		Study A	Study B	Study C
1.	Study Conducted By:			
	Manufacturer			
	Independent party			
2.	Study Location (specify):			
	Laboratory			
	In-field in California			
	In-field elsewhere			
3.	Study Date/Period:			
4.	Report Available?			

Please enclose copies of all completed study reports. Include relevant information about the study, including location, size of unit tested, catchment area size, land use, testing protocols, characteristics of storms sampled (flow depth, duration, antecedent period), and influent and effluent concentrations.

Product Maintenance
Recommended maintenance frequency:

Is the recommended maintenance frequency based on experience or "best professional judgment"?

Recommended maintenance procedure (summarize):

Estimated maintenance costs:

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Product brochure available? (please enclose if yes): _____
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EFFECTIVENESS OF STREET SWEEPING FOR STORMWATER POLLUTION CONTROL

TECHNICAL REPORT
Report 99/8
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COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

Effectiveness of Street Sweeping for Stormwater Pollution Control

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Cooperative Research Centre for Catchment Hydrology

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Preface

This report investigates the effectiveness of street sweeping as a stormwater pollution source control measure. The Cooperative Research Centre for Catchment Hydrology (CRCCH) Project U1 (Gross pollutant management and urban pollution control ponds) focuses on ways to improve the quality of stormwater runoff. The project covered means to reduce gross pollutants both before and after they entered the piped stormwater drainage system. This report describes a scoping study to assess the efficiency of Australian street sweeping practices in the removal of pollutants from street surfaces. This study has provided information on the effectiveness of street sweeping, currently practiced, in the collection of pollutants across the range of particle sizes representative of a street surface load.

It is a pleasure to acknowledge the contribution of Tracey Walker and Tony Wong to the Urban Hydrology Program. This work has provided important insights into the limited role street sweeping plays in improving stormwater quality.

Tom McMahon
Program Leader, Urban Hydrology
Cooperative Research Centre for Catchment Hydrology

Executive Summary

Street cleansing is a common (and expensive) practice undertaken by most urban municipalities with annual expenditure by a municipality often exceeding one million dollars. Street sweeping, essentially the operation of large trucks for cleaning street surfaces, is primarily performed for aesthetic purposes. It is, often perceived to lead to improvements in the environmental conditions of urban waterways by preventing pollutants deposited on street surfaces from reaching the stormwater system. There is, however, little available evidence to quantify the extent to which street sweeping can improve stormwater quality. This report investigates the effectiveness of street sweeping for stormwater quality improvement.

The effectiveness of street sweeping for stormwater pollution control is examined for two types of pollutants, gross pollutants (> 5 mm) and sediment (including associated pollutants). The research literature on street cleaning indicates a general dearth of studies that address the issues of gross pollutant management. Most studies predominantly examine the effectiveness of street sweeping for sediment and associated contaminant removal. This study looks at the effectiveness of street sweeping for gross pollutants using the results of Australian field studies, while sediment and other suspended solid removal is investigated with interpretation of results from overseas studies.

Experimental studies overseas found street sweeping to be highly effective in the removal of large solids greater than 2 millimetres under test conditions. However, field conditions are expected to significantly reduce the efficiency of solid removal because of limitations with sweeper access to source areas (mainly due to street design and car parking), sweeping mechanisms used and operator skills. Field studies undertaken by the Cooperative Research Centre for Catchment Hydrology (CRCCH) in Australia found significant stormwater gross pollutant loads generated from source areas in spite of a daily street sweeping regime.

An earlier CRCCH study, involving analysis of gross pollutant loads from a 50 hectare urban catchment of mixed residential, commercial and industrial land-use, found a clear relationship between the gross pollutant load in the stormwater system and the magnitude of the storm event. The shapes of the curves relating gross pollutant load to event rainfall and runoff were found to be monotonically increasing and representable by a logarithmic function. The shape of these curves suggests that the limiting mechanism affecting the amount of gross pollutants entering the stormwater system is rainfall dependent (ie. the available energy to re-mobilise and transport deposited gross pollutants on street surfaces) rather than being source limiting (ie. the amount of available gross pollutants deposited on street surfaces).

Overseas studies indicate that street sweeping is relatively ineffective at reducing the street surface load of fine particles (below 125 µm). The particle size distribution of suspended solids conveyed in stormwater in Australian conditions typically range from 1 µm to 400 µm with approximately 70% of the particles smaller than 125 µm. Therefore, street sweeping as it is currently practiced cannot be expected to be effective in the reduction of suspended solids and associated trace metals and nutrient concentrations in stormwater.

The study concludes that the performance of street sweeping for stormwater pollutant control is limited and must be accompanied by structural pollutant treatment measures to effectively reduce the discharge of gross and sediment associated pollutants in stormwater. The incremental benefits in increasing the frequency of street sweeping beyond what is required to meet street aesthetic criterion is expected to be small in relation to water quality improvements. As a result, there seems little benefit in conducting an in-depth field-based study into the effectiveness of street sweeping for stormwater pollution control.

Acknowledgements

The authors of this report would like to acknowledge the continued assistance and support provided by the Moreland City Council, particularly the cleansing manager, Les Horvath for sharing his knowledge of street cleaning operations. Many thanks to all those who were interviewed for Council information, especially Peter Barton from the City of Greater Dandenong who also arranged participation in an early morning street sweeping program.

In addition, Ranger Kidwell-Ross from American Street Sweeper magazine is thanked for his help and direction, and Roger Sutherland for forwarding current literature from America. The authors also wish to acknowledge in particular Dr Robin Allison for his advice and discerning suggestions, and Dr Francis Chiew for his comments and input.

1 Introduction

This report presents the findings of an investigation on the effectiveness of current Australian street sweeping practices in the collection of pollutants across the typical range of particle sizes found on street surfaces. The study was initiated to define and scope a further more-detailed field-based study to quantify the effectiveness of current street sweeping practices as an at-source stormwater pollution management measure. The term street sweeping is used here to describe essentially the operation of large trucks to remove deposited litter and debris from the kerb and channel of major roadways, streets, and carparks. The study examines the effectiveness of street sweeping practices to remove pollutants of two types:- (i) gross pollutant and litter removal and (ii) sediment and associated contaminant removal.

Over the past decade there has been an increase in the management of urban stormwater to protect urban waterways and receiving waters. These initiatives have, in part, resulted from community awareness of environmental impacts of urban stormwater pollution and their expectation that urban aquatic ecosystems should be protected from further environmental degradation.

Pollutants generated from urban land-use activities are transported by stormwater to urban receiving waters. Pollutants washed off street surfaces include gross pollutants, sediment and associated metals, nutrients, hydrocarbons and dissolved pollutants. Increased volumes of stormwater runoff and discharge rates resulting from increased impervious surface areas and hydraulically efficient drainage infrastructure throughout urban catchments have meant that the transport of urban pollutants to receiving waters is particularly efficient.

Most urban metropolitan councils perform cleansing of streets and similar impervious surfaces. This is commonly for the purpose of controlling gross pollutants, particularly litter, to maintain a level of street cleanliness and aesthetic quality. The focus on environmental issues is growing and local authorities are now considering street sweeping as a beneficial at-source method for reducing the amount of street borne pollutants entering the stormwater system. The actual contribution of street sweeping to the abatement of stormwater pollution is however not well understood. The objectives of street sweeping for street aesthetics and stormwater pollution control are very different, with the former placing particular emphasis on the visual impact of environmental pollution while the latter encompasses a much wider range of pollutant types and sizes. Despite street sweeping being widely considered an at-source stormwater pollution control method its effectiveness is unknown.

This report undertakes an interpretation of relevant street sweeping literature, research and survey results. The background to street sweeping operations, focusing on the effectiveness of sweeping for removal of street surface pollutants, is established in Section 2. The methodology undertaken for this investigation is discussed in Section 3. Results from a survey of 21 Melbourne Metropolitan councils on street sweeping practices are assessed in Section 4, to establish an understanding of current operations, target pollutants and sweeping frequencies. The different types of street sweeping mechanisms and their measured effectiveness are examined in Section 5. Pollutant types found on street surfaces are reviewed in Section 6, including an analysis of Australian sediment characteristics to assess the influence of street sweeping practices on fine particulates and associated contaminants.

Inter-event dry periods can influence street sweeping effectiveness and these are determined using Australian rainfall statistics in Section 7, and compared with current sweeping frequency and timing information. Section 8 examines field data to determine gross pollutant load generation and the influence of catchment land-use and associated sweeping frequency on pollutant load. The impact street sweeping has on gross pollutant loads entering the stormwater drainage system is discussed in Section 9, highlighting important issues affecting current sweeping efficiencies. Section 10 concludes with a summary of specific observations from each of the sections of the report from which the effectiveness of street sweeping as a stormwater pollution control method is assessed.

2 Background

2.1 Street Sweeping Pollutant Removal Monitoring

The role and usefulness of street sweepers to control street surface pollutants was first investigated in the late 1950's and early 1960's by the United States Environmental Protection Agency (US-EPA) and its associated researchers. Many of the US-EPA's National Urban Runoff Program (NURP) studies measured the efficiency of street sweeping as a stormwater pollution control method with particular emphasis placed on sediment and sediment-bound contaminants.

Since the late 70's studies have measured street sweeping effectiveness in terms of the reduction in end-of-pipe runoff pollution concentrations and loads rather than assessing the effectiveness of specific equipment. Sartor and Boyd (1972) found sweeping schedules based on a seven day cycle to be almost totally ineffective while daily sweeping was shown to potentially have a high level of pollutant removal for larger sized pollutants typical of street surface material (Sartor and Gaboury, 1984). Pitt and Shawley (1982) and Bannerrnan et al. (1983) concluded that only minor benefits to stormwater quality are provided by street sweeping practices. However, Terstrierp et al. (1982) and Pitt and Bissonette, (1984) demonstrated that street sweeping collects significant amounts of particles, for select particle size ranges, from street surfaces. The overall conclusion reached by the US-EPA, was that, as a water quality best management practice, street sweeping did not appear to be effective at reducing end-of-pipe urban runoff pollutant loads.

Subsequent investigations into the effectiveness of street sweeper mechanisms for water quality improvement report findings that vary to those presented in the conclusions of the earlier NURP studies. Alter (1995) and Sutherland and Jelen (1996b) assert that the NURP studies concluded that street sweeping is largely ineffective, because the sweepers used at the time of these studies were not able to effectively remove very fine accumulated sediments which are often highly contaminated. Sutherland and Jelen (1996a) suggest that street sweeping can significantly reduce pollutant washoff from urban streets due to the improved efficiencies of newer technologies now employed to conduct street sweeping in some American states. Their investigations showed that when street sweeping mechanisms and programs are designed to remove finer particles (ie. small-micron surface cleaners or tandem sweeping) it can benefit stormwater runoff quality.

2.2 Modelling Sweeper Pollutant Removal Efficiencies

Sweeping technologies with the ability to effectively remove accumulated sediments, including fine particles, may significantly increase the efficiency of sweeping for the removal of a variety of stormwater pollutants. Sutherland and Jelen (1993) described the use of a calibrated version of the Simplified Particle Transport Model (SIMPTM) as being able to accurately simulate the complicated interaction of accumulation, washoff, and street sweeper removal that occurs over a time period. For varying street sweeping operations Sutherland and Jelen (1997) employed the SIMPTM to predict the average annual expected reduction in total suspended solids (TSS) at two sites in Portland, Oregon. Sweepers used in their simulations included the NURP era broom sweeper, a mechanical broom sweeper, a tandem operation involving a mechanical broom followed by a vacuum sweeper and a newer technology, the small-micron sweeper. The predicted reductions in TSS showed that all of the newer street sweeping technologies are significantly more effective than the NURP era broom sweeper. It was further concluded that new street sweeping technologies designed for effective removal of fine particles, are capable of removing significant sediment loads and associated pollutants from urban street surfaces.

In a further study Sutherland and Jelen (1998) compared the new small-micron street sweeping technology to wet vaults, a widely used stormwater quality treatment method. The ability of the small-micron street sweeper to achieve significant reductions in urban pollutant washoff led Sutherland and Jelen to consider it an effective Best Management Practice (BMP) for stormwater pollution control.

2.3. *Factors Influencing Street Sweeping* Effectiveness

The pollutant reduction effectiveness of any street sweeping operation is dependent on the equipment used and the environmental and geographic conditions (eg. wind and presence of parked vehicles). Unless other influential factors (such as street parking) are addressed, the efficiency of individual sweeping mechanisms can be a relatively insignificant factor in the overall effectiveness of street sweeping operations. It is anticipated that the effectiveness of street sweeping programs depend more on factors such as land-use activities, the inter-event dry period, street sweeping frequency and timing, access to source areas and sweeper operation than the actual street sweeping mechanism. These factors all influence the deposition, accumulation and removal rates of pollutants on street surfaces. Physical features such as the degree of catchment imperviousness and the hydraulic characteristics of street surfaces can also influence the effectiveness of street sweeping. These factors require consideration before a thorough assessment of street sweeping efficiency for stormwater pollution control can be achieved.

3 Methodology

This study assesses the effectiveness of street sweeping for stormwater pollution control by:

- reviewing previous studies on sweeper performances and street pollutant characteristics,
- reviewing objectives for street sweeping operations (eg. aesthetic),
- considering rainfall distributions with street sweeping frequency and timing to investigate likely sweeper performance,
- examining field data from an earlier CRC study and others on gross pollutants,
- investigating the potential effects of changing street sweeping regimes on the gross pollutant loads in stormwater.

This study interprets available Australian and overseas field data on the measured efficiencies of street sweeping and street surface sediments. Various studies describing the particle size distribution of sediment loads were also collated to provide an insight into the particle size distribution pattern of suspended solids typical of street surface runoff. Some significant overseas studies on the partitioning of sediment sizes and the contaminant associations (eg. metals and nutrients) with each particle size partition were used to assess the pollutants likely to be discharged into the stormwater system from street surfaces. Information regarding street sweeping efficiencies and sediment contaminant associations from these studies are combined with data on Australian stormwater suspended solids characteristics to enable an assessment of street sweeping practices on removal of fine particulate associated pollutants.

A survey of street sweeping practices amongst municipalities in Melbourne was carried out to examine current sweeping objectives, procedures and mechanisms in these municipalities. This survey was also used to determine the perceived effectiveness of street sweeping in maintaining a certain standard of street aesthetics. Australian rainfall distributions were then examined and used to assess typical statistics of inter-event dry periods for Melbourne and other major capital cities in Australia. Melbourne inter-event periods were compared to the surveyed results of typical sweeping frequency and timing to investigate likely sweeper performance. This information facilitates a "hydrological basis" for selecting a street sweeping frequency that would optimise gross pollutant removal.

The study also examines data obtained from field studies previously undertaken by the CRC for Catchment Hydrology and others to investigate the effectiveness of street sweeping on litter and gross pollutant removal. Gross pollutant load data gathered at 192 side entry pit traps (SEPTs - baskets fitted into roadside stormwater entry pits) in the suburb of Coburg in Melbourne by Allison et al. (1998) were grouped according to the street sweeping frequencies in their respective streets. Similar data are available at two further study catchments in the suburbs of Carnegie and McKinnon in Melbourne (Hall and Phillips, 1997). The load data captured by the SEPTs during a typical street sweeping program are used to evaluate the amount of gross pollutants typically entering the stormwater system under normal Melbourne street sweeping frequencies and conditions. While it was not possible to compute a measure of pollutant removal efficiency owing to an inability to account for pollutants by-passing the SEPTs, the data nevertheless provided an insight on what might be the expected gross pollutant export load from streets that are swept at regular intervals.

4 Melbourne Street Sweeping Practices

4.1 Street Sweeping Operations

The responsibility of keeping urban streets clean, commonly by sweeping road surfaces with large vacuum trucks is an operation carried out by local government. A survey of 21 Melbourne metropolitan councils was performed to determine the motivation for the large expenditure on street cleaning. The results indicated that street sweeping is primarily undertaken for aesthetic purposes in response to community expectations. Table 4.1 summarises the street sweeping practices of 21 municipalities in Melbourne.

4.2 Target Pollutants

Street cleansing programs are generally designed to concentrate on collecting human derived litter to address the obvious visual impacts. However, during autumn, organic matter becomes a focus and the sweeping frequency is altered to reduce the safety hazard associated with decomposing leaf litter on street surfaces and to reduce drain blockages. Street surface sediment collection was not identified as a major issue when designing street sweeping programs.

Street cleansing programs involve what is often termed 'building line to building line' cleansing, incorporating footpath cleaning, and the standard kerb and channel street sweeping where it is apparent a large proportion of litter accumulates. This requires a combination of cleansing methods and equipment for the successful removal of such pollutants. Australian streets are cleaned customarily with large truck mechanical broom and vacuum systems. However, it is becoming common practice to operate smaller broom and vacuum sweepers designed for cleansing areas inaccessible to the traditional larger plants. The most commonly used sweepers are the regenerative air model, for both large truck and small plant systems.

4.3 Contracts and Sweeping Frequency

Under new competitive tendering legislation, the bidding process for street cleansing contracts establishes a requirement for operators to become very competitive. Contractor performance is measured against output based specifications set by the council. This means the council stipulates a set of cleanliness requirements they wish to achieve with a street cleansing program but not the frequency or operation methods used. Street sweeping practices therefore differ considerably between Melbourne metropolitan councils. Street sweeping frequencies can range from every two weeks to every six weeks in residential areas and from daily to every two weeks in commercial areas. Shopping centres and commercial areas are swept more frequently, typically ranging from once or twice a day in busy areas and once or twice a week in less popular areas. Street sweeping frequencies for residential areas range from once a week for highly populated areas to every six weeks in less populated areas.

Table 4.1 Street Sweeping Practices for Melbourne Municipalities

COUNCIL	PURPOSE	TARGET POLLUTANT	CONTRACT	FREQUENCY		SWEEPING MECHANISM	COUNCIL PERSPECTIVE
				Commercial	Residential		
Bayside:							
Hobsons Bay	Aesthetic	Litter / Leaves	Internal (3-5yrs)	1 day	4 weeks	Regenerative	Effective
Port Phillip	H&S / SW / CD	Litter / Leaves	Internal (3-5yrs)	1 day	2 weeks	Regenerative	Effective
Bayside	SW / aesthetics	Litter / Leaves	Internal (3-5yrs)	1 day	3 weeks	Regenerative	Effective
Kingston	SW / aesthetics	Litter / Leaves	External (3-5yrs)	1 day	5 weeks	Regenerative	Effective
Inner City:							
Banyule	Amenity / SW	Litter / Leaves	Internal (3-5yrs)	2 weeks	5 weeks	Regenerative	Effective
Boroondara	Aesthetics / H&S / SW	Litter / Leaves	Internal (3-5yrs)	3-7 days	4 weeks	Regenerative	Effective
Glen Eira	CD	Litter / Leaves	External (3-5yrs)	1-3 days	4 weeks	Regenerative	Not Effective
Manningham	Amenity / SW / CD	Litter / Leaves	Internal (3-5yrs)	1 day	6 weeks	Regenerative	Effective
Whitehorse	Aesthetics / SW	Litter / Leaves	Internal (3-5yrs)	1 day	3 weeks	Regenerative	Effective
Stonnington	Amenity / Aesthetics	Litter / Leaves	Internal (3-5yrs)	1 day	1-2 weeks	Regenerative	Effective
Moonee Valley	SW	Litter / Leaves	Internal (3-5yrs)	1 day	6 weeks	Regenerative	Effective
Melbourne City	CD / amenity	Litter / Leaves	External (3yrs)	1 day	2 weeks	Regenerative	Effective
Maryibynong	CD / aesthetics	Litter / Leaves	Internal (3-5yrs)	1 day	2 weeks	Regenerative	Effective
Monash	Aesthetic / CD / SW	Litter	Internal (3-5yrs)	1 day	6 weeks	Regenerative	Not Effective
Moreland	CD / aesthetics / SW	Litter / Leaves	Internal (3-5yrs)	1 day	2 weeks	Regenerative	Effective
Outer City:							
Brimbank	SW / CD	Litter / Leaves	Internal (3-5yrs)	1 day	5 weeks	Regenerative	Effective
Hume	Amenity / SW	Litter	Internal (3-5yrs)	1 day	4 weeks	Regenerative	Effective
Greater Dandenong	CD / amenity	Litter / Leaves	Internal (3yrs)	1 day	17 days	Regenerative	Effective
Knox City	SW / CD	Litter / Leaves	Internal (3-5yrs)	2 days	5 weeks	Regenerative	Effective
Moroondah	CD / amenity / SW	Litter	Internal (3-5yrs)	1 day	21 days	Regenerative	Effective
Nillumbik	Aesthetic / SW	Litter / Leaves	Internal (3yrs)	1-2 weeks	4 weeks	Regenerative	Effective

Note: Councils not listed were conducting tender negotiations for street sweeping practices during the time of the survey.
H & S = Health and Safety
SW = Stormwater Quality
CD = Community Demand

4.4 Council Perspective of Effectiveness

All but two councils indicated that street sweeping as it is currently practiced was an effective way of collecting litter. Numerous councils stated that street sweeping aided in the prevention of litter entering the stormwater system and therefore reduced the occurrence of stormwater pollution and drain blockage but had no data to validate these observations. Several councils regarded street sweeping as effective only when practiced in conjunction with other source pollution control methods such as bins, side entry pit traps and other gross pollutant traps.

Overall the survey indicated a general satisfaction with the effectiveness of street sweeping in collecting human derived litter and organic matter (gross pollutants) for aesthetic objectives. However, there is little quantitative information for councils to assess the effectiveness of street sweeping practices on stormwater pollution reduction. Throughout the literature there are many suggestions that street sweeping can have an effect on stormwater quality although the degree to which this practice is effective is unknown.

The assessment of the effectiveness of street sweeping in stormwater pollution control rather than just aesthetic requirements will need a detailed analysis of the following major influencing factors.

- street sweeping mechanism
- pollutant types (from sediment and associated contaminants to gross pollutants)
- sweeping frequency & timing
- pollutant load wash-off characteristics

Each one of these factors is examined in detail in the following sections of this report.

5 Street Sweeping Mechanisms

5.1 Types of Sweeping Mechanisms

Types of street sweeping mechanisms commonly utilised in Australian practice include:

1. Mechanical broom sweepers involving a number of rotating brushes sweeping litter into a collection chamber;
2. Mechanical broom and vacuum systems involving the combination of rotating brushes and a vacuum to remove street litter;
3. Regenerative air sweepers which are like mechanical vacuum sweepers but use recirculated air to blast the pavement, dislodging litter before it is swept by rotating brushes towards a vacuum for pick-up. This sweeper also uses water sprays for dust suppression,
4. Small-micron surface sweepers which combine rotating brooms enclosed in a powerful vacuum head in a single unit, performing a dry sweeping/vacuuming operation. A powerful fan pulls debris and air into a containment chamber before the air is finally passed through a series of filters to capture small micron material.

5.2 Sweeper Effectiveness

Pitt and Bissonnette (1984) found following a period of street sweeping trials that street sweeping equipment was unable to remove particles from the street surface unless the loadings were greater than a certain threshold amount. This value was found to be three times higher for a mechanical broom cleaner, most referred to in the US-EPA's NURP studies, compared to the regenerative air street sweeper trialed for a comparison in a study by Pitt and Bissonnette (1984). The study found the regenerative air vacuum sweeper to exhibit a substantially better performance than the regular mechanical street sweeper, especially for the smaller particle sizes. Such findings have progressively led to the mechanical broom method being replaced by the vacuum system method for street sweeping practices. The removal effectiveness data for the smallest particle sizes (less than 125 µm) between the two methods of street sweeping was however found to be inconclusive.

The regenerative air vacuum sweeper (Figure 5.1) is a common mechanism used for street sweeping in Australia. The recirculating air cycle tends to improve the effectiveness of sweepers for the removal of heavy debris but is less effective for removing fine sediment. The air blast is able to dislodge heavier

Figure 5.1 Australian streets are cleaned with large truck vacuum sweepers

materials and propel them into the vacuum airflow however finer materials often remain uncollected (Pitt and Bisonnette,1984). Fine particles may become airborne as a result of the air blast and take some time to settle back onto the road surface or may be left behind on the street surface.

The most recent technology to be employed for street sweeping is a highly effective, vacuum-assisted dry sweeper (the small-micron surface sweeper) originally developed and manufactured by Enviro Whirl Technologies Inc in the United States of America. The sweeper was originally developed for the containment of spilled coal dust along railway tracks. This system is reported to be extremely effective in removing fine street surface sediments and preventing their escape into the air by filtering air emissions down to sizes as small as 4 µm. Sutherland and Jelen (1997) described this system as having an advanced ability, when compared to other sweeping mechanisms, to remove a broad range of particles from road surfaces down to sub micron particulates. The small-micron surface cleaning technology has been shown by Sutherland and Jelen (1997) to have total removal efficiencies ranging from 70% for particles less than 63 µm up to 96% for street surface pollutants larger than 6370 µm.

Despite there being new street sweeping technologies reported to be more efficient, most municipalities and private street sweeping companies in Australia continue to use the mechanical broom and regenerative air vacuum street sweepers. This is because of the high capital costs of newer technologies and their limited availability on the Australian market.

Street Sweeping Mechanism:

- Mechanical and regenerative air street sweeping equipment requires a minimum threshold load of sediment on the street surface before they become effective.
- The threshold load can be three times higher for the mechanical sweeper compared to the regenerative air system.
- Overall the regenerative air sweeper exhibits a substantially better performance than the regular mechanical sweeper.
- Street sweeping technology is developing and improving to remove finer street surface particles for a variety of street surface loads,

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6 Pollutant Types

The effectiveness of street sweeping to remove pollutants, across the typical range of particle sizes found on street surfaces, has not yet been successfully quantified for Australian conditions. The examination of street sweeping effectiveness in the present study focuses on two pollutant types:- (i) gross pollutants and litter and (ii) sediment and associated contaminants. Gross pollutants have been defined as any solids that are retained by a 5 mm mesh screen by Allison et al. (1998) and this definition is adopted here. Solids washed off street surfaces which are smaller than 5 mm and not considered to be gross pollutants include a proportion of litter and organic matter but are predominantly sediment particles, typically between the course sand to fine silt range, and sediment associated contaminants.

6.1 Gross Pollutants

Allison et al. (1997a) undertook an investigation into the types of gross pollutants derived from an urban catchment. The study found typical urban gross pollutants transported by stormwater to include litter (predominantly paper and plastics) and vegetation (leaves and twigs) as shown in Figure 6.1. Organic matter comprised the largest proportion by mass of the collected gross pollutants and therefore should be a major consideration in street cleaning programs. The data was based on field monitoring of gross pollutants retained in a Continuous Deflective Separation (CDS) unit treating a catchment area of 50 hectares in Coburg, an inner city suburb of Melbourne.

Only a small number of investigations have examined street sweeping effectiveness on gross pollutant removal. Nilson et al. (1997) conducted an investigation into source control of gross pollutants in Adelaide and attempted to assess the efficiency of street sweeping for gross pollutant removal in stormwater. This study sought to quantify the amount of gross pollutants entering the drainage network in three similar streets swept at different intervals. Catch baskets in side entry pits were used to collect gross pollutants which were not otherwise collected by the sweeper for a street swept every day, once a week, and not at all. Trapped pollutants in these

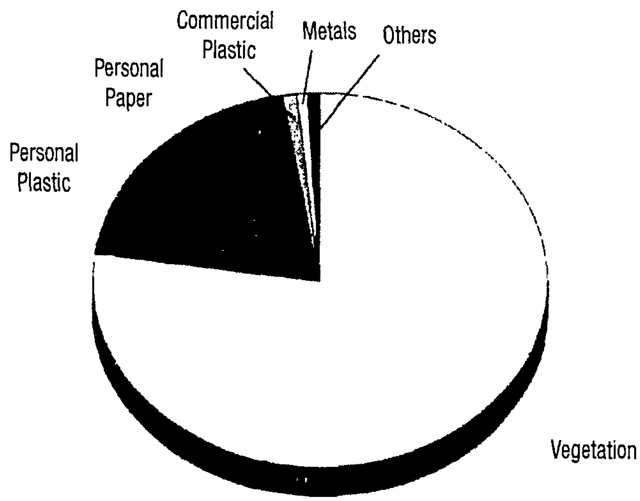

Figure 6.1 Composition of Gross Pollutants by Mass (Allison et al., 1998)

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baskets were removed and quantified weekly during the study.

The results of the study by Nilson et al. (1997) show little correlation between the frequency of sweeping, rainfall or wind-run in the catchment with the gross pollutant load collected in the catch baskets. The study provided little conclusive information on the effectiveness of street sweeping with respect to gross pollutants. The study found that typically, a significant amount of gross pollutants were mobilised into the stormwater system from the street during bursts of rain, wind or both, irrespective of the nature of the street sweeping program implemented. These results suggest the amount of gross pollutants or street surface load does not limit the amount transported into the stormwater system regardless of the street sweeping frequency.

The observed composition of the gross pollutant material collected by Nilson et al. (1997) was consistent with other studies conducted by Sartor and Boyd (1972), O'Brien (1994) and Allison and Chiew (1995), where gross pollutant loads measured in dry mass comprised approximately 70-90% organic matter, and 10-30% litter.

Broad-based investigations into street sweeping conducted by the US-EPA suggest that street sweeping efficiency increases with particle size. Sartor and Boyd (1972) found sweeper efficiency to be nearly 80% for the collection of particles greater than 2 millimetres under 'test' conditions (ie. sweeping more frequently than the occurrence of rainfall events and effective use of parking restrictions). Ideal street cleaning conditions are unlikely to occur during normal street sweeping operations, and sweeper efficiencies for collecting gross pollutants would be expected to be considerably lower than the recorded 80% despite any improvements gained through refinements of equipment since the study. In practice, the effectiveness of street sweeping for gross pollutant removal is influenced by a number of factors including: access to the street load, operator skills and sweeping speed, sweeping mechanism, time of day sweeping is conducted and weather conditions.

Gross Pollutants:

- Typical urban gross pollutants transported by stormwater include litter (predominantly paper and plastics) and vegetation (leaves and twigs).
- Significant amounts of gross pollutants are mobilised into the stormwater system during bursts of rain, wind or both.
- There is little correlation between the frequency of sweeping and the transport of gross pollutants into the stormwater system.
- Street sweeping efficiency increases with particle size.
- Sweeper efficiency can be up to nearly 80% for particles greater than 2 millimetres under 'test' conditions (ie. Sweeping more frequently than the occurrence of rainfall events and effective use of parking restrictions).

6.2 Sediment and Other Suspended Solids

Street sweeping performance for smaller street surface particles depends considerably on the type of street sweeper used and also conditions such as the character of the street surface (texture, condition and type), street dirt characteristics (loadings and particle sizes), and other environmental factors (Pitt and Bissonnette, 1984).

Sartor and Boyd (1972) found the removal efficiencies of sediment by conventional street sweepers to be dependent upon the particle size range of the street surface loads as shown in Figure 6.2. Mechanical sweeper efficiency was found to be generally low for fine material. This finding was supported by two further studies conducted by Bender and Terstriep (1984) and Pitt and Bissonnette (1984), who reported that the proportion of the total street load smaller than 300 μm was less affected by street sweeping. Pitt and Bissonnette (1984) also demonstrated that no effective removal was evident for street dirt particles smaller than about 125 μm for the regenerative air sweeper.

Mechanical broom sweepers are found to be effective at collecting larger particles but less effective than regenerative-air vacuum sweepers in removing the smaller particles (Pitt and Shawley, 1982). The regenerative air vacuum sweeper, although regarded as more effective at collecting smaller particle sizes does not successfully control or remove fine particles.

Problems are encountered with water-based dust suppression methods as they tend to resuspend the small micron particles and their associated attached pollutants, forming a slurry which either fills the cracks in the pavement or is discharged into the stormwater system. Similarly, fine particles can easily escape collection when they are re-mobilised into the air by the pavement blast used by the regenerative air sweeper to dislodge larger materials.

Studies by Pitt and Sutherland (1982) indicated that a significant proportion of the larger dirt particle sizes picked up by street sweepers are not easily transported by rain and that removal of these particles tends to expose the smaller sheltered particles. These smaller particles exposed by street sweeping are then more readily mobilised and transported into the stormwater drainage system during rainfall events. The small-micron surface sweeper sweeps dry, with no water being used, and thus overcomes problems associated with resuspension of fine particulates and associated pollutants by dust suppression sprays. These machines utilise strong vacuums in combination with uniquely-designed main and gutter brooms. The air filtration system, enables smaller particles to be removed from the street surface with the return of clean air to the atmosphere (ie. filters particles down to 2.9 microns). This relatively new technology is regarded to be a high-efficiency sweeper (Sutherland et al., 1998).

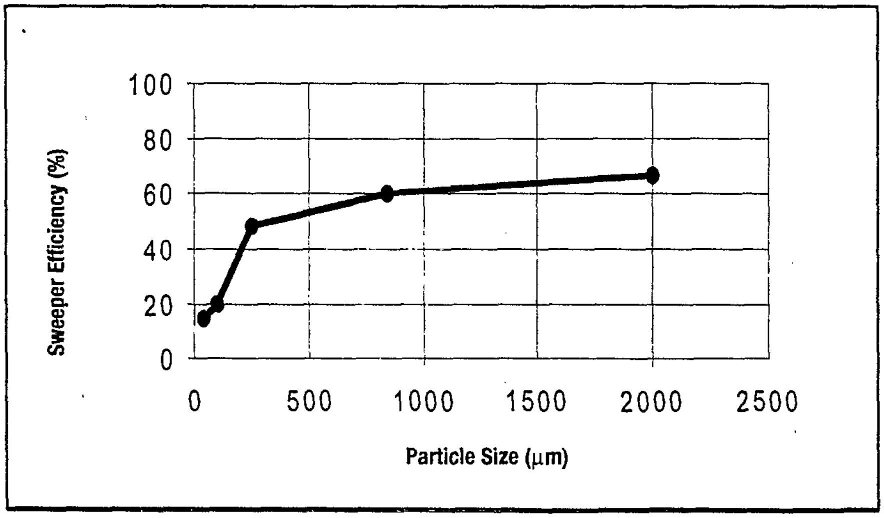

Figure 6.2 Street sweeping efficiency as a function of particle size (Sartor and Boyd, 1972)

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The removal performance of street sweepers for sediment has been often determined from sampling accumulated street dirt before and after sweeping has been conducted. Initial street surface conditions are established and the street swept at a specified speed of 7-8 kilometres per hour before it is sampled to establish the residual condition. The difference between initial and residual loadings by specific particle size defines the removal performance of street sweeping operations. It was concluded from this method that sweeping removes little, if any, material below a certain threshold. This threshold load was found to vary by particle size range. A series of mathematical equations developed by Pitt (1979) to describe this removal performance have been recently calibrated and employed by Sutherland and Jelen (1996a and 1997) to evaluate and compare the removal performance of numerous street sweeping technologies.

Sutherland and Jelen (1997), using their Simplified Particle Transport Model, tested the removal performance of the small-micron sweeper, along with a regenerative air vacuum sweeper, a mechanical broom sweeper, and a tandem operation that involved a single pass by a mechanical broom followed by a vacuum sweeper. The small-micron sweeper was shown to be the most efficient, with average total removal efficiencies of 70% for particles less than 63 μm and between 77% and 96% for particle sizes ranging from 125 μm to larger than 6370 μm. The small-micron sweeper demonstrated an ability to efficiently remove particles without any threshold level unlike the other sweepers tested. The regenerative air sweeper was shown to be the second most efficient with overall removal efficiencies calculated to range from 32% for less than 63 μm range to 100% for larger particles between 600 and 2000 μm. However, the removal efficiency of the regenerative air sweeper for particles between 250 and 2000 μm can drop to zero, due to the necessity of large threshold loads for particles within this size range. The tandem operation and mechanical broom sweeper were found to be the least efficient despite some recorded high efficiencies. This can be mainly attributed to the high threshold loads required by these operations before any significant sediment removal is recorded.

6.3 Contaminants Associated with Sediment

It is well recognised that a significant amount of metals and nutrients are transported as sediment-bound contaminants. Many investigations have found the concentration of sediment-bound contaminants to vary with particle size, with high concentrations of contaminants attached to the finer particles (Sartor & Gaboury 1984, Sartor & Boyd 1972). Hvitved-Jacobsen et al. (1991, 1994) investigated road runoff pollutant characteristics and found 60-80% of phosphorous, 30-40% of zinc, 70-80% of lead, 30-40% copper and about 55% of total nitrogen in road

Sediment and Other Suspended Solids:

- The removal efficiency of sediment and other fine organic particles by conventional street sweepers was found to be dependent upon a threshold level of load on the surface and the particle size range of the surface loads.
- Material smaller than 300 μm was less affected by street sweeping.
- No effective removal (>50% removal efficiency) was evident for particle sizes smaller than 125 um for conventional street sweepers (excluding the new small-micron surface cleaning technology).

runoff to be associated with particulates. While most particulate matter found on street surfaces is in the fractions of sand and gravel. Approximately 6% of particles are in the silt and clay soil size and they were found to contain over half the phosphorous and some 25 percent of other pollutants, as indicated in Table 6.1, adapted by Shaver (1996) from results of Sartor et al. (1974).

Many other investigations have found the concentrations of sediment-bound contaminants in street dirt to be associated with the fine particle size fraction. Pitt & Amy (1973), NCDNRCD (1993) and Woodward-Clyde (1994) have all shown that higher concentrations of pollutants such as heavy metals are associated with the smallest particle size fractions of urban dust and dirt. These data indicate that almost half of the heavy metals (represented by copper, lead and zinc) found on street sediments are associated with particles of 60 to 200 µm in size and 75% are associated with particles finer than 500 µm in size. Dempsey et al. (1993) undertook an analysis of particle size distributions for urban dust and dirt, and partitioning of contaminants into a number of size fractions to determine the concentrations of contaminants in each particle size range. Results show the highest recorded concentrations of Cu, Zn and TP to be associated with sand particles between 74 and 250 µm in size.

Colwill et al. (1984) found 70% of oil and approximately 85% of polycyclic aromatic hydrocarbon (PAH) to be associated with solids in the stormwater. That study demonstrated that over a period of dry weather conditions, increasing proportions of oil become solid associated where the highest oil content was found in sediments of 200 to 400 µm in size.

Sansalone et al. (1997), Fergusson and Ryan (1984), Baker (1980) and Wilber and Hunter (1979) all reported that heavy metal concentrations increase with decreasing particle size. Results presented by Sansalone et al. (1997) from particle size distribution and metal analysis indicate that zinc, copper and lead concentrations increase with decreasing particle size or, equivalently, increasing specific surface area. The absorption of contaminants to particles is often regarded as being directly related to the surface area per unit mass available for ion absorption. Measured specific surface area results presented by Sansalone et al. (1997) indicated that the assumption of smooth spherical particles to estimate available surface area

Table 6.1 Percentage of Street Pollutants in Various Particle Size Ranges

	Particle Size (µm)					
Pollutant	**<43**	**43 - 104**	**104 - 246**	**246 - 840**	**840 - 2000**	**>2000**
Total Solids	5.9	9.7	27.8	24.6	7.6	24.4
Volitile Solids	25.6	17.9	16.1	12.0	17.4	11.0
COD	22.7	45.0	12.4	13.0	4.5	2.4
BOD	24.3	17.3	15.2	15.7	20.1	7.4
TKN	18.7	19.6	20.2	20.0	11.6	9.9
Phosphates	56.2	29.6	6.4	6.9	0.9	0.0
All Toxic Metals	27.8	-	23.5	14.9	17.5	16.3

(Source: Shaver; 1990; adapted from Sartor, Boyd, and Agardy, 1974) grossly underestimated the actual available surface area of particulates transported in stormwater. Specific surface area values were found to deviate from the monotonic pattern expected for spherical particles. Particles in the mid-range to coarser end (100 to 1000 μm) of the distribution were shown to contribute a larger surface area than would normally be expected.

The sediment binding behaviour of other toxicants such as polychlorinated biphenyls (PCB's) and polycyclic aromatic hyrdrocarbons (PAH's) is different to that of heavy metals. Schorer (1997) reported PCB's and PAH's to have no correlation with particle size distribution or surface area but rather with the abundance of organic material. Results indicated that the organic material content in different particle size fractions was bimodally distributed with maximum measurements recorded for fine silt (2 - 6.3 μm) and fine sand fractions (63 - 200 μm). Concentrations of PAH's would therefore be expected to be attached to these particle size fractions.

A substantial database, identifying particle size distributions and other parameters that relate to reactivity and mobility of contaminants, has resulted from data collected by a number of US-EPA studies. However, to date only limited information regarding the physical and chemical characteristics of urban stormwater runoff are available for Australian conditions. Results from an investigation by Mann and Hammerschmid (1989) on urban runoff from two catchments in the Hawkesbury/Nepean basin indicated the existence of high correlations between total suspended solids (TSS) with total phosphorus (TP), total kjeldahl nitrogen (TKN) and chemical oxygen demand (COD). Ball et al. (1995) found that TSS and TP show similar characteristics and correlations to other overseas studies.

In relation to street sweeper effectiveness, the association of pollutants with sediment, particularly the finer fractions, would suggest street sweeping needs to remove these particles in order to provide effective stormwater pollution control. However, street sweeping has to date been found to be generally effective only for material larger than 300 μm (see section 6.2).

Contaminants Associated with Sediment:

- Significant amounts of metals and nutrients are transported as sediment-bound contaminants.
- Most of the total mass of contaminants is associated with the fine particles.
- Conventional street sweeping is generally ineffective at removing particles smaller than 300 μm and therefore will not effectively reduce the export of sediment-bound contaminants such as nutrients, metals and PAHs.

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6.4 Australian Conditions

Various studies undertaken by the US-EPA found the major constituents in street dirt to be consistently inorganic, mineral-like matter, similar to common sand and silt. This could be due to the fact that many of the US-EPA studies were conducted in cities where applications of screened sands are made to road surfaces. Street surface particulate matter has been described as having particle sizes ranging from about 3000 to 74 µm and less (Sartor and Gaboury, 1984).

A collation of reported particle size distribution curves for solids found on street surfaces and in street surface and highway runoff is shown in Figure 6.3. The collection of 20 particle size distribution curves presented in Figure 6.3 are derived from sampling solids from street surfaces and suspended sediment collected in road runoff from a number of overseas and Australian catchments.

It is evident from Figure 6.3 that despite the overseas data being collected from a variety of sources, locations and by various methods, they show a consistent distribution ranging from approximately 10 µm to approximately 10,000 µm. The particle size distributions derived from sampled road runoff from two Australian sites, one as part of an ongoing CRC project and the other by Ball and Abustan (1995), are also presented and appear to fall outside the range of the particle size distribution curves of the overseas catchments. The Australian data range from 2 µm to approximately 500 µm. There may be a number of possible explanations for this observed finer particle size distribution including differences in sampling and analysis techniques. However, it should be noted that the particle size distributions derived from overseas catchments were based on a variety of sampling and analysis techniques. The upper particle size limit can influence the position of the derived particle size distribution curve. Adjustments (Lloyd and Wong, 1999) to the overseas data to eliminate particles larger than 600 µm, to allow a common basis for comparison of these curves, still showed the Australian data sets to exhibit finer particle size characteristics. The significantly different particle size distribution of the Australian catchments may indicate fundamental differences in catchment characteristics.

The Australian sampled road runoff data displays a significantly finer particle size distribution, with a greater percentage of particles less than 125 µm (up to 70%). Although only based on sampling at two sites, the inefficiencies of street sweeping in removing particles less than 125 µm would result in little reduction of up to 70% of the particles found in runoff in these Australian catchments. The difficulty for Australian street sweeping is the fine nature of the sediment found on roads. Up to 70% of particles found on street surfaces are less than 125 µm compared to 20% for overseas road runoff data. The inefficiencies of street sweeping in the reduction of sediment-bound pollutants entering the stormwater system is therefore expected to have more severe implications under typical Australian conditions.

Removal of Sediment and Associated Contaminant:

- Limited sampling of sediment in street runoff in Australia indicates that 70% of particles are less than 125 µm compared to 20% for overseas data.
- The fine sediments found on Australian streets would suggest that conventional street sweeping will have a minimal effect on sediments and associated contaminants reaching stormwater systems.

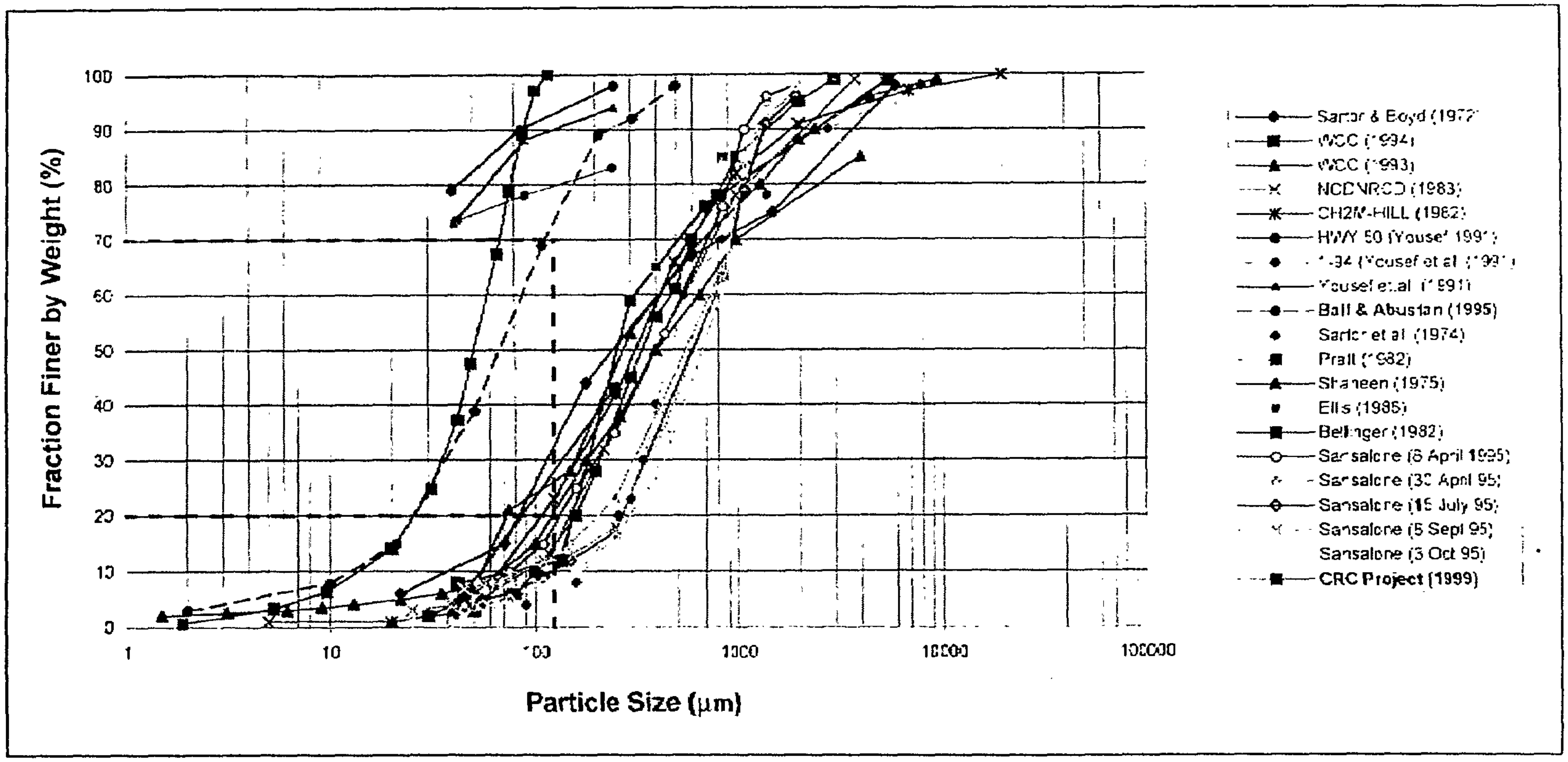

Figure 6.3 Particle Size Distribution of Suspended Solids in Road Runoff

7 Street Sweeping Frequency And Timing

7.1 Sweeping Frequency and Rainfall Patterns

Sartor and Gaboury (1984) concluded that the dominant influence on the effectiveness of street sweeping appears to be time intervals, ie. the relationship between the average interval between storm events (a function of local meteorological conditions) and the frequency at which streets are swept. Street sweeping operations are typically programmed for a fixed interval (eg. swept once per week). If the average time between rainfall events is much less than the sweeping interval, then much of the street surface load could be washed away by storm runoff, hence, making street sweeping relatively ineffective. In this context, analysis of rainfall statistics is important in the design of street sweeping programs to ensure street sweeping is compatible with the frequency of storm events and therefore optimise the effectiveness of street sweeping for removal of stormwater pollutants.

Generally street sweeping frequencies are determined according to land-use. Street sweeping frequencies, practiced by Melbourne metropolitan municipalities, generally range between daily sweeping for busy commercial areas and every six weeks for residential areas. The sweeping frequency in the CBD of Melbourne could however involve numerous sweeps throughout the day. Councils ordinarily stipulate sweeping specifications for the purpose of meeting community demands for aesthetic quality and amenity improvement. The inter-event dry period between storms is not often a factor considered when street sweeping programs are formulated. However, if municipalities are willing to incorporate stormwater management objectives into street sweeping programs, the occurrence of rainfall events should become a significant design factor.

The minimisation of pollutant washoff, particularly fine particulates and associated contaminants, from street surfaces requires compatibility of street sweeping frequency and timing with rainfall characteristics and the daily activities in the catchment. Fine particulates and associated contaminants are often mobilised with even the smallest amount of runoff while gross pollutants often require a minimum runoff rate to be reached before they are mobilised. In areas which are not swept daily, the selected street sweeping frequency should ideally reflect the relationship with the inter-event dry period (time between storm events) typical of the catchment. For those catchments currently on a daily street sweeping regime, the time of day when street sweeping is conducted should be selected to limit the period in which the pollutants deposited on street surfaces are exposed to the risk or likelihood of wash-off associated with a storm event.

7.2 Inter-Event Dry Period

It can be assumed that the majority of pollutants transported into the stormwater system occur during rainfall event periods. Therefore if the street cleaning frequency is longer than the average inter-event dry period it can be expected that the accumulated pollutants, on road surfaces, will have a higher likelihood of being washed into the stormwater system before being collected by the street sweeper.

Melbourne rainfall was characterised from analysis of rainfall over a 105 year period by Wong (1996). The analysis identified storm events as having a thirty minute minimum storm duration. A six hour minimum period of no rainfall to define the conclusion of a rainfall event. Using this definition for a storm event, the analysis found the mean period between storms in Melbourne to be 62.4 hours (2.6 days) with a standard deviation of 76.8 hours (3.2 days). There is an apparent trend in Melbourne of longer periods between storms in summer months, with a maximum mean period of 108 hours (4.5 days) in February and a minimum mean period of 45 hours (1.9 days) in August as shown in Figure 7.1. Wong (1996) also carried out an analysis of the rainfall data for a number of major cities in Australia, and the statistics according to their respective months are presented in Table 7.1. The influence of seasonality on the period between storms for the cities is shown in Figure 7.2.

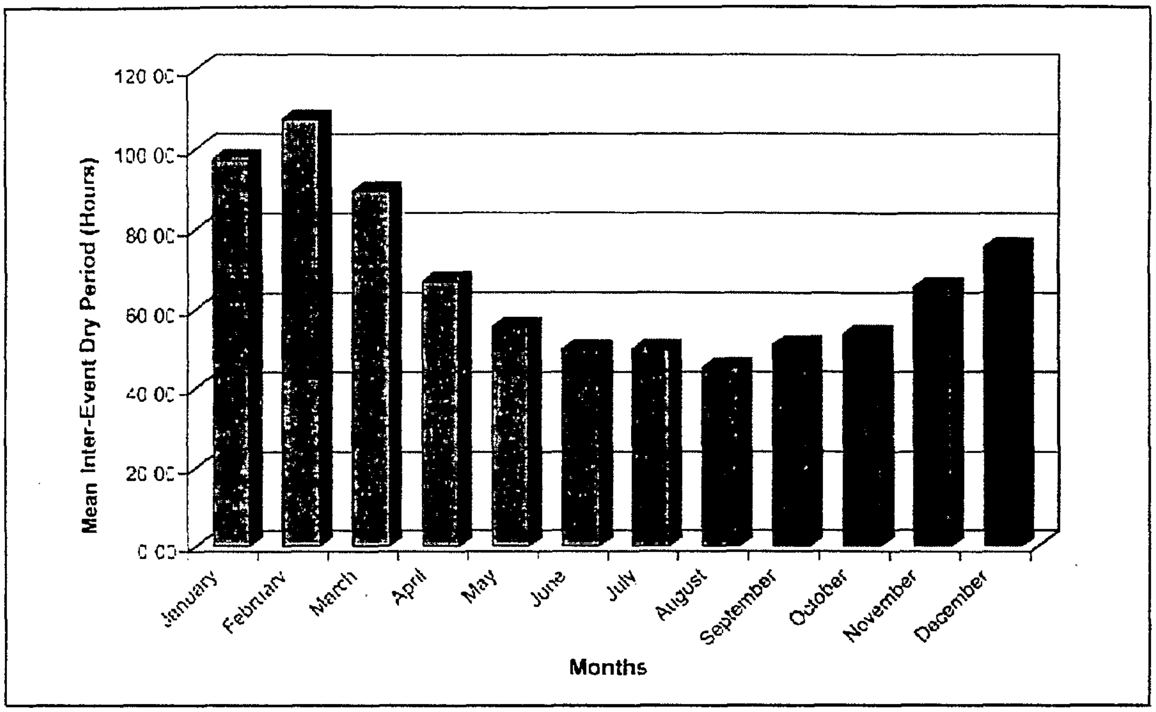

Figure 7.1 Melbourne Mean Monthly Inter-Event Dry Period

Table 7.1 Mean Inter-Event dry Periods (Hours).

CITIES	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Adelaide	165.93	189.42	156.52	94.81	61.07	51.16
Brisbane	65.39	57.28	58.08	74.48	93.68	111.03
Darwin	33.02	32.10	41.40	116.14	130.32	561.14
Hobart	72.33	83.26	74.79	60.86	56.24	50.69
Melbourne	97.38	107.55	89.56	66.68	55.21	49.46
Perth	250.70	238.29	200.54	89.21	58.02	39.91
Sydney	70.30	64.68	66.58	69.27	70.19	73.36

CITIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Adelaide	44.02	44.45	54.94	69.63	93.96	128.95
Brisbane	133.87	141.20	126.21	90.91	81.91	72.38
Darwin	416.95	240.36	217.41	120.79	62.21	58.72
Hobart	47.94	46.93	50.47	47.26	49.03	59.92
Melbourne	49.57	45.01	50.63	53.39	65.32	75.32
Perth	39.96	53.79	62.20	88.16	141.96	193.17
Sydney	91.48	98.50	97.78	77.87	68.92	76.31

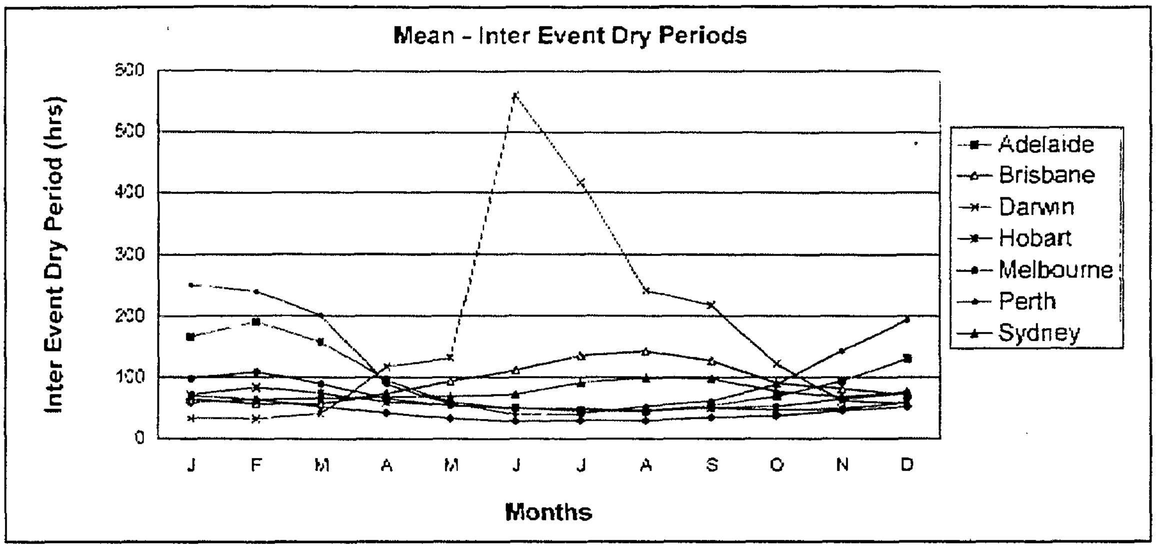

Figure 7.2 Mean Inter-Event Periods for Australian Cities

Of the cities analysed, Darwin shows the most inter-event dry period variability between seasons, ranging between 32 hours (1.3 days) and 561 hours (23.4 days), with the longer periods, unlike Melbourne, occurring during the winter months. The variable nature of inter-event dry periods, both between seasons and capital cities highlights the importance of street sweeping program design being specific to location and flexible to accommodate for season variability.

Based on consideration of typical inter-event dry periods, one would question the effectiveness of current Australian street sweeping practices in effectively preventing pollutants entering the stormwater system if the street sweeping frequency, designed for aesthetic objectives, is significantly lower than the frequency of storm events. If streets are only swept every six weeks then it is likely that storm events occurring within this period will flush a large proportion of the accumulated pollutants into stormwater drains before sweeping has the opportunity to collect it. In the case of gross pollutants, Allison et al. (1998) suggested a minimum rainfall amount before there is sufficient runoff to re-mobilise these larger size pollutants. As a gross pollutant export control, sweeping frequency equivalent to approximately three times the mean inter-event period appears to be appropriate (see Section 8.1).

Sweeping Frequency and Rainfall Patterns:

- The variable nature of inter-event dry periods, both in terms of seasonal variation and dependence on climatic locations, highlights the importance of street sweeping program designs which are specific to location and flexible to accommodate the local meteorological conditions and seasonal variability.
- It is anticipated that if street sweeping occurs at a longer interval than the inter-event dry period of the catchment, street surface pollutants will have a much higher likelihood of being flushed into the stormwater system before being collected by the street sweeper.

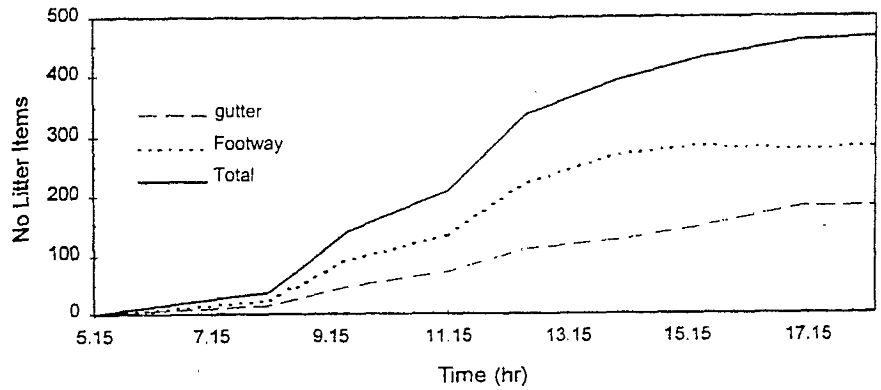

Figure 7.3 Daily Litter Generation (Hall and Phillips., 1997)

7.3 Street Sweeping Timing

Analysis of street and footpath litter accumulation along a 280 m section of strip shopping centre in the Melbourne suburb of Carnegie during a typical business day was conducted by Hall and Phillips (1997). This commercial land-use area is subject to typical street sweeping operations carried out daily by the Glen Eira municipality. Detailed recording of the gross pollutant load generated over a day from 5:15 to 18:30 commenced immediately after street sweeping and footpath cleaning and concluded when trade had effectively ended. The data indicates that the rate of accumulation of litter is highest between the times of 8:00 and 17:00 with litter accumulation effectively ending around 17:00 hours in the evening (see Figure 7.3).

The data plotted in Figure 7.3 suggest that the time of day a rainfall event occurs can alter the amount of litter available for re-mobilisation to the stormwater system. The time of day at which street sweeping is practiced is expected to have an effect on the amount of litter entering the stormwater system due to the exposure time of deposited pollutants to wash-off processes. Street sweeping is most commonly conducted in the early morning leaving the accumulated pollutants, especially litter from the day before, to a longer exposure period and the likelihood of over night rainfall events capable of flushing them into the stormwater system.

The study by Hall and Phillips (1997) also involved comparing accumulated litter items from street surfaces and side entry pit traps (SEPTs) in drains following rainfall events. The Carnegie urban catchment was monitored over a seven day period, and litter material was measured from bins, footpaths, street surfaces and SEPTs located in stormwater drain inlets. Footpath litter items were not considered when determining the effect of rainfall due to their surfaces being sheltered from rainfall and associated washoff mechanisms. When only street material is considered, up to 77% of the calculated street items entered the stormwater system during rainfall events. These data suggest that street washoff is the principal mechanism for transport of gross pollutants into the stormwater system.

Street Sweeping Timing:

- Recorded gross pollutant load generation over a typical day indicates that the accumulation of litter in a shopping strip begins at 8:00 and effectively ends around 17:00 hours.
- Early morning street sweeping allows the exposure of deposited street surface litter items to a higher likelihood of being transported into the stormwater drainage system.

8 Gross Pollutant Wash-Off Characteristics

8.1 Gross Pollutant Load Generation

The study by Allison et al. (1998) showed that stormwater runoff is the principal means by which gross pollutants are transported to the stormwater system. Ten storm events (larger than 3 mm of rainfall) and their transported gross pollutant loads in the Melbourne suburb of Coburg were monitored using the CDS unit from May to August 1996 (Allison et al., 1998). Monitoring was carried out in a 50 hectare catchment and the amount of gross pollutants transported during each of the 10 events was found to be correlated with the event rainfall depth as shown in Figure 8.1. A similarly high correlation between the gross pollutant load retained in the CDS unit and event runoff was also obtained as shown in Figure 8.2.

According to the fitted relationship between the wet gross pollutant load generated and the depth of rainfall (see Figure 8.1), events of less than 3.7 mm may be considered to be insufficient for re-mobilisation and transport of deposited street surface loads. The corresponding threshold for runoff (see Figure 8.2) is 0.70 mm. The fitted relationships between gross pollutant wet load and event rainfall depth or runoff show a trend of increasing gross pollutant load with increasing rainfall or runoff. Although the curves are monotonically increasing, the rate of increase in gross pollutant loads decreases with rainfall and runoff indicating a possible upper limit of gross pollutant load transported into the stormwater system during large rainfall or runoff events. The fitted curves in Figure 8.1 and 8.2 may be interpreted as indicating that the limiting mechanism for stormwater gross pollutant transport, in the majority of cases, is not the supply of gross pollutants but rather the processes (ie. the stormwater runoff rates and velocities) influencing the mobilisation and transport of these pollutants.

If the mobilisation and transportation of gross pollutants from the street surface depends on a rainfall depth greater than 3.7 mm, it is likely that the inter-event dry period for gross pollutant transporting storm events, in Melbourne will be longer than the calculated 2.6 days for all recorded storm events. Analysis of the cumulative frequency distribution of event rainfall depth for Melbourne over a 105 year record is presented in Figure 8.3. The analysis shows that approximately 35% of all recorded rainfall events are greater than 3.7 mm giving an average inter-event dry period of 178 hours (7.4 days) for gross pollutant transporting storm events.

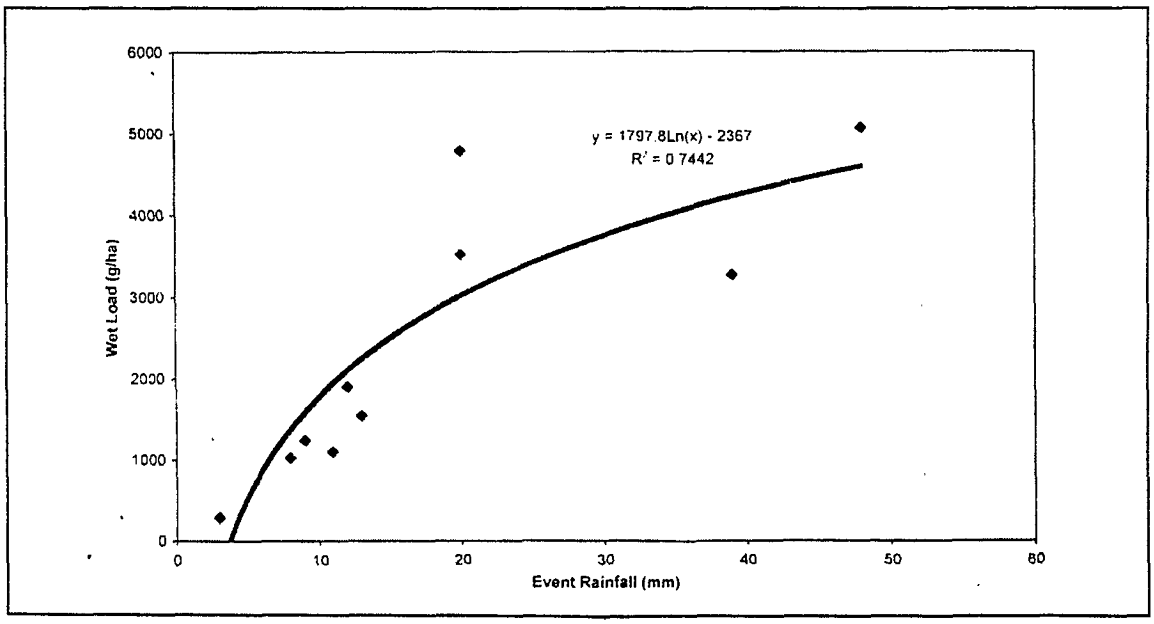

Figure 8.1 Gross Pollutant Wet Loads v's Rainfall (after Allison et al., 1998)

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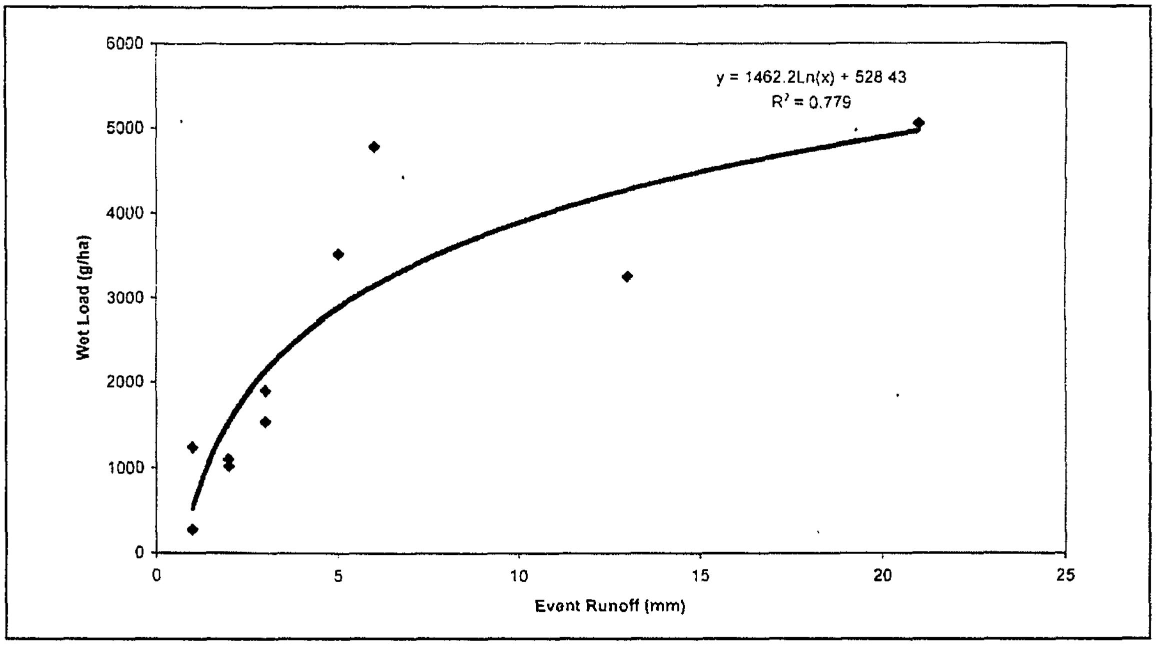

Figure 8.2 Gross Pollutant Wet Loads v's Runoff (after Allison et al., 1998)

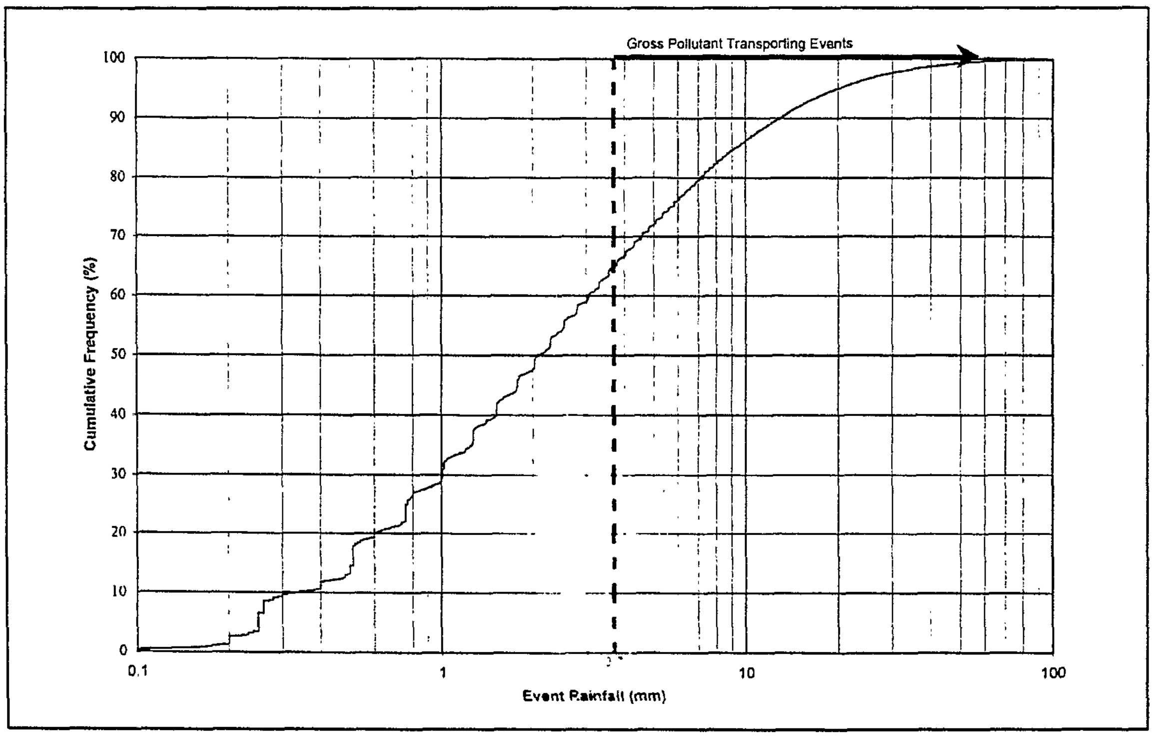

Figure 8.3 Cumulative Probability Distribution of Event Rainfall Depth for Melbourne

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The Coburg gross pollutant wet load data have incorporated the effect of Moreland City Council's street sweeping practices which range from daily to fortnightly, depending on land-use. How exactly any alterations made to the street sweeping frequency would affect the gross pollutant load in stormwater (see Figure 8.2) is not known and cannot be ascertained from the data collected. However, it is possible for some inference of the effectiveness of street sweeping in limiting the export of gross pollutants from street surfaces to the stormwater system to be made, and this will be discussed in Section 9.2.

Despite rainfall wash-off being the dominant factor transporting gross pollutants from street surfaces, litter can also reach the stormwater system during dry weather periods. The litter monitoring study, conducted by Hall and Phillips (1997), in the Carnegie commercial catchment indicated that during dry days numerous gross pollutant items are transported into the stormwater system by factors other than stormwater runoff (eg. wind or direct dumping). That study focused on measuring the number of litter items as well as material composition collected daily over seven days, from identified catchment pollutant sources. SEPTs were placed in drain entry pits located in the study area to determine the number of litter items reaching the stormwater system from the identified catchment pollutant sources (including bins, footpaths and street surfaces). The results showed that up to 78 items of litter in total (per day) were collected in SEPTs during periods without rainfall. A substantial amount of the material trapped during recorded dry days were lighter items (polystyrene) although numerous heavier items were also found, indicating possible direct littering rather than wind blown transportation of street surface pollutants.

Gross Pollutant Load Generation:

- Data collected in the Coburg catchment indicated washoff of gross pollutants becomes significant for storm events greater than 3.7 mm of rainfall depth or 0.70 mm of runoff.
- The limiting mechanism affecting the transport of gross pollutants in the majority of cases appears to be re-mobilisation and transport processes (ie. stormwater runoff rates and velocities) and not the supply of gross pollutants.
- Approximately 35% of all recorded rainfall events in Melbourne are greater than 3.7 mm giving an average inter-event dry period of 178 hours (7.4 days) for gross pollutant transporting storm events.

8.2 Influence of Catchment Land-use

As part of the same project, Allison et al. (1997b) investigated the effectiveness of side entry pit traps (SEPT's) by monitoring 192 SEPTs installed in all publicly owned side entry pits of the 50 hectare Coburg catchment as shown in Figure 8.4. The study aimed to assess the effectiveness of SEPTs by using a CDS unit located at the outlet of the catchment to collect any gross pollutants which may pass the SEPTs. The SEPTs were monitored from 2 August 96 to 15 November 96. During these four months, the traps were cleaned out on four separate occasions. For each of these clean-outs the total SEPT load (wet & dry) for each trap was calculated. Gross pollutant load data from that study are used for further analysis in this study.

SEPT gross pollutant wet load data were grouped according to the practiced street sweeping regime defined by catchment land-use. Figure 8.5 displays the three identified land-use sub-catchments in the Coburg catchment (50ha) as the daily swept South East (SE) commercial sub-catchment (13ha), the fortnightly swept North West (NW) & South West (SW) residential sub-catchments (24.5ha) and the daily / fortnightly swept North East (NE) mixed land-use sub-catchment (12.5ha).

The total SEPT gross pollutant wet loads were calculated and categorised according to street sweeping regime, defined by the three sub-catchment land-use types and are presented in Table 8.1. The days between clean outs, total rainfall between clean outs and the number of storm events, are also presented in Table 8.1. For the purpose of this analysis a storm event was identified as a storm that had the potential to re-mobilise deposited solids from the road surfaces and is described as a gross pollutant transporting event (ie. greater than 3.7 mm after Allison et al., 1997b). The SEPT wet loads have been normalised into a load (g) per unit catchment area (ha) to enable gross pollutant loads from the sub-catchments to be compared.

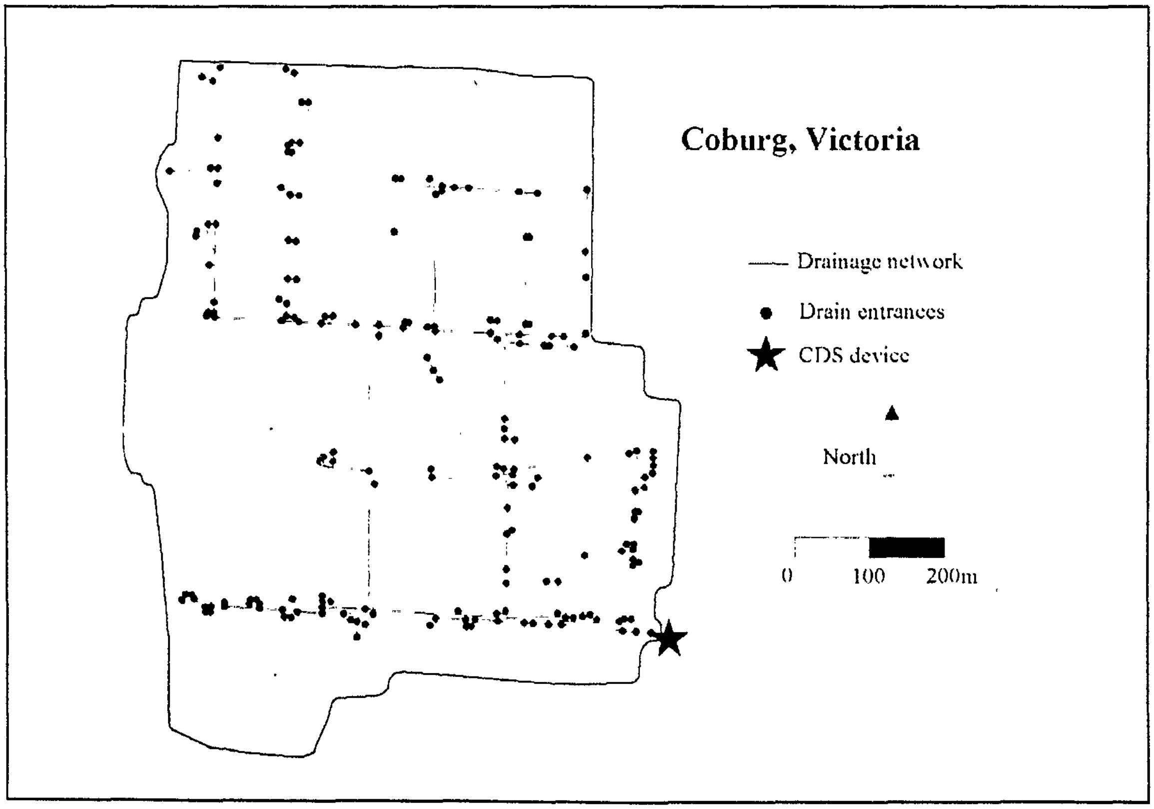

Figure 8.4 SEPT installations in the experimental 50ha Coburg Catchment (source Allison, 1998)

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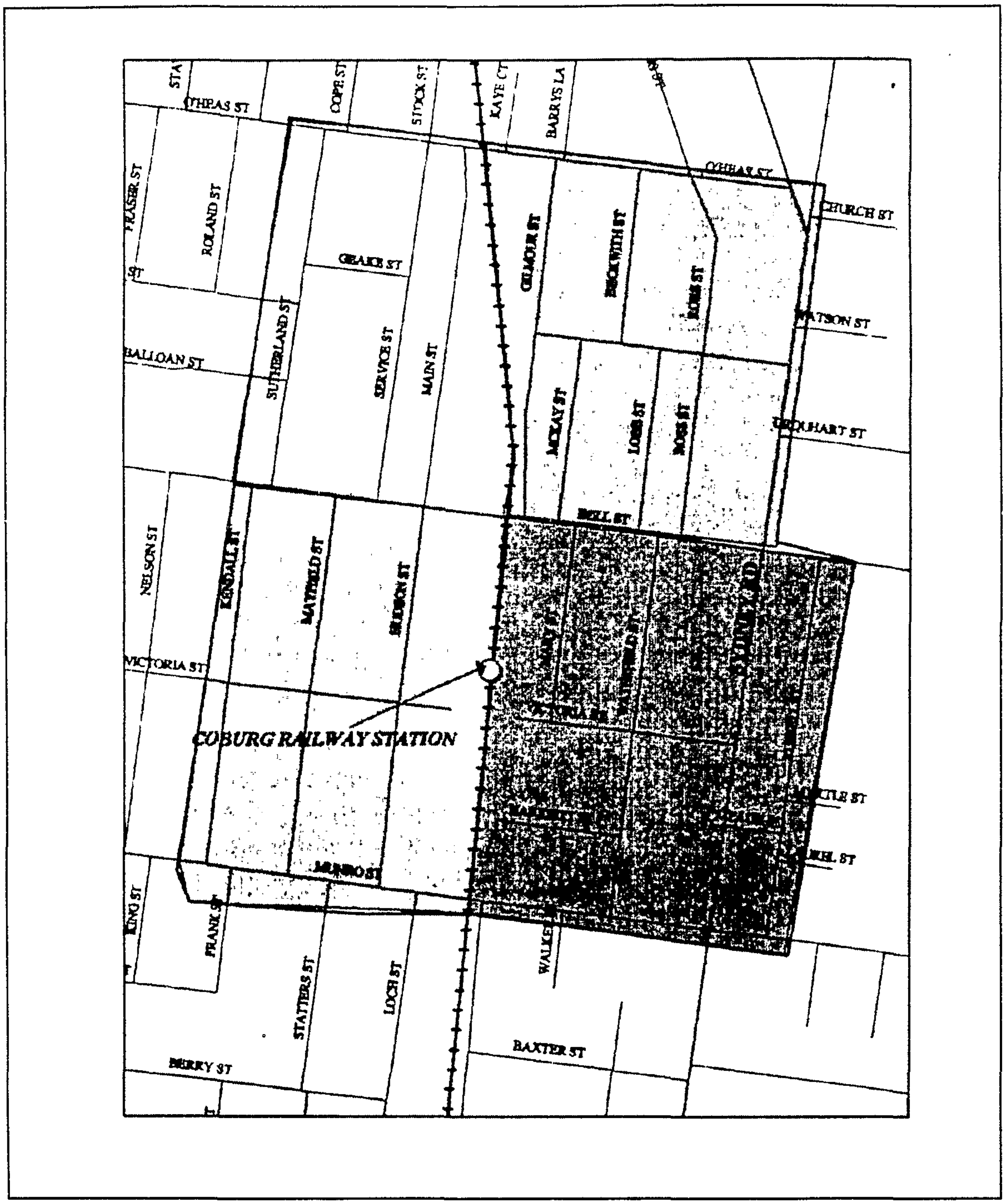

Figure 8.5 Land-use Sub-catchments in the 50ha Coburg Catchment
(source Moreland City Council and Merri Creek Management Committee, 1997)

Table 8.1 Event Rainfall and Related SEPT Total Gross Pollutant Wet Loads

Clean-out Date	Days between clean-outs	Total Rainfall (mm)	Storm Events (>3.7mm)	Single Event Rainfall (mm)	Event Rainfall (mm)	Commercial Wet Load (g/ha)	Residential Wet Load (g/ha)	Mixed Wet Load (g/ha)
29-Aug-96	27	55	5	(6.4) (10) (5) (15) (12)	48	5000	2408	1760
30-Sep-96	32	74	6	(11) (12.3) (16.4) (4.4) (9.4) (11.5)	65	20154	10041	6880
15-Oct-96	15	25	2	(8.2) (14)	22	6462	3143	1840
15-Nov-96	31	47	2	(7) (35.4)	42	6538	5878	1920

As indicated in Table 8.1, calculated total SEPT wet loads ranged from 1.8 kg/ha for the mixed land-use sub-catchment to as much as 20.2 kg/ha for the commercial sub-catchment. Figure 8.6 displays the comparison between land-use and total SEPT wet load, indicating commercial land-use contributes larger loads of gross pollutants per hectare compared to residential and mixed land-use catchments. This is in spite of daily street sweeping in the commercial sub-catchment compared to once every two weeks in residential and mixed land-use areas. Three of the four clean outs showed the ratio of gross pollutant load generation between the commercial and residential areas to be approximately 2.0. There was however, one clean out, that of the 15 November 96 which gave a significantly lower ratio of 1.1. It is interesting to note that the gross pollutant load generated from the mixed land-use was the lowest in all the four clean outs.

Many factors other than land-use contribute to the differences observed in the amount of gross pollutants exported from the different areas, including wind, traffic volume, topography, population density, community awareness and importantly the hydrologic conveyance system. Hydrologic conveyance factors which can influence gross pollutant export include the number of side entry pits in the stormwater system (ie. the average distance to entry pits from within the catchment), the degree of catchment area imperviousness and the extent of "supplementary areas" (defined as pervious areas over which runoff from impervious areas needs to traverse when discharging towards the stormwater drainage system) in these sub-catchments. Catchment topography, average distance along roadside kerbs and the extent of supplementary areas influence the required energy to re-mobilise and convey deposited gross pollutants to the stormwater system. The fraction imperviousness of the catchment influences the magnitude of the runoff from the catchment which in turn determines the energy available for re-mobilisation and transport of deposited gross pollutants in the catchment.

The results presented in Figure 8.6 are consistent with results from a separate study by Allison undertaken during 1995 to investigate the transport of gross pollutants from different land-uses within a 150 hectare catchment in Coburg. Gross pollutant loads from two storm events (27 January 95 and 31 May 95) were monitored at three locations representing mixed commercial/residential, residential and light industrial land-uses as shown in Figure 8.7 (Allison et al., 1998). On commencement of storm runoff, specifically designed gross pollutant samplers (Essery, 1994) were lowered, at varying time intervals, into the flow and used for gross pollutant sampling as illustrated in Figure 8.8.

Gross pollutant loads from the two storm events monitored for each land-use area are presented as dry mass per hectare of catchment area in Table 8.2. The computed unit area dry loads for the different land-uses were compared against the weighted average dry load for the three combined sub-catchments. These data indicate that commercial land-use catchments generate approximately twice the amount of gross pollutants compared to residential land-use and as much as three times the amount generated from light industrial land-use catchments.

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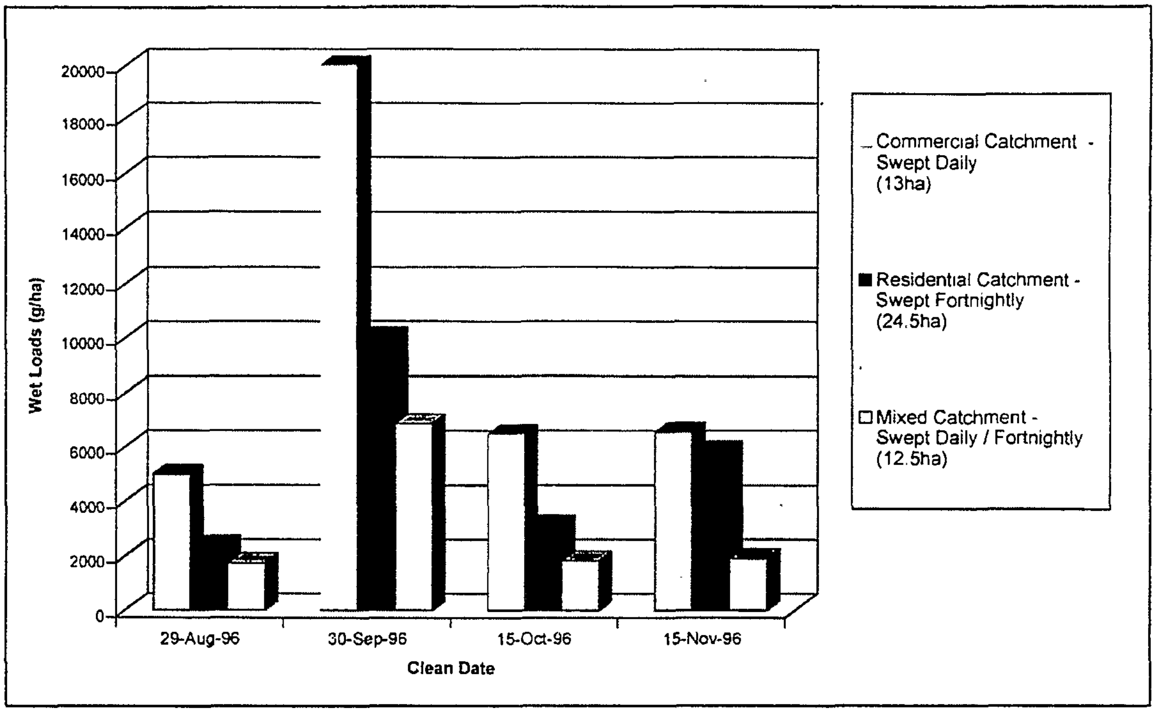

Figure 8.6 SEPT Wet Loads for Different Land use Catchment in Coburg.

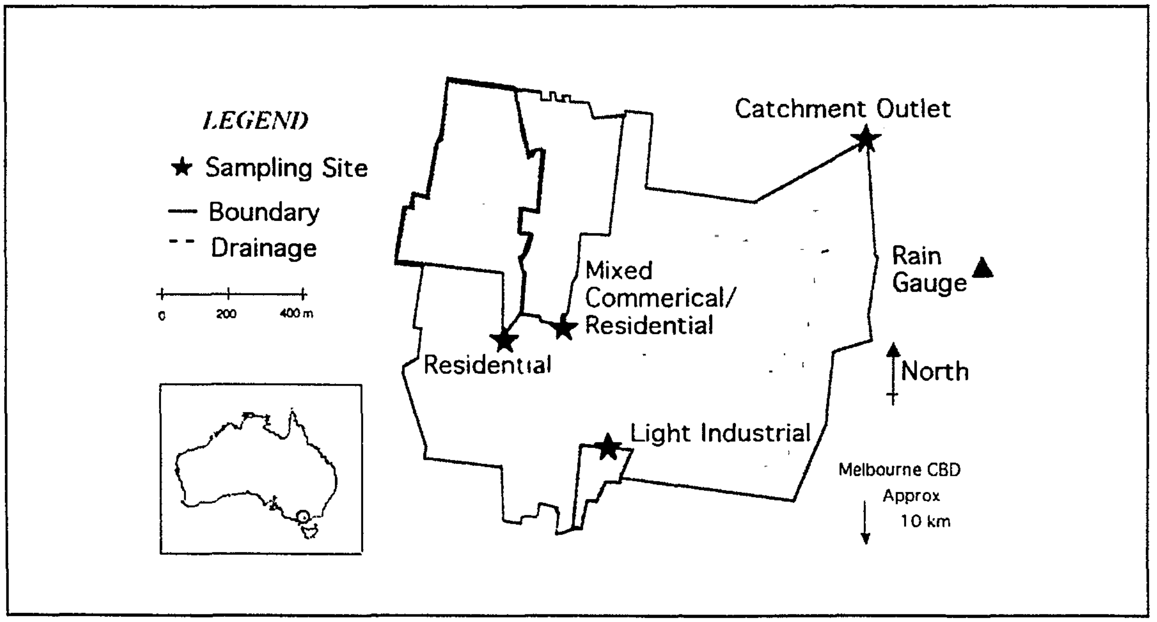

Figure 8.7 Coburg Land-use Monitoring Areas in the 150 ha Coburg Catchment
(source Allison et al. 1998)

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Table 8.2 Gross Pollutant Dry Mass Loads and Weighted Averages (after Allison et al., 1998)

Land Use	**Area** (ha)	**Total dry load per unit area**		
		27-Jan-95 (g/ha)	31-May-95 (g/ha)	Value / Weighted Average
Commercial	9.5	423	747	1.6
Residential	26.5	292	308	0.8
Light Industrial	2.5	242	63	0.5
Total	38.5			
Weighted Average		321	400	

Allison (1997b) noted that material often blinded the SEPT basket pores, leading to overflows from the baskets and thus a reduction in trapping efficiencies. The field study into the efficiency of SEPTs, found the trapping efficiency of SEPTs to be between 60% and 70% (Allison et al. 1998). The SEPT total wet loads given in Table 8.1 can thus be assumed to be an under estimation of gross pollutant loads generated from the respective sub-catchments.

The gross pollutant loads for three of the four SEPT clean-outs (see Figure 8.6) show similar relative contributions from the different land-use catchments as that derived from the study by Allison (1998) and summarised in Table 8.2. The commercial catchment was found to have generated the most load of gross pollutants on each of the clean out dates in spite of daily street sweeping. As noted earlier, the ratio of commercial to residential land-use gross pollutant load from three of the four clean out dates is approximately 2.0 except for the data from the clean out of 15 November 96. The gross pollutant load transported from the commercial area preceding the clean out of the 15 November 96 was found to be significantly lower than expected when compared to corresponding data from the residential area.

The gross pollutant load from the clean-out of 15 November 1996 was transported by two gross pollutant transporting storm events (ie.<3.7 mm), one with an event rainfall of 6.8 mm and the other 35.4 mm.

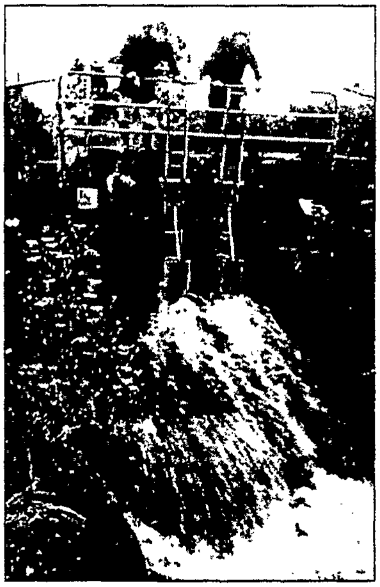

Figure 8.8 Sampling Gross Pollutants from Different Land-use Sub-catchments in Coburg (source Allison et al, 1998)

The lower than expected gross pollutant load from the commercial area in this clean-out may be related to a possible "supply limiting condition" during the large 35.4 mm storm event (a trend not apparent in the fortnightly swept, residential catchment). This notion is explored in Section 9.3.

Influence of Catchment Land-use:

- The fraction imperviousness of a catchment influences the runoff during storm events which influence the available energy for mobilisation of deposited gross pollutants.
- Commercial land-uses contribute larger loads of gross pollutants despite more intensive street sweeping frequencies.
- Relative gross pollutant loads generated from different land-uses show that commercial areas produce approximately twice the amount of gross pollutants than residential and three times as much as light industrial, despite a daily street sweeping regime in the commercial area compared to fortnightly in the residential and industrial areas.
- A number of transport factors are thought to also influence gross pollutant loads from different land-uses. Some of these factors include:-
  - Number of entrances to the stormwater system,
  - Fraction of catchment imperviousness,
  - Extent of pervious area over which runoff needs to traverse towards the stormwater drainage system.

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9 Discussion

9.1 Gross Pollutant Load and Rainfall Depth Relationship

The relationships between the gross pollutant load and rainfall depth (Figure 8.1) and runoff (Figure 8.2) derived from the Coburg data incorporate the effect of a typical Melbourne municipal street sweeping program, ranging in frequency from daily to fortnightly sweeping depending on catchment land-use. The relationships clearly show a trend of increasing gross pollutant load to the stormwater system with increasing rainfall or runoff, indicating that the limiting mechanism for stormwater gross pollutant transport in the majority of cases is stormwater runoff rates and velocities. While the curves are monotonically increasing, the rate of increase in gross pollutant loads entering the stormwater system decreases with rainfall and runoff indicating a possible upper limit of gross pollutant load transported into the stormwater system at relatively high rainfall depths or runoff. This possible upper limit of gross pollutant load may reflect the gross pollutant load deposited on street surfaces which is available for re-mobilisation into the stormwater system. A modification of the street sweeping frequency could potentially adjust this upper limit value, thereby altering the shape of the gross pollutant export curve as conceptualised in Figure 9.1.

9.2 Impact of Street Sweeping on Gross Pollutant Loads

It is not known how exactly any further alterations made to the street sweeping frequency will affect the gross pollutant export curve. Nevertheless the illustration in Figure 9.1 postulates that if street sweeping effort were reduced it can be expected that the gross pollutant load will increase, initially for those events with large rainfall depths. Further reduction in street sweeping frequency will ultimately lead to the increase of gross pollutants in stormwater systems becoming evident for even smaller storm events. Similarly, by increasing street sweeping effort, the reduction in gross pollutant load would essentially be confined to events of large rainfall depths. Figure 9.1 postulates that in most gross pollutant export events, the export load is defined by the size of the storm event rather than the available pollutant surface load.

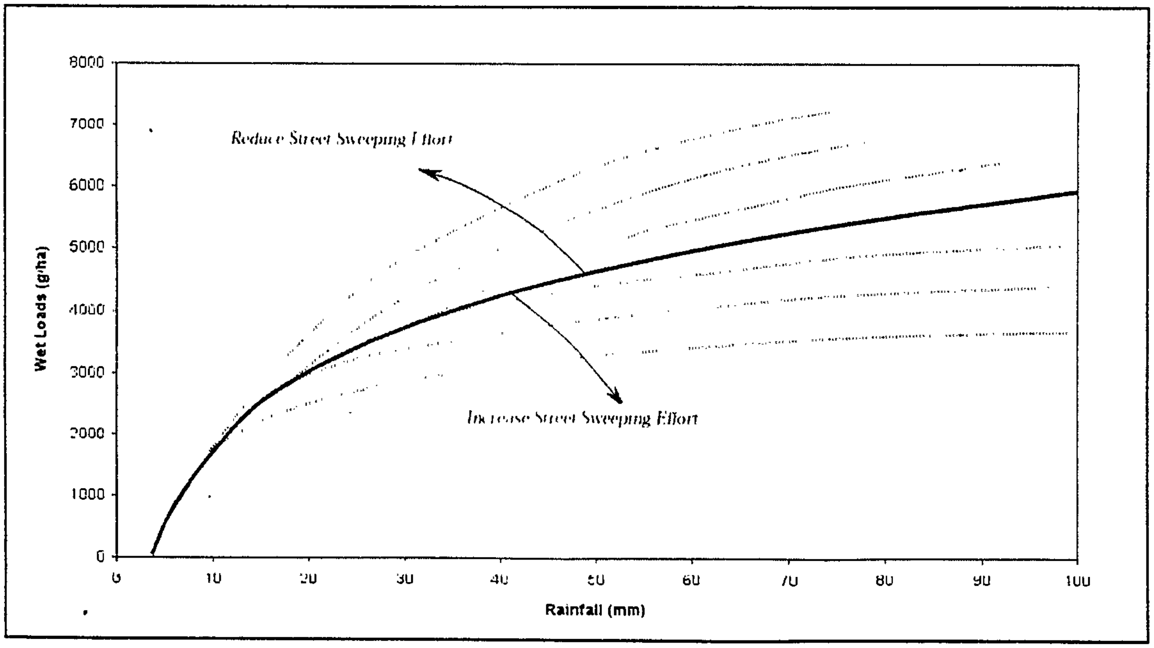

Figure 9.1 Hypothetical Gross Pollutant Load and Street Sweeping Effort

9.3 Supply Limiting Condition

The lower than expected gross pollutant load from the commercial area for the clean-out of the 15 November 96 noted in Table 8.1 of the previous section of this report may be explained by a possible "supply limiting condition" occurring during the large 35.4 mm storm event. It is possible that during this large event the available gross pollutants in the catchment have been substantially removed from the street surface and mobilised into the stormwater system, a trend not apparent in the fortnightly swept, residential catchment.

Based on the results of this investigation, it is postulated that a source limiting storm condition may have occurred during the 35 mm storm event. Storm events greater than 35 mm occur less than 3% of the time in Melbourne (see Figure 8.3) indicating that the occurrence of such a gross pollutant supply limiting condition would be very rare. This may have important implications for assessing the effectiveness of street sweeping. The incremental benefits of increasing the present street sweeping effort in the Coburg catchment (from the daily frequency of the commercial areas and fortnightly frequency in the residential areas) are expected to be low. The limiting factor affecting the transport of gross pollutants in the majority of cases appears not to be the supply of gross pollutants but instead the pollutant mobilisation and transport processes (ie. rainfall patterns and depths, runoff rates and velocities).

9.4 Street Sweeping Efficiency Issues

The use of new street sweeping technologies may contribute to reducing pollutant loads in the stormwater system as advocated by Sutherland and Jelen (1997). Taking into account influencing factors such as the inter-event dry period and catchment characteristics may enable the frequency and timing of street sweeping operations to be redesigned to meet specified stormwater improvement objectives for specific conditions. Street sweeping frequencies that are equivalent to three times the mean inter-event period (approximately 8 days for Melbourne) is considered to be appropriate as approximately 35% of storm events are considered to be gross pollutant transporting events. Also, conducting street sweeping at a time of day which enables the collection of pollutants when the rate of load acummulation of street surface has reached its highest would reduce the time pollutants are potentially exposed to the likelihood of rainfall events.

Factors contributing to inefficiencies in street sweeping are not confined to rainfall patterns (affecting the build-up and wash-off processes), frequency and timing of sweeping, size of pollutants and the sweeper mechanism. Street sweeping inefficiencies are further exacerbated by everyday practice limitations. Significant practice limitations associated with street sweeping include the inability of sweepers to access the street surface load due to parked vehicles (see Figure 9.2), inappropriate street design, poor road surface conditions and operator speed. Street sweeping program specifications must address these influencing factors as well as improving sweeper mechanisms before stormwater quality improvements may be realised from street sweeping practices.

The principle objective of street sweeping in meeting community demand for a standard of street cleanliness, and the perceived success of sweeping to fulfil this objective makes street sweeping an important municipal operation. However, there is little evidence to suggest significant incremental benefits in stormwater quality, particularly the removal of contaminants associated with the fine particulates, can be gained with increased street sweeping frequency.

The use of new street sweeping equipment may lead to increased effectiveness particularly for gross pollutants and coarse to medium sized sediment. There are however other operational limitations which will reduce the actual effectiveness of street sweeping from that determined under controlled test conditions. Furthermore, the use of new equipment will need to be associated with a street sweeping frequency that matches the catchment meteorological characteristics. Their cost effectiveness will need to be evaluated against the cost of installing and maintaining end-of-pipe or in-transit gross pollutant traps.

Figure 9.2 Street sweeping pollutant removal effectiveness is limited by parked cars

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10 Conclusions

This study has investigated the effectiveness of street sweeping for stormwater quality improvement. A number of factors are identified as influencing the effectiveness of street sweeping for the collection of street surface pollutants for stormwater pollution control rather than just aesthetic requirements. These factors include street sweeping mechanism, pollutant type, sweeping frequency and timing and also pollutant wash-off characteristics.

The most important conclusion from this study is that current Australian street sweeping practices are generally ineffective as an at source stormwater pollution control measure. Current street sweeping practices are found to be not only ineffective for the reduction of fine sediment and sediment-bound contaminants but also for larger gross pollutants capable of entering the stormwater system. Current Australian street sweeping mechanisms and practices are therefore regarded as providing very little benefit for stormwater quality improvements, due to inefficiencies at reducing a variety of pollutants from entering the stormwater system over a range of conditions. Street sweeping should be therefore accompanied by structural pollutant treatment measures to effectively reduce the discharge of gross and sediment associated pollutants in stormwater.

Increasing the frequency of current street sweeping practices beyond what is required to meet aesthetic objectives is not expected to yield substantial incremental benefits in relation to receiving water quality improvements. There seems little benefit in conducting detailed field monitoring investigations into quantifying the effectiveness of street sweeping as a stormwater pollution control measure for current Australian street sweeping mechanisms or operations. Other specific observations from this study are listed below.

Sweeping Mechanisms

- Mechanical and regenerative air street sweeping equipment requires a minium threshold load of sediment on the street surface before they become effective.
- The threshold load can be three times higher for the mechanical sweeper compared to the regenerative air system.
- Overall the regenerative air sweeper exhibits a substantially better performance than the regular mechanical sweeper.
- Street sweeping technology is developing and improving to remove finer street surface particles for a variety of street surface loads.

Gross Pollutants

- Significant amounts of gross pollutants are mobilised into the stormwater system during bursts of rain, wind or both.
- There is little correlation between the frequency of sweeping and the transport of gross pollutants into the stormwater system.
- Street sweeping efficiency increases with particle size.
- Sweeper efficiency can be up to nearly 80% for particles greater than 2 millimetres under 'test' conditions (ie. sweeping more frequently than the occurrence of rainfall events and effective use of parking restrictions).

Sediment and Other Suspended Solids

- The removal efficiency of sediment and other fine organic particles by conventional street sweepers was found to be dependent upon a threshold level of load on the surface and the particle size range of the surface loads.
- Material smaller than 300 μm was less affected by street sweeping.
- No effective removal (>50% removal efficiency) was evident for particle sizes smaller than 125 μm for conventional street sweepers (excluding the new small-micron surface cleaning technology).

Contaminants Associated with Sediment

- Significant amounts of metals and nutrients are transported as sediment-bound contaminants.
- Most of the total mass of contaminants is associated with the fine particles.
- Conventional street sweeping is generally ineffective at removing particles smaller that 300 μm and therefore will not effectively reduce the export of sediment-bound contaminants such as nutrients, metals and PAHs.

Removal of Sediment and Associated Contaminant

- Limited sampling of sediment in street runoff in Australia indicates that 70% of particles are less than 125μm compared to 20% for overseas data.
- The fine sediments found on Australian streets would suggest that conventional street sweeping will have a minimal effect on sediments and associated contaminants reaching stormwater systems.

Street Sweeping Frequency

- The variable nature of inter-event dry periods, both in terms of seasonal variation and dependence on climatic locations, highlights the importance of street sweeping program design which are specific to location and flexible to accommodate the local meteorological conditions and seasonal variability.
- It is anticipated that if street sweeping occurs at a longer interval than the inter-event dry period of the catchment, street surface pollutants will have a much higher likelihood of being flushed into the stormwater system before being collected by the street sweeper.

Street Sweeping Timing

- Recorded gross pollutant load generation over a typical day indicates that the accumulation of litter in a shopping strip begins at 8:00 am and effectively ends around 5:00 pm.
- Early morning street sweeping allows the exposure of deposited street surface litter items to a higher likelihood of being transported into the stormwater drainage system.

Gross Pollutant Load Generation

- Data collected in the Coburg catchment indicated washoff of gross pollutants becomes significant for storm events greater than 3.7 mm of rainfall depth and 0.70 mm of runoff.
- The limiting mechanism affecting the transport of gross pollutants in the majority of cases appears to be re-mobilisation and transport processes (ie. stormwater runoff rates and velocities) and not the supply of gross pollutants.
- Approximately 35% of all recorded rainfall events in Melbourne are greater than 3.7 mm giving an average inter-event dry period of 178 hours (7.4 days) for gross pollutant transporting storm events.

Influence of Catchment Land-use

- The fraction imperviousness of a catchment influences the runoff during storm events which influence the available energy for mobilisation of deposited gross pollutants.
- Commercial land-uses contribute larger loads of gross pollutants despite more intensive street sweeping frequencies.
- Relative gross pollutant loads generated from different land-uses show that commercial areas produce approximately twice the amount of gross pollutants than residential and three times as much as light industrial, despite a daily street sweeping regime in the commercial area compared to fortnightly in the residential and industrial areas.
- A number of transport factors are thought to also influence gross pollutant loads from different land-uses. Some of these factors include:-
  - number of entrances to the stormwater system,
  - fraction of catchment imperviousness,
  - extent of pervious area over which runoff needs to traverse towards the stormwater drainage system.

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National Pollutant Removal Performance Database for STPs: 2nd Edition

The Center recently completed the second edition of the *Stormwater Treatment Practice (STP) Pollutant Removal Performance Database* (the "Database") which modifies, clarifies, and expands upon the original *National Database of BMP Pollutant Removal Performance* (the First Edition) by Brown and Schueler (1997).

The First Edition included 129 studies and spanned a 19-year period; the minimum storm sampling criteria was four sampling events, and little effluent concentration data was included. Major changes to the First Edition include the following:

- Addition of 24 studies
- Elimination of studies that did not meet the new minimum storm sample criteria of five
- Update of existing entries to include effluent concentration and other data where available
- Addition of new fields

Eight of the studies included in the First Edition were deleted because of insufficient storm sample size. In addition, concentration data were added to existing studies to make the database a more powerful analysis tool. More than half of the original studies included both influent and effluent concentration data, and these data were not consistently included in the First Edition. Finally, several fields were added since the First Edition, including *Age of the Facility*, *Drainage Class* (based on drainage area), *Land Use Quantification* (e.g., percent commercial, residential, etc.), and storage in *Watershed* and *Impervious Inches*. Unfortunately, many studies did not report these data explicitly. Consequently, the database does not currently have sufficient data to develop relationships between specific site or design characteristics and performance. One exception is the *Drainage Class* field, which classifies ponds and wetlands as Pocket, Regular, or Regional. Although the results are not conclusive, sufficient data are available to characterize each data class.

Table 1. Median Pollutant Removal (%) of Stormwater Treatment Practices

	TSS	TP	Sol P	TN	NOx	Cu	Zn
Stormwater Dry Ponds	47	19	-6.0	25	4.0	26[1]	26
Stormwater Wet Ponds	80 (67)	51 (48)	66 (52)	33 (31)	43 (24)	57 (57)	66 (51)
Stormwater Wetlands	76 (78)	49 (51)	35 (39)	30 (21)	67 (67)	40 (39)	44 (54)
Filtering Practices[2]	86 (87)	59 (51)	3 (-31)	38 (44)	-14 (-13)	49 (39)	88 (80)
Infiltration Practices	95[1]	70	85[1]	51	82[1]	N/A	99[1]
Water Quality Swales[3]	81 (81)	34 (29)	38 (34)	84[1]	31	51 (51)	71 (71)

1. Data based on fewer than five data points
2. Excludes vertical sand filters and filter strips
3. Refers to open channel practices designed for water quality

NOTES:

- Data in parentheses represent values from the First Edition (Schueler, 1997; Appendix D).
- Shaded regions indicate a difference of at least ± 5% from the First Edition.
- N/A indicates that the data are not available.
- TSS = Total Suspended Solids; TP = Total Phosphorus; Sol P= Soluble Phosphorus; TN = Total Nitrogen; NOx = Nitrate and Nitrite Nitrogen; Cu = Copper; Zn = Zinc

The statistical reanalysis of the First Edition revealed some changes in the pollutant removal efficiencies of STPs (Table 1). These changes can be attributed to the addition of new studies and revisions to the older studies. Most of the shaded regions represent a pollutant removal increase of at least 5%. Three exceptions are nitrogen removal for filtering practices, which decreased by 16%; and zinc and soluble phosphorus removal of stormwater wetlands, which decreased by 18% and 10% respectively. The STP group with the greatest change over original data is filtering practices. This result is not surprising, since a significant number of changes were made to this group (five studies were added to the original 14). In particular, the negative soluble phosphorus in the original was caused by a few values from organic filters, and from one perimeter filter that had become submerged, releasing soluble phosphorus.

Table 2. Median Effluent Concentration (mg/L)[1] of Stormwater Treatment Practice Groups							
	TSS	TP	OP	TN	NOx	Cu	Zn
Stormwater Dry Ponds	28[2]	0.18[2]	0.13[2]	0.86[2]	N/A[3]	9.0[2]	98[2]
Stormwater Wet Ponds	17	0.11	0.03	1.3	0.26	5.0	30
Stormwater Wetlands	22	0.20	0.09	1.7	0.36	7.0	31
Filtering Practices[3]	11	0.10	0.08	1.12	0.55[2]	10	21
Infiltration Practices	17[2]	0.05[2]	0.003[2]	3.8[2]	0.09[2]	4.8[2]	39[2]
Water Quality Swales[4]	14	0.19	0.08	1.12	0.35	10	53

1. Units for Zn and Cu are micrograms per liter
2. Data based on fewer than five data points
3. Excludes vertical sand filters and filter strips
4. Refers to open channel practices designed for water quality

NOTES:
- N/A indicates that the data is not available.
- TSS = Total Suspended Solids; TP = Total Phosphorus; OP = Ortho-Phosphorus; TN = Total Nitrogen; NOx = Nitrate and Nitrite Nitrogen; Cu = Copper; Zn = Zinc

Median effluent concentrations by STP groups are summarized in Table 2. Effluent concentration data were added to the Database as a supplement to the pollutant removal capability of STPs. In some instances, pollutant removal percentage may not be a good indicator of the overall removal capability of a STP. Pollutant removal percentages can be strongly influenced by the variability of the pollutant concentrations in incoming stormwater. If the concentration is near the "irreducible level" (Schueler, T. 2000. "Irreducible Pollutant Concentrations Discharged from Urban BMPs," Article 65 in The Practice of Watershed Protection. Center for Watershed Protection. Ellicott City, MD.), a low or negative removal percentage can be recorded even though outflow concentrations discharged from the STP were relatively low. Although these data represent a median, unlike the group mean reported in Schueler (1996), the data suggest that the typical concentration data reported in this initial study and are high compared with the results from the Database.

The data presented in this study support the contention that most STP designs can remove significant amounts of sediment and total phosphorus in urban runoff. Most STP groups, on the other hand, showed a lower ability to remove nitrogen. This result suggests that non-structural nutrient reduction methods, in addition to stormwater STPs, may be needed to meet nutrient reduction targets.

Significant gaps do exist in our knowledge of the removal capability of certain STP designs and stormwater parameters. Filling these gaps should be the major focus of future STP monitoring research. The more well-studied STP groups (ponds, wetlands, and filters) should be re-directed to investigate internal factors (i.e., geometry and sediment/water column interactions) that may create the wide variability in pollutant removal that is characteristic of STP monitoring. Finally, more research is needed with respect to bacteria, dissolved metals, and hydrocarbons; all of these are pollutants associated with human health impacts. Such research could be of great value in developing better designs and reducing pollutant removal variability, allowing for more reliable pollutant reduction at the watershed scale.

The full report, "National Pollutant Removal Performance Database for Stormwater Treatment Practices: 2nd Edition," is available from the Center for $25. Please access our web site at www.cwp.org for ordering information.

STORMWATER MANAGEMENT

Metals Removal using StormFilter™ Technology (Field Studies)

September 11, 2000

Overview: Data collected from several StormFilters are presented below. The data pertain to both total and dissolved zinc (Zn), copper (Cu) and lead (Pb) removal using various field sites and the CSF® leaf media or surface modified zeolite (SMZ) mixed with perlite.

Site Descriptions: Several sites are presented within the Results section below. The following list helps describe each site, site use and sampling protocol used for evaluation.

Giles (Olympia, Washington) – 200-acre watershed comprised of mature commercial and residential developments, 12' x 37' StormFilter with 80 cartridges. Samples were taken using flow pacing and grab sampling.

Lake Stevens (Snohomish County, Washington) – roadway runoff prior to bridge, 30,000 ft^2 of impervious, 8' x 14' StormFilter with 9 cartridges. Sampling was flow weighted and composite.

Caltrans Maintenance (California Department of Transportation maintenance facility, San Diego, California) - storage and repair of equipment, 3) 8' x 18' StormFilters with 79 cartridges. Samples were composite and flow paced over the entire storm.

Straley's BP (Bremerton, Washington) – gas station, 8' x 16' StormFilter with 23 cartridges. Samples were taken using flow pacing. Samples were also composite to obtain a first flush sample (first 1 hour of runoff).

Results: Tables One, Two, Three, Four and Five present the acquired metals removal observed at the sites listed above. The tables are organized according to the filtration media and metal. Table One and Two pertain to the CSF leaf media and zinc and copper removal. Tables Three, Four and Five present the use of SMZ surrounded by perlite for the removal of zinc, copper and lead, respectively.

Calculations pertaining to percent removal were calculated using Equation 1 below:

$$\%\,Removed = \left(\frac{Influent\ Concentration - Effluent\ Cocentration}{Influent\ Concentration}\right)\times 100 \quad (Equation\ 1)$$

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Table One: Zinc Removal [CSF® Leaf media]

Site	Influent Total-Zn (mg/l)	Effluent Total-Zn (mg/l)/ Percent Removed	Influent Dissolved-Zn (mg/l)	Effluent Dissolved-Zn (mg/l)/ Percent Removed	Sample Type/Date
Giles	0.045	0.033 **26.7%**	NT	NT	Flow Paced/September 25, 1997
Giles	0.2	0.16 **20%**	0.15	0.12 **20%**	Grab samples/July 23, 1998
Giles	0.106	0.071 **33%**	NT	NT	Flow Paced/August 26, 1997
Lake Stevens	0.121	0.086 **28.9%**	NT	NT	Flow Weighted/October 4, 1996
Straley' BP	0.3	0.086 **71.3%**	0.27	0.076 **71.9%**	Flow Paced First Flush/April 25, 2000
Straley's BP	0.27	0.12 **55.6%**	0.24	0.11 **54.2%**	Flow Paced/April 25, 2000
Straley's BP	0.39	0.11 **71.8%**	0.23	0.11 **52.2%**	Flow Paced First Flush/June 6, 2000
Straley's BP	0.18	0.11 **38.8%**	0.13	0.085 **34.6%**	Flow Paced / June 6, 2000

NT = Not Tested

Table Two: Copper Removal [CSF® Leaf Media]

Site	Influent Total-Cu (mg/l)	Effluent Total-Cu (mg/l)/ Percent Removed	Influent Dissolved-Cu (mg/l)	Effluent Dissolved-Cu (mg/l)/ Percent Removed	Sample Type/Date
Giles	0.0072	0.0078 **-8.3%**	NT	NT	Flow Paced/September 25, 1997
Giles	0.014	0.008 **42.9%**	0.011	0.008 **27.3%**	Grab samples/July 23, 1998
Giles	0.0208	0.0137 **34.1%**	NT	NT	Flow Paced/August 26, 1997
Lake Stevens	0.013	0.01 **23.1%**	NT	NT	Flow Weighted/October 4, 1996

Table Three: Zinc Removal [Surface Modified Zeolite (SMZ) and Perlite]

Site	Influent Total-Zn (mg/l)	Effluent Total-Zn (mg/l)/ Percent Removed	Influent Dissolved-Zn (mg/l)	Effluent Dissolved-Zn (mg/l)/ Percent Removed	Sample Type/Date
D.O.T. Maintenance	0.34	0.27 **20.6%**	0.17	0.13 **23.5%**	Flow Paced / March 25, 1999
D.O.T. Maintenance	0.23	0.19 **17.4%**	0.15	0.14 **6.7%**	Flow Paced / April 7, 1999
D.O.T. Maintenance	0.18	0.084 **53.3%**	0.10	0.08 **13.7%**	Flow Paced April 11, 1999
D.O.T. Maintenance	0.58	0.31 **46.6%**	0.37	0.09 **75.1%**	Flow Paced January 25, 2000
D.O.T. Maintenance	0.60	0.32 **46.7%**	0.22	0.13 **40.9%**	Flow Paced February 16, 2000
D.O.T. Maintenance	1.0	0.41 **59%**	0.11	0.07 **38.2%**	Flow Paced / February 20, 2000
D.O.T. Maintenance	1.9	0.18 **90.5%**	0.12	0.08 **35%**	Flow Paced March 5, 2000
D.O.T. Maintenance	1.3	0.41 **59%**	0.17	0.16 **5.9%**	Flow Paced March 8, 2000

Table Four: Copper Removal [Surface Modified Zeolite (SMZ) and Perlite]

Site	Influent Total-Cu (mg/l)	Effluent Total-Cu (mg/l)/ Percent Removed	Influent Dissolved-Cu (mg/l)	Effluent Dissolved-Cu (mg/l)/ Percent Removed	Sample Type/Date
D.O.T. Maintenance	0.059	0.053 **10.2%**	0.025	0.024 **4%**	Flow Paced / March 25, 1999
D.O.T. Maintenance	0.051	0.035 **31.4%**	0.032	0.022 **31.3%**	Flow Paced / April 7, 1999
D.O.T. Maintenance	0.067	0.029 **56.7%**	0.02	0.019 **5%**	Flow Paced April 11, 1999
D.O.T. Maintenance	0.14	0.062 **55.7%**	0.10	0.017 **83%**	Flow Paced January 25, 2000

Site	Influent Total-Cu (mg/l)	Effluent Total-Cu (mg/l)/ Percent Removed	Influent Dissolved-Cu (mg/l)	Effluent Dissolved-Cu (mg/l)/ Percent Removed	Sample Type/Date
D.O.T. Maintenance	0.14	0.058 **58.6%**	0.04	0.03 **25%**	Flow Paced February 16, 2000
D.O.T. Maintenance	0.3	0.072 **76%**	0.02	0.012 **40%**	Flow Paced / February 20, 2000
D.O.T. Maintenance	0.34	0.032 **90.6%**	0.023	0.013 **43.5%**	Flow Paced March 5, 2000
D.O.T. Maintenance	1.4	0.064 **95.4%**	0.025	0.023 **8%**	Flow Paced March 8, 2000

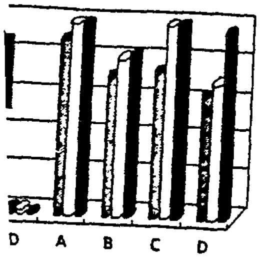
Table Five: Lead Removal [Surface Modified Zeolite (SMZ) and Perlite]

Site	Influent Total-Pb (mg/l)	Effluent Total-Pb (mg/l)/ Percent Removed	Influent Dissolved-Pb (mg/l)	Effluent Dissolved-Pb (mg/l)/ Percent Removed	Sample Type/Date
D.O.T. Maintenance	0.04	0.0034 **15%**	0.0027	0.0037 **-37%**	Flow Paced / March 25, 1999
D.O.T. Maintenance	0.019	0.016 **15.8%**	0.021	0.023 **-9.5%**	Flow Paced / April 7, 1999
D.O.T. Maintenance	0.028	0.011 **60.7%**	<0.001	<0.001	Flow Paced April 11, 1999
D.O.T. Maintenance	0.034	0.028 **17.6%**	0.0095	0.0014 **85.3%**	Flow Paced January 25, 2000
D.O.T. Maintenance	0.056	0.028 **50%**	0.0053	0.0046 **13.2%**	Flow Paced February 16, 2000
D.O.T. Maintenance	0.14	0.044 **68.6%**	0.0016	0.0017 **-6.2%**	Flow Paced / February 20, 2000
D.O.T. Maintenance	0.055	0.016 **70.9%**	0.0032	0.001 **68.8%**	Flow Paced March 5, 2000
D.O.T. Maintenance	0.14	0.059 **57.9%**	0.0067	0.0054 **19.4%**	Flow Paced March 8, 2000

Discussion: As presented, metals removal varies with influent concentration and with respect to the dissolved fraction of the metal entering the StormFilter. Most observations show that high influent concentrations produce a higher percent removal. The dissolved fraction also influences percent removal in that the higher the dissolved fraction, the more difficult the metal is to remove.

Removal of the dissolved fraction of metal is primarily associated with cation exchange where a calcium or magnesium atom is displaced by a zinc, copper or lead atom. This occurs within the media's lattice and requires that the dissolved metal carry a positive charge. However, stormwater is a complex mixture of nutrients, organic compounds and suspended solids. Metals such as copper and zinc can also travel with small dissolved organic compounds (colloids) and do not have the positive charge needed for removal through cation exchange. In a sense, these metals are inert due to charge association with the organic molecules. However, analysis of the colloidal fraction is detected when analyzing for dissolved metals although the metal is not 'purely' dissolved and carrying a positive charge. (Note: Colloids can pass through a 0.45-micron filter when filtering for dissolved metal analysis.) Removal of the colloid bound metal is difficult due to the lack of a positive charge and the extremely small size of the associated organic molecule.

Removal of the solid bound metal (actually attached to the suspended solids) is promoted through the process of stormwater filtration. The process is a physical straining of the suspended solids that, in turn, removes the associated solid bound metal. (Note: The removal of this fraction of metal is associated with total metals analysis due to all particles being larger than 0.45 microns.)



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Catch basin inserts to reduce pollution from stormwater

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Abstract Stormwater contamination represents the largest source of contaminants to many receiving waters in the United States, such as Santa Monica Bay in Los Angeles, California. Point sources to these same waters generally receive secondary or better treatment before they are released, and they are usually discharged through outfalls that diffuse the wastewater plume to prevent it from contacting the shoreline. Stormwaters receive no treatment and reach the receiving waters through a variety of ways, but most enter through catch basins or inserts to storm drains that terminate at the beach or in shallow coastal areas. Under these conditions, the stormwater discharge may have greater impact on the quality and utility of the receiving water than the treated wastewater discharges. One method of reducing pollution is to equip catch basins with an insert that can capture pollutants. A number of commercially available devices exist but few have been evaluated by independent parties in full-scale applications. A series of tests using bench and full-scale devices under both laboratory and field conditions were conducted to evaluate their ability to remove trash and debris, suspended solids and oil and grease in stormwaters. The results presented in the paper should provide a basis for future insert development and application.

Keywords Best management practice; catch basins; litter; stormwater; urban runoff

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Introduction

Most industries and municipalities in the United States have full secondary wastewater treatment, and some have nutrient removal and filtration. As a consequence of these reductions in water pollution, stormwater now represents the greatest threat to aquatic habitants in the United States. Stormwater quality has been largely ignored in many areas, although there is usually concern for flood control and flood damage prevention. As a result, we have stormwater management systems that prevent floods at the expense of environmental protection.

Los Angeles is a good example of an area that has emphasized flood control at the expense of environmental protection. In this highly urbanized area there is little opportunity to reduce stormwater pollution through traditional means. The average imperviousness is more than 60% in many cases. Land values are such that it is prohibitively expensive to retro-fit storage basins or infiltration zones. This paper addresses a potential best management practice for such urbanized areas. The stormwater system has been constructed with catch basins, which may be several cubic meters in volume. These catch basins can be retrofit with devices, called "inserts", to capture pollutants. A number of commercially available devices exist, but few have been evaluated by independent parties in full-scale applications. The authors conducted a series of tests using bench and full-scale devices to remove trash and debris, suspended solids (TSS) and oil and grease (O&G). Field tests were also performed with boards, screens and baskets to observe their ability to remove or prevent debris from entering storm drains. The results are sufficiently promising to suggest additional testing with a variety of devices.

Background

Santa Monica Bay is the receiving water for a major portion of the City of Los Angeles metropolitan area. The watershed is 1072 km^2, and is largely urbanized, serving a proportion of the three million people in Los Angeles and more than 11 million people in the metropolitan area. Only two wastewater treatment plants discharge directly into the bay; the largest is the Hyperion Treatment Plant (~1.3×10^6 m^3/day). This plant has recently achieved full secondary treatment, and discharges secondary treated wastewater via an 11 km outfall. The second source is a petroleum refinery that has advanced wastewater treatment. Another source is Los Angeles County's Joint Water Pollution Control Plant (~1.3×10^6 m^3/day, ~60% secondary), which discharges outside of the bay, and is upgrading to secondary treatment. Currents carry the partially treated wastewater into the bay.

The improved treatment has decreased pollutant discharge to the bay by more than an order of magnitude during the past 20 years. As a result, non-point sources now contribute an increased fraction of the total pollutant mass to the Bay (Wong *et al.*, 1997). The non-point contribution is already the major source for many pollutants, e.g. heavy metals, and will become the major source for many more pollutants as full secondary treatment is achieved. Reclamation and water conservation will further reduce point source contamination to the bay.

Various agencies, cities and environmental advocacy groups have proposed structural methods for reducing stormwater pollution. These methods are all difficult to employ because they are small-scale solutions that must be applied to a very broad area, across many jurisdictions with varying interests in controlling stormwater pollution. One proposed method for controlling discharges is to use catch basin inserts.

Catch basin inserts are devices that can be placed into a catch basin or stormwater insert, which will in some way reduce pollutant discharge to the receiving water. A variety of devices have been proposed and marketed, but very few have been evaluated by independent sources, or have been used long enough to create a record of performance. In order to establish creditable performance of insert devices, a consortium composed of the Santa Monica Bay Restoration Project and 14 other Santa Monica area jurisdictions funded a two-year study to determine if inserts are a viable method for controlling stormwater pollution. The results of this initial study (WCC, 1998) were sufficiently promising to warrant additional laboratory testing and a field study.

Objectives were established for testing and insert development. These were based in part upon environmental impact of the pollutants, but in greater part upon the ability of a hypothetical device to remove the pollutant in the constrained volume of a catch basin (generally only a few cubic meters). Litter (trash, debris, etc.), particulates and oil and grease were selected as pollutants of concern. Litter was selected because of its interest to regulators and its high visibility with the public. Total Daily Maximum Discharge Limits (TMDLs) will soon be applied to the Santa Monica Bay Watershed, and litter will be among the first. Particulates, as measured by total suspended solids (TSS) are especially important because a large fraction of the heavy metals in stormwater are adsorbed to their surfaces. Oil and grease, especially oil and grease from vehicular areas, is important because it may contain many anthropogenic compounds that may be toxic to aquatic life.

The approach was divided into two parts: dry and wet weather. This was required because of the seasonal rainfall and the desire to collect litter during the long dry period (generally April to November). It was envisioned that controls would be used in dry weather that would be removed in the wet season. Additionally, public agencies were adamant not to increase flood risks. The approximate cost of installation should be no more than US$ 500; cleaning should be infrequently required. A survey of the member cities suggested that, on average, catch basin cleaning occurred no more frequently than once every two months for beach communities, and approximately once per year for Los Angeles County, as a whole. A problem-solving, practical approach was required. The inserts should not

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increase flood risk and should only marginally change the way stormwater is removed from streets, without increasing the accumulation on streets. Safety considerations such as avoiding confined space entries were important. The public agencies responsible for managing the inserts would soon tire of them if they could not be conveniently, economically and safely maintained.

A sampling program was conducted and differed from previous programs in that samples were collected directly from stormwater on street surfaces, just prior to entry into catch basins. Litter was not measured in the water quality program but was measured during the dry periods as accumulation in the catch basins.

Sampling program

Four locations were selected and sampled during the storm events of the 1997–1998 wet season. This was significant in that it is an El Nino year, and rainfall was at least 200% greater than normal. Table 1 shows the sites and information about them. They were all in the City of Santa Monica and within 4 km of each other.

Samples were taken by scooping 100 to 200 ml at a time until 8 l samples were collected. For short storms only one such sample was collected. For longer storms, three samples were collected and averaged. The oil and grease concentrations were measured by solid phase extraction (Lau and Stenstrom, 1995) and do not include the oil adsorbed to suspended solids. Table 2 shows the mean and standard deviation of conventional water quality parameters for 14 storm events between October 1997 and February 1998. Generally, water quality is worse for Site 1, although the variability tends to make statistical significance

Table 1 Site description

Site number	Land use type	Area (m^2)
1	Commercial (parking lot)	14,000
2	Commercial (streets with small businesses, shops, restaurants, etc.)	7,000
3	Single and multifamily residential	23,000
4	Single and multifamily residential	18,000

Table 2 Stormwater quality (mean followed by standard deviation)

	Concentration							
	Site 1		Site 2		Site 3		Site 4	
Water quality parameter	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
TSS (mg/l)	55.1	71.6	38.6	32.3	32.7	33.0	34.1	38.2
VSS (mg/l)	38.5	60.5	21.6	14.7	18.5	18.2	18.1	17.7
Turbidity (NTU)	21.2	24.4	14.4	11.3	11.4	8.2	12.0	10.4
Conductivity (mmho/cm)	153.3	199.4	155.2	163.3	180.3	144.2	151.4	146.0
pH	6.4	0.4	6.7	0.4	6.8	0.5	6.9	0.6
Alkalinity (mg/l as $CaCO_3$)	19.1	13.2	22.5	13.0	27.8	16.7	26.0	15.6
Hardness (mg/l as $CaCO_3$)	38.8	42.4	37.8	33.8	41.3	31.1	44.9	41.2
COD (mg/l)	171.7	205.0	100.9	119.3	106.0	102.5	111.3	116.3
SPE oil and grease (mg/l)	7.4	10.3	5.5	5.7	5.3	5.2	5.8	8.0
Ammonia (mg/l as NH_3–N)	1.3	1.1	1.0	1.0	1.6	1.3	0.9	0.8
Cl^- (mg/l)	26.6	36.0	25.6	28.8	24.7	20.9	20.7	19.2
NO_3^- (mg/l as NO_3–N)	0.1	0.2	0.1	0.1	0.3	0.4	0.2	0.2
DOC (mg/l)	40.1	57.1	31.4	44.9	26.8	29.1	26.3	28.8

Av.=average; Std. dev.=standard deviation

Table 3 Selected total metals and percent adsorbed to suspended solids

Metal	Concentration							
	Site 1		Site 2		Site 3		Site 4	
	µg/l	%	µg/l	%	µg/l	%	µg/l	%
Aluminium	2235	96	1141	91	1335	91	678	76
Copper	103	53	42	6	52	8	40	11
Lead	45	93	4	33	7	46	11	17
Nickel	75	83	24	61	38	56	39	71
Zinc	2601	70	2062	63	2377	74	1321	70

%=percentage of particulate phase

Table 4 Size fraction of TSS from site 1

Size distribution (µm)	Distribution (%)
> 150	26
150 – 75	13
75 – 45	11
< 45	50

testing difficult. Trash and debris were not quantified, but trash and debris from the commercial sites was obviously greater. Table 3 shows the results for selected metals (only four storm events), as a total concentration and the distribution that was adsorbed onto the suspended solids. These results tended to confirm that metals were associated with the suspended solids.

Toward the end of the sampling period, various insert devices had been evaluated, and it became apparent that the devices could remove larger particles. Therefore additional sampling was performed to determine the size of the particles that compose the TSS. Site 1 was monitored for three storms and the TSS was determined by bailing several hundred litres of water through sieves. Particle sizes are shown in Table 4. These results suggest, for example, that a device that could remove particles larger than 75 µm could remove 39% of the TSS.

Insert evaluation

A survey of all commercially available inserts was performed. At the time of the survey (1997–1998), no devices were found that met all the criteria. A number of promising technologies were found that could treat stormwater, but not for the most common catch basin geometry used in greater Los Angeles. After some review, a concept was developed for a basket that could be inserted and removed through the opening of the catch basin, as shown in Figure 1. Several manufacturers offered prototypes featuring this general concept. This device has the advantage of being useful for both dry and wet weather applications. This design has the advantage of easy installation. An insert that is flexible, or is no greater in width than the opening in the curb, can be inserted and removed from the street. Two chains or cables to the curb support the insert. Workers do not need to enter the catch basin, which in some places is considered a confined space. Alternatively, if worker entry to the catch basin is permissible, the inserts can be installed by bolting to the interior wall. Additionally, high flows are directed around the insert, and flood risk is not increased. Additional material including photographs is available elsewhere (WCC, 1998).

The climate in Southern California presents a special opportunity for dry weather control. The litter that accumulates during the spring and summer, if not removed from catch

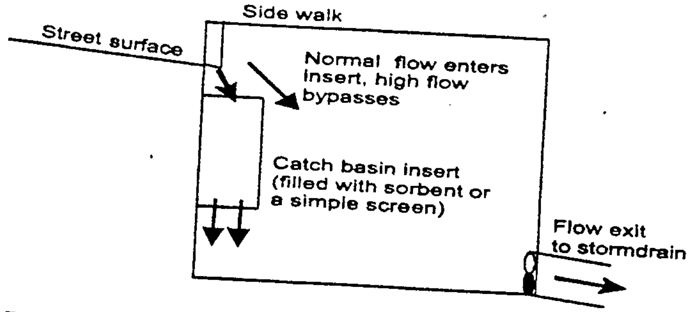

Figure 1 Elevation view of the model catch basin insert developed in this study. Typical minimum basin dimensions are 1 m tall by 0.75 m deep by 1 m wide. The minimum opening is typically 0.15 m

basins, is swept into the bay by the first large storm of the season. To mitigate this problem, the basins are cleaned in September or October. One community has routinely covered catch basins (curbside inlet only) in the dry season to prevent litter build up, insect and rodent problems. Street sweepers then remove the litter, and street sweeping is routinely practiced in these locations. The cover consisted of a plywood board, extending the entire length of catch basin with a gap of 1–2 cm between the bottom of the board and the pavement to allow for nuisance water to enter the basin. The covers or "boardovers" are used only for catch basins in sensitive or high litter-producing areas, and must be removed prior to the rainy season.

To better understand the utility of this practice, two catch basins were covered with plywood and two with wire screens with 2.5 cm square openings. Trash accumulation was monitored. The screens and boards provided roughly equal performance, preventing more than 95% of the build-up in the catch basin, as compared to controls with no covers. Tests were conducted with conventional street sweepers to show that they were capable of removing material that accumulated at the bottom of the covers, and that the sweeper did not destroy the covers. The covers are especially useful in areas with high pedestrian traffic.

Tests to evaluate the inserts' ability to remove contaminants from flowing stormwater were conducted in phases at different scales. Bench scale tests, full-scale laboratory tests and field tests were conducted. Field tests were conducted primarily during the second year of the study. The majority of the testing evaluated oil and grease removal. Many commercially available inserts or stormwater treatment devices claimed that sorbents could be used to remove the oil and grease from stormwater. Previous tests by the authors (Lau and Stenstrom, 1995) also suggested that this might be promising.

Tests were first conducted in columns with 5 cm diameter and height of 5 cm, with mixtures of used motor oil (to simulate the oil and grease in stormwater from commercial areas) and tap water using many different types of sorbents. The oil and grease concentration was generally set to approximately 25 mg/l, which is higher than found in this study, but closer to concentrations of oil and grease found in earlier studies by the author (Stenstrom *et al.*, 1984; Fam *et al.*,1987). Emulsified oil was produced by intensely blending used motor oil with 1 l of tap water to produce a "stock" mixture, which was then further diluted when pumped to the column. Free oil and grease was produced by pumping oil and grease using a syringe pump into a mixing "tee" which was then applied to the columns. The combined flow was allowed to "trickle" through the loosely packed column.

Table 5 shows some of the results. The reported efficiencies are for the period when the sorbent remains "fresh" or unexhausted. As the sorbent is saturated, its efficiency will decline. The mass of adsorbed material per unit mass of sorbent, analogous to "*Q*" or "*M*" for activated carbon isotherms, is an important parameter for overall operation. It

Table 5 Removal efficiencies of various sorbents

Sorbent type	Oil and grease type	Removal efficiency (%)
OARS polymer	Emulsified	3
Activated carbon	Emulsified	11
Aluminium silicate (e.g., perlite, Xsorb)	Emulsified	~0
Straw	Emulsified	~0
Compost	Emulsified	~0
OARS polymer	Free	88, 91
Aluminium silicate (e.g., perlite, Xsorb)	Free	88, 91, 94, 89
Compost	Free	28, 49
Polypropylene (type 1)	Free	86, 92
Polypropylene (type 2)	Free	78, 85

Table 6 Summary of OARS insert device tests

Test no.	Prototype no.	Sorbent condition	Q (l/min)	Influent O&G conc. (mg/L)	Removal efficiency (%)	Final M** (g)
A	1	New	56	20.7	91	11
B	2	New	56	14.1	74	6
1	2	Used in the field*	56	8.4	73	40
2	2	Used from test 1	56	24.7	79	172
3	2	Used from test 2	132	10.7	62	275
4	3	New	132	19.0	78	233
5	3	Used from test 4	132	14.0	65	374
6	3	Used from test 5	132	10.9	46	452
				Inf. TSS (mg/l)		Mesh size
8	3	From test 6		66	99	40
				66	96	60
				66	78	100
				200	91	Average
				PAHs (nominal conc. 50 μg/l)		
9	3	New		Acenapthene	34	
				Fluorene	31	
				Phenanthrene	33	
				Anthracene	61	
				Fluoranthene	33	
				Pyrene	42	
				Chrysene	26	
				Benzo(a)pyrene	16	

* does not include oil and grease removed in the field;
** M = total mass of O&G absorbed (g)

determines the sorbent replacement frequency and therefore the economics of operation. Further work in our laboratory is ongoing to determine these parameters. The sorbents shown in Table 5 are similar, or very similar, to commercially marketed products. The polypropylene materials are used in oil spill control pads and booms. The straw is also used for oil spill clean-up.

None of the sorbents was effective in removing the emulsified oil and grease in this type of experiment. The polypropylene sorbents were evaluated in other tests with 8 to 12 hour contact times and were able to remove 40% to 60% of the oil and grease. If tightly packed into columns, they will remove emulsified oil and grease from waters pumped through under high pressure, but this filtration procedure is not economically feasible for stormwater.

A new series of tests was performed in the full-scale catch basin simulator. This simulator is composed of a stilling chamber, a 0.6 m wide flume that simulates street surface, and a catch basin with a 0.9 m wide opening. Contaminants are released into the flume at controlled rates to produce the desired concentrations. Tap water is used for stormwater. This size is the same as the smallest catch basin routinely constructed by the Los Angeles County Department of Public Works. It was constructed of plywood and cement and built above grade to allow easy access. The 0.9 m opening could accommodate a variety of types of inserts. The inserts were temporarily clamped to the walls of the catchbasin and were easily changed and refitted, as needed.

Two prototype designs were extensively tested. The first used OARS sorbent, which was placed in metal boxes with open tops and screened bottoms. Stormwater flows from the top, through the OARS sorbent, which has a particle size from 5–30 mm with a density of 0.22 g/ml (our measurements, not the manufacturer's specifications). The internal arrangement of the box traps suspended solids and trash. This allows the box to perform as oil and grease, suspended solids, and trash removal device. It also means that in installations where high trash and suspended solids are present, the box may clog before the oil sorption capacity is reached. The second insert extensively tested used polypropylene cloth as a sorption/filtration media. The cloth is supported by a geotextile used for stabilizing soils. The cloth is available in different weights. The geotextile has openings of approximately 1 cm by 8 cm. The prototype inserts have a metal collar at the top, which forms the support for the geotextile. The insert is flexible and can be compressed for insertion though an opening smaller than its height. This design has all the previously cited advantages, and can also be easily constructed in custom sizes.

Tables 6 and 7 show the results for both sorbents. The oil and grease removal efficiency ranged from 40% to more than 90%, depending upon sorbent condition and influent concentration. Removal efficiency was generally higher with higher influent concentrations. The media used in tests 1 and 2 for OARS had been used in the field for four months and represented partially used sorbent. Several tests (Figures 2 and 3) were conducted using the same media, in an attempt to exhaust the media.

Also shown in Tables 6 and 7 are test results for TSS and PAH removal. For the case of TSS, sand particles were sieved and recombined to produce an evenly divided mixture, by mass of sand with US standard meshes of 40, 60, and 100 (approximately 400 to 120 μm). The box removed 99% of the large particles and 78% of the smallest particles. PAH removal was measured by spiking tap water with known masses of PAHs and then measuring effluent concentrations. The removal efficiency ranged from 16% to 61%. Again, the total capacity of the insert was not determined, so the mass of solids or PAHs that can be removed before maintenance is not known. This is the subject of further testing in our laboratory, and should be evaluated in the field as well.

Field tests

Field tests were conducted in the second year of the project at commercial and residential sites. Six sites were initially selected. Three used the polypropylene style insert (two in commercial areas) with double thickness liners, two used the OARS containing insert (one in a commercial area), and one used a simple wire mesh basket (~1 cm opening, in a residential area) with no sorbent or filter media. The inserts were observed to bypass flow at the greatest runoff condition and gradually bypassed more flow as they became clogged. After about two months of active rainfall, the bypassing became more frequent and the polypropylene sorbents were replaced with medium screens (see test 14 in Table 7).

Table 7 Summary of a polypropylene insert device tests

Test no.	Liner type	Sorbent condition	Q (l/min)	Influent O&G conc. (mg/l)	Removal efficiency (%)	Final M* (g)
1	12 oz	New	473	13.5	65	121
2	12 oz	New	283	28.8	82	200
3	12 oz	New	56	37.0	86	54
4	12 oz	New	720	12.7	53	145
5	12 oz	used from test no. 2	283	26.3	78	569
6	12 oz	used from test no. 5	283	21.4	79	714
7	12 oz	used from test no. 6	283	30.2	70	1400
8	12 oz	used from test no. 7	283	23.9	58	2058
9	12 oz	New	283	8.1	56	157
10	12 oz	New	283	17.6	63	366
11	12 oz	New	283	30.5	59	578
12	8 oz	New	283	8.1	49	133
13	Double bag	New	283	11.0	74	274
				TSS (mg/L)		Mesh size
14	Screen	New	283	66	34	40
				66	2	60
				66	0	100
				200	12	Average
15	12 oz	New	283	66	98	40
				66	96	60
				66	95	100
				200	96	Average
				PAHs (50 ug/l)		
16	Double bag	used from test 13		Acenapthene	55	
				Fluorene	51	
				Phenanthrene	58	
				Anthracene	88	
				Fluoranthene	61	
				Pyrene	56	
				Chrysene	82	
				Benzo(a)pyrene	69	

*M = total mass of O&G absorbed (g)

Testing ended for the OARS type sorbents. When stormwater bypassed the insert, there was no change in street runoff rate or increased accumulation on the street surface; the clogged insert had no impact on stormwater removal rate from the street. Sampling was performed as before, except that effluent samples were also collected.

Each residential site was ~12,000 m^2 in area, and the three commercial sites had areas ~5000 m^2 each. Table 8 shows the average water quality for the second year of the study. The values are similar to those shown in Table 2. The standard deviations are high, which is typical for stormwater. Site 2 in Table 2 is similar to the commercial sites used in the second year. The residential sites in the two studies are similar in land use and housing density. The high standard deviations mask water quality comparisons; however, turbidity, COD, DOC, chloride, SPE oil and grease and are higher in the commercial sites (one-tailed test at $\alpha = 0.15$).

The water quality data shown in Table 8 serves as the influent for an efficiency test of the inserts. Effluent samples were collected from the insert using a cup on a stick. Samples were collected when the inserts were not bypassing. Removals for the polypropylene insert inal M* (g)

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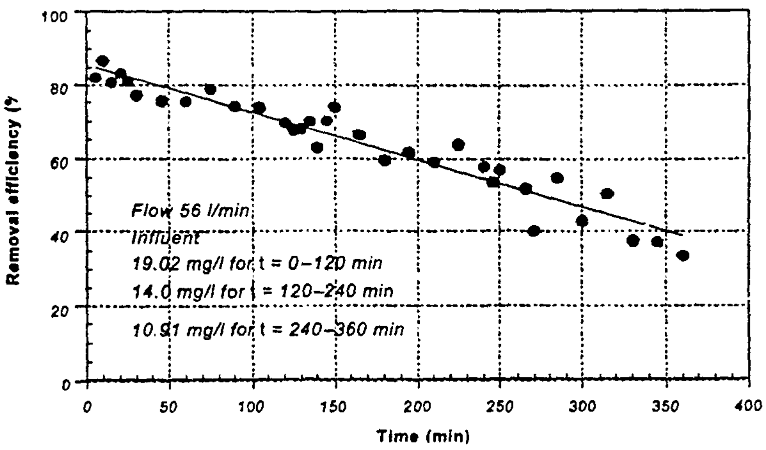

Figure 2 Oil and grease removal efficiency versus time for an insert using OARS sorbent

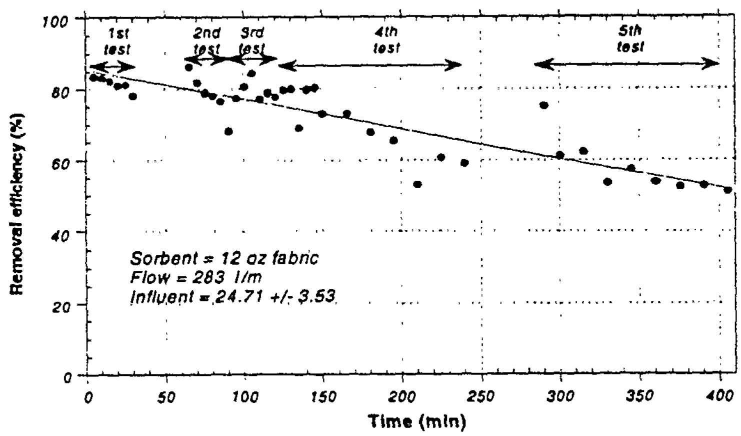

Figure 3 Oil and grease removal efficiency versus time for an insert using polypropylene sorbent

averaged 21, 36 and 34% for TSS, VSS and turbidity, respectively. The OARS device averaged 21, 9 and 12% for the same parameters. The variability in oil and grease removal rates precludes making any conclusion. Table 4 suggested that 26% of the sediment in stormwater might be removed by a filter that captures solids greater than 150 µm. The removals in actual field test are below this prediction, but are not too much different, especially considering the highly variable nature of stormwater. The TSS procedure captures 100% of all particles greater than 0.8 µm; the majority of the material that composes suspended solids is less than the size that can be removed by insert filters.

At the end of the study, the polypropylene bags and screens were removed and the contents were air dried. The material smaller than 12,700 µm (0.5 in) was weighted, screened and reweighed. Table 9 shows the results from the first part of the study. The inserts at the two commercial sites tended to recover smaller particles. Table 10 shows the results for the second part of the study. This study used a much coarser mesh screen, but still recovered many small particles. Again, there is much more finer material at the commercial sites.

The final data reduction was to calculate an equivalent concentration of captured material per unit of runoff volume. This is similar to an event mean concentration, in that the total runoff volume can be multiplied by the coefficients to produce an expected mass of

Table 8 Water quality parameters for the second year. Number of observations = 16 for commercial sites and 14 for residential sites

Water quality parameter	Commercial Mean	Commercial Std. dev.	Residential Mean	Residential Std. dev.
TSS (mg/l)	54.9	41.7	43.2	39.4
VSS (mg/l)	23.5	18.4	20.0	15.7
Turbidity (NTU)	32.5	23.7	15.6	10.0
Conductivity (mmho/cm)	136.5	95.1	118.8	61.8
pH	6.9	1.1	7.1	0.8
Alkalinity (mg/l as $CaCO_3$)	27.4	22.0	28.7	16.7
Hardness (mg/l as $CaCO_3$)	37.9	29.5	35.9	17.5
COD (mg/l)	147.6	113.5	103.6	66.7
DOC (mg/l)	36.4	33.0	22.9	11.5
SPE Oil and Grease (mg/l)	16.6	21.7	5.4	3.5
Ammonia (mg/l as NH_3–N)	1.1	2.1	0.5	0.6
Cl^- (mg/l)	13.7	10.4	7.2	6.0
NO_2^- (mg/l as NO_2–N)	0.1	0.1	0.1	0.0
NO_3^- (mg/l as NO_3–N)	0.7	0.6	0.7	0.4
SO_4^{2-} (mg/l)	9.3	9.6	7.3	4.7

Table 9 Sieve results for the first part of the study

Sieve opening (μm)	Percentage finer than based on total sample: Commercial 1	Commercial 2	Residential
12,700	100.0	100.0	100.0
6,350	56.6	69.0	93.4
3,175	38.2	57.1	82.6
1,999	24.1	40.5	64.3
841	23.5	39.8	60.5
419	15.5	24.9	32.8
249	10.8	14.6	14.8
150	7.6	8.9	5.5
74	4.8	4.4	1.9
Pan	2.2	1.2	0.6

Table 10 Sieve results for the second part of the study

Sieve opening (μm)	Percentage finer than based on total sample							
	Commercial 1					Residential 1		
	1	2	3	4	5	1	2	3
12,700	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6,350	49.7	42.4	33.9	79.6	65.9	97.0	49.1	29.8
3,175	38.5	32.8	25.5	66.7	55.1	89.5	31.1	19.1
1,999	25.1	24.3	19.1	53.4	44.9	76.0	20.8	11.0
841	24.1	23.3	18.9	51.0	37.3	72.3	19.7	10.6
419	13.3	21.3	14.7	30.3	20.1	43.6	9.4	7.1
249	7.2	17.8	10.4	14.2	15.6	17.8	3.3	3.9
178	3.7	12.4	7.4	5.8	9.7	6.3	1.2	1.8
150	2.2	8.5	5.9	3.2	6.3	2.8	0.5	1.0
74	1.6	6.5	5.0	2.3	4.7	1.6	0.3	0.7
Pan	0.5	2.1	2.6	0.8	1.3	0.3	0.1	0.2

Table 11 Unit loading rates of collected material (kg/m³ of runoff)

Size (µm)	Commercial 1	2	3	4	5	Residential 1	2	3
> 12,700	0.92	1.24	2.06	0.68	0.82	0.62	0.17	0.11
12,7000 – 6,350	0.20	0.21	0.26	0.43	0.26	0.22	0.03	0.28
6,350 – 3,175	0.25	0.18	0.20	0.44	0.24	0.13	0.02	0.50
< 3,750	0.46	0.52	0.60	1.79	1.08	0.25	0.03	2.84
Total	**1.83**	**2.15**	**3.12**	**3.34**	**2.40**	**1.22**	**0.25**	**3.73**

captured litter and particles. Table 11 shows these results. The coefficients are shown in units of kg/m^3. Note that the solids larger than 12,700 µm are included. These coefficients were calculated using the catchment area for each site, rainfall observed during the study, and runoff coefficients of 0.39 for residential and 0.6–0.7 for commercial sites. These totals include material swept or blown into the catch basin during non-rainy periods, which in Southern California is the majority of the time. The coefficients in Table 11 will have two systematic errors. The coefficients will be lower than the actual load, since the insert devices are imperfect and bypass at high flow. The coefficients are higher than the actual load carried by stormwater, due to the flux of material in dry weather. The coefficients can be used as a first-order approximation of the litter and debris to be expected from commercial and residential sites in urban areas in climates similar to Los Angeles.

Conclusions

This manuscript has briefly described the results of laboratory and field tests to determine the opportunities for using catch basin inserts to remove specific pollutants (oil and grease, litter and suspended solids). The inserts have the advantage of using the existing urban infrastructure to remove stormwater pollutants at low cost. The estimated cost of each insert is less than US$ 500. An insert design has been proposed that is easy to install and does not require workers to enter the catch basin. Observations during storms showed that they do not create flooding problems, even when they are clogged. Laboratory testing has showed that free oil and grease (simulated by used automobile crankcase oil) can be removed by a variety of sorbents in simple flow-through contacters. Emulsified oil can generally not be removed. Oil and grease removal in field tests was inconclusive. Laboratory testing showed that particles can be removed down to a size of 100 µm, and field results showed that much smaller particles can also be trapped. Laboratory testing showed that the sorbents can remove dissolved PAHs with efficiencies ranging from 16 to 88%. Additional testing is needed to further demonstrate the utility of these inserts. The removal capacities for oil and grease and suspended solids, which will dictate maintenance frequency and cost, need to be determined. The results presented in this paper are preliminary and should be applied with caution. The authors hope that they will stimulate others to develop catch basin insert technology.

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Performance of a Proprietary Stormwater Treatment Device: The Stormceptor®

The Stormceptor® is a popular proprietary storm water treatment device that has been widely applied across the U.S. and Canada in recent years. Its primary application is on small, highly impervious sites. A schematic of the device is shown in Figure 1. The device is popular because it is relatively easy to design, can be easily installed in a wide variety of applications, and can be installed in small sites without sacrificing land area. The typical device incorporates a circular holding tank that receives runoff from a flow diversion structure. Storms that exceed the capacity of the off-line device are diverted to the downstream drainage network. Unlike other stormwater practices, the Stormceptor® is designed and sized primarily on the *rate* of stormflow rather than its *volume*. Consequently, the Stormceptor® provides treatment within a much smaller area than is possible with most other stormwater practices.

A much anticipated monitoring study was recently completed by Steve Greb (Wisconsin DNR) and Robert Waschbusch (USGS) that provides the most comprehensive and independent performance evaluation of Stormceptor to date. They installed a Stormceptor® unit as a retrofit at the Badger Road public works maintenance yard in Madison, Wisconsin in mid-1996. The maintenance yard was about 4.3 acres in area and almost completely impervious. The yard was used for refueling, maintenance and parking of heavy vehicles, and also for storage of road salt, sand, yard wastes, and other materials.

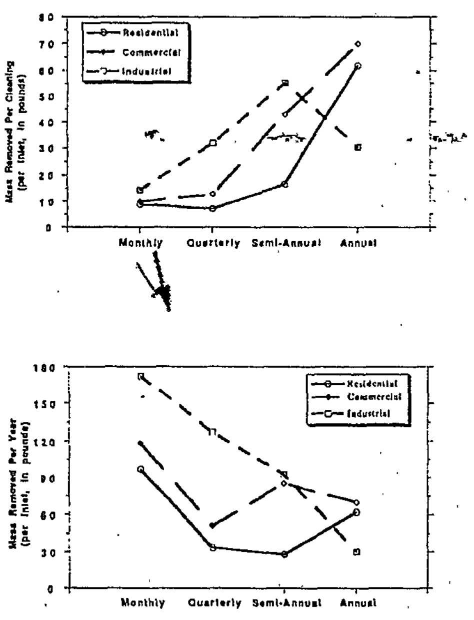

Figure 1: Schematic of Stormcepter® Unit with Sampling Locations

Maintenance yards often rank among the "dirtiest" pollutant source areas in the urban landscape, and the Badger Road yard was no exception. The median total suspended solid (TSS) concentration was reported to be 251 mg/l, which slightly higher than the Wisconsin commercial street median concentrations of 232 mg/l (Bannerman *et al.*, 1996). The median chloride and total dissolved solids (TDS) runoff concentrations were 560 and 3,860 mg/l respectively, suggesting that stockpiled salt and other organic materials at the yard were a key pollutant source area.

The Stormceptor® unit selected for the retrofit at the Madison yard was the STC 6000 model with a sediment storage capacity of 610 ft^3. According to Stormceptor®'s sizing guidance, this unit has a sediment storage capacity of 142 ft^3/ac and is projected to have a suspended solids removal rate of approximately 75% (Stormceptor®, 1997).

Greb and his colleagues had to develop sophisticated monitoring techniques to measure the performance of such a small treatment unit. They installed flow-integrated storm samplers at the inflow and outflow locations of the Stormceptor® treatment tank, as well as at the bypass weir (see Figure 1 for locations). This sampling arrangement was needed to determine how much runoff volume bypassed the unit and was therefore not treated. If the bypass volume is high, then the treatment efficiency for the device would need to be adjusted downward. Although 24% of monitored storm events experienced some flow bypass around the Stormceptor® treatment tank, the team computed that only 10% of the total runoff volume during the study actually bypassed the device during the sampling period.

Flow was measured directly using a flow meter which was connected to a data-logger to initiate sampling during storm events. One composite sample was

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collected at the inflow and outlet for each storm event containing between five and 40 subsamples that was used to compute event-mean concentrations for the various pollutant constituents.

The sampling team evaluated the performance of the Stormceptor® during 45 precipitation events over a nine-month period that ranged in size from .02 inches to 1.31 inches. The monitoring study extended from August, 1996 to May, 1997 and included snowmelt events. During 15 storm events, the team evaluated 37 different pollutants, including a variety of solids, nutrients, metals, and polycyclic aromatic hydrocarbons (PAHs). For the remaining 30 storms, the team measured only three parameters: total suspended solids, total dissolved solids, and total phosphorus.

So how well did the Madison Stormceptor® work? Generally, the observed removal rates were lower than the manufacturer's expectations. The computed removal rates for the Madison unit are provided in Table 1. The Stormceptor® performed about as well as conventional catch basin inlets (Pitt, 1998) and certainly better than the traditional oil/grit separator. Note that the removal rates in Table 1 indicate both the actual removal efficiency of the tank, and an overall efficiency that accounts for untreated bypass flow. For example, the TSS removal rates drops from 25 to 21% when stormflow bypass is considered. The team conducted a particle size analysis and found less than 5% of the trapped sediment in the tank was of the silt or clay sized particle size. Nearly all of the trapped sediment were larger sand sized particles.

Closer examination of Table 1 indicates that Stormceptor® had a low to moderate ability to remove particulate pollutants (e.g., solids, PAH and metals), but virtually no ability to remove soluble pollutants (with the exception of dissolved phosphorus). This is not surprising since the device relies on particulate settling for pollutant removal. Total PAHs had among the highest overall removal rate at 37%. Although oil and grease were not directly monitored, the team found that about 120 gallons of oily material had accumulated in the tank during the nine-month study. The sizeable volume of oily material was likely generated from diesel fuel from a nearby refueling station.

Another key finding of the Madison study was that Stormceptor®'s ability to remove suspended solids was dependent on the depth of rainfall in each storm event (see Figure 2). The Stormceptor® achieved fairly high rates of TSS removal (40 to 80%) when rainfall depths were less than 0.2 inches, but removal rates dropped sharply as rainfall depths increased. Winter storm events were excluded from Figure 2(a) because imported stockpiled snow at the yard contributed snowmelt that could not be related to specific measured rainfall depths.

Several factors could have affected the overall performance of the Madison Stormceptor®. First, the sampling effort included storm events during the late winter and spring of 1997. Cold temperatures and the high salinity of the water could have degraded particle settling conditions within the Stormceptor® tank during these events. Pitt (1998) found that winter settling velocities were about half of the settling velocity expected during the summer months for the same-sized

Table 1: Reported Pollutant Removal Efficiencies for the Stormceptor® From Madison, Wisconsin, Dept. of Public Works Maintenance Yard (Sreb *et al.*, 1998)

	Tank Efficiency			Overall Efficiency Including Bypass		
Pollutant	Total load in	Total load out	Removal efficiency (%)	Total upstream load	Total downstream load	Overall removal efficiency (%)
TSS (kg)	1,257	943	25	1,506	1,192	21
TDS (kg)	29,743	36,022	-21	30,051	36,330	-21
TP (kg)	1.43	1.16	19	1.60	1.33	17
Dissolved P (kg)	0.39	0.31	21	0.49	0.40	17
Total Lead (kg)	0.104	0.075	28	0.120	0.096	24
Total Zinc (kg)	0.590	0.465	21	0.728	0.603	17
Total PAH (kg)	0.058	0.036	37	0.066	0.045	32
Cl (kg)	6,066	7,685	-27	6,147	8,036	-25
$NO_2 + NO_3$ (kg)	0.270	0.254	6	0.297	0.281	5

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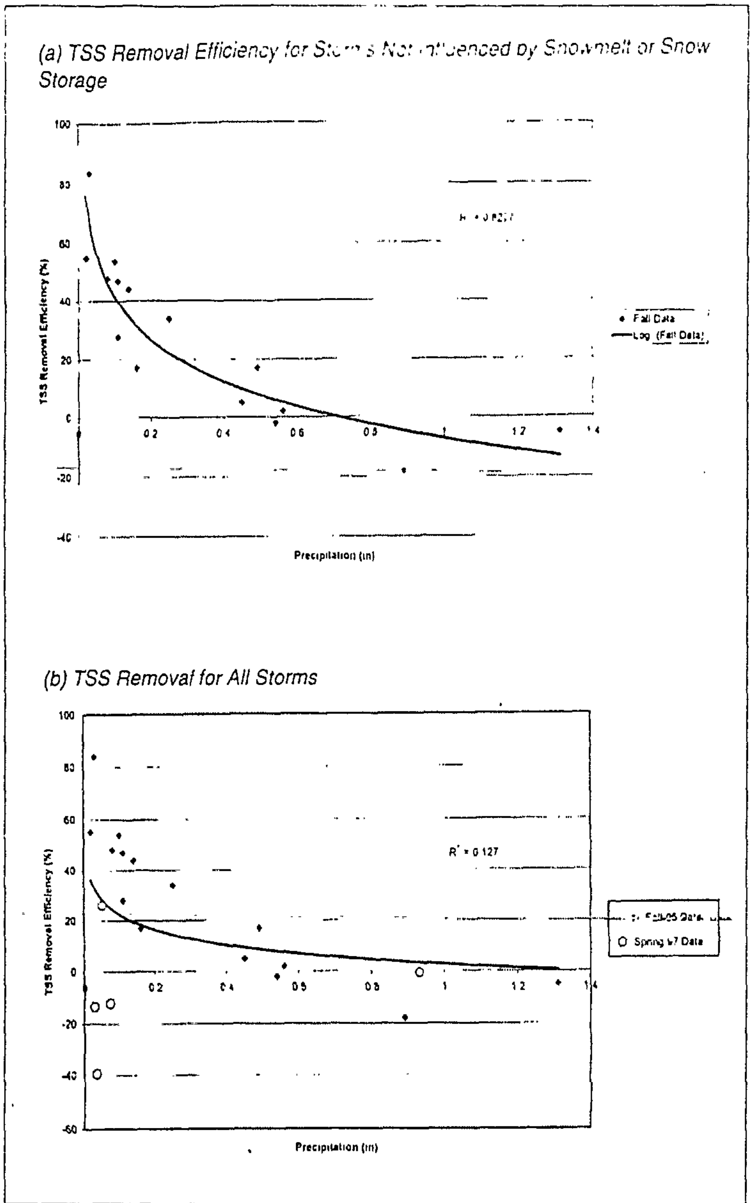

Figure 2: TSS Removal as a Function of Rainfall Depth as a Function of (a) Storms Not Influenced by Snowmelt and (b) All Storm Events

particles. Further, snowmelt from stockpiled snow at the yard increased the inflow to the unit in the winter and spring. By contrast, summer and fall storm events were not influenced by high chloride levels but experienced the greatest rainfall intensity and, consequently, the most storm bypasses.

Second, the sampling methods for measuring TSS could have slightly underestimated the actual removal since it did not fully measure the transport of sand. Sample intakes were located above the bottom of the inflow pipe and therefore could have failed to sample larger sand sized particles moving along the bottom of the pipe. The sampling team was able to calculate the missing bedload by measuring the amount of sediment actually trapped in the tank at the end of the study. They estimated that the unsampled bedload was about 8% of the total sediment load, and the maximum solids removal efficiency would increase to about 29 to 33% if the bedload was included.

Stormceptor Field Tested in Edmonton, Alberta, Canada

A second and more limited independent evaluation of Stormceptor® was performed by the City of Edmonton, Alberta, Canada (Labatiuk, 1997). The City monitored nine storms at a 9.9 acre commercial shopping center. The monitoring protocol required that three consecutive dry days occur before the storm sampler was triggered, in an effort to test the capability of Stormceptor to remove pollutants from "first flush" storms. Table 2 illustrates the pollutant removal rates for several pollutants, based on an analysis of four storm events during the second year of monitoring. Mean TSS removal was about 50%.

During the first year of monitoring, equipment difficulties and improper installation of some plumbing severely limited the validity of the sampling results. The results for the first year included five storms with a mean TSS removal rate of 6.9% and a standard deviation of 11.1%, but these results should be viewed with some skepticism given the monitoring difficulties and the fact that the Edmonton unit may have been undersized. Given the limited number of storms and the lack of on-site rainfall data, it was not possible to determine how pollutant removal rates were related to rainfall depths at the Edmonton site.

Conclusions

While the Madison monitoring effort was certainly comprehensive, more questions need to be answered to fully assess Stormceptor® technology. For example, how well would the Stormceptor® work in a more typical urban installation? Clearly, the Madison maintenance yard was a stormwater hotspot, and the salt and snow storage at the yard may have influenced the performance evaluation. For example, the settling characteristics at the Madison site may have been unusual due to extremely high levels of chlorides in the runoff. Second, the Madison tank may have been too deep. A shallower tank would allow particles to reach the bottom of the settling chamber faster, possibly increasing solid removal.

Interestingly, the Edmonton unit, with a smaller storage capacity, a shallower tank, and larger drainage

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area, out performed the Madison unit, at least for the limited number of events sampled. This may have been due to the shallow depth of the Edmonton tank, or simply a reflection of the small sample size of the Edmonton study. Clearly, more monitoring data are needed, since the Stormceptor® has been tested in a few locations and a relative handful of storms events. Additional Stormceptor® performance tests are currently underway in Colorado, Texas, and the Pacific Northwest that will expand our understanding of its performance. Based on what is known now, it is not clear whether the Stormceptor® has sufficient sediment and pollutant removal capability to serve as a "stand alone" stormwater management practice in most development situations.

Another perspective on the Madison Stormceptor® can be obtained by comparing its performance to that of the multi-chamber treatment train (MCTT) developed by Robert Pitt. One of the MCTT units also served a maintenance yard in Wisconsin, and sediment removal rates from between 83 to 98% were reported. Removal of other pollutants was on the order of 65 to 95%. The MCTT retains a much larger runoff volume per unit area than the Stormceptor®, and employed advanced techniques for inlet screens, sedimentation and filtration. By way of comparison, the MCTT had about 30 times more runoff storage volume per unit drainage area than the Stormceptor® yet also costs about 20 to 30 times as much as a Stormceptor®.

This initial round of Stormceptor® monitoring indicates that it can be reasonably effective at trapping sand, oil and grease if regular tank clean out occurs. This suggests that it may be useful for pre-treatment for other stormwater practices, particularly those that can easily clog with sediment, and at ultra urban hotspot situations where space is at a premium and designers must go underground.

—RAC

Table 2: Summary of Results of 1996 Stormcepter® Monitoring at Edmonton, Alberta, Canada Westmount Shopping Center (Labatiuk *et al.*, 1997)

Pollutant	Removal efficiency (%) *	Standard deviation (%)
Total suspended solids	51.5	20.5
Oil and grease	43.2	24.1
Total organic carbon	31.4	5.0
Lead	51.2	17.9
Zinc	39.1	7.9
Copper	21.5	7.5

* Mean of four storm events monitored in 1996

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Article 47

Feature article from Watershed Protection Techniques. 3(2): 647-656

The Benefits of Better Site Design in Commercial Development

Modern commercial development is dominated by the parking lot. Indeed, as much as half of the entire surface area of a typical office park or shopping center is devoted to parking. No one has ever stepped up to claim that they invented the parking lot, and their reluctance is understandable: the parking lot is a prime habitat for the car and not much else.

From an environmental standpoint, parking lots rank among the most harmful land uses in any watershed. Parking lots not only collect pollutants that are deposited from the atmosphere, but also accumulate pollutants that leak, drip or wear off cars. Researchers have found that parking lot runoff can have extremely high concentrations of nutrients, trace metals and hydrocarbons. Parking lots also influence the local air and stream temperatures. In the summer months, pavement temperatures can exceed 120 degrees Fahrenheit, which in turn increases local air temperatures five to 10 degrees compared to a shaded forest. Parking lots can also exacerbate smog problems, as parked cars emit greater levels of smog precursors under extreme heat island conditions (Scott *et al.*, 1999).

Perhaps the greatest environmental impact of parking lots is hydrological in nature. Simply put, there is no other kind of surface in a watershed that produces more runoff and delivers it faster than a parking lot. When this runoff is discharged into a headwater stream, its great erosive power steadily degrades the quality of downstream habitats, unless exceptionally sophisticated stormwater practices are installed.

Is it possible to design a better parking lot? At first glance, there seems to be little opportunity to incorporate better site design into parking lots. However, the better site design techniques described earlier in this issue suggest a key design strategy: *work to incrementally shrink the surface area of the parking lots and then use the space saved to integrate functional landscaping and better stormwater treatment within the parking lot.* Through a series of relatively minor design adjustments, it is possible to reduce the surface area of parking lots by five to 20%. These design adjustments include curbing excess parking, incrementally reducing parking demand ratios, providing credits for mass transit, shrinking stall sizes, narrowing drive aisles, and using grid pavers for spillover parking areas.

In this article, we examine some of the benefits of employing better site design as they apply to commercial development. As with the residential redesign, this analysis also uses the Simplified Urban Nutrient Output Model (SUNOM) to compare actual commercial development sites constructed in the 1990s with the same sites redesigned utilizing better site design techniques. The two commercial developments analyzed include a retail shopping center and a commercial office park.

Our fairly conservative approach to parking lot redesign is intended to reflect realistic opportunities in a suburban setting. For example, we did not utilize shared parking, porous pavement, or structured parking in any of the redesigns, although each of these techniques is very effective. Nor did we reduce the basic footprint or size of the buildings in either scenario, although smaller "boxes" may well have been more appropriate for the zoning. Instead, our basic approach was to make a series of relatively modest changes in parking lot design to shrink parking lot area, and then implement better landscaping and stormwater treatment measures within the saved space.

This article reports on the potential benefits of parking lot redesign in terms of reduced runoff, pollutant export and development costs. It also reviews the initial experience of communities that are experimenting with new and innovative parking lot designs, and concludes with some implications for both the engineer and watershed manager.

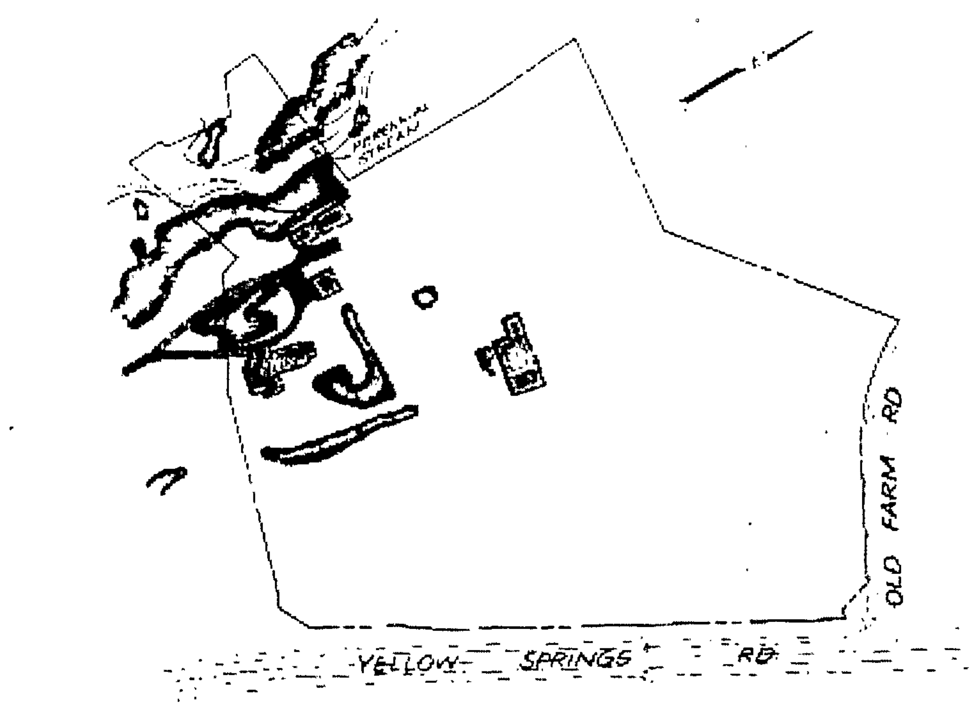

Figure 1: Predevelopment Conditions at the Old Farm Shopping Center Site

Redesign of the Old Farm Shopping Center

The undeveloped Old Farm shopping center, located in the City of Frederick, Maryland, was primarily meadow, with some shrubby forest and a few farm buildings. Bordered by two major arterial roads and served by existing public water and sewer, the site was a prime candidate for commercial development (Figure 1).

Construction of the shopping center site parcel commenced in 1992. The 9.3 acre site is a typical suburban "strip" shopping center with two large retail stores, other retail space, a gas station and a drive-in bank (Figure 2). In terms of surface cover, the shopping center devoted 50% of its total area for parking, as compared to 16% for the actual footprint of the retail buildings. Another 24% of the surface area was devoted to landscaping or stormwater treatment. Less than 10% natural cover was retained on the site, and part of the project encroached on the 100-year floodplain and the stream buffer. The entire site was mass graded during construction. The basic layout was designed to accommodate the car, with generous parking located in front of the stores. The parking lot design provided 5.2 full-size stalls per 1,000 square feet (sf) of retail space, which exceeded the already generous local parking requirement of five spaces per 1,000 sf. According to the most recent national parking research, only 4.0 to 4.5 spaces are needed to serve shopping centers (ULI, 1999).

The stormwater treatment system at Old Farm consisted of an infiltration basin located near the rear of the shopping center that captured runoff from about a third of the site, and three oil grit separators that provide some treatment for the remaining two-thirds of the site. After discharging from the oil/grit separators, runoff traveled through a series of storm drains that extended along the road and eventually discharged to the stream (albeit without detention of any kind). It should be noted that recent performance monitoring has shown that oil grit separators have little or no pollutant removal capability (see articles 119 and 120).

The Redesigned Old Farm Shopping Center

The Old Farm shopping center was redesigned using a "U-shaped" layout that maintained the same amount of gross floor area, but sharply reduced the site area devoted to parking (Figure 3). The new design reduced walking distances, encouraged pedestrian use, and created a more intimate shopping experience. Parking dropped from 50% of the total site area to 38%, primarily because the parking demand ratio was reduced from 5.2 spaces to 4.4 spaces per 1,000 sf of retail area.

The rationale for the lower parking demand was justified in two ways. First, no extra parking spaces were allowed beyond those required by the locality. Second,

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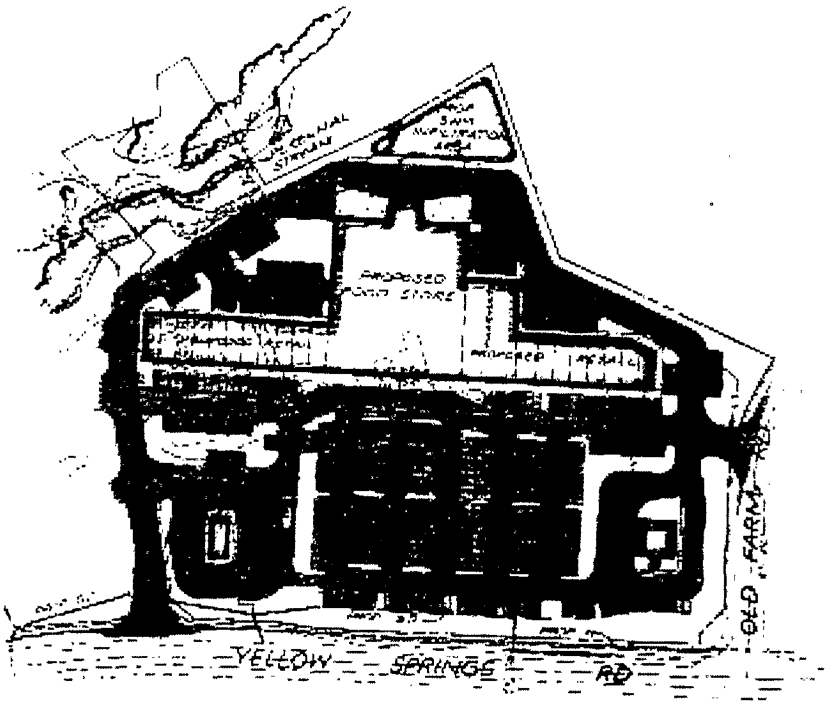

Figure 2: The Conventional Design of the Old Farm Shopping Center

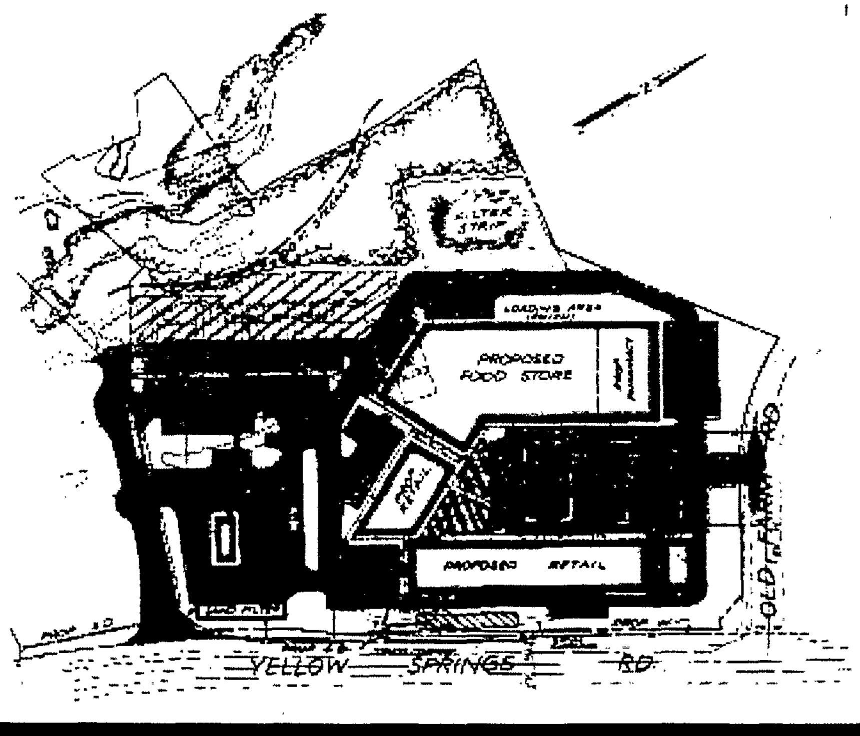

Figure 3: The Innovative Design of the Old Farm Shopping Center

Table 1: Hydrology of the Old Farm Shopping Center Case Study				
		Pre-Developed	Conventional Parking Lot	Innovative Parking Lot
Runoff (inches/yr)	no practice	2.6	24.5	20.6
	practices		18.1	15.1
Infiltration (inches/yr)	no practice	11.8	2.7	3.4
	Practices		9.1	8.9

the existing parking demand ratio was reduced by about 15% to reflect actual parking demand more accurately. As a result, the total number of parking spaces dropped from 343 to 291. In addition, 17% of the parking stalls were designed for compact cars, which require slightly smaller stalls than standard full-sized spaces. Taken together, these changes eliminated slightly more than one acre of parking area, which provided enough space to design a more effective landscaping and stormwater treatment system.

Several parking lot islands were increased in size and converted into bioretention areas to treat stormwater. Other elements of the stormwater treatment system included a sand filter, an infiltration trench, and a filter strip. Furthermore, 25% of the entire parking area was designated for "spillover parking," and grid pavers were used rather than normal paving materials. The grid pavers helped store the first few tenths of an inch of rainfall that would have otherwise run off the parking lot (ICPI, 2000). Lastly, the redesign enabled reforestation and greater protection of the buffer along the stream that runs along the edge of the property. As a result, the proportion of natural cover at the site climbed from 7% to 19% as a result of the parking lot redesign.

Comparative Hydrology at the Old Farm Shopping Center

As expected, the construction of the original shopping center dramatically changed the hydrology of the site (Table 1). The increase in impervious cover from 1% to more than 70% increased annual runoff volume by a factor of nine. The infiltration basin used in the original design helped put some runoff back into the ground, but even so, annual runoff was seven times greater than the pre-development condition. The redesigned parking lot, by virtue of its lower impervious cover and improved stormwater practices, produced about 20% less runoff than the original design. Nevertheless, the stormwater practices at the redesigned parking lot were not able to match the pre-development hydrology.

Comparative Nutrient Output from the Old Farm Shopping Center

The conversion of the meadow into a shopping center greatly increased nutrient export from the site; the SUNOM model indicated that annual phosphorus and nitrogen export would increase tenfold as a result of the development (see Figure 4). Nutrient export from the shopping center was dominated by stormwater runoff, as the model indicated that stormwater runoff contributed about 95% of the annual nutrient export from the site. Nutrient loads were not greatly reduced by the infiltration basin or oil/grit separators that were installed at the conventional parking lot. Nutrient export was still projected to be eight to 10 times higher than pre-development conditions, even after these stormwater treatment practices were installed.

In contrast, the redesigned parking lot sharply reduced nutrient export (Figure 4). In fact, the redesigned parking lot *without* stormwater practices produced about the same nutrient load as the conventional parking lot *with* stormwater practices. This reduction was a direct result of the lower impervious cover associated with the redesigned parking lot. When the redesigned parking lot was combined with more sophisticated stormwater practices (i.e., bioretention, sand filter, infiltration trench and filter strip), the total nutrient export was half that of the conventional parking lot with stormwater practices. It is interesting to note, however, that this load was still about five times higher than that produced by the meadow prior to development.

Comparative Cost to Develop the Old Farm Shopping Center

The cost to develop the redesigned parking lot was marginally lower than the cost for the conventional parking lot — about 5%. Considerable cost savings were realized due to less paving, shorter sidewalks, and fewer curbs and gutters, but these savings were largely offset by added costs for improved stormwater practices, landscaping and grid pavers. Overall, the estimated cost to build the conventional parking lot was $782,500, compared to $746,270 for the redesigned parking lot. The extent of potential cost savings depends heavily on the level of sophistication of the original stormwater treatment system. In this case, the unsophisticated stormwater practices used in the conventional parking design were fairly inexpensive, but were also not effective in removing nutrients.

Summary

Figure 5 summarizes the redesign analysis of the Old Farm Shopping Center. The redesigned parking lot resulted in less impervious cover, stormwater runoff, and nutrient export for a slightly lower development cost than the conventional design.

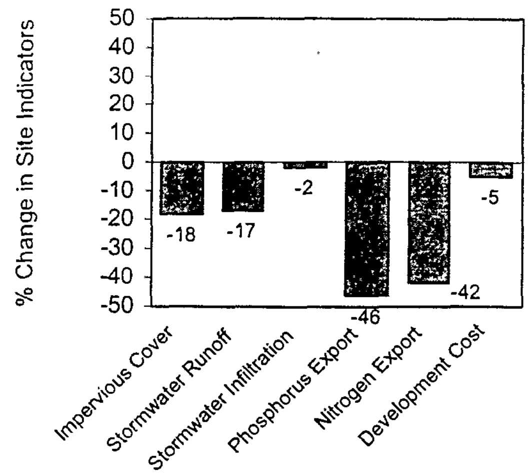

Figure 5: Percentage Change in Key Site Indicators From a Conventional Design of the Old Farm Shopping Center to an Innovative Design, Both With Stormwater Practices

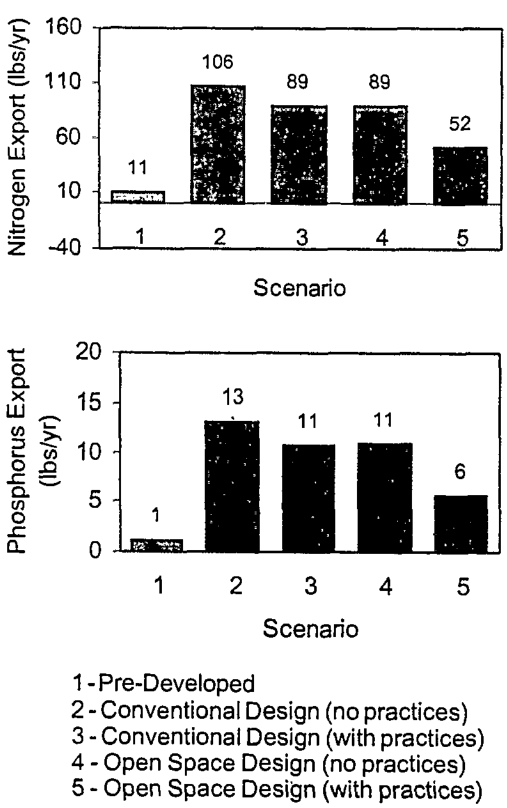

Figure 4: Annual Nitrogen and Phosphorus Export in Each Old Farm Shopping Center Development Scenario

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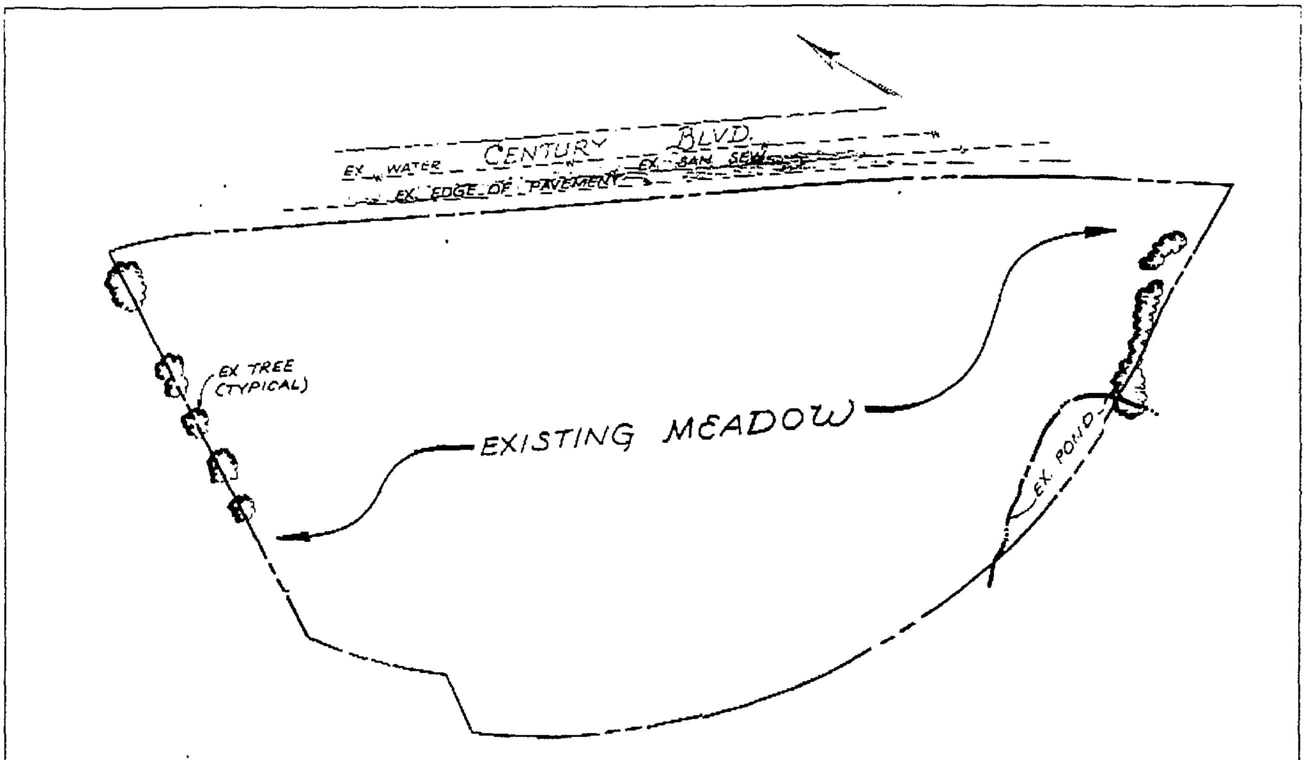

Figure 6: Predevelopment Conditions at the 270 Corporate Office Park Site

Redesigning the 270 Corporate Office Park

The second case study involved the redesign of a typical suburban office park. The 12.8 acre parcel is located in Germantown, Maryland in the mildly sloping terrain of the Piedmont (Figure 6). The existing cover at the site was almost entirely meadow, except for a few trees and an old farm pond that bisected the property boundary. No wetlands or other sensitive natural features were evident on the site. The site was zoned for office development, and existing infrastructure made it an attractive candidate for development. An existing network of public water and sewer, electric, gas, and other utilities ran along the frontage of a large arterial road.

The layout of the conventional suburban office park design is depicted in Figure 7. The project included a pair of five-story office buildings, surrounded by a sea of parking. Over half (52%) of the surface cover at the office park was devoted to parking, as compared to only 11% for actual footprint of the office building. Most of the remainder of the site was utilized for landscaping, stormwater treatment or turf. Only 2% of the natural cover was retained on the site, and nearly all of the parcel was mass graded during construction.

As with many suburban office parks, the location of the building and parking were primarily oriented toward the car. The parking lot was sized using a parking demand ratio of 3.1 spaces per 1,000 sf of building, which slightly exceeded the minimum parking requirements of the locality. As a result, the parking lot created room for 745 standard stalls, along with 33 larger stalls for vans and disabled access. The parking bays also featured roomy aisles between the stalls (24 feet wide). The design was intended to provide some amenities for the office workers, including a short path system between buildings, an ornamental stormwater pond, and some landscaping in required setbacks and parking islands.

The conventional design featured the classic "pipe and pond" approach to stormwater management. Parking lot runoff was initially collected by a curb and gutter system that sent runoff into underground storm drain pipes that, in turn, discharged into two very small wet ponds. Each pond served roughly half of the site and was expected to have a reasonably good capability to remove nutrients.

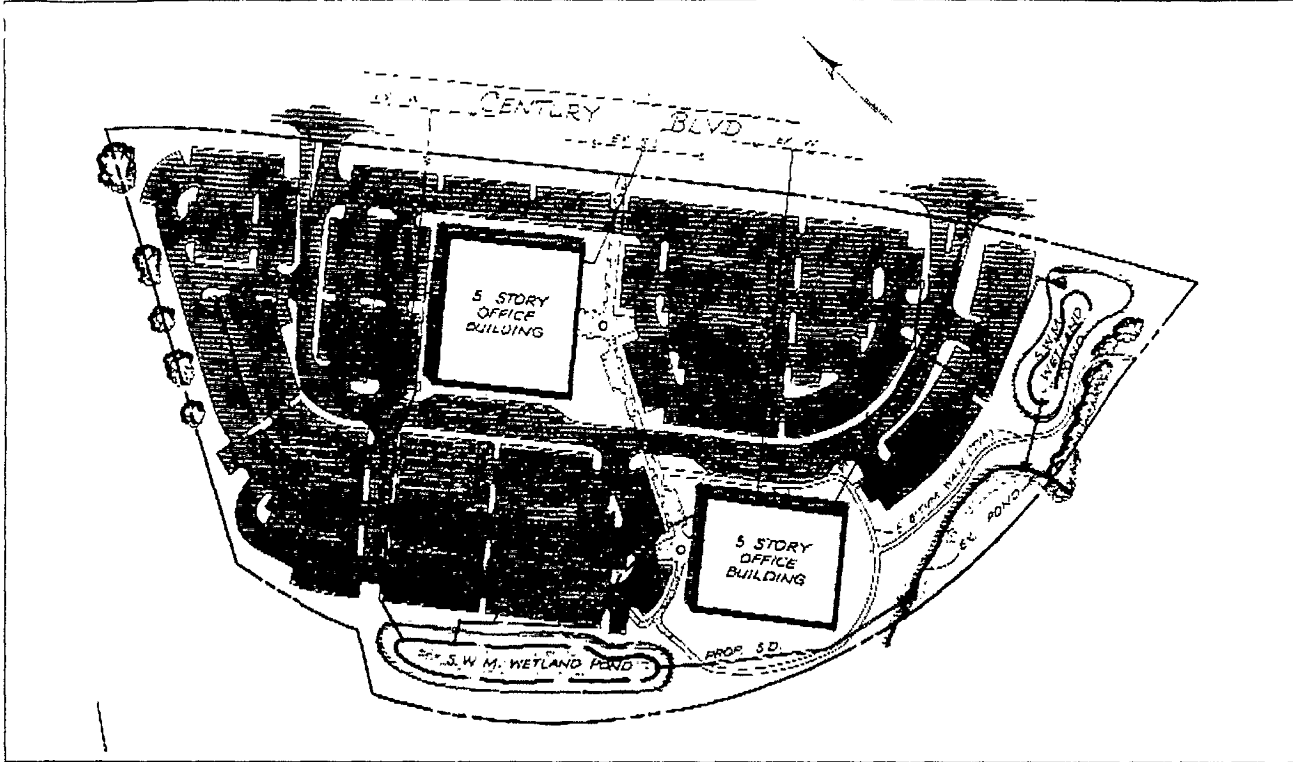

Figure 7: The Conventional Design of the 270 Corporate Office Park

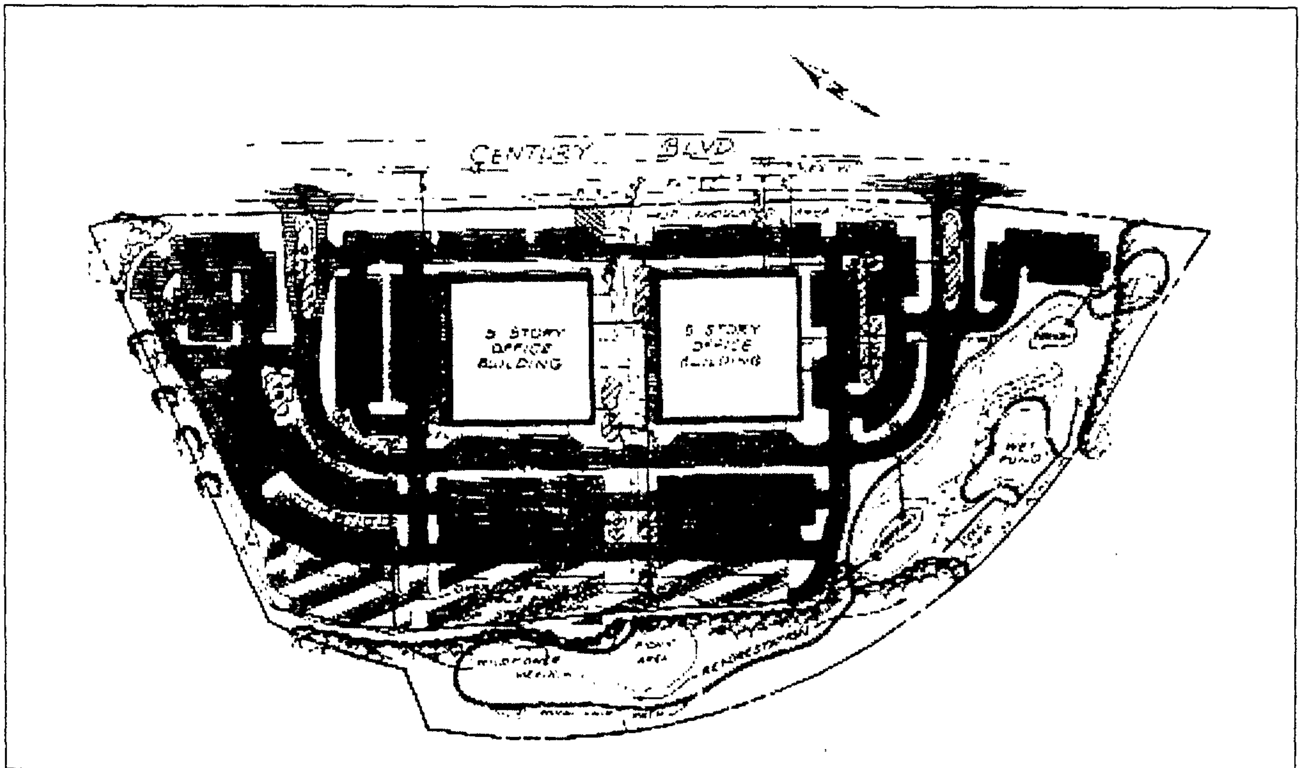

Figure 8: The Innovative Design of the 270 Corporate Office Park

The Redesigned 270 Corporate Office Park

The redesigned site employed a number of techniques to minimize impervious cover and improve stormwater treatment (Figure 8). The office park featured the same amount of office space, but the two office towers were situated closer to the road to shorten utility extensions, and pedestrian access to a bus stop was provided to encourage the use of public transportation.

The key strategy employed in the redesign was to incrementally reduce the size of the parking lot, and this was achieved in five ways. First, no excess parking spaces were allowed over those required by the local parking demand ratio. Second, the local parking demand ratio was reduced by 8% to reflect actual parking demand. Third, the parking demand ratio was reduced by another 10% to reflect the proximity to the bus stop. Fourth, the size of approximately 20% of all parking stalls was downsized to accommodate compact cars. Lastly, drive aisles in many parking bays were reduced from 24 feet in width to 20 feet. Combined, these measures reduced the total parking lot area by nearly 30%, or about two acres. Once again, the savings in paving gave the designer more room to integrate landscaping with more effective stormwater treatment.

For example, larger landscaping islands were installed in the parking lot to plant shade trees, and some of these areas were also converted into bioretention areas to treat stormwater. A dry swale was used to treat stormwater within a landscaped setback area in another part of the site. About 15% of the lot was designated for spillover parking, and grid pavers were used to attenuate runoff in this area. The basic stormwater management goal was to attenuate, treat, or recharge as much runoff from smaller storms as possible in the parking lot itself. Runoff from larger storms was treated in a wet detention pond near the outlet of the property.

As a result of the redesign, roughly 14% of the office park was either retained in natural land cover or reforested (compared to 2% under the conventional design). This green space, combined with the water features and a walking path, created a more tranquil environment for office workers. Overall, the total impervious area associated with the redesigned office park dropped from 68% to 53%.

Comparative Hydrology for the 270 Corporate Center Office Park

The hydrological story was much the same for the 270 Corporate Center as for the shopping center. Construction of the conventional design sharply increased annual runoff volumes and decreased infiltration (Table 2). Runoff did not increase as much in the redesigned parking lot, primarily because its impervious cover was much lower. Annual runoff volumes were 21% lower in the redesigned parking lot compared to the conventional design, and infiltration volumes were 42% higher. Despite these improvements, the redesigned parking lot was unable to mimic the hydrologic conditions prior to development.

Nutrient Output at the 270 Corporate Center Office Park

As expected, the conversion of the meadow into an office park greatly increased nutrient export. Annual phosphorus and nitrogen export increased roughly tenfold, according to the SUNOM model (Figure 9). As with the shopping center, stormwater runoff was found to generate about 95% of the annual nutrient export from the site. The two wet ponds were reasonably effective in removing nutrients at the conventional office park, but still resulted in nutrient export that was seven to eight times higher than pre-development conditions. In contrast, the redesigned parking lot sharply reduced nutrient export (Figure 9). The combination of lower impervious cover and more effective stormwater practices reduced nutrient export by about 40 to 50%, when compared to the conventional parking lot design *with* stormwater practices.

Table 2: Hydrology of the 270 Corporate Office Park Case Study

Hydrologic Factor	Pre-Developed	Conventional Parking Lot	Redesigned Parking Lot
Runoff (inches/yr)	2.7	23.9	18.9
Infiltration (inches/yr)	11.8	2.6	3.7
Note: no change in the annual volume of runoff or infiltration was calculated as a result of the stormwater practices installed at either the conventional or redesigned parking lot.			

Comparative Cost to Develop the 270 Corporate Office Park

The cost to develop the redesigned office park was approximately the same as the cost to develop the conventional office park, although the component costs were somewhat different. Less was spent on paving, sidewalks and utility pipes, but these savings were largely offset by higher costs for improved stormwater treatment practices, landscaping, grid pavers and curiously, curbs and gutters (the higher cost for this last item was due to the wider parking islands used for bioretention areas). Overall, the estimated cost to build the conventional parking lot was $948,900, compared to $921,200 for the redesigned parking lot.

Overall Summary: Office Park Redesign

The redesigned parking lot at the 270 Corporate Office Park resulted in less impervious cover, stormwater runoff, and nutrient export for about the same development cost as the conventional design. The results are summarized in Figure 10.

The Limits and Potential of Parking Lot Redesign

To our knowledge, no one has yet tried to quantify the potential economic and environmental benefits of better parking lot design at new commercial developments. This initial analysis provides compelling evidence that better site design is an important, if not indispensable, tool for managing the quantity and quality of stormwater runoff from parking lots.

In each of the case studies, the redesigned parking lot resulted in less impervious cover, stormwater runoff, and nutrient export for about the same or even slightly lower cost than the conventional design. Taken together, better site design techniques reduced impervious cover by at least 15% in each case. While this is an impressive reduction, about half of each site remained impervious after the redesign. Perhaps the most critical benefit of each redesign was that it created more room to locate more effective stormwater treatment practices. When smaller parking lots were combined with better stormwater practices, the resulting nutrient export was almost half that of a conventional parking lot.

In each case study, the critical ingredient was an incremental reduction in the local parking demand ratio. Without this capability to shrink the surface area devoted to parking, designers have little ability to devise the more sophisticated stormwater treatment and landscaping systems that can help mitigate the impact of the parking lot. Therefore, the first and most important step in implementing better site design for commercial developments *is to reduce local parking demand ratios, even if only by*

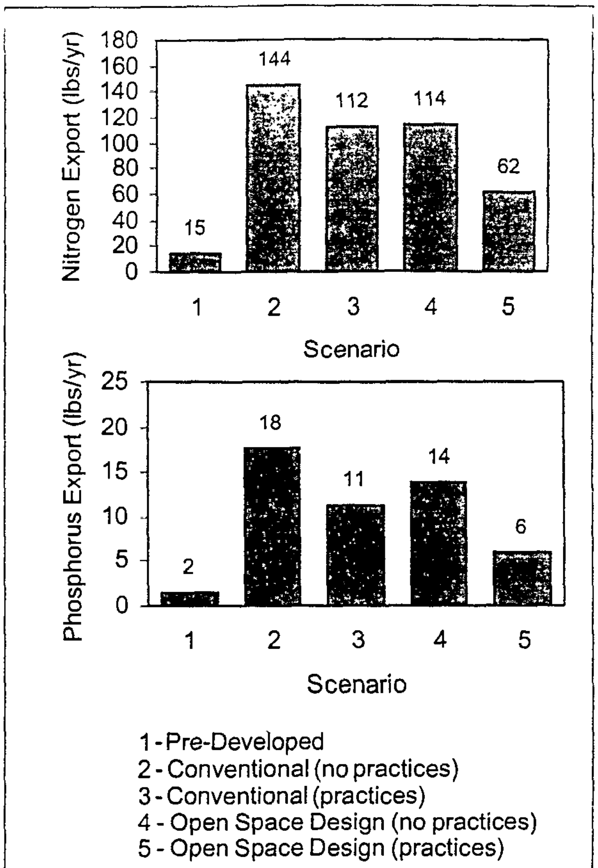

Figure 9: Annual Nitrogen and Phosphorus Load in Each 270 Corporate Office Park Development Scenario

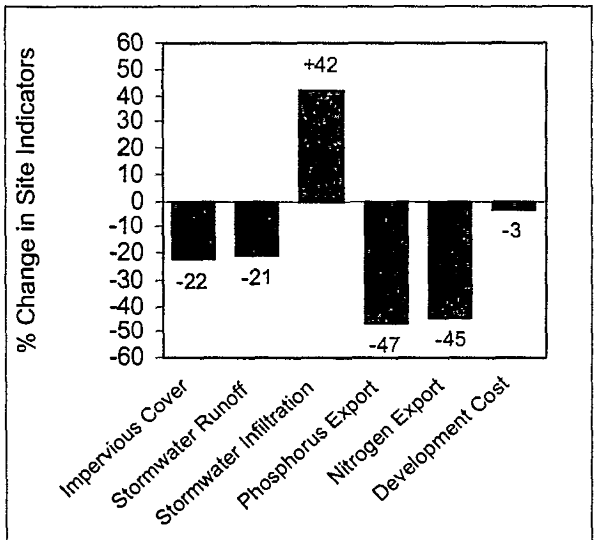

Figure 10: Percentage Change in Key Site Conditions from a Conventional Design to a Redesigned Parking lot at the 270 Corporate Office Park, Both With Stormwater Practices

five or ten percent. For many communities, however, this modest step may seem like a terrifying leap, possibly off a cliff.

Developers, bankers, retailers and drivers all have a shared interest in abundant and convenient parking, and it is hard to convince them that any attempt to downsize parking lots, however modest, will not work against this goal. This kind of thinking is quite understandable. Most people can easily recall the rare situation where parking was hard to find, but the more common situation where parking is plentiful generally escapes our everyday notice.

Small wonder, then, that so many communities are prone to inertia when it comes to changing parking codes. Perhaps the only way watershed advocates can overcome this inertia is to document the existence of excess parking capacity in each community. Indeed, it is a rather simple step for volunteers to count cars and photograph empty stalls during peak times at similar commercial land uses to demonstrate how generous local parking requirements actually are.

A small but growing list of communities are now experimenting with their parking standards and parking lot designs, including cities like Scarborough, Ontario; Oakland, CA; Olympia, WA; Sacramento, CA; Bellevue, WA; Davis, CA and Prince George's County, MD. Each community has worked in different ways to redesign their parking lots, and many of their successful experiences are recounted in *Better Site Design: A Handbook for Changing Development Rules in Your Community* (CWP, 1998a).

Given the prevalence of parking lots in our urban landscape and the environmental harm they cause, we need to fundamentally change the way that parking lots are sized and designed. The modest ideas presented in this article are merely an initial step in this direction. A wide range of professions collectively influence the form and function of parking lots, including engineers, hydrologists, landscape architects, urban foresters, soil scientists, developers, leasing agents, plan reviewers, transportation researchers and many, many others. Working together, these groups can move us closer toward the goal of a truly sustainable parking lot, i.e., one that not only provides car habitat, but also prevents damage to other habitats, as well. - ***JAZ***

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EPA

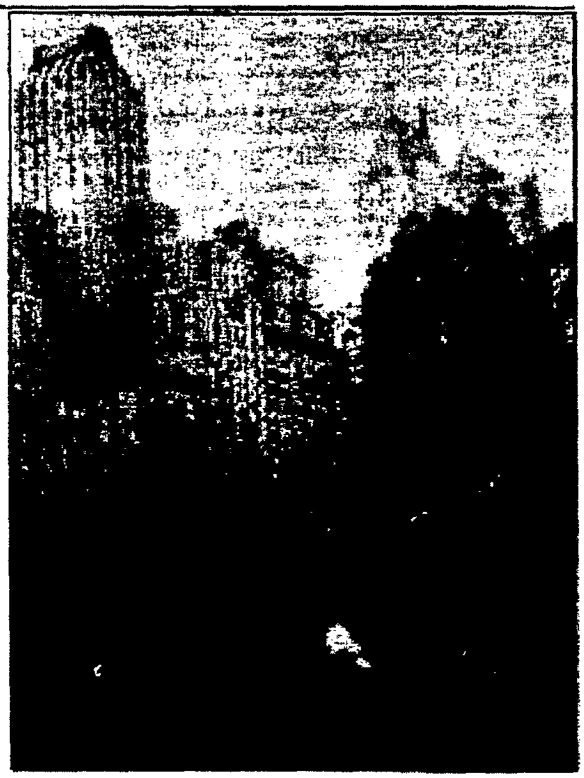
Urban Runoff Impacts to Receiving Waters

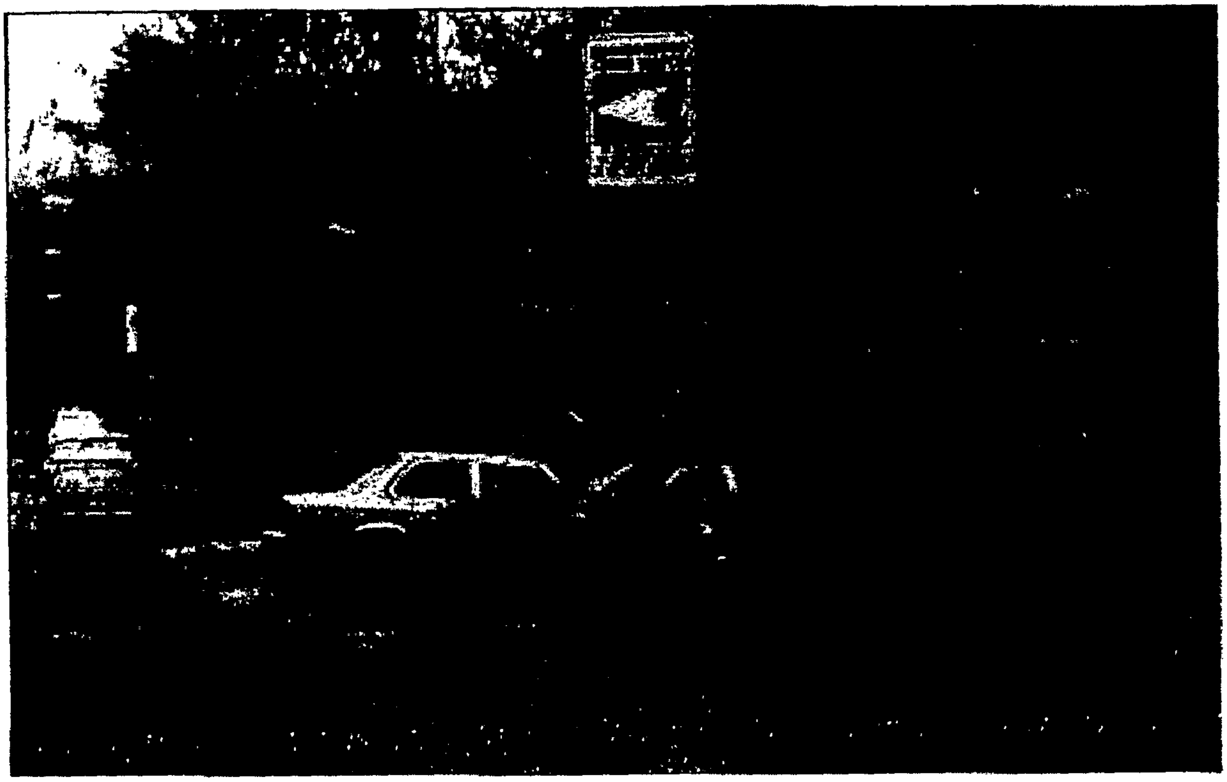
Introduction

The EPA-sponsored National Urban Runoff Program (NURP) identified the potential of stormwater to adversely affect receiving waters and aquatic biota through increased frequency and duration of peak flow rates, erosion/sedimentation, eutrophication, or toxic impact. Assessments completed under state clean lakes and nonpoint source programs have identified the extent to which urban runoff is impairing water use.

Stormwater Contaminants

The state assessments identified several categories of potential urban stormwater pollutants: suspended solids, nutrients, bacteria, oils/grease, toxic organics, and toxic inorganics (heavy metals). Critical pollutants were identified by: (1) frequency of occurrence within the stormwater database, and (2) high concentrations relative to the EPA water quality criteria. An additional consideration was the degree to which urbanized stormflow hydrology alone impacted biota in natural stream courses. Potential impacts resulting from the presence of the above pollutants include: (1) physical impairment or habitat disruption to biota, (2) enrichment and subsequent eutrophication of receiving waters, and (3) exposure and physiological response to toxic substances by aquatic biota. The presence of such impacts are considered an impairment of the receiving water resource.





Automobile traffic is a major source of pollutants resulting from urban stormwater runoff.

High Flows/Erosion/ Suspended Solids

Various urban runoff studies have effectively demonstrated the impacts of high flows, erosion, and deposition on urban streams and other sensitive receiving waters. Increased frequency and duration of high flows result in increased erosion-related impacts to (1) eroded sites, (2) conveyance systems including streams, and (3) sites of deposition. In-stream impacts are related to increased streambank erosion during high flows, increased turbidity and suspended solids concentrations, scouring habitat, and downstream depositional impacts that degrade habitat and reduce hydraulic channel capacities. Increased suspended solids concentrations and turbidity in streams can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, and reproduction. The deposition of relatively fine-grained sediments in stream beds can dramatically reduce their value for insect production and fish spawning. Erosion/ sedimentation impacts can be costly, requiring removal of deposited materials to restore water supply storage, flood control, habitat, and recreational benefits of impacted resources.

Nutrients

Increased nutrient (phosphorus, nitrogen) concentrations in stormwater have been shown to result in greater nutrient enrichment and associated algal productivity in lakes, embayments, and other quiescent receiving waters, often creating undesirable excessive growth conditions. Phosphorus is often emphasized as the nutrient controlling algal growth; phosphorus loading rates from urban areas have been determined to be three to seven times greater than undeveloped woodland. However, a preponderance of stormwater inflow has been demonstrated to inhibit algal growth as a result of the presence of toxic substances, despite elevated nutrient concentrations.

Toxic Organics

Toxic organic pollutants that are prevalent in urban runoff include pesticides, phenols, phthalates, and polynuclear aromatic hydrocarbons (PAHs). While some exceedances of EPA freshwater chronic water quality criteria have been reported, concentrations in general are sufficiently low to preclude significant impacts to aquatic biota. However, their potential for bioaccumulation and status as human carcinogens warrants continued consideration as pollutants of concern.

Toxic Metals

Toxic metals are the pollutants of greatest concern in urban runoff. Lead, zinc, copper, and cadmium have both a high frequency of occurrence and high absolute concentrations in stormwater; numerous exceedances of water quality criteria for these metals have been reported. Metals have the potential to bioaccumulate and persist in the environment.

EPA water quality criteria have been developed for both acute and chronic toxicity values from bioassays on representative biota; criteria are designed to protect 95 percent of aquatic species. Physiological effects of metals exposure include algal growth inhibition and zooplankton/fish mortality through gill adsorption and respiratory impairment.

Uncertainties of Toxic Impacts

While stormwater impacts related to aesthetics, hydrologic changes to stream habitat, elevated fecal coliform counts, and eutrophication have been adequately demonstrated, the adverse effects of toxicants have been more difficult to establish. Although some water quality degradation may be occurring, such degradation has generally not been perceived to result in significant impairment to aquatic biota. For example, of over 10,000 fish kills investigated by EPA during the period 1970-1979, less than 150 were attributable to urban runoff. If present, potential toxic impacts have been more subtle and more easily overshadowed by larger, definite impacts associated with scour and sedimentation. Other sources of uncertainty regarding toxic pollutant impacts include the following:

1. Water quality metals criteria and most stormwater analyses are based on total concentrations, whereas only the smaller dissolved fraction is directly related to toxicity. Criteria are therefore conservative as they also assume dissolution of the inert particulate fraction.

2. Criteria are based on continuous bioassays for the defined exposure period. In reality, stormwater toxic exposure is intermittent and of short duration, whereupon receiving waters recover to relatively acceptable quality. These are recognized by EPA under the term "Estimated Effect Levels for Intermittent Exposure."

3. Bioassays and water quality criteria are based upon end-of-pipe stormwater concentrations. Criteria therefore do not assume dilution capability by the receiving water.

4. Pollutant forms and concentrations are dynamic relative to product and use trends. For example, lead concentrations in stormwater have declined in recent years with the progressive conversion of the motor vehicle fleet to lead-free combustion engines. Similarly, some pesticide products are being retired in favor of new products being introduced to the market.

Summary Assessment of Urban Runoff Impacts

The majority of pollutant loading attributed to urban stormwater originates from endemic sources such as motor vehicle traffic and atmospheric fallout. While toxic metal criteria established from continuous exposure bioassays are regularly exceeded in stormwater, receiving water resources and local perception often do not reflect a corresponding beneficial use impairment of the resource. Possible reasons for this disparity are due to the conservative nature of water quality criteria designations and the complexity of biochemical cause and effect relationships. Instead, perceived or documented impairments focus on aesthetics from oil and floatable debris, species displacement from erosion/sedimentation in conveyance streams, and enhanced eutrophication potential from nutrient enrichment.

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A Guide to Protecting the Urban Environment

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Contents

Foreword

Despite the gains achieved by Clean Water Act requirements and the installation of municipal sewage treatment systems in most communities, water pollution still remains a problem. Although industries and municipal treatment systems continue to affect water quality, states estimate that nonpoint source pollution causes one- to two-thirds of the impairment or threats to waterbodies.

Nonpoint source pollution results from land runoff, precipitation, atmospheric deposition, drainage, seepage, and hydrologic modifications. In urban areas nonpoint source pollution is created when sediment, toxic substances, nutrients, pathogens, and even garbage wash off fields, lawns, and impervious surfaces into our nation's waterbodies.

This guide is intended to help decisionmakers, such as local government officials and planners, understand the causes of nonpoint source pollution and design and implement a program to control this pollution. The guide provides a framework for developing a nonpoint source program tailored to an individual community. It includes examples of successful runoff management programs that illustrate the variety of strategies state and local governments have adopted.

Technical guidance and expertise, however, are essential components in this process. *Urbanization and Water Quality* lists a number of sources for such expertise: publications, contacts, and summaries of several federal programs mandated by the Clean Water Act and Coastal Zone Management Act. Applied within the community's structure, this information can help improve and protect the quality of nearby waterbodies.

Chapter 1

How Urban Runoff Affects Your Community: The Problem

The thirsty earth soaks up the rain,
And drinks, and gapes for drink again.
Abraham Cowley (1618-1667)

While centuries of poets have praised the virtuous qualities of rain, urban decisionmakers are forced to face the harsh reality — rain and its close relative, snow, are the major carriers of nonpoint source pollution. Such pollution occurs in developed areas when water runs off the land and streets — gathering pollutants in its path and depositing them in nearby waterbodies.

Urban runoff carries pollutants from many sources and activities — automobiles, oil and salt on roads, atmospheric deposition, processing and salvage facilities, chemical spills, pet wastes, industrial plants, construction site erosion, and the disposal of chemicals used in homes and offices. In fact, pollutant levels in urban waterbodies are generally much greater than in forested watersheds.

Runoff water quality worsens as urbanization increases:

- Trees that once intercepted rainfall are gone.
- Natural dips or depressions that had formed temporary ponds for rainwater storage are lost by grading and filling for development.
- Thick, absorbent layers of natural vegetation and soils are replaced by paved (impervious) surfaces such as roads and roofs.
- Eroded paths such as streambanks become channels, increasing the amount of sediment carried by runoff.

As asphalt and concrete replace vegetation, runoff increases and reaches waterbodies faster and with greater force. And when the land loses its capacity to absorb and store rainwater, the groundwater table drops and stream flows decrease during dry weather.

The Symptoms

Local governments must be alert to the obvious symptoms of water pollution. They include

- scum and algal mats floating near lake shores,
- excessive plant growth choking waters used by boaters and swimmers,
- sediment-clogged drainage ditches and sewers,
- decreasing depth of a lake,
- fewer fish and wildlife,
- contaminated water supply for drinking, recreation, or industry,
- fish kills that may destroy sport fisheries or close beaches,
- fish advisories caused by bacteria or toxic substances found in fish, and
- extreme flooding or streambank erosion.

The Sources

Pollution from urban runoff can affect water in various ways, depending on the pollutant. The impacts and sources of pollutants have been researched by many organizations, including the Metropolitan Washington Council of Governments, from which much of this information was extracted (see Table 1).

■ Sediment. Sediment — organic and inorganic material suspended and settling in water — clogs storm drains; fills river channels, lakes, wetlands, and reservoirs; and increases the potential for flooding downstream. Sediment may fill in water supply reservoirs, eventually requiring costly dredging or new water sources.

These suspended solids make the water appear muddy, decreasing its value for fishing and recreation. As sediment settles to the bottom, phytoplankton, fish, and invertebrates have difficulty feeding and reproducing. Other aquatic life may be smothered or deprived of essential sunlight. Sediment can also carry other materials — such as nutrients, pesticides, and trace metals — that can harm both aquatic life and human health.

Sediment and erosion are at their peak when the soil is disturbed along with the vegetation that stabilizes it. And once sediment enters a stream, it can take many years to travel through the waterway. As silt, clay, and sand move downstream, they erode the streambank, affecting fish and wildlife habitat along the way.

■ **Nutrients.** Nutrients — excessive levels of phosphorus and nitrogen — pose a severe problem as urban development intensifies. Nutrients encourage undesirable algal blooms and excessive aquatic weed growth. This nutrient-rich process, called eutrophication, greatly decreases the water's quality.

In lakes, for example, decomposing plants can cause surface scums and unpleasant odors, discolor water, and decrease oxygen. This breakdown limits swimming, boating, fishing, and other recreational uses; reduces fish and wildlife habitat; and contaminates water supplies. The water-holding capacity of lakes and reservoirs may also decrease.

Urban runoff carries nutrients from roads, sidewalks, and parking lots, and from lawns, golf courses, parks, cemeteries, homes, and commercial sites. In some areas, improperly maintained household septic systems add to the problem.

■ **Bacteria.** Urban runoff often contains high levels of harmful bacteria and viral strains, including fecal streptococcus and fecal coliform from human and animal wastes. When these levels exceed public health standards, as they often do, water is unsafe to drink, beaches are closed, and harvesting shellfish beds is restricted.

Older, more intensively developed areas produce the most bacteria from organic wastes and sanitary sewer overflows. In addition, pet and bird wastes increase the nutrient and bacteria content of runoff.

■ **Oil and grease.** Oil, grease, and other petroleum-based substances contain hydrocarbons, some of which are harmful to sensitive animal species and aquatic life. Hydrocarbons attracted to sediment settle in the bottom of waterbodies, where they may harm bottom-dwelling organisms and be transferred through the food chain.

Hydrocarbons also degrade fisheries habitats and damage the appearance of the water's surface. They lower dissolved oxygen by limiting the interaction of water and air. Oil and grease problems are highest in the runoff from parking lots, roads, and service stations. Oil held in the soil can eventually seep through to the groundwater and be carried to the streams.

■ **Heavy metals.** Heavy metals — including lead, copper, cadmium, zinc, mercury, and chromium — can be toxic to aquatic life and contaminate drinking water supplies. Heavy metals affect sensitive animal species, plants, and fisheries and enter the food chain through animal tissue ingested by humans and other animals.

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Table 1.—Pollutants typically found in urban runoff.*

COMMON URBAN RUNOFF POLLUTANTS	SOURCE	AVERAGE CONCENTRATIONS	NONPOINT SOURCE IMPACTS
Sediment	Urban/ Suburban	average 80 mg/L	Fills in ponds and reservoirs with mud; contributes to decline of submerged aquatic vegetation (SAV) by increasing turbidity and reducing the light available for photosynthesis. Acts as a sink for nutrients and toxicants and as a source when disturbed and resuspended.
Total Phosphorus	Urban Suburban	1.08 mg/L 0.26 mg/L	A contributing factor cited in eutrophication (nutrient over-enrichment) in receiving waterbodies and subsequent algal blooms. Algal blooms contribute to the decline of SAV by reducing light available for photosynthesis, further degrade water quality by decreasing the level of dissolved oxygen (DO), and may cause changes in the composition of plankton and fish species.
Total Nitrogen	Urban Suburban	13.6 mg/L 2.00 mg/L	Like total phosphorus, contributes to eutrophication and algal blooms.
Chemical Oxygen Demand	Urban Suburban	163.0 mg/L 35.6 mg/L	Decreases the concentration of dissolved oxygen. Low DO concentration and anaerobic conditions (complete absence of DO) can lead to fish kills and unpleasant odors. Primarily released as organic matter in the "first flush" of urban runoff after a storm.
Bacteria	Urban Suburban	average — 200 to 240 000 MPN/L	High concentrations can lead to closure of shellfish harvesting areas and prevent swimming, boating, or other recreational activities.
Zinc	Urban Suburban	0.397 mg/L 0.037 mg/L	Most commonly found toxic metal in the mid-Atlantic coastal region; chronically exceeds EPA water quality criteria. Primary cultural source is the weathering and abrasion of galvanized iron and steel.
Copper (Nationwide Urban Runoff Program average)	Urban Suburban	0.105 mg/L 0.047 mg/L	Chronically exceeds EPA water quality criteria. Primary cultural source is as a component of antifouling paint for boat hulls and, in urban runoff, from the leaching and abrasion of copper pipes and brass fittings. An important trace nutrient, it can be bioaccumulated and, thereby, create toxic health hazards with the food chain and increase long-term ecosystem stress.
Lead	Urban Suburban	0.389 mg/L 0.018 mg/L	Lead from gasoline burning in automobiles is less of a problem today because of unleaded gasoline use. However, lead from scraping and painting bridges and overpasses remains. Chronically exceeds EPA water quality criteria. Attaches readily to fine particulates that can be bioaccumulated by bacteria and benthic organisms (e.g., oysters and mussels) while feeding. Lead has adverse health impacts when consumed by humans.
Oil and Grease	Urban/ Suburban	average 2-10 mg/L	Toxicity contributes to the decline of zooplankton and benthic organisms. Accumulates in tissues of benthic organisms, a threat to humans when consumed directly or when passed through the food chain. Primary cultural source is automobile oil and lubricants.
Arsenic	Urban/ Suburban	average 6.0 µg/L	An essential trace nutrient. Can be bioaccumulated, creates toxic health hazards within the food chain and increases long-term stress for the entire ecosystem. Accumulates within tidal, freshwater areas, increasing the toxicity for spawning and juvenile fish. Primary cultural source is fossil fuel combustion.
Cadmium	Urban/ Suburban	average 1.0 µg/L	Urban runoff contributes a major portion to the mid-Atlantic coastal region. Primary cultural source is metal electroplating and pigments in paints. Can be bioaccumulated; creates toxic health hazards within the food chain and increases long-term toxic stress for the entire ecosystem.
Chromium	Urban/ Suburban	average 5.0 µg/L	Primary cultural source is metal plating and as a component of paint pigments. An essential trace nutrient, it can be bioaccumulated, creating toxic health hazards within the food chain and increasing long-term toxic stress for the entire ecosystem.
Pesticides	Urban/ Suburban	average <0.1 µg/L	Primary urban source is runoff from home gardens and lawns. Can bioaccumulate in organisms and create toxic health hazards within the food chain. Observed levels currently below standards.

Based on mid-Atlantic Coast data.** ***Source: Metropolitan Washington Council of Governments, 1993.

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Most metals found in urban runoff come from corroding, decaying surfaces, often accelerated by acidic rain, and from dissolving or leaching materials. Among the sources of metals are roofing materials, downspouts, leaded gasoline, galvanized pipes, metal plating, paints, wood preservatives, catalytic converters, brake linings, and tires. Maintenance of bridges and other structures can also contribute paint scrapings and abrasives.

■ **Toxic substances.** Toxic chemicals, including pesticides and polychlorinated biphenyls (PCBs), can seriously impair water quality and threaten human and animal health. In addition to pesticides, toxic wastes are found in fertilizers, herbicides, and household substances such as paints and cleaning materials. Proper use and disposal of these substances are mandatory.

■ **Chlorides.** Chlorides or salts are toxic to many freshwater aquatic organisms, which can tolerate only a certain level of salinity. Increased levels of sodium and chloride in surface and groundwater can also affect soil structure, stressing plant respiration and lessening viability.

The main source of chlorides is road salting to remove ice and snow. Chlorides run off roads, parking lots, and sidewalks, and find their way into wetlands, streams, lakes, and groundwater. Because of their high mobility, chlorides can have a major impact on groundwater.

■ **Temperature.** Even a slight rise in water temperature can adversely affect some aquatic life and insects in and around a waterbody, including stoneflies, mayflies, and trout. This is particularly true of streams that alternate between cold and warm water.

Runoff can raise stream temperatures as a result of passing over an urban landscape warmed by structures and paved surfaces. Less shade because of fewer trees also raises stream temperature. Runoff stored in shallow ponds and heated by the sun between storms, especially pollution controls that hold runoff for extended periods, can also harm aquatic life.

■ **Trash and debris.** Floatable wastes collect at impasses in streams and lakes, disturbing water flow and impairing the aesthetic quality of the environment. This debris, from street litter and careless disposal practices, washes into waterbodies both over land and through the storm drain system.

■ **Impervious surfaces.** Paved surfaces absorb less rainfall, thus directly increasing water velocity. More sediment will be deposited downstream; and the rapid, forceful flow may drastically erode streambanks, making the area vulnerable to flooding. Increases in paved surfaces can be directly linked to the accelerated loss of aquatic habitat. Heavier sediment loads clog streambeds with sand and silt, destroying habitat. Pool and riffle stream areas also become severely degraded, leaving poor conditions for both the fish community and the macroinvertebrate insect community on which fish depend for food.

■ **Disturbance of stream habitats.** Development inevitably requires that roads and pipelines cross streams, rivers, and wetlands. Construction activities can upset ecosystems and habitats; permanent structures such as culverts can block the movement of fish, preventing recolonization.

Wildlife habitat may also be affected by the replacement of vegetation by roads and structures. Installation of concrete-lined storm drainage channels, for example, often requires removing tree canopies and results in a loss of riparian and aquatic habitats.

Open spaces play an important role in controlling nonpoint source pollution in most urban areas. Therefore, the whole watershed should be considered in making conservation decisions. Maryland, for example, has a Forest Conservation Act that protects existing forests while allowing continued development. It requires a developer to map existing forests and submit a forest conservation plan. This type of program can serve as a reference for urban communities facing similar decisions.

In the past, communities have treated pollution crises as they arose. They have built treatment plants to control point sources of pollution, and used various best management practices (BMPs) to address urban runoff (see Chapter 4). But today, communities are realizing that the hydrology and ecology of their entire watershed influence water quality (see Fig. 1).

Communities are also recognizing that the greatest loss from water pollution is that people can no longer use and enjoy the natural resource. They can't swim, boat, fish, picnic, or just enjoy a lake or river. As a result, the economic impact on the community is significant — people must go elsewhere for recreation, taking with them dollars that could be spent on gas, food, lodging, and entertainment. Pollution may also cause property values to fall, eroding the tax base.

With this increased awareness and knowledge, communities of all sizes are building two-pronged water quality programs: (1) they are identifying and correcting existing problems, and (2) they are focusing on preventing future problems. Communities are finding that a comprehensive nonpoint source management program will help them avoid many of the problems caused by urban pollutants *before* they occur.

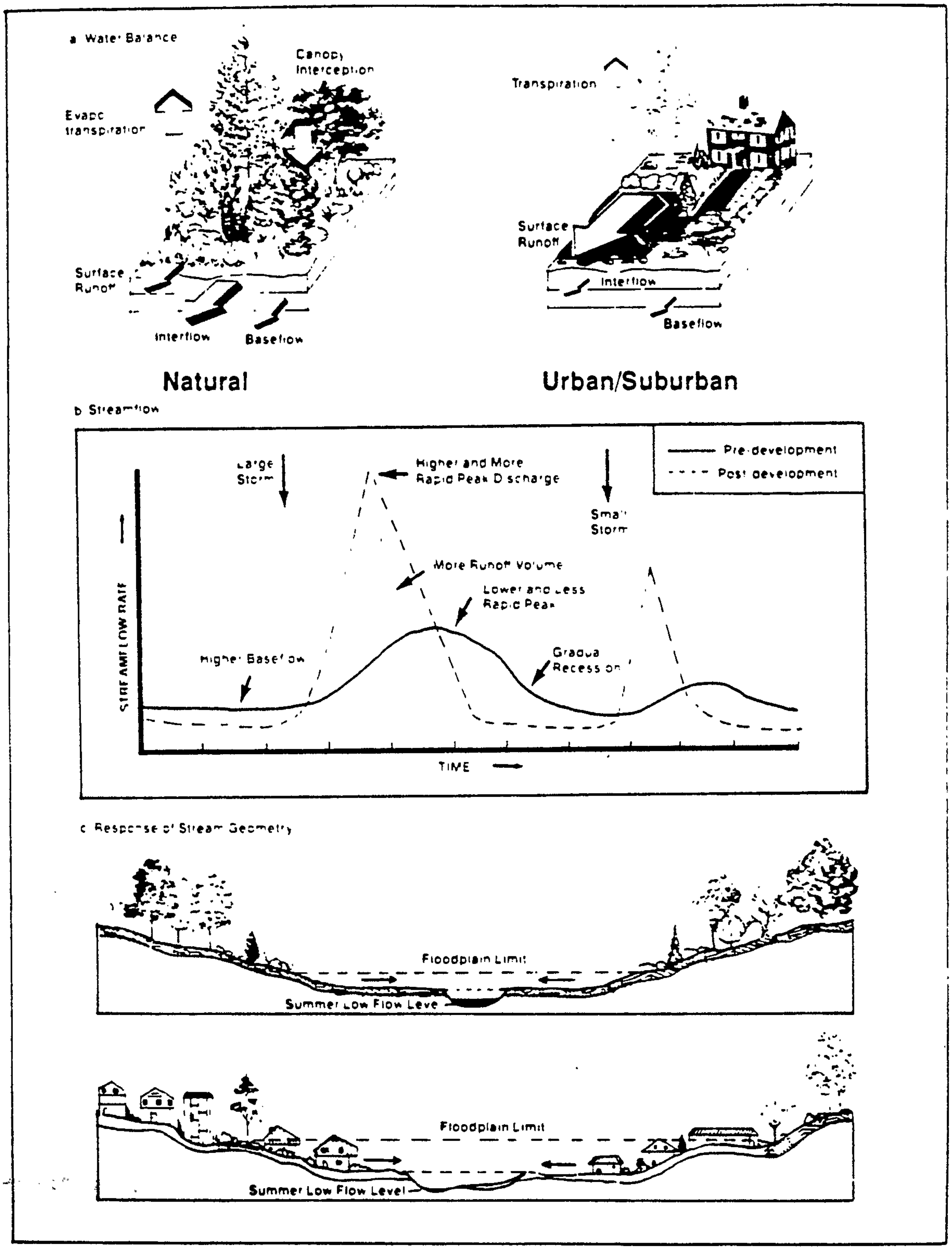

Figure 1.—Changes in watershed hydrology as a result of urbanization. ***Source: Metropolitan Washington Council of Governments, 1987.***

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Chapter 2

Controlling Urban Runoff: Designing a Nonpoint Source Management Program

With urbanization inevitably comes nonpoint source pollution. This pollution stems from the basic processes of urbanization and the individual lifestyles of citizens.

A nonpoint source management program is one element within a community's overall management plan, just as the effects of urban runoff are one concern. But each piece connects within the community puzzle, if only within the budget. Therefore, the task of controlling nonpoint source pollution must be accomplished by the entire community, planning and working together.

Conservation techniques on undeveloped land — floodplains, wetlands, stabilized streambanks, and slopes — go far in assuring water quality. These natural features play important roles in managing nonpoint source pollution in local communities and should be included in any comprehensive management approach.

This chapter describes a step-by-step approach to designing a nonpoint source management program, a process that a community can adapt to its own situation. Subsequent chapters contain information on the pollution prevention and control methods that can be applied to managing urban runoff.

Figure 2 charts some of the elements of a successful nonpoint source management program. While most programs begin with defining the problem, a program requires continued revisiting, reevaluating, and adjusting. A central element in all phases of program development and implementation is educating and involving the public. In fact, the program's success depends on public support and buy in. Chapter 5 discusses techniques to be incorporated at every phase of the program to keep the public aware and supportive.

The following is a step-by-step guide to constructing a successful nonpoint source management program:

Step 1: Define the current or potential problem.

Step 2: Evaluate existing programs and resources.

Step 3: Build program infrastructure.

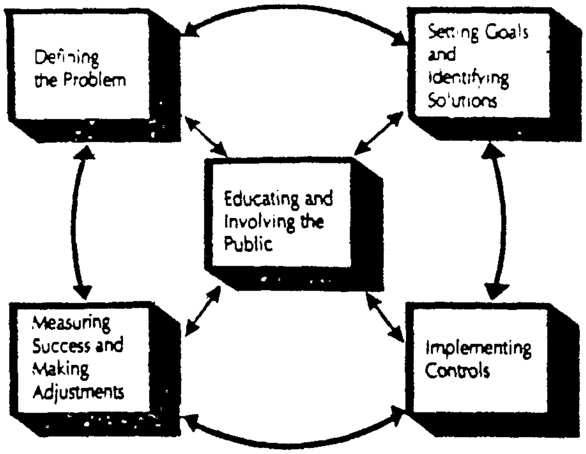

Figure 2.—Elements of a successful watershed project. *Source: U.S. Environmental Protection Agency, The Watershed Protection Approach: A Project Focus, 1994.*

Step 4: Identify potential options.

Step 5: Evaluate options and alternative strategies.

Step 6: Set program goals.

Step 7: Select a final strategy.

Step 8: Develop a work plan.

Step 9: Adopt and implement the work plan.

Step 10: Monitor, evaluate, and revise the program.

A Nonpoint Source Management Program

Step 1: Define the current or potential problem.

Whether you are reacting to citizen complaints or planning ahead to prevent potential problems, you will need substantive, reliable data to define your community's current or future problems.

Enlist staff, interns, and/or volunteers to determine what information is needed, why it is important, and how to obtain it. Emphasize accuracy in collecting data and keep meticulous records on when, where, and how the data were collected.

Organize and store data for ease of use and accessibility, preferably in a computer database, complete with backup copies.

Your most important task is to first get to know your entire community to evaluate it for actual and potential nonpoint source pollution problems. All factors are important — from the people who live there to the community's physical position within its watershed.

Research and inventory your resource area and community to completely understand the community's strengths and weaknesses in relationship to the watershed. You'll find most of this information at your local soil and water conservation district or your state water quality authority. The U. S. Geological Survey, your regional planning commission, and local universities can also help. Table 2 lists further sources of various data.

Table 2.—Sources for natural resource assessment, inventories, and other data.

TYPE OF INFORMATION NEEDED	CONTACTS
Water Quality Data	U.S. Geological Survey, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U S Fish and Wildlife Service; state water quality agencies, fish and game departments, departments of health; and tribal environmental offices
Land Use Data	U S. Department of Agriculture's Soil Conservation Service and Agricultural Stabilization and Conservation Service, U S. Forest Service, Bureau of Indian Affairs, U S Bureau of Reclamation, U.S Bureau of Land Management; state cooperative extension services, land office; tribal environmental or agricultural offices, local government offices such as city planners and county commissioners
Economic Data	County extension service, councils of government, economic research services, chambers of commerce; state department of commerce; tribal councils; real estate agents, private consultants
Demographic Data	Councils of governments, census reports, chambers of commerce, state statistics bureaus, almanacs

Source: Terrene Institute, Clean Water in Your Watershed: A Citizens Guide to Watershed Protection, 1993.

An important resource for community programs is section 319 of the Clean Water Act. This provision requires each state to assess and design a management program to control potential nonpoint source pollution problems. Contact the responsible state agency to pinpoint local problems and determine if resources have been allotted.

■ **Identify and map your watershed.** Include smaller watersheds within its jurisdiction and specific sites needing attention because of development or other special circumstances (see Fig. 3).

- Locate wetlands and other critical areas.
- Identify vegetation strips and other areas that can control pollution or urban runoff.
- Map your community's drainage pattern downstream and the location of groundwater aquifers and those used for drinking water (see Fig. 4).

■ **Identify the land uses within the watershed.** Map and calculate the number of acres within the watershed for each type of use. Check with your zoning commission first, and if you need more detail, go to

- land ownership and variance zoning records,
- site approvals,
- building permits, and even
- aerial photos.

You may not be able to obtain comprehensive, absolutely accurate and precise land use information — but the more details you gather now, the better your community will understand the land use in and around its watershed.

Categories can be defined broadly — residential, commercial, industrial, agricultural, and open space — and further subdivided as necessary.

For example, low-density residential has a different impact on water quality than high-density residential. Among industrial uses, a mining company may cause more nonpoint source pollution than a sugar processing plant. And forests differ from wetlands.

Some questions to ask:

- How much of the agriculture is dairy, soybeans, pasture, rangeland, or other?
- Are open spaces forest, meadow, or wetlands?

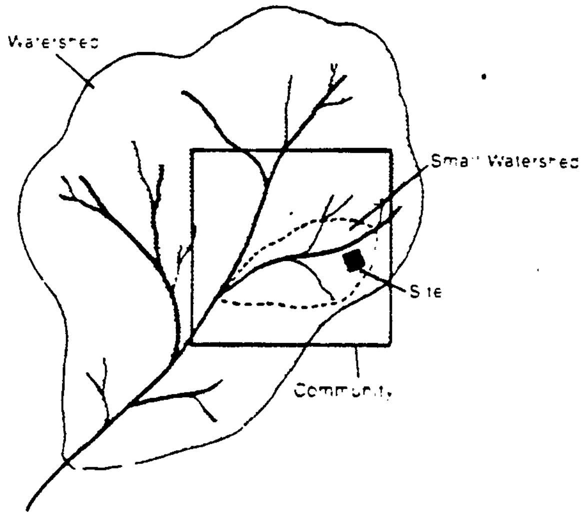

Figure 3.—Watersheds nest within each other; a site within a small watershed lies within the community and is part of the larger watershed.

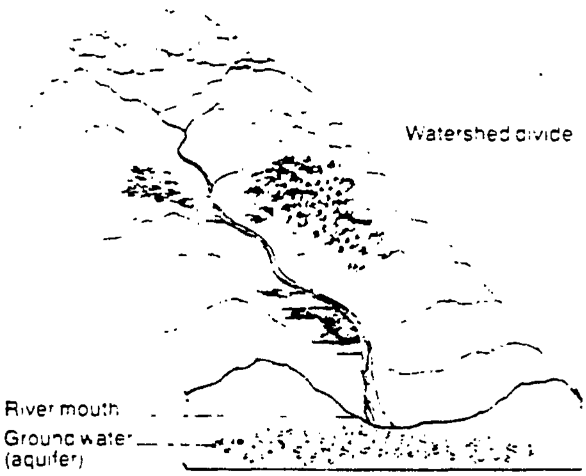

Figure 4.—A watershed graphically depicted. ***Source: Puget Sound Water Quality Authority.***

- How rapidly are the urban areas developing?
- How are urban areas divided for development (commercial, residential, industrial, other uses)?

■ **Investigate environmental factors.** Assess geology, topography, soil characteristics, vegetation, groundwater recharge areas, flood-prone sites, and hydrologic and biological characteristics.

Get help in determining what principles of geology, topography, soil, and vegetation are important in

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understanding water quality. Study USDA Soil Conservation Service (SCS) soil maps, Federal Emergency Management Agency (FEMA) floodplain maps, and U.S. Geological Survey topographic maps. You can find assistance locally from the USDA Extension Service, soil and water conservation district, and university and high school science departments.

■ **Determine current waterbody quality.** Obtain basic information on your waterbodies — pollutant concentrations, vegetative cover, and aquatic life — and determine if the state has monitored or designated them by classes. Water quality standards specify the concentrations of various pollutants allowable according to how the waterbody is used. Water quality designated uses include fishing, boating, water supply, priority wetlands or floodplains, and productive or open shellfish beds.

The state water quality agency should be able to provide current data, including documentation of any known water quality problems. If the state has information for your waterbody, a baseline database on its water quality may exist. If not, determine how to establish baseline data; perhaps your local college or university can help.

Investigate ongoing efforts to collect data, such as those obtained from citizen monitoring groups (see Chapter 5).

■ **Determine actual threats to surface and groundwater.** Is an industrial park being developed with the potential for construction runoff and, later, operational discharges from high traffic parking and maintenance lots? Is land use changing significantly — or at a rapid rate? Is there a known trouble spot?

Threats to groundwater include high water tables, uncapped abandoned wellheads, discharges associated with industrial development, and failing and inappropriately located septic systems.

■ **Identify other problem areas.** Identify specific sites that need attention, using land use maps to define areas of greatest imperviousness. Additional actions can include

- researching water quality and biological resources;
- walking along streams to visually assess excessive erosion, lack of riparian cover, water quality conditions, and physical stream conditions;
- identifying point sources by obtaining copies of National Pollutant Discharge Elimination System (NPDES) permits for discharge levels;
- obtaining data related to flood control or stormwater best management practices;
- obtaining information from local resource managers familiar with water resources; and
- checking sections 319 and 314 (Clean Lakes) assessments and 305(b) reports made by your state water quality agency on impaired waterbodies (EPA requires these reports from each state).

■ **Research the local economy.** An accurate picture of the local economy is important to make growth projections and to assess what funds might be available to protect water quality.

- Determine what portion of the watershed's population is rural and what portion is urban.
- Describe factors specific to the area, such as a large plant opening or a long-time employer closing.
- Assess the growth trends in the community and in the watershed. Development is a major cause of both short- and long-term nonpoint source pollution. Understanding population and growth trends also helps determine the areas most vulnerable to water quality deterioration.
- Assess income levels compared to national and regional averages and calculate the local tax base and revenues available from government grants and other sources. Current and projected tax revenues and other income sources will determine the amount of resources available to manage water quality.

■ **Evaluate industry and infrastructure.** Are industrial plants and infrastructure, such as sewage and stormwater systems, potential nonpoint source polluters? Assess age, state of environmental technology and practices, and other features. Seek guidance from experts in this assessment.

Assess the condition of roads, bridges, airports, marinas, and other parts of the transportation network.

- Note needed or ongoing repairs or new construction, and specify possible nonpoint source pollution hazards.
- Observe current road and ditch maintenance practices and note opportunities for improvement.

DETERMINING FINANCING STRATEGIES

Communities must answer several questions before selecting the best financing option for the situation:

- *Are funds sustainable? Will they last over the long term or are they only a short-term band-aid approach?*
- *Are funds easy to obtain? Is the application complicated? Does it require multiple approvals?*
- *Are funds difficult to administer? Will you need additional staff to track and prepare reports or assess and collect fees?*
- *Does a correlation exist between the funding and the problem? Will those who pay for the benefits receive them?*
- *Will the funding be used appropriately? Will it be a quick fix or will it have secondary benefits?*
- *Have legal restrictions been placed on the use of the funds?*

Step 2: Evaluate existing programs and resources.

■ **Identify existing ordinances and enforcement authorities.** Identify state and local laws that authorize government to proceed with control methods. For example, zoning ordinances might authorize setbacks or buffer strips, limit development on impervious areas, or establish erosion and sediment controls. Existing programs and authorities should be used — and strengthened — to benefit water quality.

Determine if your governmental unit has the legal authority to protect its floodplains and enforce ordinances using fines, permits, inspections, stop work orders, or other methods to make a nonpoint source program work. Communities often set fines for septic violations, for example.

■ **Investigate funding options.** Review funding options and select those that best suit your community. For an overview of traditional and innovative funding mechanisms, refer to EPA's "A State and Local Government Guide to Environmental Program Funding Alternatives" (Appendix B).

STORMWATER UTILITY FINANCING

The stormwater utility is a creative approach to funding that also addresses political and institutional questions. One of the most important benefits of a stormwater utility is that it can provide a steady stream of funds to develop, operate, and maintain a comprehensive stormwater management system. This, in turn, permits the development of integrated, long-range planning from one source.

Establishing a stormwater utility can be complicated. It requires collecting water and analyzing its quality, assembling land use and economic information, and establishing an equitable billing system. Moreover, establishing the utility can prove expensive because of costs for engineering, legal, and financial studies; new staff, and information management systems. Local officials must educate citizens to overcome public resistance to a new utility charge.

Many cities have such programs, including Bellevue, Washington, and Billings, Montana (see Appendix C for contact information).

Federal sources

- Federal Construction Grants Program — States provide seed money loans to local governments for water quality projects to be repaid from local fees or taxes. This program, however, is being gradually replaced by the State Revolving Loan Fund.
- State Revolving Loan Fund — Administered by a state agency, loans can be used to fund projects to control nonpoint pollution and be repaid from local revenue.
- EPA Clean Lakes Program Grants — Publicly owned lakes may qualify for federal grants available through state environmental agencies.
- Section 319, Clean Water Act — EPA provides grants to specific nonpoint source projects that demonstrate progress in controlling and abating nonpoint source pollution.

State and local sources

- Special use taxes — State or community levies, fees, or taxes on cigarettes, boat licenses, hotel rooms, or permits.

CALIFORNIA NONPOINT SOURCE STATE REVOLVING FUND LOANS

California was one of the first states to use state revolving funds for nonpoint source projects. Projects included demonstration projects, retention/detention basins, wetlands for stormwater treatment, and a variety of best management practices. Eligible programs also include training, public education, technology transfer, and development of ordinance and management practices.

Loans can cover 100 percent of the project cost. Repayment, which can take as long as 20 years, begins one year after the program begins. Interest rates are determined by the state's general obligation bond rate.

The loan request begins with an eight-page application and background information. The local government passes a resolution establishing repayment arrangements. The State Water Board places the project in the SRF Intended Use Plan approved through a public hearing process.

- BMP tax credits — Used for installing best management practices or similar controls.
- Drainage fees — Used to compensate for excessive runoff from a site.
- Bonds — Paid for by fees from developers or users.
- Special assessments — Levied through utility districts established by communities.

Step 3: Build program infrastructure.

■ **Identify all participants and determine their objectives.** Participants with a vested interest might include state and local agencies, governing bodies such as legislatures and city/county councils, local or national public environmental groups, trade associations, citizens, and business leaders. Establishing a working relationship with the lead state nonpoint source pollution agency is particularly important for information, resources, and support.

■ **Match the resources with the problems.** Determine what governmental units fit into your proposed plan and which methods of funding will work best. You may not need a staff as much as you need the ability to coordinate the available resources.

TYPES OF NONPOINT SOURCE PROGRAM FINANCING

A number of creative strategies for financing water quality programs have been implemented in recent years. Examples of the most successful are

- **Real estate transfer fee:** *Nantucket, Massachusetts, has funded a land purchase program through a 2 percent transfer fee on all property sold on the island. From the land bank's beginning in 1984 until June 1993, the fee has collected nearly $27 million.*
- **License fees:** *In Iowa, the Groundwater Protection Fund includes revenue from increases in pesticide dealer license fees. Chemical manufacturers are also assessed a 75 cent per ton tax on nitrogen-based fertilizers.*
- **Impact fees:** *In Florida local governments can assess development impact fees when issuing permits to cover infrastructure costs associated with new development.*
- **Sales tax:** *Washington increased state sales tax on cigarettes by 8 cents a pack to finance water pollution control programs. 50 percent for marine, 10 percent for nonpoint source, 10 percent for freshwater, 10 percent for groundwater, and 10 percent for discretionary programs.*
- **Stormwater utility fees:** *Some governments have created a stormwater utility service to achieve multijurisdictional solutions. Charges are based on the amount of a property owners' impervious surface and generally range from $1 to $4 a month.*
- **Environmental trusts:** *Minnesota established a trust with proceeds from the state lottery; half of the net proceeds will remain in the fund for five years.*
- **State revolving funds (SRF):** *These funds were authorized by the Water Quality Act of 1987 specifically to improve water quality. The SRF money is loaned to local governments, who repay it with revenue raised from local fees or taxes. SRF funds recycle a set amount of money to finance numerous projects over an extended period.*

Local governments. Identify the units within your community with the authority, knowledge, and resources to coordinate a nonpoint source control program — for example, departments of public works, public health, or the environment. In small communities, the conservation commission, planning board, or code enforcement office might have the authority. Other relevant governmental units might include regional planning commissions or the departments of park maintenance, road maintenance, waste disposal, or health.

Existing municipal programs can be modified to address urban runoff concerns. For example, a pretreatment inspection program for a publicly owned treatment works (POTW) can be expanded to look at runoff at each industrial facility. Similarly, fire and safety programs can be expanded to inspect runoff collection points. This coordination should be high priority since it can be much more cost effective to use existing program resources than to start a new program.

Find out what actions neighboring cities and counties, particularly in your watershed, are taking to control nonpoint source pollution. While you cannot control other jurisdictions, even though their actions might affect your water quality, you should be well informed of their problems and methods of controlling them.

State agencies. Determine agencies responsible for nonpoint source management, groundwater, water quality standards, floodplains, wetlands, coastal zone management, land conservation, land planning, endangered or threatened species; and scenic and wild river protection.

Find out what help the lead nonpoint source agency can offer and fit this resource into your control strategy. State nonpoint source coordinators may not be able to help with all problems — they have their own agendas, determined by state and federal priorities. With the diversity of funding sources for nonpoint source control, the community may need to enlist the support of several different agencies.

Federal resources. U.S. EPA and USDA can provide technical advice and materials. In addition, the Army Corps of Engineers can provide technical guidance, information, and permits. The U.S. Fish and Wildlife Service is a source for biological information, and the National Park Service and U.S. Geological Survey can provide watershed information.

VIRGINIA STORMWATER MANAGEMENT

Virginia's stormwater management ordinance is an example of state-enabling legislation (Code of the Commonwealth of Virginia: Title 10.1, Chapter 6, Article 1.1). Municipal ordinances can be established by reference to the state law or tailored to local needs. Specifically, the components of Virginia's legislation are

- *statement of purpose;*
- *definition of terms;*
- *authorization for local programs;*
- *guidelines for developing technical criteria and administrative procedures;*
- *statement on the status of state projects and lands;*
- *specification of the state's oversight responsibilities;*
- *authorization for establishing more stringent local requirements;*
- *procedures for submitting plans and approving and exempting land uses;*
- *authorization for collecting performance sureties, recovering administrative costs, and assessing service charges;*
- *description of the appeals process;*
- *specification of civil penalties and enforcement options;*
- *authorization for cooperation with federal and state agencies; and*
- *statement exempting the legislation from limiting the authority of other agencies.*

The Virginia legislation includes all minimum critical elements and provides the legal authority for local governments to adopt their own stormwater management ordinances. The Virginia law places the primary burden on new development by defining existing runoff levels and the corresponding level of water quality effects, erosion, and flooding as a point of reference. Local governments can require performance bonds or escrow accounts for development. If proper stormwater controls are not installed, resources will be available to complete required activities without burdening taxpayers.

Cognizant of EPA's municipal stormwater requirements, the Virginia law also authorizes local governments to cooperate with federal agencies.

Appendix C lists these and other information sources, including some interstate programs or compacts, such as the Chesapeake Bay Program, the Gulf of Mexico Program, EPA's National Estuary Program, FEMA's National Flood Insurance Program, and NOAA programs.

■ **Determine public attitudes and perceptions.** Alert citizens can be your best allies and informants. Use citizen complaints about water quality to spot current problems. Citizens often express such complaints in phone calls or letters to council members or the local newspaper editor. Look for newspaper articles on local lake or river problems.

If necessary, use a survey to assess public attitudes and perceptions regarding water quality issues and to determine the level of support and cooperation the program might elicit. Formal citizen monitoring projects are extremely successful components of many state and area water quality programs.

Step 4: Identify potential options.

The following chapters will help you think about your options for controlling urban runoff. Add to them the information you have garnered through your exploration of the agencies and organizations already working in the nonpoint source pollution arena. Your state nonpoint source coordinator can point to techniques that will work in your area.

- List each option to be considered for your plan (and your specific problems).
- For each option, list reasons favoring its use and those in opposition.
- Estimate the cost, including maintenance and longevity, for each option.

Step 5: Evaluate options and alternative strategies.

By now, you should have mechanisms in place to share information and thoughts about the process with many groups and individuals — both those knowledgeable in the field and interested citizens. At this point, you certainly need to know how your community is thinking. In addition to local stakeholders, make sure to include federal and state landowners and other groups such as the Department of Defense and the Conservation District.

Some jurisdictions use the consensus method, requiring support from all members, to make water policy decisions. Collecting information, airing viewpoints in group discussions, and analyzing the problems and solutions lead to acceptable compromises. The consensus process frequently produces a more creative and binding outcome, important when a community commits to a long-term project.

In exploring the merits of each option for controlling nonpoint source pollution, carefully consider the following issues:

- benefits and costs to the community;
- feasibility of implementation;
- public support and/or opposition;
- funding sources;
- staff to administer, enforce, and monitor;
- potential for problems and adverse reactions;
- technical support; and
- long-term maintenance ability.

■ **Models.** Computer models can be used as a design tool to project possible scenarios for pollution control programs, but they should be used with care and expertise. Modeling can be an expensive exercise that does not always relate to the real world. Models now in use include several versions of SWMM, a Storm-water Management Model developed by EPA, and its companion, RECEIV, and AGNPS, the Agricultural Nonpoint Source Model. Many states and regional governmental units are using GIS (Geographic Information System), another computerized tool, to predict erosion and other factors. Local governments can adapt GIS to their own needs.

Step 6: Set program goals.

After analyzing the information collected, determine the focus of your program. This step takes you back to the original premise: Does your community have an immediate problem, or has it simply recognized the wisdom of preventing future nonpoint source problems?

Thus, your program goals will be driven either by the need (1) to take immediate action, or (2) to achieve community support for a long-term preventive program. Of course, you may have to balance both concerns.

The basic steps in setting realistic goals, however, are based on setting priorities and matching them with available resources:

- Identify and list your community's most serious problems.
- List all other problems, both immediate and potential.
- Rank all problems for immediate, medium-range, and long-term action.
- Establish a series of objectives and a timeline for achieving each goal.

Visible progress is important to build community support. As you set program goals, try to identify at least one objective that can be accomplished quickly to assure your community that progress is being made.

Step 7: Select a final strategy.

The strategy selected should meet several objectives. At a minimum, it should

■ **Establish the legal, financial, and administrative framework for the nonpoint source management program.**

■ **Develop a comprehensive public education/participation program that ensures community buy-in to the nonpoint source management process.** Far from being an isolated element, public education, understanding, involvement, and support are vital elements in each stage of a project—from defining a problem, to developing workable solutions, to adjusting and monitoring the progress (see Fig. 5).

■ **Restrict construction/development in highly erodible areas — steep slopes and erodible soils.** Some slopes are not amenable to runoff control and some soils are impermeable — unable to absorb runoff. These areas should be identified and conventional ground-disturbing construction prohibited.

■ **Reproduce predevelopment hydrological conditions.** In addition to controlling runoff, a nonpoint source control program should, to the extent possible, diminish the hydrological changes brought about by development. Successful planning requires recognizing and addressing the serious implications of such changes.

■ **Reduce or remove pollutants.** Because control methods differ markedly in removal mechanisms, their performance in removing pollutants can vary significantly. Applying best management practices is one method of achieving goals (see Chapter 4 for discussion of BMPs). However, BMPs change with time and conditions and should be monitored and modified as necessary. Retrofitting includes constructing new BMPs or modifying existing practices in developed areas. Control practice effectiveness should constantly be reevaluated considering new technology, maintenance, repair, or upgrading needs.

■ **Use strategies appropriate to the watershed and the site.** Many control methods do not work because they are unsuited to the geographic area or site. Inappropriate methods can cause maintenance problems or nuisance conditions; in some cases, inappropriately located methods may not function at all. Decisionmakers need to understand a site's special characteristics. For example, plans may need to be modified after field reviews of the site's physical condition.

TARGETING

Implement a comprehensive management program by stages based on water quality problems — particularly when resources are limited. By ranking problems according to your specific area needs and targeting them for control, you can realize the greatest water quality benefits for resources expended. See Chapter 4 for discussion of best management control practices.

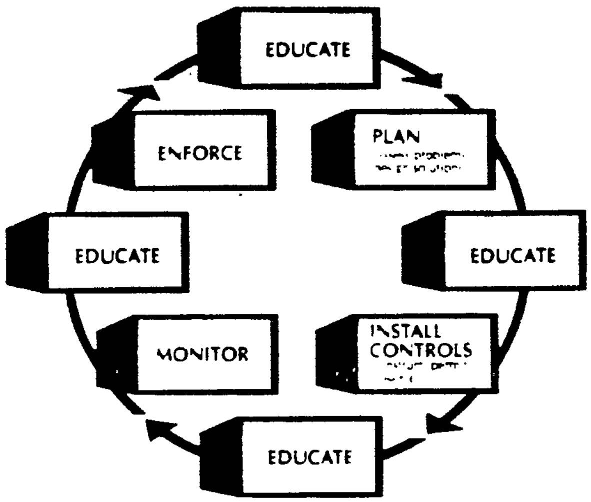

Figure 5.—Comprehensive public education/participation program. *Source: Terrene Institute, Clean Water in Your Watershed: A Citizens Guide to Watershed Protection, 1993.*

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■ **Protect and preserve vegetative treatment systems with nonpoint source benefits.** Buffers and natural systems filter out many pollutants in urban runoff before they become a problem. Communities should identify and preserve these natural vegetative treatment systems, because once they are altered, they cannot be easily replaced.

■ **Protect critical aquatic habitats and natural wetlands.** Determine the aquatic species most threatened by nonpoint source pollution in the watershed. What can be done to protect their habitats? Is the preferred technique compatible with other uses of the water? Should more than one control method be used?

■ **Be responsible for maintenance of controls.** Controls are effective only if regularly maintained, and maintenance costs can be significant. Over 20 years, structural BMPs can exceed their initial construction costs, passing on costs to future residents or taxpayers. While some effective BMPs require significant maintenance, others — particularly some nonstructural BMPs — are not expensive to maintain. Anticipate future maintenance needs and consider the cost factor compared to other needs and resources.

■ **Positively affect the environment.** Control methods significantly affect the natural environment and adjacent community, either positively or negatively. Small investments in design, landscaping, and maintenance can make a control method an attractive, or at least an unobtrusive, feature in a community. Without such effort, controls can become unsightly nuisances. If that occurs, public support for nonpoint source control is jeopardized.

Step 8: Develop a work plan.

After defining the goals and the strategy, develop a specific work plan. The work plan should express the community's goals in definitive terms, yet be broad and flexible in their execution. It should ultimately be a practical, easy-to-use guide to decisionmaking over the long term.

The work plan should also include specific measurable objectives to meet community goals (e.g., nitrogen concentration will drop 10 percent by 2000 from 1990 levels) and fit into the existing infrastructure. The plan should complement existing plans, translating local goals, priorities, and resources into action.

Consider other plans in developing a work plan for your community:

- comprehensive land use plan
- stormwater management plan
- roadway/transportation plan
- zoning map
- water and sewer network
- open space conservation plan
- preservation of critical areas

Also consider

- legal authorities
- local/state agencies
- existing land use patterns and zoning

The following is an outline for developing a nonpoint source pollution control work plan:

I. Formulate goals, objectives, assumptions.

II. Describe the size and scope of plan.

III. Identify legal authority.

IV. List the responsible agency or agencies.

V. Describe staff and training needs.

VI. Describe existing conditions and resources, using data relating to the community, including water quality problems and opportunities for improvement.

VII. Describe demand pattern for water. Analyze how water use patterns relate to demographic and economic groups; measure impact on residents, nonresidents, and tourists; assess impact of fees and other charges on demand patterns; analyze why existing opportunities (i.e., recreation, fishing) are not being used.

VIII. Provide needs analysis. Analyze supply and demand relationship; develop program standards; describe water quality needs, state need for a plan/program, and local government's ability to meet program needs.

IX. Analyze present policies and programs as they relate to program goals and outcomes. Recommend and justify the option selected.

X. Appendix. Include background studies (pertinent information collected), data and methods, bibliography (sources), and acknowledgments and credits.

Step 9. Adopt and implement the work plan.

The work plan must be adopted by the community's governing body. Information gained in developing the work plan should be used to further the effort to educate and involve the public and community decision-makers. Whether a public referendum is required to pass the plan and financing mechanism or a committee or city council will make the final decision, inevitable differences of opinion can be resolved through a continued program of public information, education, and political savvy.

■ **Implementation.** After local adoption, follow an implementation plan that describes the necessary actions and who is responsible. Schedule actions by time period, group, and responsible agency. Relate costs to the general budget. Describe needs for training, legislation, public participation, and state approval process, if necessary.

■ **Training.** A successful water quality program requires a high degree of staff involvement. A program must have technical staff to develop specific controls, administrative staff to oversee the project, clerical staff to maintain records, and volunteers to carry out citizen education and monitoring functions. Staff and volunteers should help develop the plan and begin training soon after its adoption.

Workshops sponsored by federal, state, regional, and county agencies and by private environmental groups are good ways to gain expertise. In addition, local university extension curricula may offer courses that relate to the program. On-the-job training can also be effective if supervised by professional water quality specialists (see Appendix C).

Step 10: Monitor, evaluate, and revise the program.

While some revisions will occur early in the planning process, evaluation and modification should continue indefinitely. Incorporate a monitoring and evaluation plan into the work plan and see that staff or volunteer programs are in place to carry out this ongoing process.

To make sure the control method is working, develop a monitoring program that relates results to initial goals set early in the planning process. The monitoring program must have clear goals, such as

- evaluating BMP efficiency;
- specifying problems with receiving water quality;
- identifying priority sources (for example, gas stations or malfunctioning septics);
- validating results against other studies or models; and
- complying with applicable regulations, including local requirements.

Compliance may be a good area in which to involve citizens. Citizens have made valuable contributions to local monitoring programs. However, volunteer monitors must be well trained, supervised, and motivated to ensure that the data is accurate and useful. The local government should carefully supervise program activities and conduct the analyses (see Chapter 5).

A monitoring program should consider, at a minimum, the following parameters:

- beneficial uses that need protection;
- expected impacts on water resources and assorted habitat; and
- an approach to measuring impacts.

Prepare an annual report of your progress for the county or city council and other governing bodies. This serves not only as a program evaluation tool but also keeps the community informed. In addition, the state government may be able to include the report as part of its annual report required by the Clean Water Act.

Chapter 3

Planning to Prevent Urban Runoff

A successful nonpoint source management plan begins by identifying general concepts and goals in the total community development or comprehensive plan. Specific controls (see Chapter 4) to prevent pollution should be part of each site plan.

Damage that occurs as part of the development process is, at worst, irreparable and, at best, costly to clean up. Therefore, urban runoff pollution prevention should be part of the overall plans for roads, parks, utilities, and other public facilities as well as for each site.

Such plans should consider the larger drainage basin, the immediate watershed, the municipality, and, finally, the specific site. Water quality plans must work in harmony with local legislation and programs of other political jurisdictions.

Developing a Land Use Plan

Land use planning begins with the local government, but it must also adhere to state mandates and comprehensive planning. A good nonpoint source program coordinates federal and state laws with local programs in a plan that improves and protects water quality according to community needs. Local government should provide the broad legal authority to develop comprehensive plans and programs.

Land use planning can prevent pollution problems by protecting water quality, open spaces, stream valleys, and floodplains. At the same time, planning should support local economic needs. Through comprehensive planning, communities can address water quality issues by setting development goals — for environmental quality, a sustainable economy, viable commercial areas, population density, housing patterns, recreational facilities, tourism, and property values — that work together to ensure the overall "quality of life."

Land use planning reduces pollutant loads in two ways:

- by controlling the type, size, and location of development in a given area, and
- by reducing pollution generated at specific levels of development.

While comprehensive planning provides general guidance in managing nonpoint source pollution, specific practices are put in place through zoning laws that regulate development.

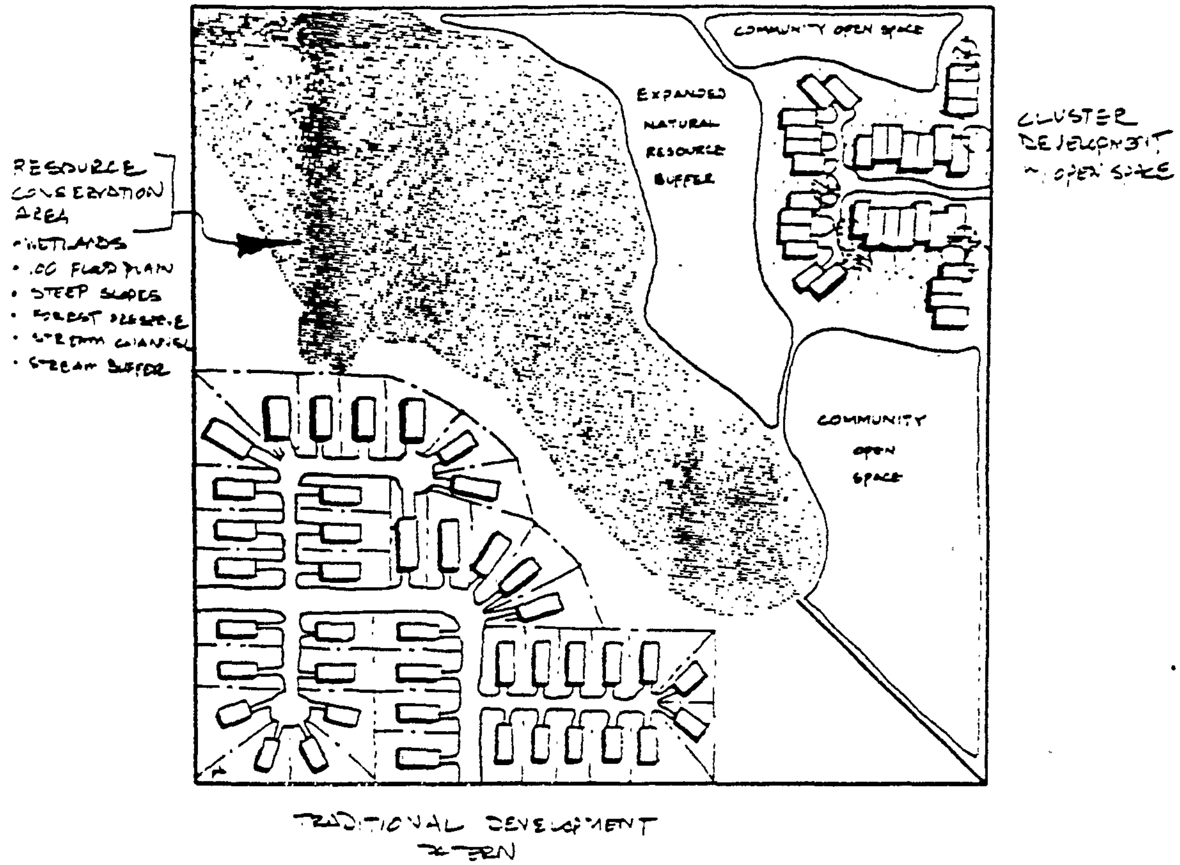

Figure 6.—Cluster versus traditional development preserves open space and reduces land disturbances.
Source: Metropolitan Washington Council of Governments, 1993.

■ **Zoning process.** Zoning specifies the density and type of land use that can occur in a given area. It is the working arm of a comprehensive plan that controls overall local development and considers water quality and other environmental goals along with a myriad of community concerns. Zoning ordinances apply only to uses that begin after the ordinance is enacted, and therefore affect only future practices.

Because zoning ordinances also regulate authorized uses (e.g., building, lot sizes, designs), they can be structured to control nonpoint source pollution. This control is particularly relevant on highly erodible steep slopes and shores or in high-density areas where developers must provide adequate drainage systems for their projects.

Several types of zoning apply to water quality issues:

Cluster development. Clustering preserves the existing topography and provides the community with more open green space by concentrating residential development on a limited portion of the site. This leaves substantial area for amenities such as playgrounds, parks, and woods (see Fig. 6).

Preserving open space and the existing tree canopy reduces impervious surfaces and the resulting runoff. Further, following the land's natural contours reduces disturbances that cause erosion, improves aesthetics, and preserves sensitive habitats.

Keeping the same population density, developers can save on necessary facilities such as roads and utility lines, since cluster development reduces the lengths of paved roadways and utilities needed.

Cluster development minimizes the need to convert agricultural land to residential use. It also allows development to match actual site capacity. Homeowners and the public can enjoy many of the amenities of rural living within an urban environment. Cluster development also helps maintain property values, one of zoning's basic goals.

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Planned unit development (PUDs). Through comprehensive development planning, PUDs provide a mix of zoning classifications including compatible commercial, residential, and even light industrial development. PUDs, which sometimes include clustered development, range in size from a few acres to over 1,000.

PUDs harmoniously blend varying uses to create an attractive, interrelated unit that preserves both property values and aesthetics. As with cluster development, a PUD's goal is to maintain density while maximizing open space. The ideal PUD locates residences and offices within walking distance of each other, dramatically reducing traffic.

A PUD's main water quality benefit is large-scale urban runoff management planning. Local governments control PUDs through negotiations between the developer, the public, and the public review authority. PUDs must maintain open space to facilitate stormwater drainage and sometimes require developers to provide special structures to handle runoff.

Incentive or bonus zoning. This method is used to promote cluster development. It permits the developer higher density than normal in return for maximizing open and/or public use space or other amenities.

Downzoning. Downzoning changes an established zone to a lower density level or less intense use. Typically, industrial zoning permits the most intense land use, followed by light industrial, commercial, and residential.

Downzoning is used on strips of land adjacent to waterways to provide a buffer between industrial sites and the streambank or on a whole area surrounding a waterbody to reverse or prevent pollution.

Phase-in zoning. Phase-in zoning is used when present development is incompatible with water quality goals but abrupt change would be too disruptive to the economy and the community. For example, to protect a lake surrounded by heavy industrial development, the community might close and decontaminate plants when their useful life is finished, rather than allowing them to be sold or leased to another industry, and prohibit new plants from opening.

Large-lot zoning. Large-lot zoning applies to large residential developments, generally 5 to 20 acres. Regulations call for designs that take advantage of common management to achieve water quality goals. These may include reducing the quantity and impact of septic system leachate to a water supply, building stormwater detention basins, or preserving open land to facilitate aquifer recharge.

Conditional zoning. Conditional zoning can be used in a standard zone or where zones are not clearly delineated. It carefully monitors and limits potentially harmful activities by permitting certain activities only under special conditions. For example, a conditional zoning might allow multiunit apartments in a single-family housing zone only if no septic tanks were used.

Floating zone. A floating zone is defined by characteristics rather than geographical location. The proposed use must be compatible with the surrounding uses and conform to the zone's expressed purposes.

Under a floating zone, for example, multifamily dwellings that conform to specific code requirements regarding septic tanks, grading, and open space preservation could be acceptable in an area zoned for single-family dwellings. Alternatively, a floating zone might restrict certain development in a wetland or around a well or aquifer recharge zone. A developer would need to show that the project does not fall within the area subject to floating zones or take adequate steps to protect water quality within the zone.

Overlay zoning. An overlay zone is a mapped district that places restrictions or requirements in addition to those of the underlying zone. Overlay zones are used to meet a special public interest that is not met by the existing zone or by rezoning. For example, these zones can protect specific water sources such as ponds, wells, or wetlands lying within residential, commercial, or industrial zones. In Figure 7, the stream valley corridor buffer overlay zones provide special protection for water resources located within the existing zones, reducing the impact of uses on water and natural habitat.

In another example, Maryland counties use overlay zoning within the Chesapeake Bay Critical Area — a 1,000-foot land buffer surrounding the tidal portion of Maryland's bay tributaries — to protect land and water resources. The critical area overlay zone is designed to foster more sensitive development activity for shoreline areas while minimizing the adverse impacts of develop-

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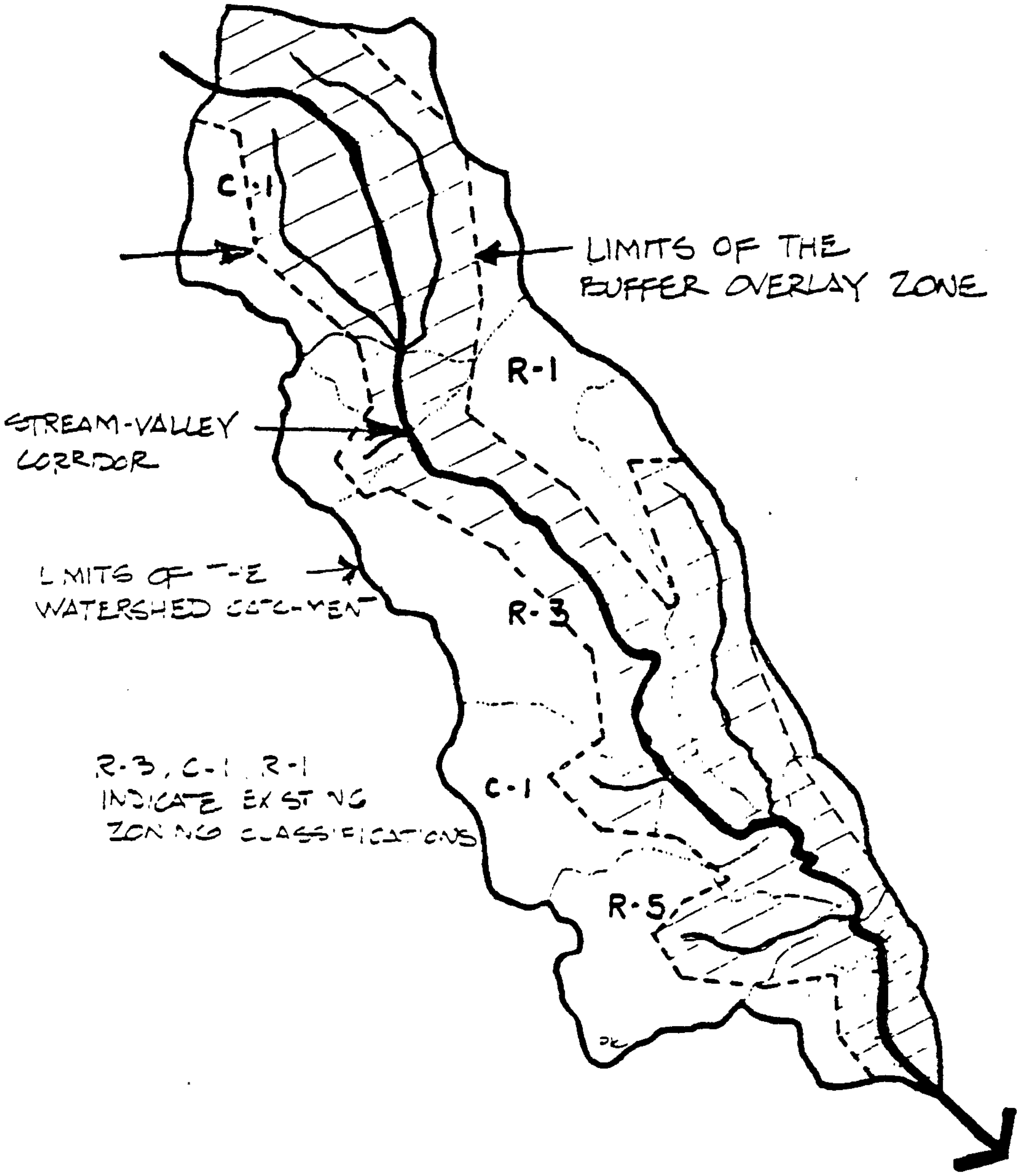

Figure 7.— Overlay zoning adds another measure of protection to critical resources. ***Source: Metropolitan Washington Council of Governments, 1993.***

ment on water quality and natural habitats. Zones are known as intensely developed areas (IDAs), limited development areas (LDAs), and resource conservation areas (RCAs).

Floodplain zoning. Building in floodplains — areas subject to periodic inundation by runoff — is considered unsafe. Except for roads or other transportation facilities, development is generally restricted. Local governments or FEMA can provide floodplain maps.

Open space preservation. This zoning protects community open spaces by creating public parks or undeveloped strips of land adjacent to waterbodies. This important zoning provides open space to allow urban runoff to seep into the ground and recharge the water table. Open space preservation also protects critical aquatic habitats such as wetlands, reduces flooding, and enhances aesthetics.

Not all open space uses benefit water quality. A zoo, for example, requires high maintenance to dispose of manure, care for parking lots, and clean up litter. In addition, open space should be used differently depending on its location within the watershed.

Aesthetic zoning. Aesthetic zoning places design restrictions on new or historic buildings, preventing development or renovation from blighting the community or destroying its style or scale continuity. Aesthetic zoning can also protect water quality by requiring open space or limiting development size and the pressure it places on the watershed. For example, restrictions can protect attractive shores and swimming, boating, fishing, and other recreational uses.

Performance zoning. Performance zoning limits development to the resources of the specific property. While the overall intensity of use meets zoning requirements, the gross density can vary, depending on the property's characteristics. Performance zoning can set a maximum use intensity (density factor) on the buildable portion of the site. This avoids many small zoning districts providing different levels of protection. The environment is protected from disturbance of unstable or rare resources, but flexibility is allowed in less sensitive areas.

In using zoning as part of an environmental program, planners should consider all options to ensure that the zoning solution is appropriate and feasible. For example, downzoning a heavily developed area to protect a waterbody might not be economically feasible, but incentive zoning could be applied to future development or an overlay zone used to augment existing zoning.

Zoning regulations promote legal issues and challenges. Courts often strike down unnecessarily restrictive or discriminatory ordinances. In addition, zoning is a political issue, often requiring a referendum or other formal adoption mechanism. Therefore, zoning plans must be carefully structured to address a variety of needs and constituencies.

■ **Subdivision review.** Land use is regulated by many zoning categories. However, before separately owned parcels of land can actually be developed, they are subject to subdivision review.

The subdivision review process includes several stages in which various government entities and agencies review development plans to ensure that the developer has met all the standards and requirements placed on the land and has obtained all necessary permits and approvals.

ZONING + SITE PLAN REVIEW

A small, primarily rural Maryland community is devising a plan to protect the water supply of its rapidly growing town.

Subdivision regulations have been amended to give the town council authority to regulate the density of development based on anticipated demands and effects on the water supply and quality. Aquifer recharge areas have been identified and an overlay zoning district established.

A site plan for a development must be prepared by a professional hydrogeologist for review and approval by the town council and the planning commission. The plan must delineate the development within the recharge area and project water demand and its effect on aquifer recharge. If the council determines that the development does not lie within any recharge area, the development plan may proceed through normal processing.

The council or planning commission may reject any plans that

- *impose adverse effects upon the aquifer recharge rate or water quality (the developer may resubmit modified plans),*
- *would create a water demand on the site greater than the groundwater recharge rate, or*
- *cause more than a 10 percent decrease in a site's recharge rate (immediate rejection).*

Other economic and water quality considerations may also be grounds for rejection.

These requirements include building lots, streets, sewers, grading, and relationships to other properties and the comprehensive plan. The review can also include runoff control, drainage, and erosion control requirements, and provisions for parks, buffer areas, open spaces, and maintenance responsibility. These features are often phased in as the project progresses, with completion required by the time the lots are sold.

Before subdivision review was part of the normal planning process, developers often sold lots without such basic design features as roads, parks, and open spaces. The community had to pay for further improvements. Reviews guarantee that developers meet requirements before construction can begin or proceed.

Subdivision review is a good time to review the design of permanent urban runoff management structures. This allows the entire parcel to be reviewed as a whole rather than in small separate parcels that may not individually require comprehensive treatment.

Site plan review is a stage in the subdivision process. It enables government to review the technical aspects of a proposed development. While not always required, site plan review ensures that new development or expanding current uses comply with zoning, environmental, health, and safety requirements. A site plan shows the proposed development in context and provides a good picture of how it will fit in with the surrounding areas. It shows existing topography, natural features, wetlands, and runoff facilities. The detailed project site includes internal roads and parking areas, building placement, recreational areas, and landscaping.

■ **Land acquisition.** To protect water quality and the environment, jurisdictions can purchase property uniquely valuable to the community. Land purchases protect wells, wetlands, and strips bordering waterways. Publicly owned land is used for parks and recreation and preserved as open space to recharge the groundwater.

While acquiring land to gain control of critical areas can be an effective technique, it is costly. Acquiring contiguous pieces of property often takes many years. Converting private lands to public ownership also removes them from the tax rolls — and requires ongoing management and maintenance expense.

In addition, land purchase is a divisive issue because of the cost and the frequent resistance to taking land out of development. Communities should prioritize potential land purchases and carefully evaluate each parcel's importance, such as ability to recharge groundwater, existing land uses, and development trends. Communities can then plan to fully purchase lands most critical to preserving water quality, and use partial purchase arrangements for less critical land.

Several types of purchase arrangements and financing mechanisms are possible.

Fee simple interest. The most expensive type of acquisition is outright purchase, where the jurisdiction gains full or "fee simple" title and the maximum measure of control over land uses. The community can benefit by establishing parks, recreation facilities, or a conservation district.

WISCONSIN STEWARDSHIP PROGRAM

The Stewardship Program, created in 1989, is part of Wisconsin's century-old history of acquiring and protecting environmentally sensitive lands.

Through the program's streambank protection category, the Wisconsin Department of Natural Resources (DNR) or nonprofit conservation organizations protect water quality and fisheries from urban and rural runoff through land purchases and easements along streams.

In 1992, for example, the department purchased a 43-acre corridor easement for $39,500. The corridor included a 7,000-foot frontage along the Milwaukee River and 27 acres of wetland and lowland woods. The easement protects water quality and fish habitat and assures public access to the shoreline.

While landowner resistance has resulted in only a modest number of easements, DNR has reported a renewed interest in the program, with some 40 landowners giving permission for easement appraisals. The addition of a fee acquisition authority by the legislature should also enhance landowner acceptance.

Source: Wisconsin Stewardship Program Progress Report, April 1993.

Partial interests. More limited interests can be tailored to specific public objectives, including environmental protection. Partial interests generally take several forms:

- *Conservation easements and restrictions.* The easement holder can prohibit actions on the property, such as restricting certain high-density development or prohibiting hazardous materials or septic tank systems. Easements apply to all subsequent landowners for the full term, which might be specified, or in perpetuity. Property owners gain benefits because easements take land off the tax roles or assess it at sharply reduced levels.

Conservation easements — such as the Maryland Environmental Trust, Eastern Shore Conservancy, Western Maryland Conservancy, and Wisconsin's Stewardship Program — are becoming more prevalent.

- *Purchase of development rights.* In this case, the right to develop the property is purchased, while ownership remains with the landowner. The landowner cannot develop the property, based on the restrictions in the deed.

- *Restrictive covenants.* A restrictive covenant attaches to the property and applies to future landowners. However, unlike an easement in which a local government can enforce restrictions, a restrictive covenant can be enforced only by other property owners similarly restricted.

  To protect water quality, a local planning board might require a restrictive covenant limiting paved surfaces as a condition to granting site plan approval for a proposed subdivision. Or, a government might purchase a parcel outright, place restrictive covenants on the title limiting future development rights, and sell the deed-restricted property back to a private party. Such restrictions can be used to prohibit specific land uses, densities, or activities that pose a threat to water quality.

While partial interests do not provide governments with total control, they have certain advantages:

- the community is not burdened with maintaining the property;

- the property remains on the tax rolls; and

- lower costs allow the community to obtain interests in more parcels.

Financing. Since full or partial purchase of land is costly, the community should carefully consider the alternatives. A number of strategies can be used to finance purchases, including those listed in Chapter 2.

- *Donations or "bargain sales."* Motivate individuals by allowing a charity or tax deduction to donate or take a loss on property sold to the local government.

FINANCING LAND ACQUISITION

Through a land bank program, Nantucket Island — off the coast of Massachusetts — has acquired 1,105 acres from purchase or gift as of June 1993. This represents 3.5 percent of the island's total acreage (see page 17, Nonpoint Source Program Financing). The land bank has targeted two coastal preserves with a large amount of shore frontage for acquisition as open space public lands. The program, funded by a 2 percent real estate transfer fee, receives favorable support from residents.

- *Purchase by conservation groups.* Encourage private conservation groups to purchase the land.

- *Increased water and sewer fees.* Dedicate "user fees" added to utility bills to land purchase.

- *Increased local property or property transfer taxes.* Levy fees on real estate transfers and trust funds set up to acquire land with the proceeds, placing the burden on developers.

- *Municipal bonds.* Issue bonds to raise money for land acquisition, depending on state law and federal limitations

Protecting Critical Resources

■ **Floodplains.** Floodplains provide flood storage, runoff infiltration, vegetative filters, and protection for wildlife and streambanks. Naturally vegetated floodplains are a valuable habitat for plants and wildlife and allow streams to find their natural courses.

Generally, state and local governments work through FEMA's National Flood Insurance Program to preserve national floodplains. States have passed enabling legislation providing various levels of assistance and coordination to local governments, which adopt measures to reduce or eliminate flood damage in return for flood insurance. When enforced, these measures prevent and/or limit development in floodplains, allowing them to continue to provide flood storage, runoff infiltration, and erosion protection.

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NATIONAL FLOOD INSURANCE PROGRAM

NFIP was created by Congress in 1968 to reduce the loss of life and property and the cost of rising disaster relief from flooding. These goals are achieved by

- *requiring that new and substantially improved buildings be constructed to resist flood damages;*
- *guiding future development away from flood hazard areas; and*
- *transferring the costs of flood losses from the taxpayer to floodplain property owners through flood insurance premiums.*

The courts have consistently upheld the land use management criteria of the NFIP and over 18,000 communities participate in the program.

The floodway, which maintains the flood-carrying capacity of rivers and streams, is the most important provision of the NFIP. The floodway is the area of the watercourse plus adjacent floodplain land that must be preserved to allow the base flood (100-year flood) discharge without increasing flood heights more than a designated amount. Communities must prohibit any development within a floodway that would increase flood heights.

A floodway — a de facto preservation tool — also protects critical riparian habitats, minimizes degradation of surface water quality, and provides for groundwater recharge.

A community that preserves and manages its floodplains also preserves a natural control for nonpoint source pollution and a no-cost alternative to detention basins and other structural controls (see Chapter 4). As an added benefit, homeowners may also enjoy lower flood insurance rates.

■ **Wetlands.** Once considered wastelands, wetlands are now highly valued for a multitude of benefits. In some cases, wetlands are even being constructed to control nonpoint source runoff. Wetlands support plants that remove suspended sediment and dissolved nutrients from runoff and provide a habitat for a variety of wildlife. They also store excess runoff and absorb destructive waves that can erode shorelines. Section 404 of the Clean Water Act protects the nation's wetlands by requiring permits to fill and dredge them.

Although wetland protection and use are critical to any comprehensive plan to reduce nonpoint source pollution, using wetlands to filter pollutants has drawbacks. Wetlands can easily become sinks, allowing trapped toxic pollutants to seep into groundwater. A nonpoint source management plan should, therefore, consider wetlands in the context of the entire drainage system.

■ **Stream buffers.** These undeveloped zones at the edge of waterbodies preserve vegetation to reduce erosion and trap sediment, nutrients, and other pollutants before they reach the water. Buffers can also shade streams to reduce temperature, improving fish and wildlife habitat. Local jurisdictions usually pass laws to establish these buffers.

■ **Stabilized hillsides and steep slopes.** Vegetative or structural controls secure banks by retaining soil, holding back runoff, and maximizing infiltration. To protect slopes, local governments have purchased the land, used a site plan review process, or passed special ordinances.

■ **Aquifers or wellheads.** A valuable water resource, these structures require protection to preserve water quality. Sources as diverse as toxic wastes, manure, pesticides, road salt, and oil can cause contamination.

EPA has estimated, for example, that 20 percent of the one million underground petroleum storage tanks may be leaking and could contaminate water supplies. Since municipal pumping systems draw substances discharged toward the well, areas surrounding wells are particularly vulnerable. Toxins can easily enter an aquifer through an open, unsealed wellhead, making wellheads a chief source of groundwater contamination. Therefore, many county health departments are identifying abandoned wellheads without adequate caps or seals.

Many jurisdictions protect areas around wells, ranging from a few hundred feet to several miles, with special ordinances, permits, and prohibitions against specific types of development and activities. In some cases, communities have purchased the land surrounding a well to assure protection. The Wellhead Protection Program, part of the 1986 Safe Drinking Water Act Amendments, provides technical assistance to communities to protect wellheads.

Intensely Developed Area

Characteristics

- Dense residential, institutional, commercial or industrial uses
- 4 or more dwelling units per acre
- Public sewer and water serving 3 or more housing units per acre

Applicable Criteria

- Reduce pollutant loadings by at least 10% from predevelopment loads
- Reduce nonpoint impacts to streams and tidal waters from redevelopment
- Protect remaining wildlife and fish habitats

Limited Development Area

Characteristics

- 1 dwelling unit per 5 acres up to 4 per acre
- Areas with public sewer or water or both
- Mixture of land usage—not dominated by agriculture, wetlands, forest, or open space

Applicable Criteria

- Replace cleared forest land on an acre for acre basis
- Restrict removal of existing forest land to 20% when development occurs
- Restrict impervious areas to 15% of the land area being developed
- Encourage clustering of dwelling units to conserve natural habitats

Resource Conservation Area

Characteristics

- Housing density of less than 1 dwelling unit per five acres
- No public sewer or water
- Primarily open fields, wetlands, forest, and agriculture

Applicable Criteria

- Limit residential development to an overall density not to exceed 1 dwelling unit per 20 acres
- Encourage agriculture and forestry

Figure 8.—Characteristics of land classifications in Maryland's critical areas, and criteria for management.
***Source:** U.S. Environmental Protection Agency, Maryland's Critical Area Program.*

Successful Land Use Programs

While land use controls vary according to location, a number of communities have successfully used these strategies to curtail nonpoint source pollution.

As mentioned earlier in this chapter, Maryland's Chesapeake Bay Critical Areas Program is one way local communities can implement state programs designed to protect water quality. The Critical Areas Commission, which established criteria to classify and protect lands in a 1,000-foot strip surrounding the tidal portions of the bay's tributaries, requires jurisdictions to write and adopt local programs. They must include both state and local comprehensive plan requirements for zoning, site planning, subdivision review, and other activities. The Critical Areas program addresses development, resource use, and resource protection.

Local jurisdictions must assign their lands in the critical area to one of the following development categories (see Fig. 8):

- intensely developed — four or more dwelling units per acre;
- limited development — one to four dwelling units per 5 acres; or
- resource conservation — less than one dwelling unit per 5 acres.

These definitions also include other characteristics, such as land usage and sewerage. Development requirements have been specified for all three categories. For example, only 5 percent of the land in a limited development or resource conservation area may be reclassified to more intense use.

Dade County, Florida, has developed a Wellfield Protection Ordinance that prohibits underground storage tanks and other potentially polluting activities in the recharge zone of public wells. The ordinance is based on a mathematical groundwater flow model that predicts the speed that groundwater travels in recharge areas. In Massachusetts, the Cape Cod

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Planning and Economic Development Commission is using a similar principle to protect its well fields.

In 1988, Washington state developed a Local Planning and Management of Nonpoint Source Pollution administrative code (chapter 400-12) that outlines procedures for state watershed management. The state code was originally developed by the Puget Sound Water Quality Authority that monitors an environmentally sensitive area encompassing 12 watersheds.

The Washington program stipulates local watershed plan development, to be funded primarily through grants from the state Department of Ecology. Under the regulation, a watershed management committee prepares plans and addresses all major watershed nonpoint sources. Unlike traditional citizen advisory committees, these local bodies have significant decisionmaking responsibility. They operate under the general aegis of a lead agency — usually a county — responsible for convening the committee and overseeing plan development. The planning committee, government entities affected by the plan, and the Department of Ecology must approve each plan.

Chapter 4

Urban Nonpoint Source Control Methods

Construction and development activities can be one of the worst sources of urban nonpoint source pollution. Improper construction erosion and sediment control can cause large volumes of sediment to impair sewers, streams, lakes, and stormwater control devices. When this excessive sediment enters small streams, wetlands, and lakes, it can damage or destroy wildlife habitat by smothering stream and lake bottoms, filling impoundments with sediment, increasing dredging costs, and impeding navigation.

After construction is complete, many changes in land use and site drainage characteristics can cause a host of additional problems. Changes include increased impervious surfaces and pollutant loadings, as well as different runoff patterns and increased volumes and temperature. Cold water fisheries may be destroyed, streambank erosion and flooding may be increased, and beneficial uses of waterbodies — such as swimming, fishing, and boating — may be impaired. To avoid or reduce these problems, a dual focus on proper construction site erosion and sediment control and postdevelopment runoff control is necessary.

A number of control practices can be used to reduce the impact of development or redevelopment. Local conditions will determine what practices are appropriate for a given situation. In most cases, standard erosion and sediment control practices can be used, although they may need to be adjusted for areas with steep slopes, intense rainfall, or highly erosive soils. Management strategies for postconstruction runoff controls are generally site specific — they must be specifically designed to fit the individual development site and local conditions. Often a combination of techniques offers the most protection.

Practices used to control sediment and erosion during construction, when the soil is not stabilized, are different from practices used for long-term runoff control after construction. During the site development process — before construction begins — an erosion and sediment control plan should be developed for each activity during construction. This plan should be developed in conjunction with a stormwater management plan to address the runoff from the newly completed project or development.

Tools of the trade are usually referred to as best management practices (BMPs). The term BMP is used to describe the most effective practice or combination of practices to control runoff and nonpoint source pollution. A BMP may be a system that reduces the pollutants that enter urban runoff or a method that reduces the amount of pollutants in the runoff before it enters a waterbody. BMPs are generally grouped into categories — structural or nonstructural — depending on the operating principle or physical mechanism used to reduce nonpoint source pollution. Nonstructural controls decrease erosion potential, while structural controls prevent and mitigate erosion and sediment movement.

Nonstructural BMPs are a cost-effective way to manage stormwater runoff and prevent nonpoint source pollution. These controls take advantage of the land's natural features and use, relying on planning, design, maintenance, education, economic incentives, and even regulation to prevent runoff contamination (see Chapter 3).

A variety of urban BMPs can be used to mitigate some of the adverse impacts caused by development. More detailed information on selecting and using BMPs can be found in the resources listed in Appendix B.

Preconstruction Planning

■ **Basic development practices.** Land use strategies for local government to plan an overall nonpoint source control program were discussed in Chapter 3. But requirements for developers before construction begins, particularly at the site plan review stage, can help prevent problems from occurring on individual sites. A developer can be required to submit a detailed plan for managing runoff and for returning the site to a predetermined hydrological condition after completing construction.

Since few control methods can handle the large loads of sediment that erode during construction, a combination of control systems should be planned for and put in place. In some cases, the measures used during construction can be modified to control runoff over the long term.

Use the following check list, singly or in combinations, to develop an urban runoff management plan.

- Respect contours and natural features of the landscape — for example, avoid stream valleys and steep slopes.
- Use downzoning to restrain development.
- Specify minimum lot sizes.
- Limit development by soil type or proximity to waterbody.
- Restrict or prohibit development in sensitive areas identified in the comprehensive plan.
- Limit density of development.
- Limit percentage of lot that can be disturbed.
- Limit percent of impervious cover.
- Preserve natural 100-year floodplain (area that will receive a flood at least once within 100 years); allow no modification of the natural floodplain; and ensure that development is consistent with the comprehensive plan.
- Prohibit clearing or grading on steep slopes (more than 25 percent recommended) and limit road grades (equal to or less than 7 percent recommended).
- Prohibit development in nontidal wetlands and require a buffer zone for these areas.
- Retain upland and riparian trees as a certain percentage of predevelopment tree cover.
- Require waterway disturbance permits for structures such as roads and utilities so they do not restrict fish migration or riparian areas.
- Reserve a minimum percent of open space on each new development site.
- Designate the percent of the land that can be exposed at one time during construction; specify the duration of exposure and the developer's revegetation/stabilization responsibilities.
- Impose time restrictions on construction — e.g., prohibit disturbances during spawning season.
- Revegetate immediately or as soon as possible following construction.
- Provide for stormwater collection or treatment, such as use of sediment control basins, wetlands, or wet ponds, to accommodate large storms.
- Route clean water around the site.
- Maintain infiltration capacity, using natural drainage conditions where possible. This may mean limiting impervious area to a fixed percentage of lot size and limiting runoff to predevelopment rates and characteristics.
- Control erosion and sediment through the watershed protection ordinance.

- Limit the grade of constructed slopes.
- Stabilize existing steep slopes by sodding and pegging to establish grass cover, building retaining walls, and planting woody vegetation on the most extreme slope.
- Dispose of construction wastes such as oil, cement, and debris.
- Require inspection during and after construction.
- Require long-term maintenance and review of plans for adjacent parcels.
- Ensure that development plan meets all existing ordinances.

■ **Groundwater considerations.** When considering options for postdevelopment stormwater control, groundwater should be considered in choosing a BMP. Activities that have a significant impact on groundwater should be controlled by design standards. For example, a standard could require runoff collection systems for roads and parking lots to control at least the first flush — the first 1/2 inch of rainfall that typically contains most contaminants — during any storm.

Controlling Development

Local governments should consider the total environment in selecting a nonpoint source pollution strategy that will provide the maximum benefit to the environment and to consumers. These benefits usually depend not only on the method itself but also on its design, maintenance, and congruence with the surrounding landscape.

A community's success in preventing pollution depends largely on how well it has planned for controls during and after the development process (see Fig. 9).

BMP	Low flow maintenance	Streambank erosion control	Aquatic habitat creation	Wildlife habitat creation	No thermal enhancement	Landscape enhancement	Recreational benefits	Hazard reduction	Aesthetics	Community acceptance
Dry extended detention	○	●	◑	●	●	◑	◑	◑	◑	◑
Extended detention w marsh	○	●	●	●	○	◑	○	◑	◑	◑
Wet extended detention	○	●	●	●	○	●	●	◑	◑	●
Wet pond	○	○	●	●	○	●	●	◑	◑	●
Infiltration trench	●	◑	○	○	●	○	○	●	○	●
Infiltration basin	●	◑	○	●	●	◑	◑	●	○	◑
Porous pavement	●	◑	○	○	●	○	○	●	○	●
Water quality inlet	○	○	○	○	●	○	○	●	○	●
Grassed swale	◑	○	○	◑	●	◑	○	●	◑	●
Filter strip	◑	○	○	●	●	◑	○	●	◑	●
Shallow marsh	○	○	●	●	○	◑	○	◑	◑	◑

○ Seldom provided ◑ Sometimes provided (w/design modifications) ● Usually provided

Figure 9.—Comparison of nonpoint source control methods in benefiting the surrounding environment and community. ***Source: Metropolitan Washington Council of Governments, 1993.***

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Factors	BMP: Pond Systems (Wet & Dry ED Ponds)	Infiltration Systems (French Drains, Dry Wells, Porous Pvmt., Trenches)	Wetland Systems (Stormwater Wetlands)	Filter Systems (Sand & Peat/Sand Filters, Grassed Swales)	Water Quality Inlets (Oil/Grit Separators)
Slope	●	○	●	○	●
High Water Table	●	○	●	○	●
Close to Bedrock	◑	○	◑	◑	○
Proximity to Foundations	●	○	●	●	○
Space Consumption	○	●	○	●	●
Maximum Depth	●	○	◑	○	○
Restricted Land Uses	●	●	○	●	○
High Sediment Input	◑	○	◑	○	○
Wetlands/Forest Permits	●	●	○	●	●
Stream Warming	○	●	○	●	●

○ May Preclude The Use Of A BMP
◑ Can Be Overcome With Careful Site Design
● Generally Not A Restriction

Figure 10.—Screening techniques for urban BMPs. *Source: Metropolitan Washington Council of Governments, 1993.*

■ Site conditions. In developing a comprehensive nonpoint source water quality protection plan, the first step is to assess the site's geographic elements and morphology (see Fig. 10).

Soil. Permeability — the ability of the soil to absorb runoff — is crucial in selecting an appropriate control method. This characteristic particularly affects infiltration methods, which can affect groundwater quality (see Fig. 11).

Slopes. Steep slopes preclude the use of several types of control methods and certain types of development. For example, porous pavement and grassed swales must be situated on sites with slopes of 5 percent or less, whereas infiltration trenches are not practical when slopes exceed 20 percent.

Size of the watershed area. The success of some control methods depends on the watershed size. For example, detention ponds normally do not work unless the watershed area is greater than 10 acres. Alternately, infiltration and vegetative controls are most successful in areas less than 10 acres (see Fig. 12).

Water table. A high water table can reduce the effectiveness of an infiltration basin. If a seasonally high water table extends to within 4 feet of the bottom of an infiltration basin, the site generally is not considered suitable. The depth of infiltration and pond controls are limited by their proximity to the water table.

Distance to bedrock. As with a high water table, a bedrock layer too close to the surface (2 to 4 feet from the bottom of an infiltration basin) will prevent the infiltration basin from draining properly. Similarly, controls that use ponds generally will not work if the bedrock lies within an area that must be excavated to provide stormwater storage.

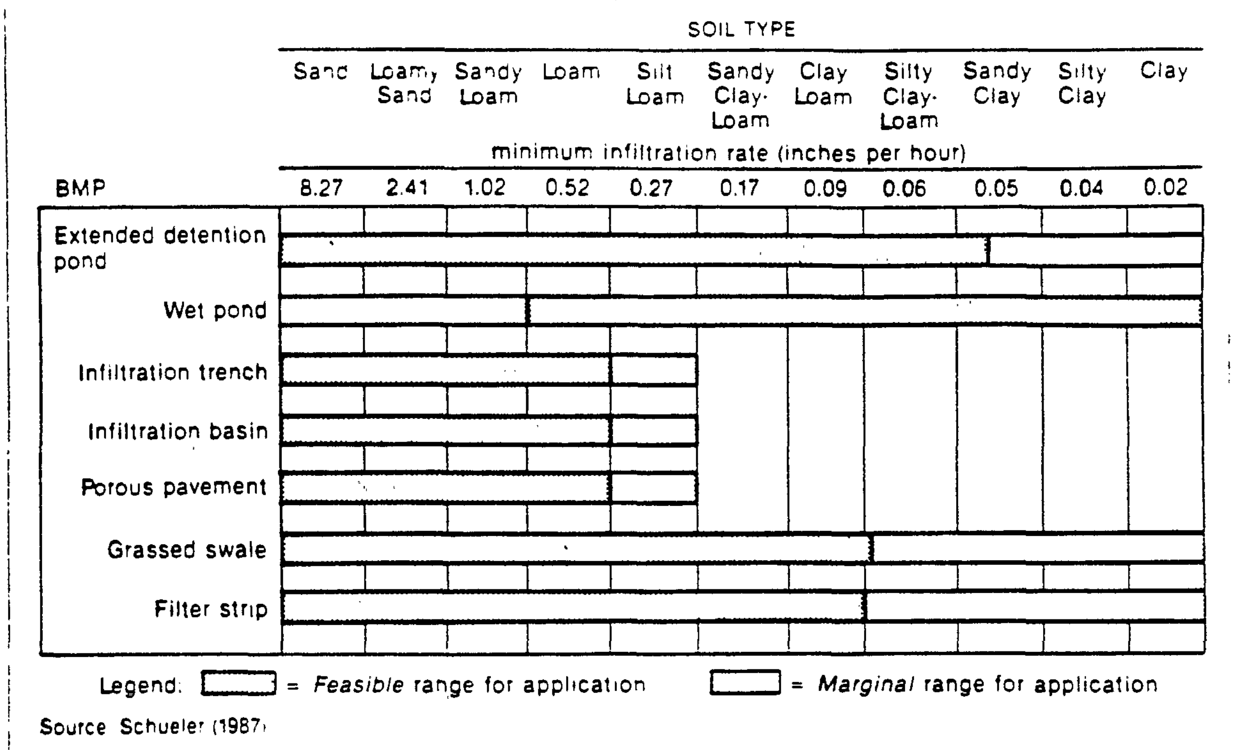

Figure 11.—Restrictions for BMP application based on soil permeability. *Source: Schueler, 1987.*

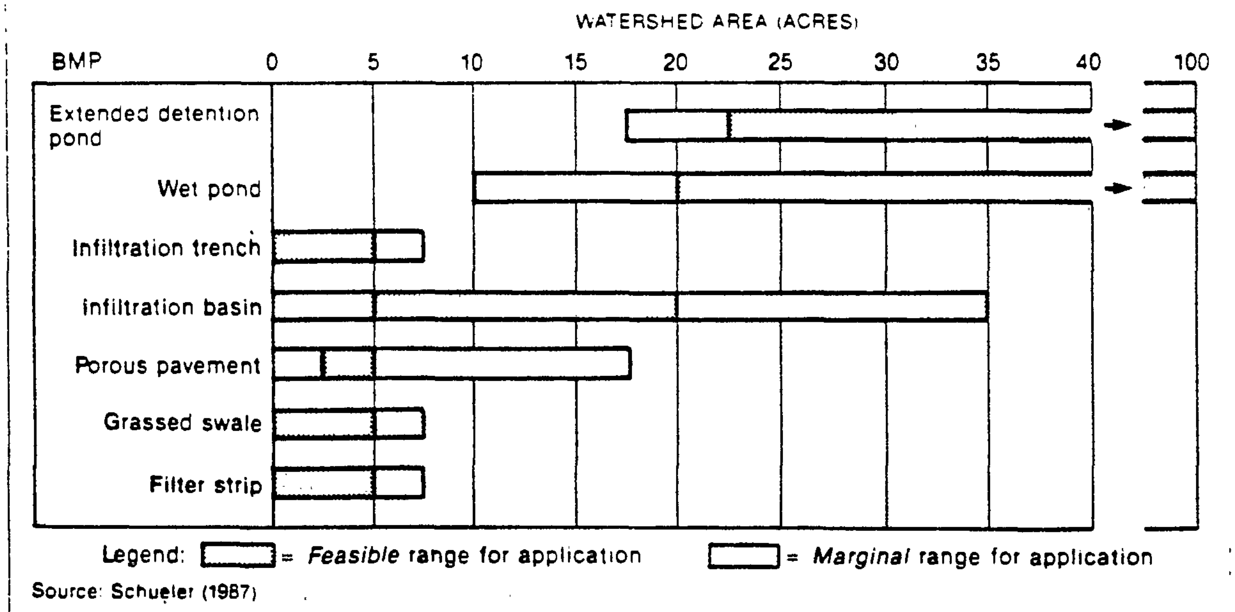

Figure 12.—Feasible BMPs for different watershed sizes. *Source: Schueler, 1987.*

Proximity to foundations and wells. Infiltration basins should be at least 100 feet away from drinking water wells to prevent groundwater contamination. Wellhead protection areas may require even greater distances to properly protect public water supplies. To prevent seepage, they should be installed at a reasonable distance (100 feet) from a building foundation.

Land use. A very small or intensively developed site may preclude the use of space-consuming controls such as detention ponds and porous pavement. In addition, some controls are appropriate only to particular types of land uses. For example, sand filters are suitable for parking lots, while grassed swales are effective only in low density residential areas.

Effects of temperature. Shallow marshes and wet ponds heat up rapidly during the summer, and their runoff into colder streams can harm aquatic life.

■ **Predevelopment status.** The second step in selecting a control method is to determine which option comes closest to duplicating the site's hydrology prior to development. Consideration involves a number of factors:

Control of peak flows. Some local regulations require that a nonpoint source control method be able to control the peak flow from a two-year storm — a storm expected to produce a flood every two years. Some jurisdictions require control of even larger storms. Ponds are an excellent method for achieving this goal; infiltration basins are somewhat less effective.

Control of first flush. First flush is the disproportionately large amount of pollutants usually found in runoff during the early part of a high intensity or large volume storm, caused by the rapid runoff of accumulated pollutants. First-flush control — the first 1/2 inch of rainfall — can also be required for a runoff area. However, if storms in an area are frequent, the first flush may not be significant and further monitoring may be needed.

Volume control. Infiltration basins can reduce the runoff volumes of smaller storms by diverting much of the runoff back into the soil.

Groundwater replenishment. Infiltration basins provide an excellent way to replenish groundwater lost because of development; however, this benefit must be weighed against the potential for groundwater contamination.

Streambank erosion control. While some nonpoint source pollution methods control streambank erosion to some extent during a two-year storm if properly designed, installed, and maintained, more severe storms require large extended detention ponds and infiltration controls to prevent downstream erosion.

■ **Pollutant removal.** The third step is to determine which control method will remove the greatest volume of pollutants. Important interrelated factors are the removal mechanisms, types and percentage of runoff to be treated (first flush versus total runoff), and the type of pollutant being removed.

The nature of the pollutant is the most important factor in a control method's effectiveness. For example, most control methods are extremely effective in removing sediment and trace metals, which are usually adsorbed into sediment surfaces. However, vegetative systems are more effective in removing soluble pollutants such as phosphorus, nitrogen, and chloride. Systems that combine nonvegetative and vegetative features are generally highly effective.

■ **Cost.** A final step in selecting a control method is estimating the cost by taking into account all factors associated with the method. Construction and both short- and long-term maintenance are, of course, the major cost components. Costs may include

- labor,
- materials,
- land purchase,
- loss of tax revenue on acquired lands, and
- downstream mitigation.

Flood Control and Retrofitting

In the past, flood control efforts have focused primarily on decreasing the volume of water that abruptly enters waterbodies. Traditional methods to reduce flooding include using dry detention basins that temporarily store excess runoff, constructing channels, streambank hardening, and floodplain restrictions that limit development along or in flood-prone stream areas.

These flood control measures were not originally designed to control pollution caused by increased urbanization. The historical focus was on quantity control — not quality control. Urban planners and water quality professionals now recognize that these issues must be incorporated into an overall strategy that assesses both flooding and pollutant removal. Existing flood control BMPs are now being redesigned or retrofitted to protect water quality. New flood control BMPs are almost universally being built with this dual focus.

A comprehensive watershed protection strategy, which uses nonstructural and structural BMPs, will reduce the long-term costs of both controlling floods and protecting water quality.

Identifying and preserving buffers and natural systems is an important component of a watershed management plan. These areas serve as nonstructural controls, filtering out many pollutants in urban runoff that might reach the waterbodies. However, in existing developments, they have often been altered. When nonstructural controls are impossible or impractical because of existing development, a community may turn to structural practices — constructing new runoff treatment structures or retrofitting existing runoff management systems.

Retrofitting requires modifying runoff control structures or conveyance systems, originally designed to control flooding, to also control water quality. Modifications might include enlarging structures, changing the inflow and outflow patterns, and increasing detention times.

Retrofitting costs are a major hindrance in improving water quality in developed areas. Therefore, communities may need to identify the most insidious pollutants and then select the most cost-efficient and effective solutions to deal with them, thus improving water quality in urban runoff.

Urban Best Management Practices

BMPs should be selected as part of an erosion and sediment control plan during the site development process, with long-term runoff management part of the objective. The best system of practices to control nonpoint source pollution after construction is completed may be a modification of the practices used during the construction process.

Selecting the proper BMP system is critical in achieving the ultimate goal — reducing the pollutants in urban runoff. In selecting the most appropriate BMPs for a specific site, consider the following:

- the site's physical condition and development status;
- runoff control benefits provided by each BMP option;
- the pollutant removal capability of each BMP option under several design scenarios;

URBAN RUNOFF CONTROL PROGRAMS

Several states and localities have made significant advances in developing and implementing runoff controls. Two particularly noteworthy examples are in Maryland and Florida.

- **Maryland** *began its stormwater management program with the passage of a 1982 state law requiring each county and municipality to adopt a stormwater management ordinance based on state criteria. Criteria call for maintaining predevelopment hydrological conditions and reducing erosion and pollution.*

  The state Sediment and Stormwater Administration reviews and approves local ordinances and develops stormwater management programs for state and federal construction projects. The ordinances must include an approved stormwater management plan, criteria and procedures for stormwater management, proper implementation of the plan (including design criteria for specific proposed controls), maintenance and inspection procedures, and penalties for noncompliance. The ordinances are required for any new construction projects, with a few exceptions for single-family homes on small parcels of land.

- **Florida's** *stormwater management program applies to all new development. Administered through a stormwater rule that serves as a performance standard, Florida's program ensures that runoff volume, speed, timing, and pollutant loads are close to predevelopment levels.*

  The standard requires that a stormwater management system remove at least 80 to 95 percent of the annual pollutant load of sediments, nutrients, and many heavy metals. If permit applicants show that they can meet the standard, the state assumes that water quality requirements will not be violated. But if violations occur, the state can impose more stringent requirements, even if the basic performance standard has been met.

- the environmental and human advantages of each BMP option; and
- the long-term maintenance cost of the BMP.

Table 3 compares the effectiveness of a number of currently used urban best management practices. Urban BMPs are generally grouped into four categories based on the operating principle or physical mechanism used to reduce the amount of runoff pollutants — detention basins, retention/infiltration devices, vegetative controls, and source controls.

■ **Detention basins.** Detention basins are most popular and effective in reducing suspended solids and particles by temporarily holding the runoff and allowing the sediment to settle.

In addition to reducing the pollution in runoff, detention basins also delay the amount of runoff released into receiving waters, thus reducing flooding and streambank erosion and lessening the stress on the physical habitat. The slow release also dilutes the runoff, thereby reducing the concentration of pollutants entering the stream.

With proven success in controlling runoff, detention basins can reduce suspended solid concentrations by 50 to 95 percent. These basins can be used for large drainage areas, be incorporated into new development site plans, and enhance the value of the surrounding property.

Often, however, finding suitable land for a detention basin is difficult and constructing basins in developed areas may not be possible. One solution may be to convert dry ponds previously installed for flow control; they can usually be economically retrofitted to detention basins.

Routine maintenance is required for detention basins. Solids should be removed regularly, because removing accumulated solids after 10 to 20 years can be expensive.

Detention basins are generally of three types:

Dry ponds. Used for flood and erosion control, dry ponds remain dry and available to catch water following large storms. While intended to control water quantity, they can be retrofitted to improve water quality.

Wet ponds. Designed to hold water permanently, wet ponds can be highly efficient in removing sediment and in reducing nutrients through biological activity such as algal growth if properly constructed.

Extended detention dry ponds. These ponds catch stormwater and retain it for 24 to 40 hours, remaining dry at other times. They remove pollutants by trapping sediment particles and allowing them to settle.

■ **Retention/infiltration devices.** Retention or infiltration devices allow runoff to percolate into the ground, reducing the amount of pollutants released into the receiving water. The filtration and adsorption mechanism traps many pollutants — particularly suspended solids, bacteria, heavy metals, and phosphorus — in the upper soil layers and prevents them from reaching the groundwater.

Infiltration devices can remove up to 99 percent of runoff pollutants, depending on the percolation rate and area, soil type, pollutants present, and available storage volume. Success also depends on the rainfall. Not only do infiltration devices have high pollution removal rates, but they can also be built in developed areas and effectively reduce the volume of runoff.

However, poor site conditions such as impermeable soils, a high water table, and bedrock can lessen the effectiveness or cause failure of retention/infiltration devices. These devices must also be installed carefully to prevent soil compaction from heavy machinery, and they require such pretreatment devices as grass filter strips to remove coarse sediment from the infiltration surface. Operation and maintenance are also critical. Many infiltration BMPs have failed from lack of maintenance. Devices must be designed for ease of access, maintenance, and operation.

Retention devices fall into the following categories:

Infiltration basins. An infiltration basin is a natural or excavated large open depression. It temporarily stores runoff until the water percolates through the bottom or sides. Excess runoff can overflow through elevated outlets to maximize the storage volume. Because runoff usually percolates in a day or two, these basins can be dry.

Infiltration trenches and dry wells. Similar in design, infiltration trenches and dry wells are excavated holes filled with coarse stones and then covered. Dry wells are used primarily for roof drainage; trenches are used on larger areas such as streets and commercial parking lots. In both designs, runoff infiltrates the surrounding soil or is collected by perforated underdrain pipes and routed to an outflow. Infiltration trenches preserve the natural hydrology of an area and can fit on small sites. However, they require considerable maintenance and can contaminate groundwater under certain conditions.

Table 3.—A comparative assessment of the effectiveness of current urban best management practices.

URBAN BMP OPTIONS*	RELIABILITY FOR POLLUTANT REMOVAL	LONGEVITY*	APPLICABLE TO MOST DEVELOPMENTS	WILDLIFE HABITAT POTENTIAL	ENVIRONMENTAL CONCERNS	COMPARATIVE COST	SPECIAL CONSIDERATIONS
STORMWATER WETLANDS	Moderate to high, depending on design	20+ years	Applicable to most sites if land is available	High	Stream warming, natural wetland alteration	Marginally higher than wet ponds	Recommended with design improvements and the use of micropools and wetlands
EXTENDED DETENTION PONDS	Moderate, but not always reliable	20+ years, but frequent clogging and short detention common	Widely applicable, but requires at least 10 acres of drainage area	Moderate	Possible stream warming and habitat destruction	Lowest cost alternative in size range	Recommended with design improvements and the use of micropools and wetlands
WET PONDS	Moderate to high	20+ years	Widely applicable, but requires drainage area of greater than 2 acres	Moderate to high	Possible stream warming, trophic shifts, habitat	Moderate to high compared to conventional	Recommended, with careful site evaluation
MULTIPLE POND SYSTEMS	Moderate to high; redundancy increases reliability	20+ years	Widely applicable	Moderate to high	Selection of appropriate pond option minimizes overall environmental impact	Most expensive pond option	Recommended
INFILTRATION TRENCHES	Presumed moderate	50% failure rate within five years	Highly restricted (soils, groundwater, slope, area, sediment input)	Low	Slight risk of groundwater contamination	Cost-effective on smaller sites; rehab costs can be considerable	Recommended with pretreatment and geotechnical evaluation
INFILTRATION BASINS	Presumed moderate, if working	60 – 100% failure within 5 years	Highly restricted (see infiltration trench)	Low to moderate	Slight risk of groundwater contamination	Construction cost moderate, but rehab cost high	Not widely recommended until longevity is improved
POROUS PAVEMENT	High (if working)	75% failure within 5 years	Extremely restricted (traffic, soils, groundwater, slope, area, sediment input)	Low	Possible groundwater contamination	Cost-effective compared to conventional asphalt when working properly	Recommended in highly restricted applications with careful construction and effective maintenance
SAND FILTERS	Moderate to high	20+ years	Applicable for smaller developments	Low	Minor	Comparatively high construction costs and frequent maintenance	Recommended, with local demonstration
GRASSED SWALES	Low to moderate, but unreliable	20+ years	Low-density development and roads	Low	Minor	Low compared to curb and gutter	Recommended, with checkdams as one element of a BMP system
FILTER STRIPS	Unreliable in urban settings	Unknown, but may be limited	Restricted to low-density areas	Moderate if forested	Minor	Low	Recommended as one element of a BMP system
WATER QUALITY INLETS	Presumed low	20+ years	Small, highly impervious catchments (<2 acres)	Low	Resuspension of hydrocarbon loadings; disposal of hydrocarbon and toxic residuals	High, compared to trenches and sand filters	Not currently recommended as a primary BMP option

* **Based on current designs and prevailing maintenance practices.** ***Source: Metropolitan Washington Council of Governments, 1992.***

Sand filter. Sand filters, used to pretreat runoff before it enters another stormwater structure, are suitable for small sites in highly impervious areas and can be retrofitted into existing urban areas. To use sand filters, drainage areas must be stabilized against erosion. Designed mainly to enhance water quality, sand filters are also used to control first-flush water quantity in smaller drainage areas.

Porous pavement. Most practically used for parking lots, porous pavements increase infiltration of water into the soil, maintaining the water balance at nearly the same level as before the land was paved. Runoff rapidly permeates the pores of several layers of different permeable materials and filters the pollutants into the underlying subsoil or perforated drain pipes. The rate of pollutant removal depends on the amount of filtered runoff and underlying soil type.

A study by the Metropolitan Washington Council of Governments found that porous pavement removes as much or more suspended sediment and other pollutants — phosphorus, nitrogen, bacteria, lead, and zinc — as detention/retention basins. Porous pavements can also moderate runoff rate and volume so that drainage patterns and surrounding vegetation remain normal, improving erosion control and enhancing water quality.

Operation and maintenance must be considered in the use of porous pavements, however. They do eventually clog and should be routinely vacuumed.

Oil/grit separators. Also known as water quality inlets, oil/grit separators are designed to remove sediment and hydrocarbons from runoff before it is released to the storm drain network or infiltration system. Runoff passes through long, rectangular concrete chambers — modified to remove sediment, grit, and oil — before exiting through a storm drain pipe.

Oil/grit separators are used infrequently because of their limited ability to remove pollutants caused by low average detention times and the possibility that pollutants removed during one storm could reenter runoff from later storms. However, oil/grit separators can remove coarse-grained sediments from urban runoff and treat runoff before it enters underground filtration systems. They are unobtrusive, compatible with storm drain networks, and easily accessed.

OPERATION AND MAINTENANCE OF URBAN BMPS

Proper operation and maintenance of urban BMPs are critical to their success. A 1990 study of four Maryland counties showed that in 434 wet and dry detention ponds, 70 percent were not operating properly. Poor maintenance was the most frequently cited reason.

To ensure that stormwater management facilities are an asset to the community, not a liability, maintenance must include

- *periodic inspections;*
- *debris and sediment removal from basins and channels;*
- *pipes, pumps, and structure maintenance;*
- *general housekeeping, such as grass cutting and repairs;*
- *mosquito control;*
- *fish stocking; and*
- *vegetation control.*

Before adopting a nonpoint source program using urban BMPs, include sufficient funding for regular maintenance to ensure proper functioning.

Maintenance can be performed by private corporations, individuals, or local government staff. While homeowners' associations and individual property owners can do some maintenance, depending on private citizens to maintain urban BMPs is risky. Legal maintenance and monitoring agreements can be negotiated between a developer and the local public works department. When maintenance is clearly its responsibility, local government may choose to contract with a private company.

A realistic cost estimate is vital to making the community aware of its responsibility for nonpoint source pollution. Maintenance requires staff time to record and assess routine maintenance checks and on-site visits to perform the routine checks.

■ **Vegetative controls.** Vegetative BMPs decrease the velocity of stormwater runoff, promoting infiltration and settling of suspended solids and preventing erosion (see Fig. 13). For maximum effectiveness,

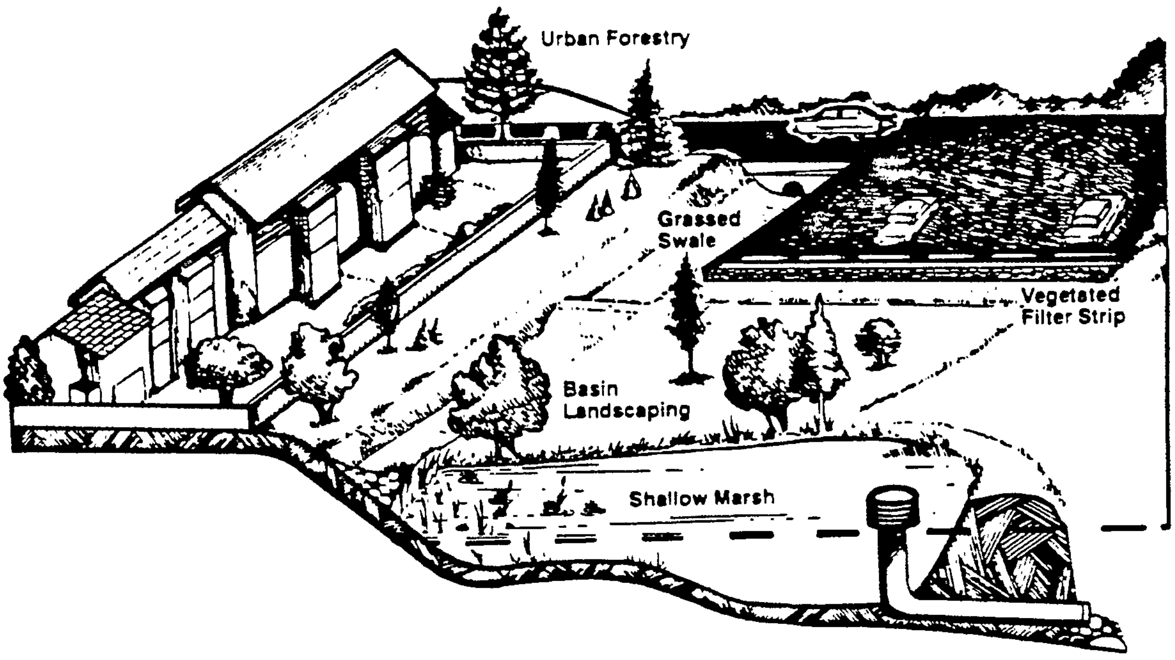

Figure 13.—Vegetative BMPs take many forms and are used for various purposes. *Adapted from Schueler, 1987.*

vegetative controls must be used in combination with other BMPs as a first line of defense in removing suspended solids before more intensive treatments take over. Vegetative BMPs also remove organic material, nutrients, and trace metals.

Less costly than other control practices, vegetative controls enhance the attractiveness and value of sites. Using vegetative controls to pretreat runoff improves the operation and maintenance of other BMPs.

The ultimate performance and practicality of vegetative controls depend on the site's physical features. Plant material must be selected carefully and regularly maintained. Because they have limited ability to control runoff, and effectiveness varies according to the season, vegetative controls should not be a site's only control practice.

Several types of vegetative controls are as follows:

Basin landscaping. Landscaping can improve a stormwater basin's effectiveness in removing pollutants. Landscaping around a basin reduces the amount of impervious surface area, provides an attractive, green buffer along streambanks, and protects and enhances the use of existing wetlands. Proper landscaping can route stormwater runoff through green areas and away from erosion-prone steep slopes and other areas.

Grassed swales. Grassed swales are depressions, such as gullies, that infiltrate and transport runoff water. They are often used in residential developments and on highway medians as an alternative to curb and gutter drainage systems.

Swales control peak discharges by reducing runoff velocity. The swale allows some runoff to infiltrate the soil, thus diminishing the volume of water passing downstream. Swales are easy to construct, attractive, and a potential habitat for wildlife. However, effectiveness varies considerably from site to site; swales may encourage mosquitos, ragweed, dumping, and erosion.

Filter strips. While similar to grass swales, filter strips are shallower and distribute runoff across a wider area. Their efficiency depends on strip length, slope, and size; soil porosity; normal runoff velocity; and vegetation type. Grassy strips supplemented with shrubs and small trees increase the ability to absorb and retain nutrients.

Riparian reforestation. Trees planted near streambanks can stabilize soil, cool water, and benefit many forms of aquatic life.

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■ Pollution prevention. Local governments should establish ongoing programs to reduce the generation and exposure of pollutants that accumulate on streets and other surfaces, and eventually wash into lakes and streams. These source reduction programs are usually called pollution prevention programs.

In most cases, pollution prevention is more cost effective than structural BMPs in reducing pollutant loadings. However, a combination of source reduction efforts and structural BMPs is generally needed to fully control the effects of urbanization.

Pollution prevention controls — also known as nonstructural controls — include land use planning and zoning strategies, as well as public education efforts. Storm drain painting, recycling, and household hazardous waste collection offer high value for the initial investment. Incentives to use public transportation or otherwise lower emissions that generate pollutants are also considered source controls. (See *Clean Water in Your Watershed: A Citizens Guide to Watershed Protection* for more information on source reduction controls and areas to target for community participation.)

Pollution prevention controls can generate a sense of community; in addition, they have aesthetic or economic benefits. To be effective, source reduction practices require a combination of education, regulation, and guidance. Chapter 5 more fully discusses these issues relating to citizen involvement and education.

Listed below are common pollution prevention controls communities can consider. Local governments can

- collect and recycle crankcase oil;
- begin leaf and other yard waste collection programs;
- establish catch basin drainage programs;
- redesign road salting programs to minimize the salt quantity and, where feasible, use an alternative deicer;
- educate the public about the hazards of fertilizers and pesticides used in commercial lawn care and grounds maintenance operations and the alternative organic treatments;
- start remedial erosion control programs;
- educate the public on how to reduce litter and properly dispose of pet wastes and household pollutants;
- remove illegal and improper industrial and commercial connections to storm drains that discharge directly into receiving waters without prior treatment; and
- plug or seal abandoned wells and cisterns that are conduits for nonpoint source groundwater pollution.

Other administrative strategies may include hazardous waste restrictions or contingency plans. Source prohibitions — barring storage or use of dangerous materials in a defined area — are common ways to protect health and the environment. Many jurisdictions, for example, now prohibit handling or storing toxic chemicals where a spill could threaten groundwater supplies. Jurisdictions also offer hazardous waste amnesty days, which provide residents the opportunity to properly dispose of hazardous waste.

Many commercial and industrial users produce hazardous wastes that threaten water quality. They include dry cleaners, auto service stations, industrial plants, trucking and railroad facilities, and airports. Other activities — such as agriculture, junk yards, machine shops, landfills, and septic systems — also use hazardous materials.

Most of these activities are controlled by NPDES industrial or municipal stormwater permits, but local governments should check with their permitting authorities to determine the degree to which permit requirements are being met and controls inspected.

Chapter 5

Community Education and Citizen Involvement

Even the best planned nonpoint source pollution program cannot succeed without community participation and cooperation. Citizen monitoring groups and solid public information and education programs are invaluable tools to be planned for and nurtured.

Because nonpoint source pollution is a continuing issue related to development and individual life styles, a water quality program must be established and embraced to succeed. Organization and ordinances mean nothing without community support. The community must buy in and accept the program, just as it does a sewage treatment system.

To gain support, you must understand your community. Is your community small or large? Are residents primarily retired or parents with young children? Are residents commuters or do they earn their living in the community? Do most residents stay in the community all year or seasonally? How much do residents know about nonpoint source pollution? How will they be affected by a nonpoint source management plan? How can they be expected to react to the proposed plan?

A public opinion survey or series of well-publicized public hearings throughout the watershed and in your immediate community will help you get to know the community and give you a basis for measuring public opinion.

■ **Public awareness.** Public information and education are important ways to curb nonpoint source pollution, since the solution lies largely in changing individual behaviors and lifestyles. An informational program must educate citizens about the problem and make citizen involvement part of the solution.

■ **Framing the message.** An initial step in developing a public awareness program is to frame your message. Determine what information about nonpoint source pollution you wish to convey, and stress this message at every opportunity. The tone and level of complexity of your message depend on the community's composition and sophistication. The program should include concrete information about using and disposing of toxic substances in homes, yards, farms, and work places.

■ **Targeting the audience.** Nonpoint source pollution affects everyone in the community. On the issue of control, business people, developers, and homeowners each have an individual agenda. Make sure your public awareness program considers these individual needs and interest.

Tailor your messages and presentations to specific groups — for example, college faculty, city employees, developers, civic organizations, or youth groups. Involve environmental groups such as the Izaak Walton League, state associations of conservation districts, and other public or private organizations.

■ **Reaching your audience.** A targeted public awareness campaign uses a variety of tools to convey your message and attain your goals. Some of the tools include

- *Media.* Techniques include press releases, articles, photos with captions, talk shows, news programs, public service announcements, newsletters, and public notices to publicize your message.
- *Community events.* River/lake festivals, county/city fairs, and other special events are educational and public awareness opportunities to make your message known to a variety of audiences.
- *Awards.* Broaden your visibility, recognize good work, and gain a variety of advocates for your program through conservation awards for young people, public service awards, and participation and sponsorship awards.
- *Meetings.* Use public gatherings, club meetings, special conferences, and workshops to explain your program; customize your message to the needs and interests of your audience.
- *Speakers' bureau.* Face-to-face communication to a specialized audience provides a powerful opportunity to deliver your message, answer questions, and clarify ambiguities.
- *Educational materials.* Brochures and posters obtained from EPA, the state water authority, or other groups can be distributed to schools, civic groups, and businesses to further support your message.

■ **Using a variety of information/education tools.** The numerous techniques available to make your community aware of the nonpoint source problem and its solutions are limited only by your imagination and budget. See the following list and Table 4 for ideas to ensure support from your community:

- Publicize your program in all possible ways — use fact sheets inserted into utility statements, flyers, radio, TV, newspapers, public hearings, group meetings; develop personal contacts with reporters — offer story and photo opportunities.
- Tailor your message to various levels of knowledge — from those who understand the concept of nonpoint source pollution to those who have never heard of it.
- Form committees to work on specific aspects of the program; include representatives from all interest groups.
- Offer field trips to groups. Seeing the watershed's problem has much more impact than reading about it.
- Distribute drafts of the plan to interested groups for review.
- Set up meetings using existing organizations such as 4-H or Extension Service and organize community informational watershed workshops.
- Involve schools — make presentations to classes or conduct field trips.
- Set up nonpoint source pollution displays at every opportunity — county fairs, local Earth Day events, conferences, school events.

■ **Citizen monitoring.** Environmentally conscious citizens have made great contributions to local programs nationwide. Groups such as the Chesapeake Bay Watch and the Streamwalk Committee in Seattle, Washington, have become integral parts of the water quality program. Citizen groups can collect valuable information on basic parameters — they can monitor and identify problems, collect surface water samples, and measure turbidity.

Table 4.—Community education and citizen involvement methods.

METHOD	MOST EFFECTIVE USE	RESULTS
Newsletters	Announce meeting time and dates, update information on actions already taken, list issues to be discussed at upcoming meeting	Public awareness
Newspaper articles	Same as newsletter — provide additional detail about local success stories, photos of citizen activities, feature articles provide information about problems and solutions	Public awareness
Demonstration sites	Exhibit innovative technology — should be accompanied by signs, brochures, or permanent on-site interpretive staff	Public awareness, knowledge, understanding
Printed and taped material (e.g., factsheets, videos)	Explain new technology, describe case studies, provide training information for new employees, outline facts to stakeholders	Public awareness, knowledge, understanding
Signs	Mark watershed boundaries, identify critical areas, promote specific behaviors in specific places, identify cooperators in project, explain adjacent project and its BMPs, provide interpretive natural resources information	Public awareness, knowledge, understanding
Meetings	Share information, plan actions, evaluate progress	Public awareness, knowledge, understanding, desire/ability to act
Field trips	Observe resources to be protected, view installed BMPs, learn how BMPs operate, monitor (assessment or compliance type) BMPs	Public awareness, knowledge, understanding, desire/ability to act
On-site inspections	Identify problems, recommend corrective actions, evaluate effectiveness of pollution controls, identify noncompliant stakeholders, educate individuals	Action
Training	Provide new skills to stakeholders	Action
Technical assistance	Identify problems, recommend solutions, assist with installation of BMPs, educate individuals, evaluate effectiveness of solutions	Understanding, desire/ability to act, action

***Source:** Terrene Institute, Clean Water in Your Watershed: A Citizens Guide to Watershed Protection, 1993.*

Local officials see two advantages to citizen monitoring. First, these activities are an economical way to gather high quality data. Second, citizen monitoring is a valuable tool to build grassroots interest in water quality issues. In addition to helping officials identify and avert potential water problems, citizen groups build public support for nonpoint source programs and remedial actions, when necessary.

Despite these benefits, a volunteer program needs careful handling. Everyone is not suited to be a volunteer monitor. Groups and individuals may have difficulty staying motivated throughout an entire sampling project. Inappropriate training or procedures can result in useless data. Sampling also involves a slight risk of injury; local governments must have sufficient liability insurance to cover such situations.

Consider the following recommendations concerning volunteer monitoring programs:

- Citizen monitoring projects should not stand alone but should be integrated into a total water quality management program.
- A qualified water quality specialist should develop the sampling design, analyze the data, and prepare the final report.
- A qualified water quality specialist should train and supervise volunteers in the field, review data frequently, and work closely with the state water quality agency.

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*TVA RESERVOIR LANDS PLANNING PROGRAM**

The Tennessee Valley Authority manages some 300,000 acres of public reservoir lands, spanning seven states and including 23 multipurpose reservoirs with more than 11,000 miles of shoreline.

When he established TVA in 1933, President Franklin D. Roosevelt charged it with "the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin."

TVA uses the land for activities ranging from generating electrical power to managing recreation, forestry, and wildlife areas. Communities and the public use TVA's reservoir lands for industrial and navigation facilities, agriculture, community parks, and recreation.

Since it receives more than 1,500 requests for land use each year, TVA considers planning a land management priority. To accommodate the growing demand for development on its lands, TVA initiated a planning process to balance competing demands for public and private uses with environmental needs and national, regional, and local values.

TVA uses planning teams to determine how the land should be used. The team considers public comment, compatibility with existing and adjacent land uses, and legal requirements in making its decision. Plans approved by the TVA Board are continually revised to keep up with growth pressures, economic trends, public needs, environmental conditions, and changing laws. A Geographic Information System (GIS) keeps track of an endless amount of resource data on which the team bases and updates its recommendations.

As part of its planning process, TVA developed a three-step public participation plan. First, TVA identified why and how the public should be involved; next, it identified its audience; and finally, it planned how to involve the public. During public meetings, for example, private citizens and local, state, and federal agencies identify regional concerns and local land use issues. This information is incorporated into the GIS data and used to make social, cultural, and environmental planning decisions.

TVA's land planning process provides a continuing opportunity for local governments and citizens to offer their views on how public reservoir lands should be used, with public acceptance an added benefit. This objective assessment of regional needs guides TVA in handling a multitude of land use request.

Constant public involvement and reevaluation give TVA an insight into early problems, avoiding later crisis management. In addition, local governments and interest groups have a clear understanding of TVA's land use and development intentions. Finally, this process provides warnings of potential detrimental impacts to water quality from proposed uses.

**Adapted from TVA Reservoir Lands Planning and Land Management Planning Applications of a Geographic Information System fact sheets.*

- The sample design should be relatively simple and not dependent on precise measurement.
- Volunteers should be carefully recruited and trained; periodic training may be necessary to replace drop-outs and refresh monitoring skills of current volunteers.
- The water quality specialist should encourage frequent reports, personal presentations at group meetings, and media coverage to keep the group motivated.

The Missing Link — Community Partnership

The optimum situation — informed watershed planning to identify and correct existing problems and prevent future problems — will achieve the best environment possible. But all planning, no matter how complete, must be done *with* your community, not *for* it.

The advantages of the prevention/restoration ethic are impressive and would tempt any community — clean, usable waterbodies attract business and recreational dollars and measurably improve the economic health of the community. Remedial measures, designed to address current environmental conditions, can return water resources to an acceptable purity level.

However, billions of dollars are lost on public works projects, declining property values, and missed revenues from tourism, recreation, and other uses because of the missing link — community partnerships. Without community buy-ins by educated citizens who understand their individual responsibility and the community's needs, remediation will need to be repeated in each generation, if not more often.

Planning and prevention within the total community and watershed area comprise a vital permanent solution to water quality issues. In some cases, eliminating the cause of pollution may not be enough — the waterbody will still need rehabilitation. In other cases, communities must restore the quality of a waterbody even as they prevent further harm.

So plan for the optimum, seeking guidance and cooperation from your community along the way. When the community agrees to implement the plan you know will work, you will have served them — and the environment — well.

Appendix A

Federal Water Quality Program Summary

Coastal Zone Management Act of 1972 (CZMA)

This act established a program to encourage states and territories to develop comprehensive programs to protect and manage coastal resources, including the Great Lakes. To receive federal approval and implementation funding, states and territories had to demonstrate programs and enforceable policies sufficiently comprehensive and specific to regulate land and water uses and coastal development and to resolve conflicts between competing uses. They also needed authority to implement the enforceable policies.

Under federally approved state and territorial programs, the program must protect and manage important coastal resources, including wetlands, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitats. Resource management and protection are accomplished through state laws, regulations, permits, and local plans and zoning ordinances.

Water quality protection was not specifically cited as a purpose or policy of the original statutes. The Coastal Zone Act Reauthorization Amendments of 1990 specifically charged state coastal programs, and state nonpoint source programs, to address nonpoint source pollution affecting coastal water quality.

Coastal Zone Act Reauthorization Amendments of 1990 (CZARA)

In these amendments, Congress recognized that nonpoint pollution is a key factor in the continuing degradation of many coastal waters and established a new program to address this pollution. Congress further recognized that the solution to nonpoint pollution lies in state and local action. In enacting CZARA, Congress called upon states to develop and implement state coastal nonpoint pollution control programs.

EPA developed the technical guidance to help states develop control programs. The guidance specifies management measures for sources of nonpoint pollution in coastal waters — agriculture, silviculture, urban, marinas, and hydromodification. Management measures are economically achievable measures to control the addition of pollutants to coastal waters; that is, they reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

National Pollutant Discharge Elimination System (NPDES)

Traditional point sources of water pollution are regulated by EPA and the individual states under the NPDES permit program established by section 402 of the Clean Water Act, which establishes permit requirements for certain municipal and industrial stormwater discharges.

Under Phase I, NPDES permits are required for municipal separate storm sewers serving large or medium-sized populations (greater than 250,000 or 100,000 people, respectively) and for stormwater discharges associated with industrial activity. Permits are also issued, case by case, if EPA or a state determines that a stormwater discharge contributes to a violation of a water quality standard or significantly contributes pollutants to U. S. waters.

Under Phase II, EPA is to prepare two reports to Congress that (1) assess the remaining stormwater discharges, (2) determine, to the maximum extent practicable, the nature and extent of pollutants in such discharges, and (3) establish procedures and methods to control stormwater discharges to the extent necessary to mitigate impacts on water quality. Then EPA is to designate stormwater discharges in addition to those addressed in Phase I that must be regulated to protect water quality and establish a comprehensive program to regulate those designated sources.

Section 319 of the Clean Water Act

This statute establishes a national program to control nonpoint sources of water pollution and to protect groundwater. Under section 319, states address nonpoint pollution by assessing the problems and causes within the state, adopting management programs to control the pollution, and implementing the management programs.

States are required to submit an assessment of state waters not expected to meet water quality standards because of nonpoint source pollution and a management program for controlling nonpoint source pollution. Section 319 authorizes EPA to issue grants to states to assist them in implementing management programs or portions of management programs that have been approved by EPA.

National Estuary Program

Administered by EPA under section 320 of the Clean Water Act, this program focuses on point and nonpoint pollution in geographically targeted, high-priority estuarine waters. In this program, EPA assists state, regional, and local governments in developing comprehensive conservation and management plans that recommend priority corrective actions to restore estuarine water quality, fish populations, and other designated uses of the waters.

Section 320 authorizes EPA, on its own or at the request of a state, to convene a management conference to address water pollution problems in estuaries. This conference must identify the causes of environmental problems within the estuarine zone and develop a comprehensive conservation and management plan for the estuary that recommends corrective actions and compliance schedules for controlling point and nonpoint sources of pollution.

Pesticides Program

Administered by EPA, this program controls some forms of nonpoint pollution under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). It authorizes EPA to control pesticides that may threaten groundwater and surface water. FIFRA provides for the registration of pesticides and enforceable label requirements, which may include maximum rates of application, restrictions on use practices, and classification of pesticides as "restricted use" pesticides, which would limit their use to certified applicators trained to handle toxic chemicals.

Source: Adapted from U.S. Environmental Protection Agency, Guidance Specifying Management Measures from Sources of Nonpoint Pollution in Coastal Waters, 1993.

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Appendix C

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SOIL AND WATER CONSERVATION COMMISSION
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DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY
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Permits Division
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Appendix D

Watershed Restoration and Pollution Control Programs

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Environmental Protection Agency (EPA)	Administers educational and regulatory programs designed to protect the environment (prevent and control pollution). Provides environmental assessments, water quality monitoring, regulations and regulatory oversight, education, planning, technical assistance, grants, and loans for pollution control. Works mainly with state, federal, regional, and local agencies on pollution control efforts	Staff, information and data, laboratories and research facilities, grants and loans for pollution control, educational materials, monitoring equipment. Offices located in 10 regional centers and Washington, DC.
EPA Water Quality	Overall water quality planning and management: • Nonpoint Source Control program oversees and approves state development of water quality assessments and implementation of management programs designed to control nonpoint source pollution; directs funds to high priority watersheds or projects. • Clean Lakes program provides funds to restore or enhance publicly owned lakes. • Water Quality Standards Program provides technical assistance in developing numeric, narrative, and biological limits (standards) to protect water quality and its use. • Coastal programs oversee a number of different programs and initiatives designed to assess coastal resources and study ways to protect coastal waters. Includes the National Estuary program, administers new CZARA	Staff for technical assistance to state and local agencies; review and approval of state programs, research, and special studies. Provides grants to states for most water quality protection activities, educational materials, and programs; funds for special studies or projects.

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Environmental Protection Agency (continued)		
EPA Permits	NPDES permits for industries, cities, and confined animal feeding operations, provides enforcement for noncompliance.	Staff for technical assistance with modeling and permit drafting, site inspections, and compliance monitoring; funds for special studies or projects.
EPA Pesticides	Regulates pesticide labeling and registration, including application rates, allowable crops and pests, environmental and human health cautions, disposal procedures; licenses restricted-use pesticide applicators.	Staff to review research results, assist with strategic planning, education and training, oversee enforcement procedures of states; funds for special projects and studies.
EPA Groundwater	Administers the Sole Source Aquifer Protection Program; provides technical and programmatic assistance to state wellhead protection programs.	Staff for technical assistance; funds for special studies.
EPA Wetlands	Cooperatively administers wetlands dredge and fill permits with the Corps of Engineers, enforces actions for illegal wetlands filling; technical support for wetlands delineations; research and education about wetland values and function.	Staff to oversee and enforce activities, monitoring wetland status, health, and trends, funds for special studies, educational materials, and programs; data.
EPA Monitoring and Surveillance	Provides environmental assessment, data analysis, oversight of state monitoring programs, special studies and agency research, EPA lab and Office of Research and Development coordination.	Staff for technical assistance to states and citizens on monitoring programs and projects; special studies and data analysis upon request; water quality monitoring at select locations.
EPA Drinking Water	Regulates public drinking water supplies and suppliers; special studies on human health and risk; develops drinking water criteria and maximum contaminant levels (MCLs). Administers special program for watershed treatment to decrease pollution loads to drinking water supplies if installation of BMPs is cheaper than the water treatment method needed.	Staff for technical assistance to set drinking water standards. Special studies, oversight, and compliance monitoring of public water supplies and suppliers.
EPA National Environmental Policy Act (NEPA)	Reviews and comments on other federal agencies' environmental impact statements (EISs); prepares EISs for EPA-sponsored projects.	Staff for technical assistance to prepare NEPA documents and review pollution control techniques required as part of federal action.
EPA Office of Research and Development (ORD)	Conducts basic and applied research to support EPA's mission, including biological and physical studies on fate and transport of environmental contaminants; studies ecosystems at large.	Provides reports, data, maps, monitoring equipment, study and demonstration sites, staff for technical assistance in interpreting research results. Laboratories and research stations located throughout the country.
U.S. Department of Agriculture (USDA)	Stabilizes and supports efficient production, marketing, and distribution of food and fiber. In addition to commodity and public welfare programs, administers a number of conservation programs to assist private and federal land owners or managers in natural resource conservation and multiple-use management. Works mainly with private individuals on improving resource management.	Staff, technical assistance, information and data, educational materials, cost-share funds, engineering equipment. Field offices located in nearly every county, state, and Washington, DC

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Department of Agriculture (continued)		
USDA — Multiple agency administration of the 1985 and 1990 Farm Bill programs:		
Conservation Reserve Program	Conserves and protects highly erodible or other environmentally sensitive land from production with permanent vegetative cover through 10-year easements and annual rental payments.	In most cases, responsibilities within programs are divided between various USDA departments: **SCS** — Technical assistance in planning, designing, and implementing BMPs. **ASCS** — Administrative oversight of program and cost-share funding disbursement. **CES** — Education and information about the variety of conservation and economic choices available **CSRS** — Research, data, and the results of demonstration field trials of new technologies.
Wetlands Reserve Program	Available only in pilot states to return drained wetlands to wetland status and protect existing wetlands. Uses same easement/payment method as CRP.	
Sustainable Agricultural Research and Education Program	A practical research and education and grant program to promote lower input methods of farming	
Conservation Cross Compliance (Sodbuster and Swampbuster)	A quasi-regulatory program that denies subsidy payments to farmers who plow highly erodible land or drain wetlands.	
Water Quality Incentives Program	A watershed treatment program designed to improve or protect soil and water resources in watersheds impacted or threatened by NPS pollution	
USDA Soil Conservation Service (SCS)	Technical assistance on planning site-specific design, and installation and management of soil and range conservation, animal waste, and water quality management systems, special land and water resource assessments and inventories. Cost-share funds to install BMPs on private lands available from some programs	Staff and equipment in field offices for technical assistance including engineering designs, survey work and planning for water resource protection.
USDA SCS — Small Watershed Program (PL-566)	Evaluates and treats small agricultural watersheds with multiple resources to protect. Targets resources for both technical and financial assistance and educational programs.	Staff for technical assistance to landowners and decisionmakers in the watershed; funds for demonstration projects
USDA SCS — Great Plains Conservation Program (GPCP)	Intensive conservation treatment for individual farms located within the Great Plains ecoregion through long-term agreements (3 to 10-year contracts) with farmers.	Technical assistance and cost-share funds up to 75 percent of the average cost of selected high priority conservation practices
USDA SCS — Resource Conservation & Development Program (RC&D)	Helps local governments in authorized areas plan and use natural resources and solve local problems.	Planning assistance for small communities for resource protection; financial assistance up to 25 percent of a project — not to exceed $50,000.
USDA SCS — River Basin Program	Assists state and local governments identify water and related land resource problems, evaluate alternative solutions, and develop their implementation program.	Staff for technical assistance to decisionmakers for inventory and planning activities.
USDA SCS — Natural Resource Assessment Programs: Soil Survey, Natural Resources Inventory	Various programs to map and assess the condition of natural resources (soil, water, vegetation, and wildlife) and conservation treatments.	Maps, reports, data information, statistical analysis.

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Department of Agriculture (continued)		
USDA Agricultural Stabilization and Conservation Service (ASCS)	Provides administrative oversight and cost-sharing programs for approved conservation practices from ASCS and other USDA administered programs, tracks crop production and other statistics; distributes crop subsidy and deficiency payments.	Financial assistance (i.e., cost sharing); map and conservation practice information.
USDA ASCS — Agricultural Conservation Program (ACP)	Annual cost-sharing for a number of soil conserving, production improving, and water quality practices.	Funding for cost-share programs generally limited to $3,500 per farm per year.
USDA ASCS — Emergency Conservation Program (ECP)	Annual cost-sharing to replace conservation treatments (mainly structural) destroyed in areas designated as natural disaster areas.	Cost-share funds for high priority conservation practices.
USDA ASCS — Water Bank Program	Designed to improve and restore wetland areas through financial compensation for 10-year easements on private property.	Funding for easement compensation on eligible lands in participating states.
USDA ASCS — Colorado River Salinity Control Program (CRSCP)	Financial assistance on farm projects that seek to control salinity levels delivered to the basin, primarily irrigation water management.	Funds, reports, data on level of conservation treatment and demonstration sites; cost-sharing, monitoring, and education.
USDA ASCS — Forestry Incentives Program (FIP)	Cost-share to revegetate and improve timber stands on private lands.	Cost-share funds.
USDA Cooperative Extension Service (CES)	Educational programs and information to aid individuals in selecting, operating, and maintaining the most beneficial conservation treatments. Economic analysis and data for each farm or ranch, technical assistance in integrated pest management and landscape issues. Programs generally carried out in cooperation with state land-grant universities.	Staff to offer educational programs and technical assistance and personalized economic analysis; coordinates small-scale demonstrations on local farms; educational materials.
USDA Cooperative State Research Service (CSRS)	Applied research, usually at state experiment stations, on agricultural production and soil and water conservation, generally using demonstration plots. Conducts the Sustainable Agriculture Research and Education (SARE) program. Many projects in cooperation with state land grant universities.	Provides reports, data, equipment; occasionally has funds for joint or special projects outside the normal research agenda; grants for Agriculture in Concert with the Environment (ACE) program.
USDA Forest Service (FS) — National Forest System (NFS)	Manages national forests and grasslands for sustained production and multiple use. Works with individuals, industries, and other agencies.	Staff, maps, reports, equipment for construction and monitoring, educational materials; occasionally funds for special projects. Field offices located in each national forest; regional offices located in 9 areas and Washington, DC.
USDA NFS — Permit Program	Oversees timber sales and harvest contracts, grazing leases, and minerals developed on FS property; provides technical assistance to permittee in proper resource use.	Staff for technical assistance and compliance monitoring.
USDA NFS Air and Watershed Programs	Overall environmental planning and technical support for forest management decisions; special studies and watershed demonstration projects in certain areas.	Funds for special studies and watershed demonstration projects; natural resource inventories and reports, water quality or habitat monitoring; environmental analysis of resource trends and conditions.
USDA NFS — Research	Basic and applied research on range and forest lands.	Technical papers on effects of management on water quality

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Department of Agriculture (continued)		
USDA NFS — State and Private Forestry —Forest Stewardship Initiative	Technical assistance and cost share to inholding or privately owned lands adjacent to national forest lands for installing BMPs.	Funds for and technical assistance to individuals
USDA Farmers Home Administration (FmHA)	Loans and loan guarantees to eligible producers for operating expenses, land purchase, and conservation measures	Funds and loans for property improvement and conservation, treatment installation, and water conservation practices. Located in counties, states, and national offices.
USDA Agricultural Research Service (ARS)	Basic and applied research on agricultural production and conservation measures, including fertilizers, pesticides, and BMP effectiveness	Reports on BMP effectiveness and environmental fate and transport data, demonstration sites; occasionally provides funds for joint sponsored projects. Research stations, located throughout each state, specialize in particular types of investigations
U.S. Department of Commerce — National Oceanic and Atmospheric Administration (NOAA)	Administers programs in cooperation with states to inventory and manage coastal resources, funds and performs basic research and assessments relating to coastal eutrophication, maintains database for agricultural pesticides and nutrient loadings	Funds to state coastal programs; staff for technical assistance, data reports, and educational materials; occasionally administers funds for special demonstration projects
NOAA — Coastal Zone Management Act Programs (CZMA)	Administers a quasi-regulatory coastal protection program, in cooperation with EPA, that sets performance-based management measures for control and prevention of nonpoint source pollution in coastal areas for all land use activities	Staff for technical assistance, funds for plan development.
U.S. Department of Defense (DOD) Army Corps of Engineers (COE)	Oversees construction and operation of large flood control and public water supply reservoirs, conducts water quality monitoring on lakes within its jurisdiction, regulates in-lake activities and shoreline development. Cooperatively administers wetlands dredge and fill permit program with EPA and Fish and Wildlife Services; can enforce permit requirements for wetland BMPs or other mitigation measures	Maps, special studies, water quality monitoring data, staff and funds for improvement of existing projects, staff to review and oversee 404 (wetlands) permits. Field offices located in various districts throughout states and Washington, DC.
U.S. Department of the Interior (DOI)	Oversees, manages, or monitors national natural resources, including land, water, and wildlife.	Staff, maps, reports, demonstration sites, educational materials, monitoring equipment. Offices located in regional centers, management areas, and Washington, DC.

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AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
U.S. Department of the Interior (continued)		
DOI Fish and Wildlife Service	Oversees and regulates the nation's wildlife resources; manages national wildlife reserves; enforces federal game and fish laws; cooperatively administers national wetlands program with the Corps of Engineers and EPA. Cooperative projects to enhance wildlife habitat; special studies, especially fisheries investigations.	Staff to enforce Endangered Species Act and other laws on public and private land; research reports and data on habitat, populations, and management of wildlife. Funds for cooperative projects. Educational materials, teacher training, curricula, and maps.
DOI Bureau of Land Management (BLM)	Administers and manages federal lands; oversees grazing leases, mineral exploration, and extraction bids and leases on BLM lands; technical assistance to permittees on BLM land in proper resource use; oversees recreational users of BLM land.	Staff for environmental analysis and trend evaluation on BLM land, technical assistance, and oversight. Funds for special studies and cost-share for permittees for certain conservation practices (generally grazing/range management); funds for range improvement, riparian area management, and recreational area development projects Maps
DOI Bureau of Indian Affairs (BIA)	Technical assistance to tribes on tribal lands mainly for social services; some assistance for conservation work and educational programs, natural resource inventories and monitoring surface and groundwater.	Maps; natural resource inventories of Indian and tribal lands; funds for special projects; staff for technical assistance to tribes.
DOI Bureau of Reclamation	Administers, constructs, and oversees water supply facilities in western states; regulates discharges from these facilities; jointly administers the Colorado River Salinity Control Program with many agencies to set consistent salinity standards and manage public and private lands within the basin; new initiative to reclaim lands damaged by federal irrigation projects	Staff to oversee projects and manage federal property and facilities; assesses water quality around reservoirs as part of the national irrigation water quality program, maps, reports, and some data.
DOI National Park Service	Administers and manages national parks for preservation of natural resources	Staff to oversee and administer; funds for special studies and occasional cooperative projects on land adjoining park boundaries
DOI Office of Surface Mines (OSM)	Regulates the removal and reclamation of surface mined minerals, mostly coal on private lands	Staff to oversee and provide technical assistance in mining operations, reclamation efforts, and engineering studies; vegetative site inspections and monitoring resources; educational materials, data, and reports.
DOI U.S. Geological Survey (USGS)	Long-term baseline monitoring of water resources (quantity, flow, and quality), hydrologic and geologic investigations and data, special intensive short-term studies.	Maps, data, and information on hydrology and water quality status and trends; staff for technical assistance in designing a monitoring plan.
State Water Quality Agencies	Administer many programs (similar to EPA) to protect water quality in surface and groundwaters, including the NPDES permit program, water quality standards regulations, the nonpoint source program, and ambient statewide monitoring programs.	Staff for technical assistance to local governments and individuals implementing BMPs; water quality monitoring, data, and reports, funds for pollution control projects, educational materials, and programs.

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
State Agencies (continued)		
State Natural Resource Agencies	Administer programs for wetlands and coastal protection.	Staff for technical assistance to local governments; monitor natural resource trends, reports, and data educational materials and programs
State Departments of Agriculture	Regulate pesticide registration and use and administer marketing and rural development programs, sometimes issue permits for fertilizer or feedlots	Staff to oversee pesticide applicators and other regulatory functions.
State Forestry Commissions or Departments	Oversee activities on state forest lands, administer forest practice laws or BMP regulations.	Staff for site inspections, technical assistance, and education for private landowners and state forests; information on forest resources.
State Cooperative Extension Services	Natural resource, family health, and agricultural production education and training programs for citizens	Staff, reports, educational materials, technical assistance. Field offices located in each county or state office connected with land-grant universities
State Parks and Tourism Departments or Bureaus	Administer programs to promote tourism and the use of state parks for recreation	Maps, signs, educational materials, occasional small grants for historic preservation or local development
State Natural Heritage Commissions or Boards	Administer programs to educate people and preserve historic and cultural resources	Maps signs, educational materials
State Highway or Transportation Departments	Oversee design, construction, and maintenance of state and federal highways provide assistance to local governments on road-related issues, responsible for erosion and pollution control along highway right-of-ways and during construction and maintenance activities	Maps, signs, educational materials, maintenance equipment, and flower and grass seeds, technical assistance for local governments; sometimes provide funds for special studies or beautification projects.
State Public Lands Commissions or Boards	Oversee administration of state lands, generate revenues for state treasury.	Natural resource information and maps.
State Natural and Scenic Rivers Commissions	Oversee use and protection of state designated scenic rivers; may levy taxes and take enforcement actions to protect the river.	Staff for river protection and (sometimes) assessments; occasionally provide funds for special protection or improvement projects.
State Livestock and Poultry Boards or Commissions	Regulate health, welfare, and safety of livestock, poultry production, and products.	Staff for site inspections, technical assistance, and enforcement actions; sometimes special studies and reports.
State Water Well Boards	Regulate the drilling of new wells and the sealing of old ones.	Staff for site inspections, technical assistance, and enforcement; educational materials and training for drillers.
State Oil, Gas, and Minerals Departments or Commissions	Oversee the leasing, production, and administration of state and privately owned natural resources, responsible for spills and environmental programs related to petroleum.	Staff for oversight and inspection including site-specific environmental audits and spill prevention and clean-up.

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AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
State Agencies (continued)		
State Plant Boards	Administer programs that evaluate mainly agricultural plants and conservation plantings.	Staff for technical assistance; special studies and reports.
State Health Departments	Administer septic tank and public drinking water regulatory programs; monitor water supplies; provide technical assistance to local governments.	Staff for technical assistance to local governments, monitoring, and educational programs; data, reports, and educational materials.
State Soil and Water Conservation Commissions	Administer cooperative programs with the USDA/SCS to conserve soil and water resources on private lands; provide technical assistance to individuals.	Staff for technical assistance to individuals; engineering or construction equipment, services, and supplies that support BMP implementation. Some states have cost-share funds for BMPs.
State Fish and Game Agencies	Regulate the harvest of fish and wildlife resources by individuals and commercial operations; responsible for state cost recovery of lost fish and wildlife affected by environmental contamination.	Staff for enforcement of state fish and game laws and for technical assistance in wildlife and fisheries management for private individuals; educational materials; natural resource inventory data.
State Water Rights Agencies	Allocate water rights (mostly in western states); regulate consumptive use of water resources.	Staff for permit writing and oversight; data and reports on water flow.
Local Planning and Zoning Boards, City Planning Commissions, County Planning Boards	Specify land use zoning and boundary determinations; general community planning; oversee program operation.	Maps, long-range plans, inventory of local resources, special reports, budget information, staff for technical assistance.
Local County Judges, Commissioners Court, or Parish Police Jury	Manage, construct, and maintain county roads and bridges; oversee and approve county budgets for all county programs. Taxing authority.	Information on county conditions, equipment for construction and maintenance, budget reports; occasional funds for special projects.
Local SWCDs	Local field office of state agency.	See State Soil and Water Conservation Commission.
Local Erosion and Sediment Control Districts	Oversee activities that could cause erosion and sedimentation.	Staff for on-site inspections, technical assistance, and sometimes enforcement actions.
Local Irrigation or Acequia Districts	Regulate local water use and maintain public or jointly owned irrigation projects; responsible for controlling pollution and erosion from projects.	Maintenance workers.
Local Flood Control, Water Management, or Subsidence Districts	Regulate water and land use and management to prevent subsidence or flooding.	Staff for on-site assessments and inspections; maps, reports, land use data; zoning information.
Local School Boards and School Administrations	Oversee public education within jurisdictional boundaries; can set local curricula requirements and priorities. Taxing and bond issuing authority.	Information on status of current educational programs; assistance in developing new initiatives.
Local Municipal Utilities Districts	Oversee construction and maintenance of public works projects for water, sewer, and occasionally energy. Taxing and bond issuing authority.	Information and special reports on water issues; funds for special projects to enhance system operation and reduce costs.

AGENCY AND PROGRAM	PROGRAM DESCRIPTIONS AND AGENCY RESPONSIBILITIES	RESOURCES AVAILABLE AND POSSIBLE ROLES
Regional River Authorities	Manage and coordinate activities within their basin for flood control, water quality protection, energy development. Taxing authority.	Data, reports, maps, water quality monitoring, staff for technical assistance to local government and other agencies or groups. Funds for special projects
Regional Planning Commissions and Councils of Government	Assist in coordinating activities of all governments within the area; provide technical assistance and information; promote special projects of benefit to all	Staff for technical assistance to local governments; occasional water quality monitoring, reports, and data about local conditions; funds for special projects.
Others — Commodity Groups	Various groups usually formed to improve marketing and lobbying capabilities for specific crops or livestock interests. Nearly every major crop has at least one such group.	Staff for data gathering and analysis, public education campaigns, technical support to growers, legislative and market analysis; funds from members for special projects
Environmental Organizations	Various groups formed to protect, conserve, or preserve the environment in general or to address a specific issue; lobby for environmental laws and programs as well as funding. Many perform volunteer services such as water quality monitoring, natural resource rehabilitation work, cost-share, or provide other funds for special projects	Staff and volunteers assist with local projects; educational materials and programs, reports and data on environmental conditions and trends; occasional funding for cooperative work
Social and Service Clubs	Formed for reasons other than resource protection, most have local projects that enhance or beautify community. Provide labor, supplies, and equipment on mutually beneficial projects as well as insight into the community	Volunteers for special projects

Source: Adapted from Terrene Institute, Clean Water in Your Watershed: A Citizens Guide to Watershed Protection, 1993.

Santa Monica
BAY
Restoration
PROJECT

A Health Effects Study of Swimmers in Santa Monica Bay[1]

Summary

In the summer of 1995, the Santa Monica Bay Restoration Project (SMBRP) conducted the first large-scale epidemiologic study in the nation to investigate possible adverse health effects associated with swimming in ocean waters contaminated by urban runoff. The overall objective of this study was to answer the public's most frequently asked question, *"How safe is it to swim in Santa Monica Bay?"* by investigating swimmers' reports of illness and determining whether the risks of contracting these illnesses were associated with exposure to pathogens in urban runoff.

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A Partnership To
Restore And Protect
Santa Monica Bay

Funded by US EPA
and the State Water Resources
Control Board in cooperation
with the public, local agencies,
and industry.

BACKGROUND

Since the genesis of the Santa Monica Bay Restoration Project (SMBRP), a primary focus of energy has been to find the answer to a fundamental human health question: *"How safe is it to swim in Santa Monica Bay?"* Nearly fifty million tourists and local residents come to Santa Monica Bay's public beaches each year to enjoy its recreational resources, but there has been wide public perception and some scientific evidence that there may be health risks associated with swimming in beach areas contaminated by runoff.

In previous investigations conducted by the SMBRP, human pathogens were detected in summer runoff, an unexpected result since sewer and storm drain systems in Los Angeles are completely separate. Possible sources of pathogen contamination into the storm drain system include illegal sewer connections, leaking sewer lines, malfunctioning septic systems, illegal dumping from recreational vehicles, or direct human sources such as campers or transients. Other potential sources of human pathogens in near shore areas include sewage spills into storm drains, small boat waste discharges and swimmers themselves.

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[1] "An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay."

The members of the SMBRP therefore decided that the definitive step necessary to answer this question of swimming-related health risks was an epidemiological study. Through this study, we would finally know if risks exist and whether they differ according to where one swims, and we would have the basis for revising recreational water quality standards and monitoring programs so that they are based on risks to human health.

STUDY OVERVIEW

During the course of the study (June to September 1995), 15,492 beachgoers who swam at three Santa Monica Bay beaches located near flowing storm drain outlets (Santa Monica Beach near Ashland Avenue, Will Rogers Beach at Santa Monica Canyon, and Surfrider Beach near Malibu Creek), were interviewed. Nine to 14 days after the beach interviews, 13,278 follow-up telephone interviews were conducted to ascertain the occurrence of symptoms--fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat and a group of symptoms indicative of "highly credible gastrointestinal illness" (HCGI)[2] and "significant respiratory disease" (SRD)[3].

Water samples were collected daily in ankle depth water at various distances from the drains (0, 100 yards north and south, and at 400 yards) (Figure 1) and analyzed for total and

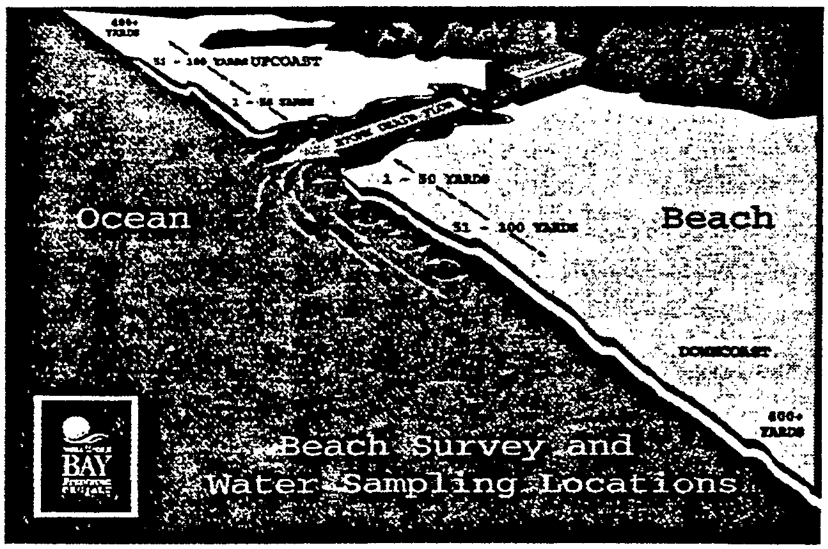

Figure 1. Beach survey and water sampling locations.

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[2] Two definitions of HCGI were used in this study and grouped as HCGI-1 (vomiting, diarrhea and fever, stomach pain and fever) or HCGI-2 (vomiting and fever).

[3] Symptoms including fever and nasal congestion, fever and sore throat, and cough with sputum.

fecal coliforms, enterococci, and *E. coli*. In addition, water samples were collected at storm drain sites every Friday, Saturday and Sunday and analyzed for enteric viruses.

SUMMARY OF FINDINGS

The analyses conducted in this study addressed two questions: a) What are the risks of illness relative to the distance one swims from a flowing storm drain?; and b) Are the risks of illness associated with measures of water quality? The major findings resulting from these analyses are as follows:

1. **There is an increased risk of illness associated with swimming near flowing storm drain outlets in Santa Monica Bay.** Statistically significant increases in risks for a broad range of adverse health effects (fever, chills, ear discharge, vomiting, coughing with phlegm, HCGI-2[4] and SRD) were found for subjects that swam in front of storm drains (at 0 yards) in comparison to those who swam over 400 yards away[5] (Table 1). For example, there was a 57 percent greater incidence of fever for swimmers at the drain than at 400 yards away. These increases in risk appeared to be limited to the 0 yards distance, as a significant drop-off in effects were observed at other distances upcoast or downcoast from the drain (Figure 2).

Table 1. Comparative health outcomes for swimming in front of drains versus 400+ yards away.

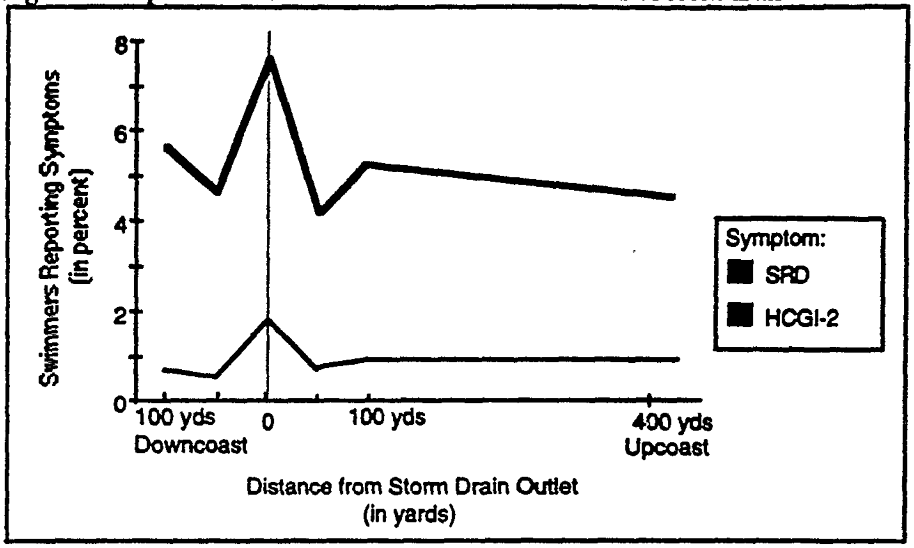
Health Outcome	Relative Risk (0 vs. 400+ Yds.)	Estimated No. of Excess Cases per 10,000 Persons
Fever	57%	259
Chills	58%	138
Ear Discharge	127%	88
Vomiting	61%	115
Coughing with phlegm	59%	175
Any of the above symptoms	44%	373
HCGI-2	111%	95
SRD	66%	303
HCGI-2 or SRD	53%	314

4 See footnote 2.

5 Indicator bacteria levels at 400 yards are low, therefore comparisons could be made between rates of illness in swimmers at this distance and at 0 yards.

The estimated number of excess cases of illness attributable to swimming at the drain reached into the 100's per 10,000 exposed subjects (greater than 1 percent) suggesting that significant numbers of beachgoers swimming near storm drain outlets are subject to increased health risks.

Figure 2. Reports of HCGI-2 and SRD relative to distance from drains.



The results did not change when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, or worry about potential health hazards at the beach. Distance results also did not change substantially when controlled for each bacterial indicator.

2. **There is an increased risk of illness associated with swimming in areas with high densities of bacterial indicators.** Researchers used "cutoff points" to determine whether there were differences in the incidence of illness for those who swam in waters with bacterial densities "greater than" versus "less than" certain cutoff levels. Symptoms were found to be associated with swimming in areas where bacterial indicator counts were "greater than" the cutoff points that are used as part of federal and state water quality standards. (Cutoffs vary by type of bacterial indicator.)

Table 2 shows the various outcomes that were found to be associated with these high densities of indicator bacteria. For *E. coli*, associations were seen for earache and nasal congestion. Only skin rash was associated with total coliforms and fecal coliforms. For enterococci, effects were noted for diarrhea with blood and HCGI-1.

Table 2. **Health outcomes associated with swimming in areas with high bacterial indicator counts.**

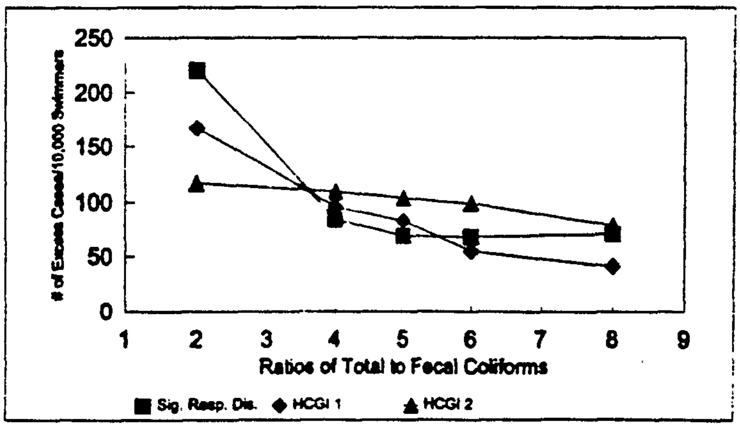
Indicator (cutoff)	Health Outcomes	Increased Risk	Excess Cases per 10,000 Persons
E. coli (> 320 cfu*)	Earache	46%	149
	Nasal Congestion	24%	211
Enterococcus (>106 cfu)	Diarrhea w/ blood	323%	27
	HCGI-1	44%	130
Total coliform (>10,000 cfu)	Skin rash	200%	165
Fecal coliform (>400 cfu)	Skin rash	88%	74

*colony forming units

3. **The total coliform to fecal coliform ratio was found to be one of the better indicators for predicting health risks.** In addition to investigating single bacterial indicators, associations between adverse health effects and the ratio of total to fecal coliforms were investigated. Significant associations were observed, with incidence of illness generally increasing as the ratio of densities of total coliforms to fecal coliforms decreased (Figure 3). When analyses were restricted to times when total coliforms exceeded 1,000 cfu, the strongest effects were generally observed when the ratio of 2:1 was used for comparison.

None of the bacterial results changed when adjusted for age, beach, gender, race, California vs. out-of-state resident, socioeconomic status or worry about potential health hazards at the beach.

Figure 3. Relationship of excess cases of illness and total-to-fecal coliform ratios.



4. **Illnesses were reported more often on days when the samples were positive for enteric viruses.** Seventeen water samples (taken in the storm drain) were positive for enteric viruses. Although based on small numbers, a comparison of subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses indicates that a number of outcomes were reported more often on days when the samples were positive for viruses versus days when samples were negative. Symptoms for which increased risks were noted include: fever (53 percent increase), vomiting (89 percent increase), HCGI-1 (74 percent increase) and HCGI-2 (126 percent increase). Results remained essentially unchanged when adjusted for covariates or for each bacterial indicator. Research with gene probes is ongoing and will be presented in a future addendum to this report.

5. **High densities of bacterial indicators were measured on a significant number of survey days, particularly in front of drains.** A great deal of day-to-day variability in bacterial indicator counts was recorded, however high bacterial densities in water samples were detected most frequently directly in front of drains (at 0 yards) (see Table 4). High densities of *E. coli*, fecal coliforms, and enterococcus occurred on over 25 percent of survey days. Total coliform levels were exceeded less frequently (8.6 percent of days). Total-to-fecal coliform ratios of less than 5 occurred on 12 percent of survey days.

Table 4. Percentage of survey days when bacterial indicator cutoff levels were exceeded in Santa Monica Bay.

Bacterial Indicator (cutoffs)	**Percent of Survey Days Bacterial Cutoffs Exceeded** — Distance from Drain Outlets: 0 yards	1-100 yards upcoast	1-100 yards downcoast	400+ yards upcoast
E. coli (>320 cfu)	25.0%	3.5%	6.7%	0.6%
Total coliforms (>10,000 cfu)	8.6%	0.4%	0.9%	0.0%
Fecal coliforms (>400 cfu)	29.7%	3.0%	8.6%	0.9%
Enterococcus (>106 cfu)	28.7%	6.0%	9.6%	1.3%
Total/fecal ratio ≤5 (total coliforms>1000 cfu)	12.0%	0.5%	3.9%	0.4%

High counts were recorded more frequently downcoast (versus upcoast) from storm drain outlets due to the general pattern of water flow along the Bay's shoreline. At 400 yards away, high counts occurred on generally less than one percent of days.

5. **Characteristics of the survey population.** Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex or race. Persons who had bathed at the study beaches within seven days of the survey date (before and after) were excluded, as were subjects who bathed on multiple days. Since a primary research question was whether the risk of illness was associated with levels of particular indicator organisms in the water, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days.

   Fifty-five percent of the subjects surveyed were male, 45 percent female. Forty-eight percent of the subjects were children (under 12 years of age); 13-to-25 year-olds comprised 26 percent of the survey population and the remaining 26 percent were aged 26 and over. The ethnicity of the survey population was 45 percent white, 43 percent Latino, 3 percent black, 3 percent Asian, 3 percent multi-ethnic, and 2 percent "other." Children and Latino subjects tended to swim closer to the drain. Sixty-three percent of subjects swimming at the drain were children under 12. Eighty-eight percent of the surveyed subjects were residents of California.

THE EPI STUDY ACTION AGENDA

The results of this health risk investigation provide both good news and cause for concern. *The good news is that, of the Bay's 50-plus mile coastline, less than 2 miles are problematic.* However, the study has also confirmed that there is a risk of illness associated with swimming immediately adjacent to flowing storm drains. Although it is not yet known what specific pathogens cause illness, the study confirms that the bacterial indicators that are being monitored *do help* to predict risk. In addition, a new tool, the total-to-fecal coliform ratio, has been found to be a useful predictor of illness. With the scientific findings now documented through this study, we have laid the foundation to develop new policies and actions that will improve our ability to protect the public's health.

As a first step, the members of the Santa Monica Bay Restoration Project have identified a preliminary "Epi Study Action Agenda" to respond to the findings of this study and because of the need to "act now." Some of these actions have already begun, but many more steps are yet to be taken. Like the broader issue of urban runoff and storm water pollution, however, prevention and elimination of pathogen contamination in recreational waters requires a long-term, comprehensive approach. There is, however, much that can begin immediately.

Educating and advising the public about the health risks of swimming near storm drain outlets, ensuring that pathogen sources are identified and controlled, and preventing contamination of runoff into the drainage system are among the governmental actions that have been initiated. The general public also has a role to play -- taking action to prevent urban runoff pollution at home, at the work site and at play.

EDUCATE AND ADVISE THE PUBLIC

1. **Improve warnings to swimmers by posting new signs and flags near flowing storm drains.** The Los Angeles County Department of Health Services (LACDHS) will revise the Beach Regulatory Protocol to ensure that beaches are well posted and/or closed as necessary. These revisions include:

    a. Strengthen the wording on warning signs posted near flowing storm drain outlets to read as follows: "WARNING! STORM DRAIN WATER MAY CAUSE ILLNESS. NO SWIMMING." This warning will be posted in both English and Spanish.

    b. Post warning signs on both sides of all flowing storm drains in Los Angeles County and place crossed flags adjacent to the signs.

    The remaining procedures contained in the Protocol (regarding incidents such as beach closure requirements in cases of sewage spills, etc.) will continue to be implemented as appropriate.

2. **Warn swimmers to stay away from storm drain outlets.** Los Angeles County Lifeguards will attempt to warn and advise swimmers to stay away from areas directly in front of storm drain outlets, especially in ponded areas.

3. **Strengthen messages about human health risks associated with contaminated urban runoff into current storm water education campaigns based on the results of this study. Integrate new messages into the educational campaigns if necessary.**

IMPLEMENT SOURCE CONTROL MEASURES

4. **Prevent and control sources of pathogens to urban runoff.** Controlling pathogen sources is but one part of a comprehensive strategy to address the problem of urban runoff pollution. The Los Angeles County Department of Public Works (LAC-DPW) and the cities in the Santa Monica Bay watershed will therefore continue to implement urban runoff source control measures (including Best Management Practices such as catch basin stenciling, storm drain inspection, illegal discharge reporting, enforcement of "pooper-scooper" laws) and where needed, will expand or accelerate these programs.

5. **Divert dry-weather flows from problem storm drains.** The LAC-DPW and cities will continue to work with municipal wastewater agencies and the Los Angeles Regional Water Quality Control Board (LARWQCB) to complete the assessments of projects to divert dry-weather flows from problem storm drains to sewage treatment facilities. Projects that are feasible and cost-effective and for which funding is available will be implemented in a timely manner.

6. **Construct a pilot dry-weather flow treatment facility at the Pico-Kenter drain.** The cities of Los Angeles and Santa Monica have been investigating construction of a pilot ozonation facility to treat dry-weather flows from the Pico-Kenter drainage area.

7. **Investigate and correct malfunctioning septic systems.** Cities and the Los Angeles County Department of Health Services will enhance programs to investigate and correct malfunctioning septic systems, especially in the watersheds along the northern Santa Monica Bay coastline;

8. **Maximize the ability to respond to and control sewage spills.** Municipal wastewater treatment facility operators will review sewage spill reporting and response procedures and develop/modify procedures where necessary to block, capture and re-direct spills to storm drains back into the sewer system.

IDENTIFY AND PREVENT PATHOGEN SOURCES

9. **Identify and eliminate illicit connections and illicit discharges to the storm drain system.** .The municipal storm water/urban runoff pollution control permit issued by Los Angeles Regional Water Quality Control Board (LARWQCB) requires

implementation of programs to identify and eliminate illicit connections and discharges to the storm drain system. To accelerate the implementation of these programs, the LAC-DPW will develop a model program which includes standardized storm drain inspection procedures, illicit connection and discharge identification and elimination procedures, and enforcement procedures to terminate illicit connections and discharges.

10. **Assess the impacts of street and sidewalk washing and develop methods to eliminate or minimize impacts.** The City of Los Angeles will, in the next year, investigate the impact of street and sidewalk washing on pathogen loadings to storm drain systems and will develop appropriate Best Management Practices to minimize impacts on water quality.

11. **Develop standardized procedures for locating sources of pathogens.** The LAC-DPW will lead efforts, with the assistance of SMBRP, to develop a standardized sanitary survey protocol (procedures) for locating sources of pathogens and based in the results of this study, develop criteria for initiation of a sanitary survey.

INCORPORATE FINDINGS INTO STANDARDS AND MONITORING PROGRAMS

12. **Provide periodic reports to the public on beach water quality.** Shoreline bacterial monitoring programs are currently conducted by the City of Los Angeles, the County Sanitation Districts of Los Angeles County and the Los Angeles County Department of Health Services. These programs currently report individual bacterial indicator counts. It is recommended that the total-to-fecal coliform ratio also be added and incorporated into the regional water quality data base maintained by the LARWQCB. Both the individual indicator counts and total/fecal ratio should be used as the basis for development of periodic reports to the public on beach water quality prepared by the LARWQCB, SMBRP, Heal the Bay or other organizations.

13. **Review and revise recreational water quality standards or criteria.** Recreational use of coastal waters occurs near urbanized regions throughout California and the U.S. Current standards/criteria for bacterial indicators are not based on epidemiological studies of swimmers in marine waters contaminated by urban runoff. Given the results of this study, it is recommended that the U.S. Environmental Protection Agency, the California State Department of Health Services and the State Water

Resources Control Board review existing recreational water quality standards/criteria for marine waters and revise them as appropriate.

14. **Review water quality data trends in Santa Monica Bay.** The SMBRP will spearhead a team to review existing water quality data utilizing analytical methodologies identified through this study, so that additional results can be incorporated into modifications of the beach warning protocol and water quality monitoring and reporting activities.

15. **Support additional research projects that help answer additional questions about potential health risks.** Examples of such studies may include an assessment of health risks to persons who frequently swim in the Bay (e.g. surfers and lifeguards) or research efforts necessary to improve our ability to more quickly detect human pathogens in urban runoff.

FINANCE SOURCE CONTROL MEASURES

16. **Seek financing at local, state and federal levels for implementation of source control measures.** The members of the SMBRP will investigate financing mechanisms to support implementation of local efforts to control storm water and urban runoff pollution.

ACTIONS THE PUBLIC CAN TAKE

In addition to governmental action, the general public can take steps to help reduce urban runoff pollution. Urban runoff pollution includes bacteria, trash and chemicals which are washed into the storm drain system from streets, neighborhoods, business locations, parking lots, construction sites, etc. This type of pollution is a problem because, unlike the sewer system, which includes treatment plants, the storm drain system carries water and whatever else is put into it--without treatment--to our streams and the ocean. Urban runoff pollution can be minimized by following these suggestions:

1. **Practice "good housekeeping " in and around the home.**
    - Clean up after your pet. Dispose of wastes in trash cans.
    - Make sure that septic tanks are properly maintained.
    - Properly dispose of disposable diapers.
    - Use a broom rather than a hose to clean up garden clippings. Deposit leaves and grass clippings in a trash can or start a compost pile.

- Take leftover household hazardous materials to a Countywide Household Hazardous Waste collection event or other local collection program.
- Take used motor oil and antifreeze to a participating gas station or other recycling center.
- Have your car inspected and maintained regularly to reduce leakage of oil, antifreeze and other fluids.
- Recycle reuseable materials.

2. **Practice "good housekeeping" at your worksite and where you play.**
   - Clean up spills of materials such as vehicle fluids, paints and solvents properly.
   - Control runoff and prevent erosion at construction sites.
   - Cover and maintain dumpsters.
   - Properly dispose of kitchen wastes. Wash down floor mats in areas that drain to the sewer system.
   - Compost or haul away manure from horses or other livestock.
   - Use pumpout and dump stations to dispose of sewage from boats and recreational vehicles.

3. **Promote pollution prevention and awareness in your community.**
   - Participate in programs such as storm drain stenciling and Coastal Cleanup Day.
   - Support your municipality by reporting any dumping of inappropriate materials into storm drains (such as oil and antifreeze) to 1-800-303-0003.

STUDY PARTICIPANTS

The SMBRP assembled a unique team to carry out the various elements of this study. Dr. Robert Haile, USC School of Medicine, Department of Preventive Medicine, was the Principal Investigator. Dr. Haile led the research team that conducted the beach and follow-up telephone interviews and conducted the health risk analyses utilizing water quality and survey data. The City of Los Angeles Environmental Monitoring Division (LA-EMD) analyzed daily water samples for total coliform, fecal coliform and enterococcus. Heal the Bay volunteers collected the daily bacterial indicator samples and their Executive Director, Dr. Mark Gold served as a principal study advisor. The County Sanitation District of Orange County (CSDOC) collected and analyzed water samples for enteric viruses. The University of Southern California, Department of Biology conducted enteric virus analysis utilizing polymerase chain reaction (PCR)/gene probe technique. The Santa Monica Bay Restoration Project and Foundation served as principal project organizer and was responsible for project management, coordination of financing and contracts, and for providing technical and policy oversight.

FUNDING FOR THIS STUDY

Many public and private entities provided the financial and human resources for this study. The Santa Monica Bay Restoration Project and Foundation thanks the following organizations for their support and commitment to this important scientific undertaking: the State Water Resources Control Board, City of Los Angeles, Beach Cities Health District, City of Santa Monica, Los Angeles County Department of Public Works, Los Angeles Regional Water Quality Control Board, Chevron Companies, Las Virgenes Municipal Water District, Milken Families Foundation, Heal the Bay, and the U.S. Environmental Protection Agency.

ABOUT THE SANTA MONICA BAY RESTORATION PROJECT AND FOUNDATION

The Santa Monica Bay Restoration Project (SMBRP) is a coalition of government, environmentalists, scientists, industry and the public charged with finding solutions to the Bay's problems. The SMBRP, established in 1988 as part of the Clean Water Act National Estuary Program, completed a comprehensive "Bay Restoration Plan" in 1994 that outlines a wide range of actions necessary to restore and protect the Bay. Implementing this health effects study was one of the Plan's highest priorities.

The Santa Monica Bay Restoration Foundation is a non-profit, 501(c)(3) community foundation of the SMBRP. The Foundation is an independent fundraising vehicle created to attract research, planning and implementation funds for activities, such as this epidemiological study, that lead to the restoration and enhancement of Santa Monica Bay.

Water quality of first flush runoff from 20 industrial sites

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ABSTRACT: A sampling program was conducted to assess the quality of first flush storm water runoff from 10 industrial groups typical of many businesses located in North Carolina. Analysis of samples collected during the first 30 min of runoff (first flush) indicated that zinc and copper were the most common of the eight metals measured in runoff from the 20 industrial sites monitored. Ten volatile organic, semivolatile organic, or pesticide compounds were found at eight different sites, with the most common being methylene chloride (three sites). Conventional pollutants such as nutrients and solids were measured at varying levels at every site, but were generally the highest where a significant amount of biological waste or exposed soil was present. *Water Environ. Res.*, **69**, 305 (1997).

KEYWORDS: metals, monitoring, runoff, stormwater, water quality

The quality of storm water runoff is a major concern in the United States. In the National Water Quality Inventory, 1990 Report to Congress, states estimated that ~30% of identified cases of water quality impairment are attributable to storm water discharges (U.S. EPA, 1992). This assessment has prompted an effort, initiated by the U.S. EPA through the National Pollutant Discharge Elimination System (NPDES) storm water permitting program, to characterize storm water discharges and develop pollution prevention plans and best management practices to control these discharges. While a considerable amount of monitoring data exists for runoff from urban areas (U.S. EPA, 1983b; Marsalek and Schroter, 1984; Bannerman *et al.*, 1993; Marsh, 1993; Thomas and Greene, 1993) similar to those subject to NPDES storm water permits, a very limited amount of data has been published on runoff from individual industrial sites (Amick, 1994; Smith *et al.*, 1995). The Nationwide Urban Runoff Program (NURP) included monitoring data from selected industrial areas; however, these areas included a combination of several facilities, streets, and other source areas.

As part of the NPDES permit program, each state that has obtained authority must issue permits for storm water discharges from certain individual industrial facilities and municipalities. Many of the permits require the industrial facility to monitor storm water discharges for certain pollutants. However, the wide range of industries involved and a lack of information about the types and concentrations of storm water pollutants that characteristically come from an industrial group or sector make it very difficult to identify pollutants that should be monitored.

Faced with issuing thousands of storm water discharge permits to industrial facilities in the next few years, the states and U.S. EPA need more information on storm water contaminants from industrial sites. Results of this study will provide some of the background data needed in issuing permits for industrial storm water discharges. These data may also serve as a comparison with sampling results submitted by industries as part of their storm water permit requirements.

Procedure

Ten industrial groups representing common industries in North Carolina were chosen (Table 1). After obtaining permission from responsible parties, two businesses, from each of the 10 groups except chemical repackagers, were selected for inclusion in the study. Only one chemical repackager was included because businesses engaged in just repackaging were relatively rare; therefore, a scrap and recycler (SR III) was substituted. Selection criteria included willingness to participate, representativeness of the plant/site for the industrial group, availability of suitable sampling locations, and hydrology of the site. While the two sites in each industrial group are similar in their activities, replication was not a criterion.

After selection, each site was visited and characterized. All data in Table 1 are based on a site plan or survey, when available, but were often obtained from observation, communication with plant operators, and, in several cases, estimations. The business size (column 3) is a cursory estimate of how the business or plant compares in production with other North Carolina businesses in the same industrial group. Data on drainage area, percent of impervious area, slope, and exposed material all pertain only to the area draining to the sampling station. The exposed material indicates the presence of a significant amount of exposed production or waste materials in the sampled drainage area.

An automatic sampler and a runoff-depth sensing device were installed at a storm water outfall or conveyance channel on each site. When sites had more than one outfall, the sampling station was located such that activities most representative of the business occurred within the sampled drainage area. Sampling locations were always upstream of storm water controls, if any were present. The sampler was programmed to collect a single grab sample within 5 min of being actuated by a flow meter or flow actuator. This actuation occurred as soon as the runoff water at the sampling point was deep enough to sample (~25 mm), which usually occurred within the first 15 min of runoff. The first flush grab sample is one of the sampling requirements for storm water permit applications. When possible, a manual grab sample was collected in place of, or in addition to, the automatic samples; however, because of the unpredictability of runoff, FM I and PM I were the only sites sampled manually.

Only first flush runoff samples collected from storm events that met the U.S. EPA NPDES storm water permit sampling criteria of rainfall accumulation >2.54 mm after a 72-hr dry period were analyzed. When feasible, events with an accumulation of precipitation within 50% of the mid-Atlantic rain zone's

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Table 1—Characterization of the 20 study sites.

Industrial group	Site ID	Business Size[a]	Area of Site, ha	Drainage Area, ha	Impervious Area, %	Slope, %	Exposed Material	Sampling Data
Chemical Repackager	CR I	medium	6.5	6.5	98	1–2	No	12/14/93
Furniture Manufacturer	FM I	medium	4.9	1.6	25	2–4	No	12/14/93
Furniture Manufacturer	FM II	large	6.9	1.2	100	0–1	No	5/15/94
Junkyard	JY I	medium	4.0	0.8	25	4–6	Yes	11/05/93
Junkyard	JY II	small	4.0	1.6	20	3–5	Yes	2/24/94
Landfill	LF I	medium	40	8.1	0	3–25	Yes	1/17/94
Landfill	LF II	large	120	2.4	0	4–6	Yes	2/24/94
Metal Fabricator	MF I	small	2.4	1.6	50	1–3	Yes	1/12/94
Metal Fabricator	MF II	medium	0.8	0.4	95	0–1	No	3/24/94
Paint Manufacturer	PM I	small	1.2	1.2	25	3–5	No	12/04/93
Paint Manufacturer	PM II	medium	1.6	1.2	70	0–1	No	11/05/93
Scrap and Recycler	SR I	medium	4.5	2.4	10	1–3	Yes	2/10/94
Scrap and Recycler	SR II	medium	4.0	1.6	50	2–5	Yes	1/12/94
Scrap and Recycler	SR III	small	2.4	1.2	100	0–1	Yes	4/27/94
Textile Manufacturer	TM I	large	8.1	0.8	100	0–1	No	12/29/93
Textile Manufacturer	TM II	medium	2.4	0.4	100	0–1	No	3/01/94
Vehicle Maintenance	VM I	medium	2.4	1.6	20	2–3	Yes	11/05/93
Vehicle Maintenance	VM II	large	2.4	2.4	100	0–1	No	9/16/93
Wood Preserver	WP I	medium	2.0	0.4	10	0–1	Yes	11/27/93
Wood Preserver	WP II	medium	4.9	3.2	30	1–2	Yes	5/03/94

[a] Cursory estimate of how facility compares in production to other North Carolina businesses in the same industrial group.

average depth (16.3 mm) and a duration of between 5.1 and 15.2 hr were sampled (U.S. EPA, 1992). These accumulation and duration guidelines were set by U.S. EPA to help ensure that storms representative of the region were sampled. Because of the time constraints of this study, some storms that did not meet the guidelines were sampled.

Eleven sites had rain gauges installed at the sampling station while for the other sites rainfall was recorded by a nearby rain gauge. The rainfall amounts in Table 2 are for the entire precipitation event. Rainfall accumulation at all sites exceeded the 2.54 mm minimum (U.S. EPA, 1992), and rainfall at 12 sites fell within the 50% optimum (8.1–24.4 mm) for the mid-Atlantic rain zone. Storm duration was not considered an important criteria because only first flush samples were collected.

A 11.32-L (3-gal) first flush runoff sample was collected from every site and iced as soon after collection as possible. Because some sites were inaccessible after business hours, some samples remained in the sampler for several hours before being iced; however, because most of the sampling was conducted during the winter months, samples were often cooled by the surrounding air until being removed from the sampler. Samples were then transported to an U.S. EPA-certified laboratory on ice and preserved and analyzed using standard, U.S. EPA-approved procedures for storm water analysis (40 CFR. Part 136; U.S. EPA, 1983a; *Standard Methods*, 1989). Samples were analyzed for many of the conventional pollutants and all but two (p-chloro-M-cresol and 1,2-diphenylhydrazine) of the 112 toxic pollutants listed in the NPDES storm water sampling guidance document (U.S. EPA, 1992). The two compounds were omitted because as a cresol, the p-chloro-M-cresol is often included in the total phenol analysis and the laboratory did not analyze for 1,2-diphenylhydrazine.

The contract laboratory maintained a rigorous quality control program during the project making and analyzing duplicate, standard, and spiked samples for ≥10% of the field samples. To investigate the possibility of cross-contamination between sites, distilled water was obtained and pumped through the sampler into a set of 12 clean sample jars. These sampler blanks were then prepared and delivered to the lab for analysis. Analysis of the blanks did not include pesticides and PCBs as these compounds were rarely detected during sampling. The first blank contained detectable concentrations of only total phosphorus (0.06 mg/L) and dissolved solids (13 mg/L), which resulted from a small amount of floating organic matter that washed off the sampler intake strainer. The intake strainer was rinsed before installation at the next site. The second blank, obtained from another sampler after completing SR I, contained no detectable levels of any compound in the list of analytes. These blanks indicated that cross-contamination between sites and contamination due to handling and transportation were negligible.

Results and Discussion

As stated above, all sampling stations were located upstream of storm water controls; therefore, the results reflect the quality of runoff directly from the pollutant sources. Several sites, including SR I, LF II, and SR II, had wet detention ponds constructed on the site downstream of the sampling point, which probably reduced first flush pollutant concentrations in runoff leaving the site. This observation is included to emphasize that most of the businesses in this study are concerned about the quality of runoff and have taken steps such as removing unnecessary debris, revegetating denuded areas, replacing the cover on stacks of treated wood, and cleaning spilled chemicals to reduce pollutant export. However, these improvements are not reflected in the data presented because the worst-looking drainage areas were sampled.

The results are discussed with the realization that this was a characterization study primarily focused on identifying the

Table 2—Concentrations of metals and other analytes in first flush runoff sample and storm rainfall[a].

Method[c] Site	206.2 As	213.2 Cd	218.2 Cr	220.2 Cu	239.1 Pb	245.1 Hg	249.2 Ni	289.1 Zn	Other compounds[b]	Rainfall
CR I	<10	<2	44	34	22	<0.2	38	220	ND	14.5
FMI I	<10	5	12	25	20	<0.2	6	220	*m*	14.0
FM II	<10	<2	67	29	12	<0.2	11	473	ND	8.1
JY I	<10	<2	25	27	67	<0.2	<10	398	*m*	10.2
JY II	<10	4	23	97	330	0.4	34	678	ND	40.6
LF I	<10	<2	7	45	25	<0.2	<10	84	ND	6.4
LF II	<10	<2	12	16	12	0.2	20	792	*a, b, p*	35.6
MF I	<10	<2	73	57	100	<0.2	49	1051	ND	16.3
MF II	<10	6	15	29	41	<0.2	17	805	ND	19.8
PM I	<10	<2	10	11	7	<0.2	<10	60	ND	33.0
PM II	<10	<2	<5	5	<5	<0.2	<10	154	ND	22.9
SR I	<10	<2	<5	110	37	<0.2	28	190	*t2, al*	10.2
SR II	<10	10	170	530	660	3	78	2689	*an, m*	16.3
SR III	<10	5	28	99	59	<0.2	28	1797	*a*	13.7
TM I	<10	<2	<5	6	<5	0.3	<10	120	ND	7.6
TM II	<10	6	<5	7	24	<0.2	12	895	*t, t1, t2*	33.0
VM I	<10	<2	<5	5	<5	<0.2	<10	154	ND	10.2
VM II	<10	<2	16	120	34	<0.2	<10	219	*e*	8.1
WP I	330	<2	610	280	48	<0.2	<10	260	ND	33.0
WP II	140	<2	1700	780	150	<0.2	200	592	ND	33.0
Mean[d]	24 ± 77	2 ± 3	141 ± 382	116 ± 194	82 ± 151	0.2 ± 0.7	26 ± 45	593 ± 638		19.3 ± 10.9
Standards[e]	50	2	50	7 (A)	25	0.012	88	50 (A)		
NURP EMC[f]				34	144			160		

[a] Metal concentrations in ppb; rainfall in mm; "<" indicates concentration below specified detection limit; ND indicates none measured above detection limits.
[b] Other compounds are: *a*, acetone; *an*, acrolein; *al*, aldrin; *b*, benzoic acid; *e*, endrin; *m*, methylene chloride; *p*, phenol; *t*, tetrachloroethylene; *t1*, 1,1,1-trichloroethane; *t2*, trichloroethylene
[c] U.S. EPA, 1983a.
[d] Means ± SD.
[e] North Carolina standards or action levels (A) for all fresh water.
[f] Median event mean concentrations from the Nationwide Urban Runoff Program (U.S. EPA 1983b).

presence of pollutants and approximate concentrations in first flush runoff. For this reason and because discharge measurements were not performed at many sites, the interpretation of the results was limited.

Toxic pollutants. Concentrations of toxic pollutants (U.S. EPA, 1992) measured in first flush runoff samples from each of the 20 study sites are shown in Table 2. Of the metals shown, zinc and copper were the most prevalent, being found at every site, and arsenic was the least prevalent. Concentrations of zinc were greater than all other metals for every industrial group except wood preservers. Samples were also analyzed for antimony, beryllium, selenium, silver, and thallium, none of which was measured in any of the samples. Method detection limits (MDLs) for the metals varied from 0.2 ppb for mercury to 50 ppb for antimony.

Zinc and copper were also found to be prevalent in storm water runoff from textile and food sector facilities nationwide. Amick (1994) analyzed storm water monitoring permit data for >110 facilities in the above two sectors and found that 38 and 31% of the runoff samples submitted by textile facilities contained zinc and copper in concentrations greater than the detection limit. For food sector facilities, 48% had detectable levels of zinc. Chromium was also prevalent being detected in 22% of the textile sector's samples reported by Amick (1994) and 75% of the sites included in this study.

To lend additional perspective to the copper, lead, and zinc data, the median event mean concentrations (EMC) for sites in the Nationwide Urban Runoff Program (NURP) were 34, 144, and 160 ppb for copper, lead, and zinc, respectively (U.S. EPA, 1983b). Thus, the first flush runoff from 9, 3, and 15 of the sites in this study contained higher concentrations of copper, lead, and zinc than NURP sites (Table 2). While first flush samples usually have higher concentrations of contaminants than EMCs, the NURP data provide a benchmark for simple comparison purposes.

Generally, higher levels of metals were found at sites that had exposed metal stored on site, except for wood preservers, which had exposed wood treated with compounds containing the metals arsenic, copper, and chromium. However, runoff from the junkyards (JY I & JY II), even though they probably had the most exposed metal on-site, did not contain the highest levels of metals indicating, that total amount of exposed material is not the only factor important in determining concentrations of metals in runoff. Other factors, such as rust, amount of cut metal surfaces, and hydrologic transport efficiency, can also effect concentrations of metals in runoff.

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While no standards exist for first flush runoff from industrial sites, comparisons with receiving water standards or action levels provide some basis for assessing the quality of runoff. State standards and action levels for all freshwater in North Carolina are shown at the bottom of Table 2. All 20 samples collected had concentrations of zinc greater than the state action level of 50 ppb while for nickel, only one sample was greater than the state standard of 88 ppb. Because the method detection limit for mercury was much greater than the state standard, determining the exact number of samples with concentrations exceeding the standard was impossible; however, first flush samples from at least four sites were >16 times the standard. Concentrations of As and Cr were high (> mean+standard deviation) compared with other industrial groups and the state standards for both of the wood preserver sites indicating a relatively high potential for contamination of surface waters. The data show that metals are present in the storm water runoff of industrial sites. How easily the metals are transported off-site and to receiving waters will determine the potential threat to designated uses.

Relatively few volatile and semivolatile organics or pesticides and PCBs (column labeled "Other") were found at concentrations greater than the MDLs which ranged from 5 to 50 ppb for all compounds, except acetone, acrolein, acrylonitrile, and 2-butanone, which had an MDL of 100 ppb. None of these compounds was measured at either of the metal fabricators, paint manufacturers, or wood preservers. Methylene chloride was the most frequently detected (>5 ppb) compound, found at three sites, with a maximum concentration of only 51 ppb. Acetone was detected in the first flush sample from nine sites, but was at concentrations below the MDL (<100 ppb) in seven of the nine runoff samples. Detection of acetone was indicated by the method of analysis but was at a concentration less than the MDL; therefore, the concentration could not be reported with any certainty and thus, was not included in Table 2.

Conventional water quality parameters.

Table 3 lists concentrations of 10 conventional water quality parameters measured in the first flush samples from the 20 study sites. These parameters are divided into aggregate organics (biochemical oxygen demand, BOD_5; chemical oxygen demand, COD; and oil and grease), nutrients (ammonia nitrogen, NH_3; nitrate plus nitrite nitrogen, NO_3+NO_2; total Kjeldahl nitrogen, TKN; total phosphorus, TP; and dissolved phosphorus), and solids (dissolved and suspended, TSS).

Comparing concentrations of aggregate organics, runoff from scrap and recycling, landfill, metal fabricating, and vehicle maintenance sites contained the highest concentrations, while runoff from textile manufacturing, chemical repackaging, and wood preserving sites had the lowest. Runoff from eight sites exceeded the NURP median EMC for COD of 65 mg/L (Table 3). While most runoff samples contained <5 mg/L (detection limit) of oil and grease, runoff from sites VM II, SR I, and SR III exceeded the storm water effluent limit of 15.0 mg/L for oil and grease (Amick, 1994).

Runoff from several sites with relatively high (> mean + standard deviation) COD levels (LF II and SR III) also had elevated concentrations of NH_3, TKN, and BOD_5 indicating that a significant portion of the COD may have originated from readily biodegradable compounds. Conversely, reduced metals, oil and grease, and/or certain pesticides and halogenated compounds probably contributed more to the elevated COD levels of runoff from sites with relatively low BOD_5 and NH_3 such as SR I, SR II, and MF II.

Although no one site or industrial group had the greatest concentrations of all nutrients, overall, runoff from SR III and LF II contained the highest concentrations of nitrogen forms and WP II the highest concentrations of phosphorus forms. Both SR III and LF II had waste food and other consumer products on-site, which probably contributed to elevated nitrogen levels, whereas all other sites had primarily inorganic industrial products and associated wastes. The relatively high level of phosphorus at WP II may be attributed to factors other than industrial activity, such as soil erosion or possibly animal waste deposited near the sampler. Factors other than business activity can affect many of the conventional parameters. This is especially the case for the elevated levels of TKN and NO_3+NO_2 at MF II which do not have an apparent source.

The solids concentrations in runoff from scrap and recycling, wood preserving, and junkyard sites were generally greater than other industrial groups, while runoff from textile manufacturing and vehicle maintenance sites had the lowest levels of solids. The sites in the three industrial groups with the highest solids concentrations each had a significant amount of exposed, unstabilized soil in the sampled drainage area. The groups with the lowest concentrations of solids had very little pervious area (Table 1) or, in the case of VM I, had all the pervious area stabilized with grass.

Comparing the 20 study sites to the NURP data, 8, 5, 10, 13, and 13 study sites exceeded median EMC for COD, NO_3+NO_2, TKN, TP, and TSS, respectively (Table 3). Only one site (TM II) had runoff with concentrations of pollutants lower than all five corresponding NURP EMCs. Using the NURP EMC as a benchmark, these data indicate that most industries evaluated in this study should focus on reducing TP and TSS, which can probably be accomplished by improved erosion control. Sites with consumer wastes such as SR III and LF II probably need to focus more on reducing organic nitrogen forms and oxygen demanding substances.

The NC Division of Environmental Management (DEM) has reported a set of "problem concentrations" that are designed to indicate nutrient levels which could cause problems in streams or rivers that enter impoundments or estuaries (NC DEM, 1983). Comparing those concentrations to the sample analysis data in Table 3, shows that 11, 15, 18, and 20 samples contain concentrations of NH_3, NO_3+NO_2, TKN, and TP greater than the corresponding problem concentration. Comparisons with problem concentrations must be made with the realization that the first flush probably contains the highest concentrations of pollutants in runoff from the entire storm and that the total volume of runoff and peak runoff rates from these sites are relatively small compared to the discharge of nearly all tributaries.

Sampling method effects on results.

The hydrology of the site and the sampling method can affect monitoring results, especially first flush pollutant concentrations. For example, because the sampling location at LF I was ≥360 m down slope of the largest active area of the landfill and the time-of-travel to the sampling point was probably >30 min, the sample was probably collected before most pollutants arrived. However, at nearly all the other sites, the runoff peaked within the first 30 min of runoff, indicating that the time-of-travel was <30 min. Most of the sampled drainage areas were

Table 3—Concentrations (mg/L) of conventional water quality parameters in first flush runoff samples.

Method[a]	5210B	410.4	5520B	4500	353.1	351.2	365.4	365.4	2540C	2540D
				Nitrogen Forms			Phosphorus		Solids	
Site	BOD_5	COD	Oil & Grease	NH_3	$NO_2 + NO_3$	TKN	Total	Dissolved	Dissolved	Suspend
CR I	NA	76.0	<5	<.04	1.29	2.0	0.55	0.31	170	362
FM I	2.7	5.6	<5	0.04	0.37	0.4	0.24	0.14	50	105
FM II	14.3	130.0	<5	0.15	0.52	1.7	0.18	0.14	102	76
JY I	NA	56.0	6	0.06	3.23	1.4	0.49	0.28	108	198
JY II	5.5	41.4	<5	0.08	3.15	1.2	0.26	<.05	208	2770
LF I	13.0	23.9	<5	0.72	0.94	1.6	0.32	0.09	85	310
LF II	520.0	870.0	<5	6.40	0.44	7.0	0.87	0.31	1570	228
MF I	9.9	22.2	<5	0.23	0.65	1.0	0.70	0.24	166	668
MF II	52.6	260.0	<5	0.89	2.28	5.8	0.69	0.62	166	128
PM I	4.9	35.3	<5	<.04	0.22	0.8	0.35	0.13	121	143
PM II	NA	28.9	<5	0.12	0.42	0.5	0.39	0.27	48	24
SR I	28.9	230.0	31	0.50	0.20	3.8	0.18	<.05	434	88
SR II	43.5	510.0	<5	0.05	0.40	2.6	1.31	0.61	454	627
SR III	130.0	530.0	28	2.30	0.13	15.6	2.88	1.01	322	402
TM I	NA	20.4	<5	0.20	0.77	0.7	0.22	0.12	46	<1
TM II	NA	11.3	<5	0.04	0.30	0.4	0.29	0.06	72	6
VM I	NA	64.0	6	<.04	0.58	1.4	0.40	0.33	65	38
VM II	28.9	130.0	51	0.04	0.56	1.1	0.41	0.28	36	93
WP I	NA	42.9	<5	0.04	0.55	1.8	1.06	0.55	138	912
WP II	14.6	42.9	<5	<.04	0.29	3.5	4.21	2.17	150	3260
Mean[b]		156.6 ± 221.8	6 ±14	0.6 ±1.4	0.9 ±0.9	2.7 ±3.4	0.8 ±1.0	0.4 ±0.5	225.6 ±329.8	521.9 ±868.2
NC Problem Concentrations				0.05	0.30	0.5	0.05			
NURP EMC[c]		65			0.68	1.5	0.33			100

[a] U.S. EPA, 1983a and APHA et al., 1989.
[b] Means ± SD.
[c] Median event mean concentration from the Nationwide Urban Runoff Program (U.S. EPA, 1983b).

relatively flat and small in area and were monitored during light- to moderate-intensity rainfall to be as consistent as possible.

The use of automatic samplers makes collecting samples in wide channels during low flow difficult because runoff is often not deep enough to submerge the sampler intake. Conversely, when runoff is much deeper than the sampler intake, floating pollutants such as oil and grease may be collected in less than representative amounts and pollutants that move along or closer to the channel may be collected in greater than representative amounts. These difficulties were also encountered during manual sampling, especially when collecting samples in ditches and natural channels. Additionally, other variability such as vaporization of volatile organics from the open sampler containers before the sample is put into sealed containers was possible. These conditions were minimized by temporarily altering the sampled channel, programming the sampler to begin at the minimum depth, and capping the sampler jars as soon as possible.

Summary

A first flush runoff (<30 min) sample was collected from each of 20 industrial sites located in North Carolina. Sample analysis results showed that the metals zinc and copper were the most common toxic contaminants being found in the runoff from all sites at concentrations ranging from 60 to 2 689 and 5 to 780 ppb, respectively. In contrast, the metals antimony, beryllium, selenium, silver, and thallium were not detected in any of the 20 samples. Volatile and semivolatile organics and pesticides were found in the runoff from eight sites with methylene chloride the most frequently detected compound. Conventional pollutants such as nutrients and solids were found in runoff from every site, many at concentrations greater than the corresponding median EMC measured from the NURP sites (U.S. EPA, 1983b).

Because only one sample was collected per site, generalizations drawn for the data should be limited; however, several observations seem appropriate. First, industrial groups with a lot of exposed metal on site (JY, SR, and MF) tended to have higher concentrations of the metals Cu, Pb, and Zn than all other groups except wood preservers. First flush runoff from wood preservers had high concentrations of As, Cr, and Cu probably due to the use of these metals in the preserving process. Finally, sites with consumer products stored or processed on site (LF II and SR III) tend to have higher BOD_5, COD, and nitrogen concentrations in runoff.

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R0011602

LOS ANGELES COUNTY

DEPARTMENT OF PUBLIC WORKS

ENVIRONMENTAL PROGRAMS DIVISION

AVERAGE LOADING ANALYSIS FOR CITIES IN THE SAN PEDRO BAY TRIBUTARY AREA

August 12, 1999

R0011603

Introduction

As requested by the Regional Water Quality Control Board (RWQCB), we performed an analysis of pollutant loading from San Pedro Bay tributary areas for 4 constituents. The tributary watersheds in this study include the Los Angeles River watershed management area (WMA), the San Gabriel River WMA, and the Dominguez Channel/L.A. Harbor WMA. We made a loading comparison among the cities in Los Angeles County that lie in these tributaries.

It is our understanding that the RWQCB may use the analysis as a tool to allocate the share of the cost of a possible San Pedro Bay receiving water study. The cost would be proportioned according to the total loading contributed by each city. Two scenarios were examined, one in which the U.S. Forest Service area was included and one in which it was excluded.

Analysis

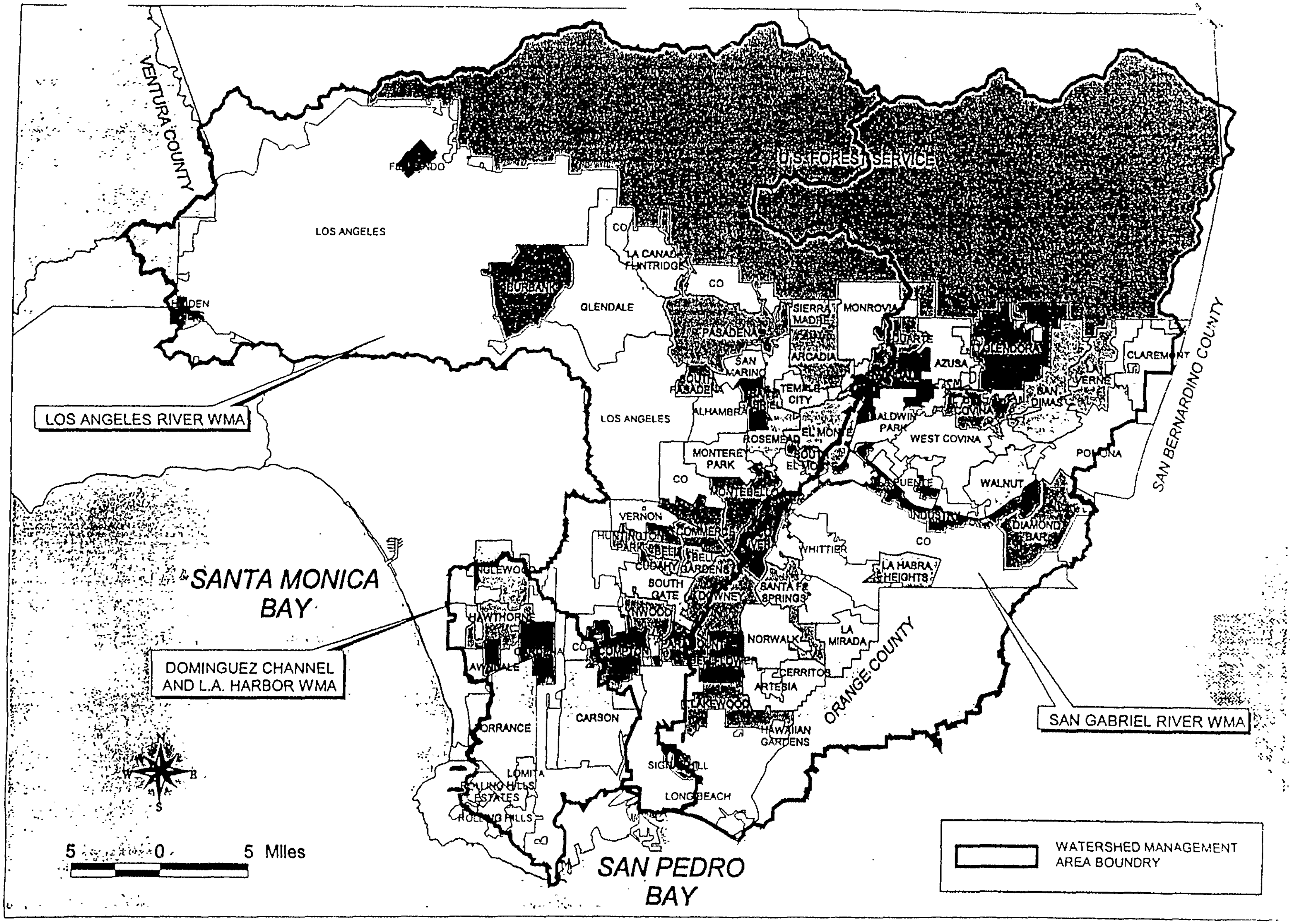
The pollutant loading was determined using the GIS Pollutant Loading Model developed by the Los Angeles County Department of Public Works (LACDPW). The model utilizes precipitation recorded throughout the county and imperviousness values assigned to land use categories to calculate a runoff flow volume. An event mean concentration (EMC) is obtained through the LACDPW water quality sampling program which collects stormwater runoff samples from eight different land use monitoring stations. The product of the runoff volume and the EMC produces an estimated pollutant loading.

As requested by the RWWCB, the analysis examined loading from four constituents: total suspended solids, total phosphorus, chémical oxygen demand (COD), and dissolved copper. The 1997-1998 seasonal EMC's of these constituents with an average annual rainfall amount were used to determine the total loading from each city and the U.S. Forest Service area. The list of cities was derived from the membership lists of each WMA. For the City and County of L.A., only those areas geographically within the WMA boundaries were included. Also note that because Rolling Hills and Rolling Hills Estates are geographically in the Dominguez Channel/L.A. Harbor WMA, they were included in the analysis, even though they administratively belong to the Ballona Creek WMA. Areas in Orange and Ventura Counties, although tributary, were not included.

The total pollutant loading was calculated by summing the loading from the individual constituents. The cities were then ranked according to the percentage of total load. The attached pages include a map of the study area, tables of the loadings for each jurisdiction along with their rank, a rainfall isohyet for the average annual rainfall, and a table of the 1997-1998 seasonal EMC's of the four constituents used for analysis.

Results

There are 72 individual jurisdictions involved in this analysis, including the U.S. Forest Service and unincorporated Los Angeles County. Based on this study, the greatest percentage of the total loading is generated by the City of Los Angeles (26.5% with U.S. Forest Service, 29.5% without) followed by the U.S. Forest Service (10.3%), where included, or unincorporated areas of Los Angeles County (9.33% with U.S. Forest Service, 10.4% without). The balance of the jurisdictions contribute less than 4% each.



SAN PEDRO BAY TRIBUTARY AREAS

PUBLIC WORKS

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SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITH U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA	LOADING (TONS)**					% OF TOTAL LOAD FROM ALL CITIES	RANK
		TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL		
Los Angeles City	LAR/SGR/ DCLAH	22,200	56.4	14,300	2.51	36,600	26.5	1
U.S. Forest Service	LAR/SGR	12,300	16.5	1,920	0.151	14,200	10.3	2
Los Angeles County	LAR/SGR/ DCLAH	7,990	19.2	4,910	0.765	12,900	9.33	3
Long Beach	LAR	2,590	7.19	1,740	0.334	4,340	3.14	4
Carson	DCLAH	2,520	4.18	1,010	0.233	3,530	2 55	5
Industry	SGR	2,480	3.77	840	0.223	3,320	2.40	6
Pomona	SGR	1,930	5.28	1,290	0.239	3,230	2.34	7
Glendale	LAR	1,590	4.28	1,100	0.173	2,690	1.95	8
Santa Fe Springs	SGR	1,940	2 92	680	0.175	2,620	1.90	9
Torrance	DCLAH	1,590	3.83	953	0.179	2,550	1.84	10
Irwindale	SGR	1,850	2.65	555	0.141	2,410	1.74	11
Pasadena	LAR	1,310	4.36	1,070	0.176	2,390	1.73	12
Burbank	LAR	1,300	3.15	775	0.150	2,080	1.50	13
Commerce	LAR	1,520	2.38	535	0.148	2,060	1.49	14
Vernon	LAR	1,520	2.04	473	0.132	2,000	1.45	15
West Covina	SGR	888	2.86	776	0.111	1,670	1.21	16
Azusa	SGR	1,100	2.14	485	0.097	1,590	1.15	17
El Monte	LAR	923	2.43	609	0.110	1,530	1.11	18
Glendora	SGR	816	2.44	605	0.080	1,420	1.03	19
Downey	SGR	823	2.26	585	0.096	1,410	1.02	20
Compton	LAR	919	1.99	481	0.100	1,400	1.01	21
Monrovia	SGR	875	1.92	460	0.075	1,340	0.97	22
Arcadia	LAR	720	2.30	605	0.084	1,330	0.96	23
Montebello	LAR	834	1.75	428	0.086	1,260	0.91	24
Whittier	SGR	631	2.04	543	0.075	1,180	0.85	25
Pico Rivera	SGR	753	1.69	407	0.068	1,160	0.84	26
Claremont	SGR	674	1.84	450	0.064	1,130	0.82	27
San Dimas	SGR	680	1.75	408	0.065	1,090	0.79	28
Cerritos	SGR	672	1.63	392	0.077	1,070	0.77	29

R0011607

SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITH U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA	LOADING (TONS)** TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL	% OF TOTAL LOAD FROM ALL CITIES	RANK
Baldwin Park	SGR	600	1.63	420	0.069	1,020	0.74	30
South Gate	LAR	653	1.43	357	0.069	1,010	0.73	31
La Verne	SGR	589	1.64	415	0.069	1,010	0.73	31
Inglewood	DCLAH	553	1.72	415	0.072	970	0.70	33
La Mirada	SGR	599	1.34	352	0.061	952	0.69	34
Norwalk	SGR	511	1.73	435	0.072	948	0.69	35
La Canada Flintridge	LAR	582	1.42	354	0.053	937	0.68	36
Hawthorne	DCLAH	603	1.33	318	0.070	922	0.67	37
Covina	SGR	486	1.64	415	0.064	902	0.65	38
Alhambra	LAR	515	1.42	380	0.062	896	0.65	39
Diamond Bar	SGR	460	1.59	409	0.061	871	0.63	40
South El Monte	SGR	599	0.950	235	0.053	835	0.60	41
Gardena	DCLAH	524	1.15	297	0.055	821	0.59	42
Paramount	LAR	554	1.07	261	0.055	816	0.59	43
Monterey Park	LAR	430	1.28	334	0.053	765	0.55	44
Lakewood	SGR	378	1.29	356	0.046	735	0.53	45
Duarte	SGR	449	1.05	254	0.043	704	0.51	46
Lynwood	LAR	370	0.901	232	0.042	603	0.44	47
Rosemead	LAR	320	1.06	275	0.041	596	0.43	48
Walnut	SGR	327	0.914	249	0.029	577	0.42	49
Signal Hill	LAR	369	0.537	130	0.033	500	0.36	50
Bellflower	SGR	243	0.961	245	0.038	489	0.35	51
Temple City	LAR	204	0.717	217	0.024	421	0.30	52
San Fernando	LAR	246	0.663	169	0.027	416	0.30	53
San Gabriel	LAR	209	0.724	197	0.027	407	0.29	54
Huntington Park	LAR	255	0.610	145	0.030	401	0.29	55
Bell	LAR	267	0.547	120	0.029	387	0.28	56
La Puente	SGR	178	0.699	185	0.025	364	0.26	57
Rolling Hills Estates	DCLAH	179	0.420	111	0.018	291	0.21	58
Sierra Madre	LAR	141	0.442	130	0.013	272	0.20	59
San Marino	SGR	145	0.462	124	0.015	269	0.19	60

SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITH U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA	LOADING (TONS)** TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL	% OF TOTAL LOAD FROM ALL CITIES	RANK
South Pasadena	LAR	124	0.490	135	0.019	260	0.19	61
Bell Gardens	LAR	137	0.361	78.2	0.017	216	0.16	62
La Habra Heights	SGR	146	0.220	29.2	0.003	176	0.13	63
Lawndale	DCLAH	84	0.338	81	0.015	165	0.12	64
Artesia	SGR	70	0.277	69.3	0.011	140	0.10	65
Lomita	DCLAH	61	0.252	69.7	0.009	131	0.09	66
Maywood	LAR	69	0.198	53.2	0.008	123	0.09	67
Cudahy	LAR	72	0.157	40.8	0.009	113	0.08	68
Bradbury	SGR	70	0.111	14.9	0	85	0.06	69
Hawaiian Gardens	SGR	42	0.158	39.6	0.006	81	0.06	70
Hidden Hills	LAR	54	0.077	10.2	0	64	0.05	71
Rolling Hills	DCLAH	51	0.077	9.37	0	60	0.04	72
TOTAL		89,455	203	48,545	81	138,218	100.00	

*LAR = Los Angeles River Watershed Management Area
*SGR = San Gabriel River Watershed Management Area
*DCLAH = Dominguez Channel/L.A. Harbor Watershed Management Area

** Parameters for the loading calculations:
Storm Event: Average Annual Rainfall
Event Mean Concentration (EMC): 1997-1998 Seasonal EMC's

R0011609

SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITHOUT U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA	LOADING (TONS)					% OF TOTAL LOAD FROM ALL CITIES	RANK
		TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL		
Los Angeles City	LAR/SGR/ DCLAH	22,200	56.4	14,300	2.51	36,600	29.5	1
Los Angeles County	LAR/SGR/ DCLAH	7,986	19.2	4,910	0.765	12,900	10.4	2
Long Beach	LAR	2,590	7.19	1,740	0.334	4,340	3.50	3
Carson	DCLAH	2,520	4.18	1,010	0.233	3,530	2.85	4
Industry	SGR	2,480	3.77	840	0.223	3,320	2.68	5
Pomona	SGR	1,930	5.28	1,290	0.239	3,230	2.60	6
Glendale	LAR	1,590	4.28	1,100	0.173	2,690	2.17	7
Santa Fe Springs	SGR	1,940	2.92	680	0.175	2,620	2.11	8
Torrance	DCLAH	1,590	3.83	953	0.179	2,550	2.06	9
Irwindale	SGR	1,850	2.65	555	0.141	2,410	1.94	10
Pasadena	LAR	1,310	4.36	1,070	0.176	2,390	1.93	11
Burbank	LAR	1,300	3.15	775	0.150	2,080	1.68	12
Commerce	LAR	1,520	2.38	535	0.148	2,060	1.66	13
Vernon	LAR	1,520	2.04	473	0.132	2,000	1.61	14
West Covina	SGR	888	2.86	776	0.111	1,670	1.35	15
Azusa	SGR	1,100	2.14	485	0.097	1,590	1.28	16
El Monte	LAR	923	2.43	609	0.110	1,530	1.23	17
Glendora	SGR	816	2.44	605	0.080	1,420	1.14	18
Downey	SGR	823	2.26	585	0.096	1,410	1.14	19
Compton	LAR	919	1.99	481	0.100	1,400	1.13	20
Monrovia	SGR	875	1.92	460	0.075	1,340	1.08	21
Arcadia	LAR	720	2.30	605	0.084	1,330	1.07	22
Montebello	LAR	834	1.75	428	0.086	1,260	1.02	23
Whittier	SGR	631	2.04	543	0.075	1,180	0.95	24
Pico Rivera	SGR	753	1.69	407	0.068	1,160	0.94	25
Claremont	SGR	674	1.84	450	0.064	1,130	0.91	26
San Dimas	SGR	680	1.75	408	0.065	1,090	0.88	27
Cerritos	SGR	672	1.63	392	0.077	1,070	0.86	28
Baldwin Park	SGR	600	1.63	420	0.069	1,020	0.82	29

R0011610

SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITHOUT U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA	LOADING (TONS)**					% OF TOTAL LOAD FROM ALL CITIES	RANK
		TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL		
South Gate	LAR	653	1.43	357	0.069	1,010	0.81	30
La Verne	SGR	589	1.64	415	0.069	1,010	0.81	30
Inglewood	DCLAH	553	1.72	415	0.072	970	0.78	32
La Mirada	SGR	599	1.34	352	0.061	952	0.77	33
Norwalk	SGR	511	1.73	435	0.072	948	0.76	34
La Canada Flintridge	LAR	582	1.42	354	0.053	937	0.76	35
Hawthorne	DCLAH	603	1.33	318	0.070	922	0.74	36
Covina	SGR	486	1.64	415	0.064	902	0.73	37
Alhambra	LAR	515	1.42	380	0.062	896	0.72	38
Diamond Bar	SGR	460	1.59	409	0.061	871	0.70	39
South El Monte	SGR	599	0.950	235	0.053	835	0.67	40
Gardena	DCLAH	524	1.15	297	0.055	821	0.66	41
Paramount	LAR	554	1.07	261	0.055	816	0.66	42
Monterey Park	LAR	430	1.28	334	0.053	765	0.62	43
Lakewood	SGR	378	1.29	356	0.046	735	0.59	44
Duarte	SGR	449	1.05	254	0.043	704	0.57	45
Lynwood	LAR	370	0.901	232	0.042	603	0.49	46
Rosemead	LAR	320	1.06	275	0.041	596	0.48	47
Walnut	SGR	327	0.914	249	0.029	577	0.46	48
Signal Hill	LAR	369	0.537	130	0.033	500	0.40	49
Bellflower	SGR	243	0.961	245	0.038	489	0.39	50
Temple City	LAR	204	0.717	217	0.024	421	0.34	51
San Fernando	LAR	246	0.663	169	0.027	416	0.34	52
San Gabriel	LAR	209	0.724	197	0.027	407	0.33	53
Huntington Park	LAR	255	0.610	145	0.030	401	0.32	54
Bell	LAR	267	0.547	120	0.029	387	0.31	55
La Puente	SGR	178	0.699	185	0.025	364	0.29	56
Rolling Hills Estates	DCLAH	179	0.420	111	0.018	291	0.23	57
Sierra Madre	LAR	141	0.442	130	0.013	272	0.22	58
San Marino	SGR	145	0.462	124	0.015	269	0.22	59
South Pasadena	LAR	124	0.490	135	0.019	260	0.21	60

SAN PEDRO BAY TRIBUTARY AREAS
"AVERAGE" LOADINGS WITHOUT U.S. FOREST SERVICE LAND

JURISDICTION	WATERSHED MGMT AREA*	LOADING (TONS)**					% OF TOTAL LOAD FROM ALL CITIES	RANK
		TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	COD	DISSOLVED COPPER	TOTAL		
Bell Gardens	LAR	137	0.361	78.2	0.017	216	0.17	61
La Habra Heights	SGR	146	0.220	29.2	0.003	176	0.14	62
Lawndale	DCLAH	84	0.338	81	0.015	165	0.13	63
Artesia	SGR	70	0.277	69.3	0.011	140	0.11	64
Lomita	DCLAH	61	0.252	69.7	0.009	131	0.11	65
Maywood	LAR	69	0.198	53.2	0.008	123	0.10	66
Cudahy	LAR	72	0.157	40.8	0.009	113	0.09	67
Bradbury	SGR	70	0.111	14.9	0	85	0.07	68
Hawaiian Gardens	SGR	42	0.158	39.6	0.006	81	0.07	69
Hidden Hills	LAR	54	0.077	10.2	0	64	0.05	70
Rolling Hills	DCLAH	51	0.077	9.37	0	60	0.05	71
TOTAL		77,151	187	46,625	8	124,018	100.00	

*LAR = Los Angeles River Watershed Management Area
*SGR = San Gabriel River Watershed Management Area
*DCLAH = Dominguez Channel/L.A. Harbor Watershed Management Area

** Parameters for the loading calculations:
Storm Event: Average Annual Rainfall
Event Mean Concentration (EMC): 1997-1998 Seasonal EMC's

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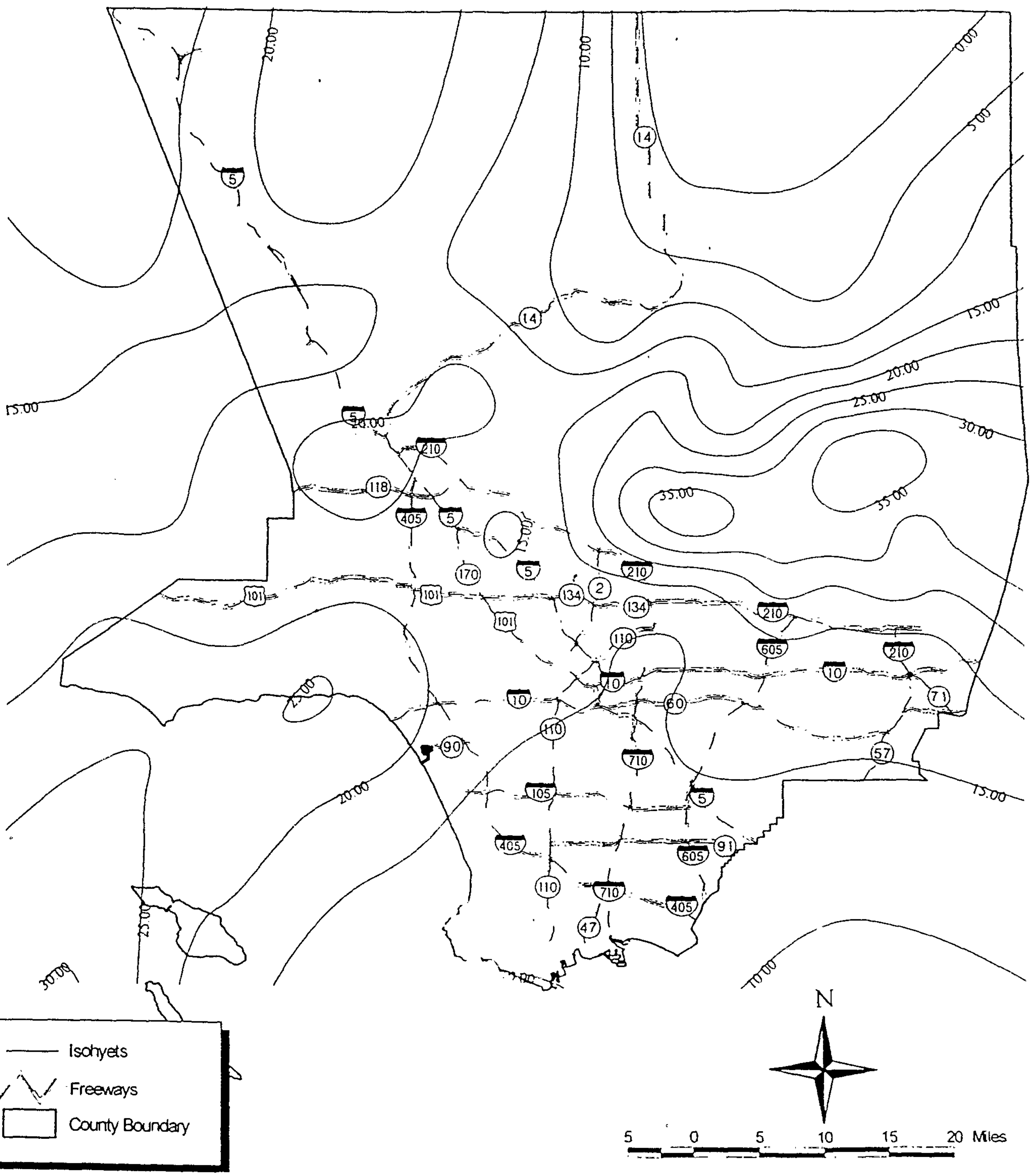
RAINFALL ISOHYETS



STORM EVENT DATE: Average Annual Rainfall, EMC: 1997-1998 Storm Season

RUN DATE: 06/29/1999

R0011613

1997-1998 SEASONAL EVENT MEAN CONCENTRATIONS

LAND USE	TOTAL PHOSPHORUS mg/l	TOTAL SUSPENDED SOLIDS mg/l	DISSOLVED COPPER ug/l	COD mg/l
High Density Single Family Residential	0.28	81.5	8.16	97.7
Light Industrial	0.50	404	32.2	122
Vacant	0.13	96.9		12.3
Commercial	0.40	48.8	14.2	74.9
Multi-Family Residential	0.13	30.9	8.52	45 9
Transportation	0.42	56.5	33.3	54 5
Education	0.31	81.0	14.3	38.0
Mixed Residential	0.25	65.2	11.6	88 0

NOTE Blank cell indicates not enough statistically valid data to compute seasonal emc

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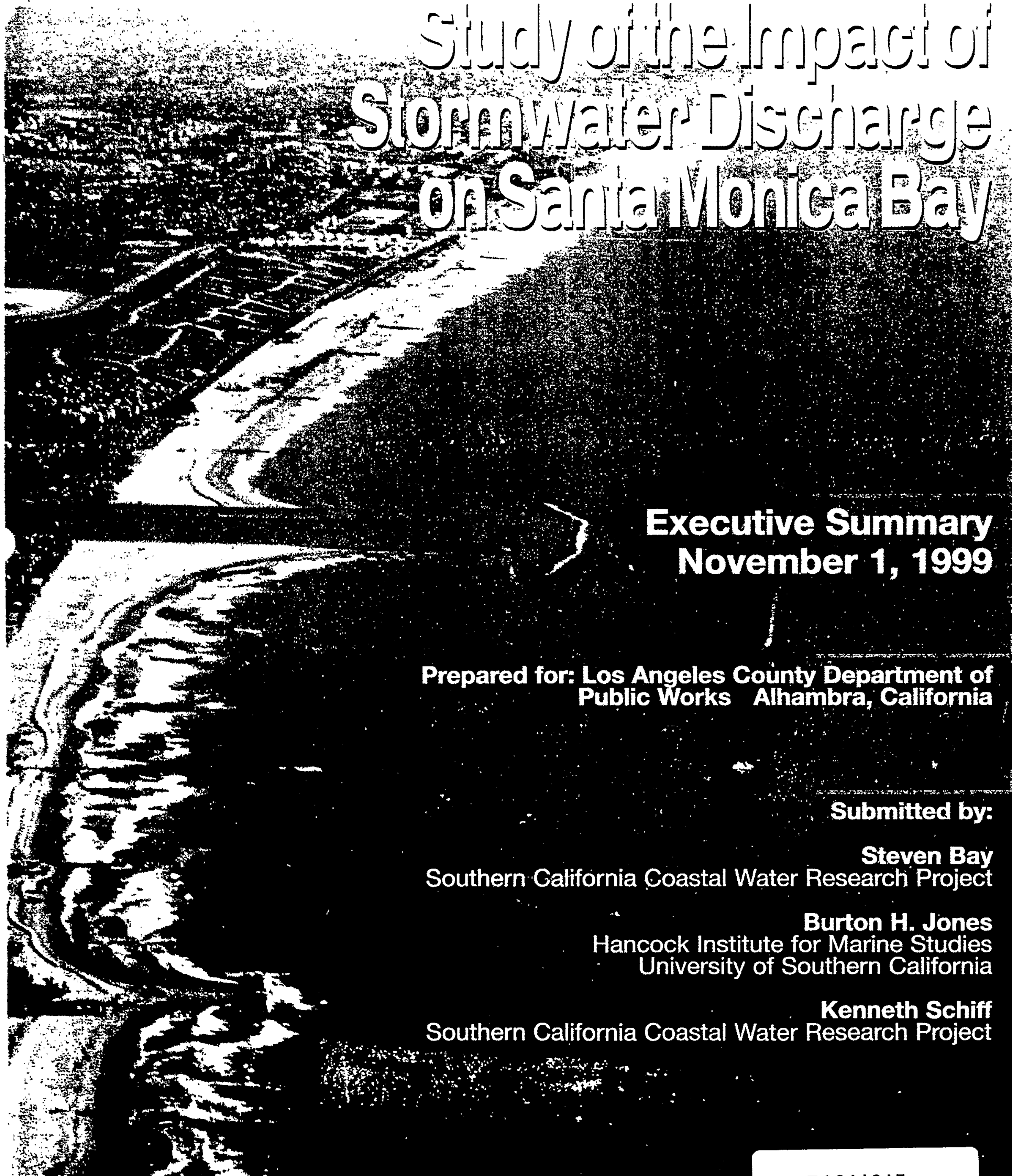
Sea Grant
University of Southern California

Study of the Impact of Stormwater Discharge on Santa Monica Bay



Executive Summary
November 1, 1999

Prepared for: Los Angeles County Department of Public Works Alhambra, California

Submitted by:

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The conclusions presented in this document are the views of the authors and do not necessarily represent positions of the Los Angeles County Department of Public Works, the Natural Resources Defense Council, or other collaborating agencies.

Sea Grant Program
University of Southern California
USCSG-TR-02-99

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Bob Van Wagenen, Ecoscan Resource Data, Watsonville, CA

INTRODUCTION

Urban stormwater runoff is now regarded as one of the largest sources of pollution to the coastal waters of the United States. In Southern California, point source control and advanced sewage treatment have greatly reduced the emissions of contaminants from sewage treatment plant and industrial discharges into the ocean. As a consequence, mass emissions from stormwater runoff now constitute a much larger portion of the constituent inputs to receiving waters and may represent the dominant source of some contaminants such as lead and zinc.

Stormwater runoff is widely believed to be one of the largest sources of contaminants to coastal waters.

While stormwater runoff can produce impacts in both freshwater and seawater environments, effects on the ocean are of greatest concern in urban Southern California. Our coastal waters provide many beneficial uses, including recreation, aesthetic enjoyment, fishing, marine habitat, fish reproduction, industrial water supply, and navigation. Ocean-dependent activities contribute approximately $9 billion annually to the economies of coastal communities in Southern California.

Substantial resources are spent monitoring the chemical constituents in stormwater runoff, yet little is known about the effects of these inputs once they enter the ocean. Of greatest concern to the public are whether impairments are occurring to the beneficial uses that relate to human health (safety of swimming and seafood consumption) or ecosystem health (presence of a natural balance of species). Stormwater discharge has the potential to impair these beneficial uses through: 1) contamination of recreational waters or seafood with disease-causing microbes, 2) aesthetic degradation from trash and reduced water clarity, and 3) ecosystem degradation from contaminants or other stormwater constituents.

Current water quality monitoring programs do not assess the effects of stormwater runoff on the environment.

Understanding the effects of stormwater on beneficial uses is essential. Information about the extent and type of adverse impacts is useful to guide and refine management actions to improve water quality. The monitoring programs of various agencies collect information that is useful for assessing some beneficial use impairments, primarily those related to human health. For example, public health and sanitation agencies regularly conduct shoreline microbiological monitoring near storm drain discharges, which indicates impacts to swimming and shellfish consumption. However, very little information is available to assess the impacts of urban stormwater on ecosystem health. Studies of impacts to freshwater systems (particularly in the west) are rare; impacts to the coastal ocean have never been assessed.

This report summarizes a three-year study funded by the Los Angeles County Department of Public Works, Southern California Coastal Water Research Project (SCCWRP), and University of Southern California (USC) Sea Grant Program.

This study is one of the first to assess stormwater impacts on the marine ecosystem.

This study examined plume characteristics, water column and seafloor biology.

The purpose of the study was to assess the impacts of urban stormwater runoff to the receiving waters of Santa Monica Bay. The goal of this study was to examine impacts that were relevant to ecosystem health, rather than impacts related to human health or recreation issues. This effort was conducted by an interdisciplinary team of scientists from SCCWRP, the University of Southern California, and the University of California at Santa Barbara.

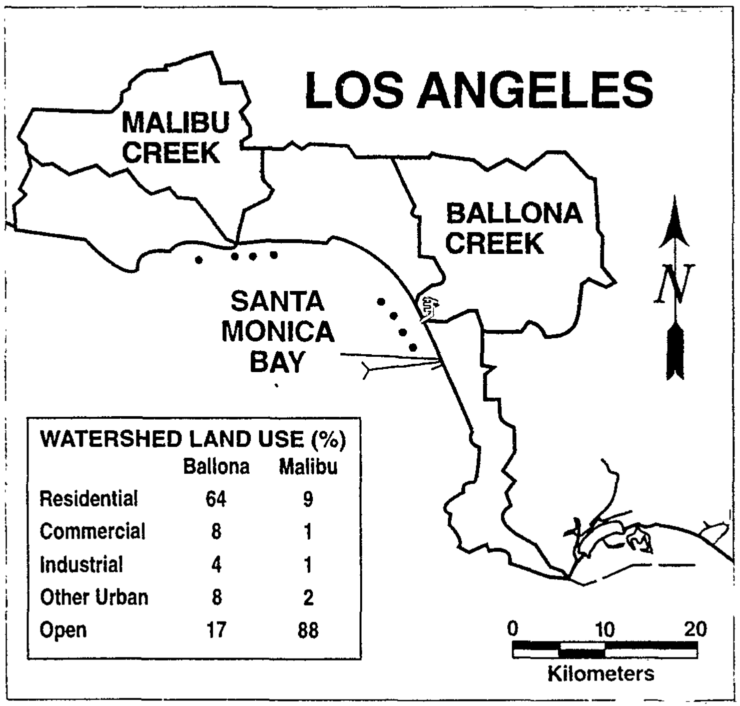
The Santa Monica Bay Receiving Waters Study incorporated four design elements. The first element used physical and optical oceanographic instruments to characterize the size, composition, and mixing of stormwater plumes, providing information on the impacts to beneficial uses that are associated with water clarity. The second element used toxicity tests to assess the biological effects of runoff on water column biota and to identify the responsible toxicants. The third element examined seafloor biota and chemistry in order to assess the long-term effects of storm-discharged particles with their associated contaminants.

Comparisons between Ballona and Malibu Creeks evaluated effects of different watershed types.

The fourth element of the study design was a comparison of stormwater impacts from different watershed types. Land use patterns and development within a watershed are thought to influence the composition and quantity of stormwater runoff. The influence of watershed type was investigated by comparing stormwater impacts in the receiving water offshore of the highly urbanized Ballona Creek watershed with impacts in the receiving water offshore of the less-urbanized Malibu Creek watershed (Figure 1).

Sampling and analysis were conducted over three wet seasons (1995/96 to 1997/98). This document provides a summary of the study and focuses on major concepts and important findings. For the detailed results and raw data, we encourage readers to consult the Annual Progress Reports, available through USC Sea Grant.

FIGURE 1



WATERSHED LAND USE (%)	Ballona	Malibu
Residential	64	9
Commercial	8	1
Industrial	4	1
Other Urban	8	2
Open	17	88

Locations of Ballona Creek and Malibu Creek sub-watersheds and the offshore sampling stations for sediment measurement. Other portions of the Santa Monica Bay watershed are shown in white.

STORMWATER PLUME CHARACTERIZATION

The impact of stormwater on the coastal ocean is determined by the composition of the stormwater and the dynamics (mixing, transport, and persistence) of the stormwater plume once it enters the coastal ocean. These dynamics influence the location, duration, and magnitude of impacts from stormwater.

The low salinity and high turbidity of stormwater provide markers that allow plumes to be mapped in the ocean.

The research team mapped the three-dimensional distribution of the stormwater plumes resulting from several winter storm events during 1996-1998. Mapping was performed using a towyo system, which carried sensors to measure temperature, salinity, light transmission (turbidity), chlorophyll fluorescence (plant biomass), and ambient visible light. The towyo was towed through the water in a vertical zigzag pattern that enabled us to map the horizontal and vertical distributions of the measured parameters. In addition, surface water was pumped to similar sensors on the boat so that the distribution of these parameters at the water's surface could be mapped. Maps were constructed for two regions of Santa Monica Bay, the receiving waters offshore of Ballona Creek and those offshore of Malibu Creek.

The characteristics of stormwater discharged into Santa Monica Bay from the two watersheds were similar in several respects. The most obvious and important physical characteristic was that the stormwater, being primarily composed of freshwater, had very little salinity. This low salinity enabled us to trace the stormwater plume in the ocean and differentiate it from the ambient seawater, which was not directly influenced by stormwater discharge. The stormwater also contained high concentrations of suspended particulate material, derived from various sources such as land erosion, street dust, aerial deposition, and litter. Suspended particulate material increased the turbidity of water by scattering and absorbing light. The turbidity and salinity together allowed the differentiation of seawater influenced by stormwater discharge from seawater containing freshwater from direct rainfall input.

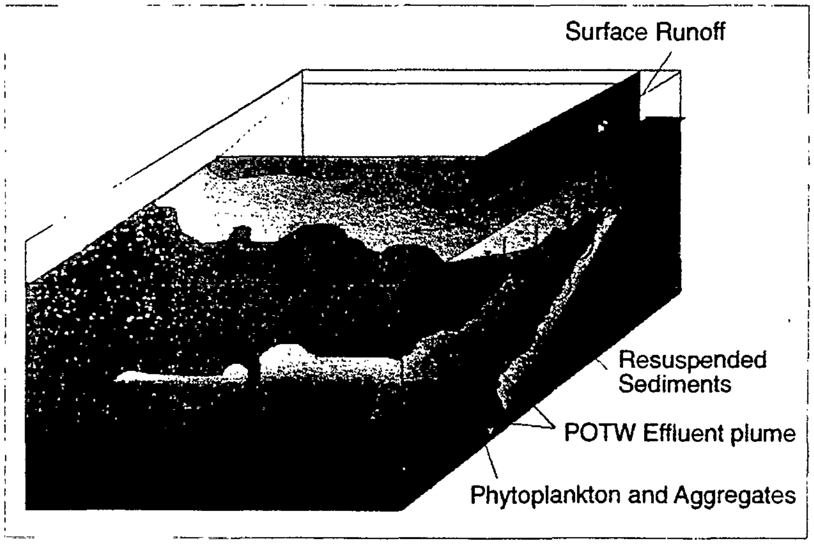


FIGURE 2

Schematic of coastal ocean with several sources of suspended particulate matter. Sources include surface runoff, Publicly Owned Treatment Works (POTW) discharge, bottom resuspension, and naturally occurring phytoplankton and detiritus.

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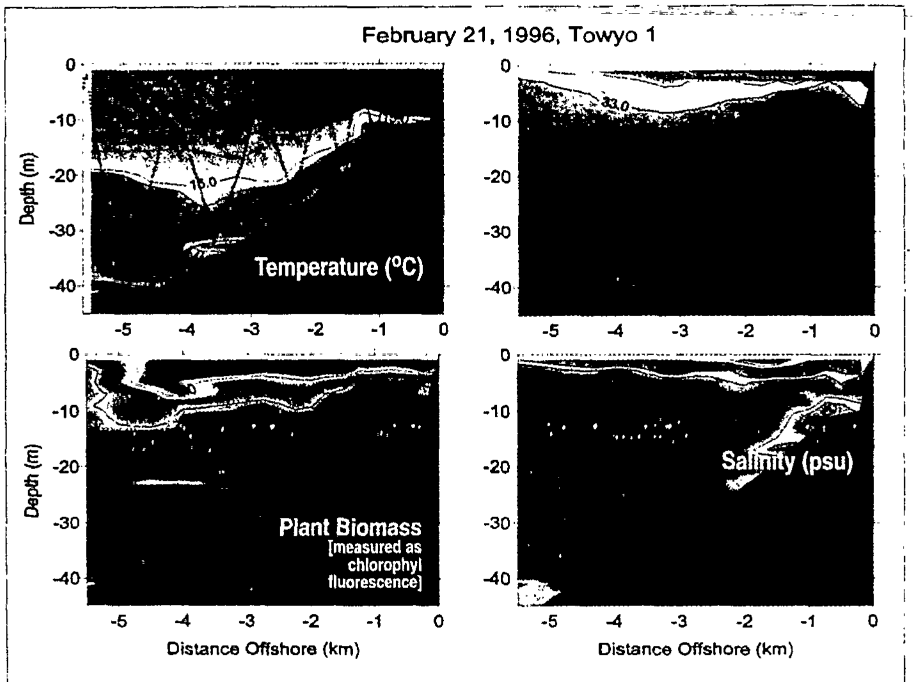
The stormwater plume was most concentrated in the surface layer.

Understanding the dispersion and fate of stormwater plumes is a complex task. The distribution of dissolved components such as nutrients and small particles is dependent upon the amount of rainfall, the coastal currents, and the winds, which can drive currents and cause vertical mixing (Figure 2). Large stormwater particles often have a different fate; they settle out of the low salinity plume, become incorporated into bottom sediments, and may be redistributed later by wave resuspension and transport. As the plume disperses, the components of stormwater mix with other sources of suspended particles, nutrients, and freshwater in the receiving water. These sources include bottom resuspension, phytoplankton growth, and wastewater discharge.

FIGURE 3



Vertical cross-shelf sections of the Ballona Creek discharge plume following a storm event in February, 1996. The maps shown were generated using a towyo system, which carried sensors for temperature, salinity, turbidity (beam attenuation), and plant biomass (chlorophyll fluorescence). The zigzag pattern on the temperature section indicates the path of the towyo. The stormwater plume is indicated by water with a salinity less than 33.0 practical salinity units (psu).

Stormwater plumes usually formed relatively thin layers at the surface of the ocean that are 2-10 m deep (Figure 3). The depth of penetration increased with time as winds mixed the upper layer vertically. The horizontal scales of the plumes studied in Santa Monica Bay were variable, with plumes extending from 1 to 6 miles cross-shelf (offshore) for storms of 1- to 2-year frequencies (0.8 to 4 in. of rainfall). During the February 19-21, 1996 storm (4 in. of rainfall), the plume spread approximately 4 miles offshore of Ballona Creek (Figure 4).

The speed and direction of coastal currents determine the cross-shelf scale of the plume. The Coriolis force (an apparent force that acts on oceans and lakes) also has an influence on the distribution of stormwater plumes. This force is due to the rotation of the earth and its motion through space, resulting in a tendency for currents to turn toward the right in the Northern Hemisphere. If the plume is carried to the north when it enters the ocean, it will be more likely to remain near the coast due to the influence of the Coriolis force.

The distribution of stormwater plumes along the coast depended upon the tidal variations in the currents, the presence of additional runoff sources, and the amount of runoff. Longshore distances of up to 6 miles were measured for plumes within Santa Monica Bay.

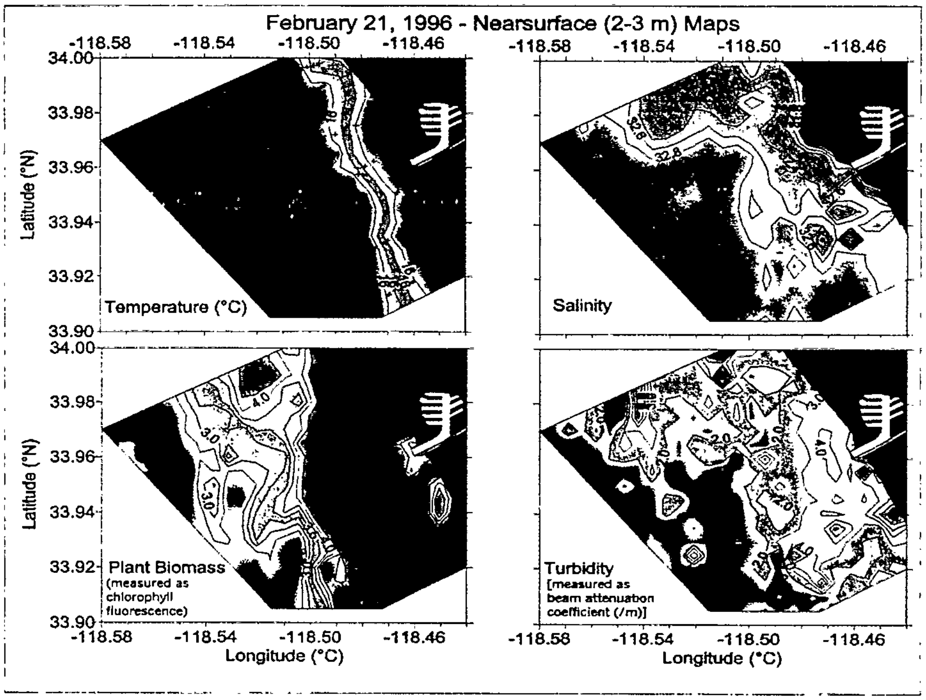
Spatial gradients in the dissolved and particulate components of the plume occurred as it was diluted through mixing with the receiving water. Although larger stormwater particles tended to settle out from the plume rapidly, smaller, lighter particles remained in suspension near the surface (Figures 3 and 4), where they can reduce the amount of light available for photosynthesis by marine plants. Measures of primary production were not part of this study, so adverse effects on phytoplankton in Santa Monica Bay resulting from turbid stormwater plumes were not determined.

Stormwater plumes reduced surface water clarity and persisted for several days after a storm.

The duration of stormwater plumes depends upon the rate of plume dispersion and particle sinking. Stormwater plumes were observed to persist in Santa Monica Bay for at least three days, even for the smallest storm sampled (0.8 in. rainfall). The maximum duration of stormwater plumes could not be assessed in this study because measurements did not extend more than three days after a storm.

High concentrations of the plant pigment chlorophyll were present in the surface layer during some storm events, indicating the presence of increased phytoplankton populations. Phytoplankton growth may have been stimulated by stormwater discharge due to the addition of nutrients to the surface layer, where light is readily available. Dense patches of phytoplankton were observed off of Malibu Creek on the boundary of stormwater plumes 1-2 days after rain events. Off of Ballona Creek, we observed increased phytoplankton in the plume even while a large proportion of suspended particulate material was still present in the surface water. The ecological effects of these changes in phytoplankton density were not determined in this study.

FIGURE 4



Near surface map of the February, 1996 stormwater plume from a 2-year storm off of Ballona Creek. The plume (surface water with a salinity less than 33.0 psu) extended approximately 4 miles offshore.

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WATER COLUMN BIOLOGY

The initial and most concentrated exposure to stormwater occurs in the upper few meters of the water column. A diversity of organisms occupies this habitat, ranging from mobile fish and mammals to drifting microscopic plants and animals (plankton). Plankton have a relatively high potential to be affected by stormwater toxicants because they have a limited ability to avoid the plume and are often more sensitive to contaminants than larger animals. Changes in the abundance and type of plankton present can have important consequences for the marine ecosystem. This group of organisms constitutes the base of the food chain for most marine life, so changes in plankton numbers may affect populations of other species. The larvae of many fish and other animals such as sea urchins, clams, and shrimp occur in the plankton, providing the potential for diminished reproductive success if their survival is reduced by water column toxicity.

Water column effects were measured using toxicity tests.

Toxicity tests were used to determine whether stormwater plumes contained harmful concentrations of dissolved constituents. Surface water samples were collected offshore of the two study sites in conjunction with measurements of the plume characteristics so that the data could be related to the concentration of the stormwater discharge plume. Samples of stormwater collected from Ballona Creek were also measured for comparison. The toxicity tests used sensitive stages of marine species that occur in Southern California. Most samples were measured using the sea urchin fertilization test, in which the effect of the sample on the ability of sea urchin sperm to fertilize eggs is measured. Sea urchin sperm are highly sensitive to some types of dissolved metals. The fertilization test is appropriate for stormwater monitoring because it is rapid (40 min exposure) and uses an organism which spends a portion of its life cycle in the water column of Santa Monica Bay. All tests were adjusted to the appropriate salinity prior to exposure so only the effect of chemical constituents were evaluated.

Virtually every sample of Ballona Creek stormwater tested was toxic.

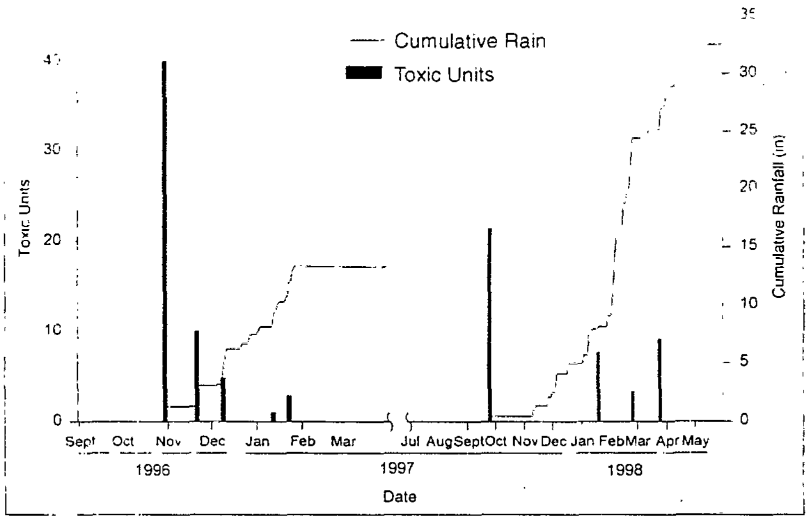
Undiluted samples of urban stormwater collected from drainage channels (before discharge into the ocean) usually contained toxic concentrations of constituents. Toxicity was detected in virtually every sample obtained from Ballona Creek and this toxicity was often present even after the sample was diluted 10-fold in the laboratory. The results indicated that even though a large portion of the constituents present in stormwater may be bound to particles, the dissolved concentrations of some materials are high enough to cause toxicity. Prior research by SCCWRP and others has detected toxicity in stormwater from other watersheds in Los Angeles, Orange, and San Diego Counties.

The first storms of the year produced the most toxic stormwater.

The results showed that time of year was an important variable influencing stormwater toxicity (Figure 5). Samples of Ballona Creek stormwater, obtained from the first storm of the season, were between two and ten times more toxic than samples from later storms. These data indicated that the first storms of the year provide the most concentrated inputs of toxicants to the environment.

Toxicity was frequently detected in surface water within the stormwater plume offshore of Ballona Creek, indicating that the initial dilution of stormwater discharge from this watershed was not sufficient to reduce the concentrations of stormwater toxicants below levels that are harmful to marine organisms. The magnitude of toxicity was greatest in the portion of the plume nearest the mouth of Ballona Creek (Figure 6), where the highest concentrations of stormwater were present. Within the plumes studied, toxicity was usually present whenever stormwater concentrations above 10% were present. The duration of toxicity in surface waters was not specifically addressed in this study, but can be expected to be determined by the rate of plume dispersion. In this study, toxicity was detected in surface water near the mouth of Ballona Creek two days after a storm event.

FIGURE 5

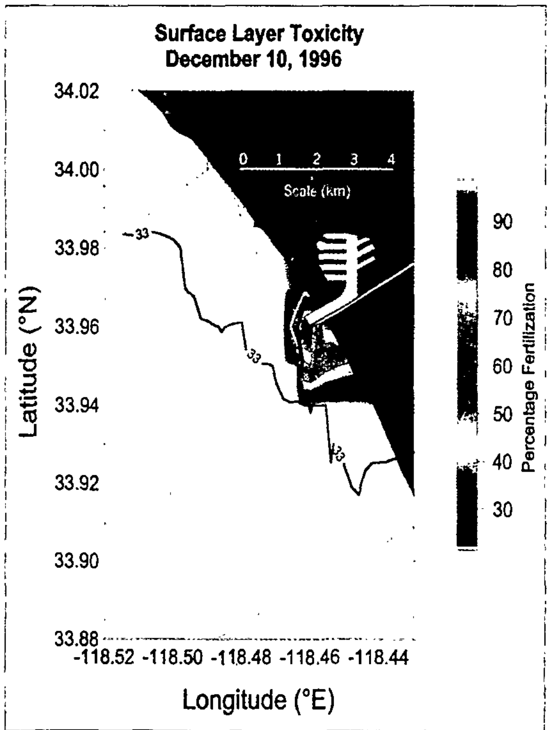


Seasonal changes in the toxicity of Ballona Creek stormwater over two storm seasons. Toxicity was measured using the sea urchin fertilization test. The greatest toxicity was observed in stormwater obtained from the first storm of each year.

Toxic portions of the stormwater plume were variable in size, extending from 1/4 to 2 miles offshore of Ballona Creek.

The spatial extent of surface water toxicity varied between storms, and was influenced by the amount of storm flow, the degree of toxicity of the stormwater, and the amount of mixing that occurred upon discharge. The greatest offshore extent of toxicity was measured following a storm on February 21, 1996, a two-year event, when toxicity was detected 2 miles offshore of Ballona Creek. For other storms, the toxic portion of the plume extended ¼-1 mile offshore. The distribution of toxicity along the shoreline was not determined in this study. The boundaries of stormwater plumes can be described using a number of parameters (i.e., salinity, turbidity, and toxicity) each with different thresholds of detection. Because a relatively high concentration of stormwater is

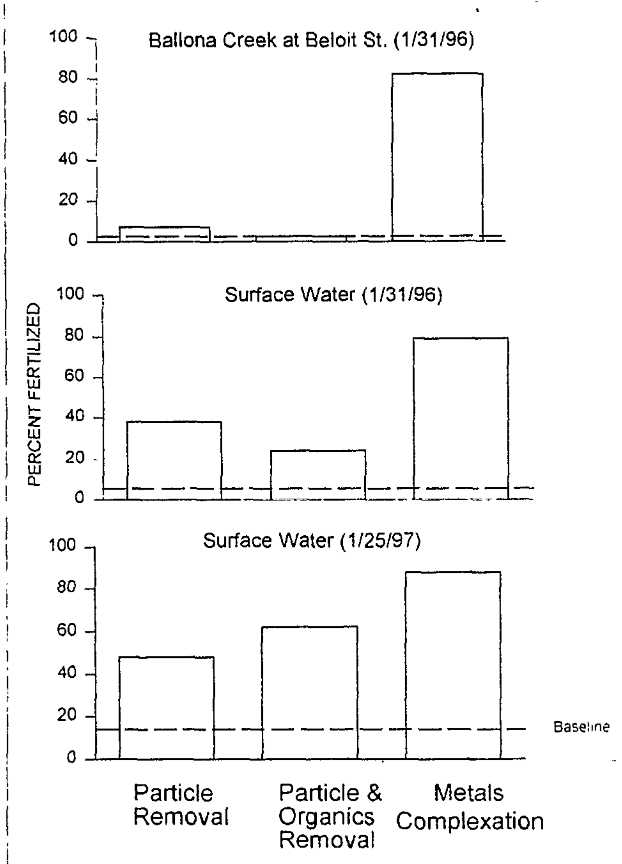
FIGURE 6



Map of surface layer toxicity (effect on sea urchin fertilization) from Ballona Creek stormwater discharge following a 2-year storm in December, 1996 (3.1 in. rainfall). Expected toxicity was calculated from measurements of salinity (indicates concentration of stormwater) and the concentration dose-response curve for the effects of stormwater on sea urchin fertilization. The greatest toxicity (lower fertilization percentage) was present closest to the point of discharge. The area of toxicity was smaller than the physical extent of the plume, as indicated by the solid line showing a salinity of 33 psu. This figure illustrates the relative size of the toxic portion of the plume for a single storm, but does not represent the largest plume offshore for other storms.

Surface water toxicity caused by unidentified sources was frequently encountered during dry weather.

FIGURE 7



Effect of toxicity identification evaluation treatments on the toxicity of Ballona Creek stormwater and two samples of surface water collected within the Ballona Creek discharge plume. Complexation of metals by addition of EDTA usually eliminated toxicity, as shown by the large increase in sea urchin fertilization above the untreated (baseline) value. Other treatments, removal of particles by filtration and removal of organic compounds, were of limited effectiveness. Similar results were found for other samples of stormwater and surface water.

needed to produce toxicity, the area of potential biological impact within a plume will be smaller than the region defined by physical characteristics such as salinity (Figure 6).

An unexpected result of this study was the detection of toxicity in receiving waters that appeared to be due to sources other than urban runoff. An average of 53% of the surface water samples collected offshore of Ballona and Malibu Creeks during periods of dry weather were found to be toxic. The location of the toxic samples was variable and there was no relationship between toxicity and the amount of freshwater in the samples, indicating that dry weather urban runoff was not the cause. Additional sources of receiving water toxicity were also indicated during the wet weather sampling, as some water samples were more toxic than could be accounted for by the amount of stormwater present.

The dry weather toxicity results suggest that factors other than stormwater discharge have a major influence on surface water quality in Santa Monica Bay. While the cause of dry weather toxicity was not determined, its frequent detection indicates that impaired surface water quality in Santa Monica Bay extends beyond the spatial and seasonal boundaries associated with stormwater discharge. Potential sources of dry weather toxicity include the deposition of contaminants from the atmosphere, biological events such as red tides, and inputs from boating activities.

Dissolved metals in stormwater were identified as important contributors to impaired water quality in Ballona Creek stormwater plumes. This conclusion was the result of experiments that combined chemical treatments designed to remove specific types of constituents in water samples with sea urchin toxicity tests, a process known as Toxicity Identification Evaluation (TIE). The toxicity of Ballona Creek stormwater and receiving water samples was usually eliminated when treatments were applied that neutralized toxic trace metals by complexation (Figure 7). Chemical analysis confirmed that dissolved concentrations of zinc, and occasionally copper, were at toxic levels in undiluted stormwater. The dissolved concentrations of other metals were below toxic levels for the sea urchin test. Measurements of receiving water also detected elevated concentrations of zinc (but not copper) in the stormwater plume offshore of Ballona Creek.

Chemical analysis were unable to attribute all of the toxicity measured to zinc and copper, indicating that additional constituents may contribute to the toxicity of stormwater discharged into Santa Monica Bay. The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5-44% of the observed toxicity. Zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory. The unaccounted-for toxicity may be due to synergistic interactions between toxic metals, variability in the chemical analysis, or the influence of other toxic chemicals, such as pesticides. Additional research is needed before these alternatives can be evaluated. TIE studies have not been completed for other stormwater discharges into the Bay, so we do not know if the pattern demonstrated for Ballona Creek is representative of other sites.

Zinc was the most important toxic constituent identified in stormwater. Copper and other unidentified constituents may also be responsible for some of the toxicity measured.

SEAFLOOR BIOLOGY

Much of the natural diversity and many of the commercially important species in the ocean occur on the seafloor. Clams and shrimp live in this environment, as well as worms and starfish, all of which serve as food for fish. This is also the location where stormwater particles, and associated contaminants, eventually settle. Unlike the water column, where a stormwater plume eventually mixes and disperses, the sediments on the seafloor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons. These inputs can alter the seafloor biology by either changing the habitat, such as altering sediment grain size, or by the build-up of pollutants. The potential for impacts to seafloor organisms is great because they are not mobile and are therefore subjected to the accumulated stormwater inputs for long periods of time. Typically, these seafloor organisms are relatively sensitive and changes to the number or types of organisms may result in changes to fish populations.

The deposition of stormwater particles influences the physical and chemical characteristics of the seafloor.

We estimated impacts of stormwater runoff discharges on the seafloor by collecting samples from the ocean bottom between one and two weeks following large storm events, after the stormwater plumes had dispersed and particles had time to settle, and then again during dry weather. Seafloor samples were collected directly offshore of Ballona and Malibu Creeks at 75 ft. depth in the heart of the stormwater plumes, along intervals upcoast and downcoast representing gradients of plume impact, and then outside the area of the plume. The top 2 cm (< 1 inch) of these seafloor samples, which represented the most recent seafloor accumulations, were collected for contaminant analysis and toxicity testing. Sediment samples were analyzed for contaminants including trace metals, chlorinated hydrocarbons (DDTs and PCBs), and petroleum hydrocarbons (PAHs). The toxicity tests included survival of crustaceans (an amphipod) and sea urchins, fertilization success and development of sea urchin embryos, and bioaccumulation of contaminants from seafloor mud in adult sea urchins. A second sediment sample was collected, sieved through a fine mesh screen, and the organisms were enumerated to determine the abundance and diversity of the native seafloor fauna.

An increase in sediment constituents was present on the seafloor offshore Ballona Creek.

TABLE 1

		Sediment Concentration	
		Ballona Ck (n=8)	Malibu Ck (n=7)
Fines	% dry	31.6	**53.1**
TOC	% dry	0.594	**0.963**
Aluminum	µg/dry g	11492	**17280**
Arsenic	µg /dry g	5.1	5.6
Cadmium	µg /dry g	0.5	0.7
Chromium	µg /dry g	40.7	**52.6**
Copper	µg /dry g	12	13
Iron	µg /dry g	14997	**21720**
Lead	µg /dry g	**26.4**	10.3
Mercury	µg /dry g	**0.18**	0.08
Nickel	µg /dry g	14.29	**27.76**
Silver	µg /dry g	**0.95**	0.31
Zinc	µg /dry g	54	56
Total DDTs	ng/dry g	**25.6**	15.5
Total PCBs	ng/dry g	**21.5**	3.0
Total PAHs	ng/dry g	**240.6**	56.2

Average concentrations of sediment constituents offshore (75 ft. depth) of creek mouths in Santa Monica Bay following storm events between 1995 and 1997. Boxed numbers indicate significantly higher concentrations. Sediment offshore of the less urbanized watershed (Malibu Creek) had higher levels of naturally occurring constituents such as aluminum and iron. Higher concentrations of anthropogenic constituents such as lead and PAHs were present offshore of the more urbanized watershed (Ballona Creek).

Alterations to the seafloor habitat and sediment constituent concentrations had occurred offshore of the Ballona Creek watershed (Table 1). The sediments offshore of Malibu Creek generally had higher concentrations of naturally abundant constituents including fine-grained particles, organic carbon, and trace metals such as chromium. In contrast, the sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants including common stormwater constituents such as lead and zinc, as well as other rarely detected constituents in routine stormwater monitoring programs, such as DDTs, PCBs, and PAHs. Moreover, sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area. Concentrations of copper, lead, zinc, DDTs, PCBs, and PAHs were highest directly offshore of the creek mouth and then decreased in both the upcoast and downcoast directions at distances up to 3 miles away (Figure 8). The increased sediment contamination was also observed more than 1 mile offshore, where water depths reached over 100 feet.

Biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek (Table 2). Both areas had comparable abundance and similar species composition. Seventeen of the 19 most commonly found taxa offshore of Ballona Creek were present offshore of Malibu Creek, and both watersheds had a low abundance of so-called "pollution indicator" organisms. Both areas had healthy benthic communities, as measured by the Benthic Response Index, which is a tool for assessing the relative importance of pollution indicator species at a site. Species richness and diversity were statistically higher near Malibu Creek than Ballona Creek.

Biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of Southern California (Table 2). The mean abundance, mean number of taxa per sample, and mean diversity at the creek sites were comparable to reference sites located in waters of similar depth, but distant from river and creek mouths. The present study was limited to the area offshore of the Ballona Creek jetty; previous studies by other scientists have shown impacts to benthic communities and the presence of pollution indicator organisms inside of the jetty (adjacent to Marina del Rey).

The seafloor biology results were consistent with the results from sediment toxicity tests. Seafloor sediments offshore of Ballona Creek did not kill amphipods or impair the fertilization success or normal embryo development of sea urchins. However, seafloor sediments were found to be a potential source of contaminants that bioaccumulate in seafloor organisms such as adult sea urchins. Concentrations of lead, DDTs, and PCBs were three to ten times higher in sea urchins exposed to sediments collected offshore of Ballona Creek than in sea urchins living on sediments from our reference location. While the effect of this bioaccumulation on the sea urchin is not known, it does represent a mechanism by which sediment- associated pollutants can enter the food chain and biomagnify within fish.

The fate of most stormwater constituents is unknown.

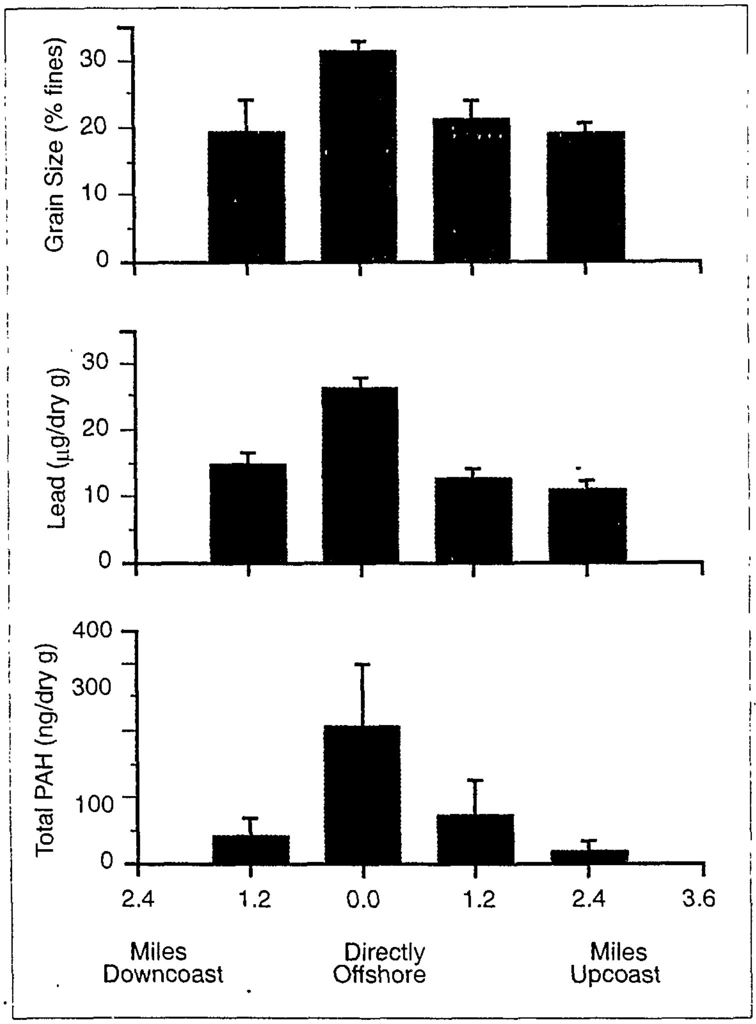
One significant finding of this study was that the fate of most stormwater constituents discharged to Santa Monica Bay is unknown. Although we documented the accumulation of contaminants on the seafloor offshore of Ballona Creek, these amounts were not permanent and represent only a fraction of the total mass emissions discharged. Further, reductions in constituent concentrations were observed at some locations that may have resulted from the resuspension and transport of sediments by waves and currents. Until the location where this material eventually settles is known, we cannot be certain that we have examined the seafloor areas having the greatest influence from stormwater or dry weather discharges. An additional concern is that constituents from other sources may have similar transport and fate mechanisms, producing enhanced impacts from the cumulative effects of multiple sources.

TABLE 2

	Ballona (n=8)	Malibu (n=7)	Reference (n=29)
Abundance (No. organisms/ 0.1 m²)	238 (±51)	316 (±55)	276 (±61)
No. Species (No. taxa/ 0.1 m²)	75 (±6)	91 (±8)	71 (±9)
Diversity (Shannon-Wiener H')	1.65 (±0.02)	1.73 (±0.04)	1.55 (±0.15)
Benthic Response Index (BRI units)	24.0 (±1.7)	1.65 (±0.7)	3.0 – 30.6

Biological community parameters offshore of a highly urbanized watershed (Ballona Creek), a less urbanized watershed (Malibu Creek), and other reference areas in near-coastal waters of Southern California at similar depths (30 to 75 feet). Values are the mean (±95% confidence limits).

FIGURE 8



Grain size and contaminant concentrations in surface sediments across the gradient of stormwater influence offshore of Ballona Creek. Sampling stations were located 1.5 miles offshore (75 ft. depth) and at various distances upcoast or downcoast of the creek. Each value represents the mean (±95% confidence interval) of eight samples, each collected after a storm event. The influence of stormwater particle deposition is shown by the elevated values directly offshore of Ballona Creek.

EFFECTS OF WATERSHED TYPE

The comparison of receiving water impacts from different watersheds is a powerful tool to distinguish between natural and man-made effects. Although the Ballona Creek and Malibu Creek watersheds are similar in size and discharge into the same body of water (Santa Monica Bay), they differ in their degree of urbanization (Figure 1). The measurement of similar parameters in each receiving water area provides the information needed to distinguish between natural processes and impairment due to man-made factors. This approach also identifies which monitoring methods are most useful for detecting man-made impacts.

Different impacts to Santa Monica Bay were produced by an urbanized and an unurbanized watershed.

The characteristics and impacts of stormwater from the Ballona Creek and Malibu Creek watersheds were found to differ in a number of respects (Table 3). The impacts observed were the result of the interaction of three key factors: land use, flow characteristics, and receiving water conditions. Receiving water impacts were less near Malibu Creek and were related to the discharge of less toxic stormwater and lower peak flows.

Ballona Creek watershed is highly urbanized. Stormwater entering the concrete channel is rapidly transported to the ocean, with little opportunity for dilution.

Malibu Creek drains a mostly undeveloped watershed. Stormwater flow and particle inputs into the ocean are moderated by the presence of a natural creekbed and coastal lagoon.

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TABLE 3

	Ballona Creek	Malibu Creek
Watershed Characteristics	The largest watershed draining to Santa Monica Bay, 83% of its 130 square miles is developed. The principal land use is residential.	Similar in size to Ballona Creek (110 square miles), 88% of this watershed is undeveloped.
Flow Characteristics	The largely impermeable surface area (41% overall) and concrete channel drainage system results in rapid changes in flow following rainfall. Peak flows are relatively high and of shorter duration compared to other areas.	More permeable surface area (96% overall) absorbs early season rainfall and increases lag time between rainfall and peak flow. Discharges have relatively lower peak flows but duration can be days longer than concrete channelized systems. Discharge into Malibu Lagoon may reduce flows and particle loads to ocean.
Plume Characteristics	The stormwater plume in both areas consisted of a thin buoyant layer of low salinity water floating at the surface. The dissolved and particulate components of stormwater were most concentrated in the upper 2 m of the water column. Plumes extended up to 6 miles offshore and were widely distributed along the shore.	
	Higher flows and less mixing produced well-defined plumes that contained higher concentrations of stormwater near Ballona Creek.	Lower flows, more mixing, and discharges from adjacent canyons resulted in more complex and ill-defined plume boundaries near Malibu Creek.
Debris	Floating debris was often concentrated near the margins of the plume and contained many items of man-made origin, such as plastic.	Floating debris was dominated by organic materials of natural origin, such as twigs and charred wood.
Water Clarity	Less mixing of stormwater usually produced larger areas of reduced water clarity.	Stormwater inputs were often more turbid, but lower flows and greater dilution near the mouth resulted in better clarity.
Stormwater Toxicity	Samples from the creek were always toxic to sea urchins. Concentrations higher than 10% stormwater usually produced adverse effects in laboratory tests.	Samples were less toxic than Ballona Creek stormwater and occasionally nontoxic. High concentrations (>25%) usually needed to produce toxicity.

Characteristics of a highly urbanized watershed (Ballona Creek) and a less urbanized watershed (Malibu Creek) adjacent to Santa Monica Bay, California.

R0011629

TABLE 3 Continued

	Ballona Creek	Malibu Creek
Receiving Water Toxicity	Surface water in most concentrated portion of plume was often toxic to sea urchins. Toxicity was detected in receiving waters up to 2 miles from discharge.	Toxicity in water column was rarely present and was not related to plume concentration.
Cause of Toxicity	Zinc is responsible for a portion of the stormwater toxicity. The influence of pesticides and other organics is uncertain.	Metals are implicated but have not been confirmed as important toxicants.
Seafloor Habitat	Sediments were higher in urban stormwater associated contaminants, such as lead and zinc.	Higher concentrations of constituents were derived from natural sources, such as fine sediments and organic carbon.
Sediment Toxicity	Changes in sediment toxicity were minor and not related to stormwater discharges.	
Seafloor Biological Communities	Biological communities were similar among Malibu Creek, Ballona Creek, and background reference sites.	

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RECOMMENDATIONS FOR FUTURE STUDIES

The Santa Monica Bay Receiving Waters Study produced the first integrated assessment of impacts from stormwater discharges into the Bay. The presence of well-developed plumes containing toxic materials demonstrates the need for continued studies of the impacts from urban stormwater runoff in Santa Monica Bay and elsewhere. Additional information regarding the sources, characteristics, and extent of the receiving water impacts should be determined in order to refine management actions.

A high priority should be placed upon locating sources of toxicity and contamination within the Ballona Creek watershed. Identification of the land uses or regions of the watershed that contribute most to the impacts will enable management actions to be targeted where they will have the greatest beneficial impact. Source identification studies should include sampling of systems tributary to Ballona Creek for measurement of toxicity and chemical constituents.

Additional receiving water studies are recommended for Santa Monica Bay to provide a more complete understanding of the nature and magnitude of stormwater impacts. Future studies should include constituents of concern that were not emphasized in this study, such as bacteria, nutrients, pesticides, and trash. These constituents should be incorporated into studies of plume persistence, cause of toxicity, and constituent fate.

Information on the duration, size, and cause of adverse impacts is needed to identify appropriate stormwater management actions.

Plume persistence information is needed to estimate the duration of exposure of: 1) swimmers to bacteria and 2) marine life to stormwater toxicants and nutrients. Improved information on plume persistence can be obtained by the use of moored sensors in the discharge area in combination with data from remote sensing instruments (e.g., satellites). A goal of these studies should be to develop plume dilution and/or tracking models of plume duration and magnitude. This information is valuable because different management responses may be appropriate for stormwater discharges that produce short- versus long-lived impacts.

Toxicity testing using multiple marine species is also needed to provide a more complete assessment of the causes of toxicity in stormwater discharged into Santa Monica Bay. Identification of zinc and copper as contaminants of concern was based primarily on studies with a single species (sea urchin). Because different species vary in their sensitivity to contaminants, tests with multiple species are needed to determine if other contaminants are present at toxic concentrations. Tests with crustaceans (e.g., shrimp) are especially recommended as they are likely to be sensitive to pesticides such as diazinon and chlorpyrifos, which have been found to be important factors in the toxicity of stormwater from other watersheds. These tests should include toxicity identification procedures so that potential constituents of

A suite of species should be used to identify toxicants in stormwater.

concern (e.g., metals and pesticides) can be confirmed and others can be discounted. Toxicant identification is needed to prioritize chemical-specific management actions.

The fate of stormwater particles must be determined in order to assess seafloor impacts.

Chemical and oceanographic studies are needed to determine the fate of stormwater particles discharged into Santa Monica Bay. Although some of the particles in Santa Monica Bay stormwater plumes may be deposited near the mouth of an urban watershed, they do not necessarily persist there for long periods of time. Since the spatial extent of particle dispersal in Santa Monica Bay was not determined, there may be areas of significant accumulation that were not investigated. Studies of currents, sediment resuspension, and sediment transport, coupled with chemical source identification methods, should be conducted to determine whether stormwater discharge is a significant source of adverse sediment contamination within Santa Monica Bay. This information is needed to identify areas of the seafloor with the greatest potential for biological impacts from stormwater discharge.

Additional receiving water systems should be studied to identify impairments from other watersheds.

The impacts of stormwater runoff on other receiving water systems should also be studied. This is because differences in watershed size and land use patterns will likely result in different levels of risk to the receiving water beneficial uses. For example, changes in land use may contribute different toxicants, and changes in watershed size will influence the magnitude of the toxicant input. The nature of the receiving water environment is also important. Semi-enclosed water bodies, such as most bays and harbors, do not have the mixing and dilution capacity of the open coastal environment studied in Santa Monica Bay. The potential for impairment will be greater in these areas because organisms will have an increased exposure to the stormwater plume and more stormwater particles will settle nearby and influence sediment quality. Until the effects of variations in watershed or receiving water characteristics can be accurately predicted, additional integrated studies will be necessary to assess impacts to receiving waters in other areas.

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R0011633

DRAFT
Sediment Sampling Results: Ballona Creek Sediment Contaminants Source Study

Submitted to

U.S. Army Corps of Engineers

Submitted by

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R0011634

Introduction

Twenty-one sites, including tributary drains and the main creek bed, were sampled for bedload sediment quality along Ballona Creek. The sediment sampling stations were designed to trace the upstream sources of contaminants of concern associated with sediment deposition at the mouth of Ballona Creek and the entrance to Marina del Rey Harbor. Deposited sediments were sampled from sediment accumulation areas representative of a variety of storm drain inputs into Ballona Creek. This report is a summary and evaluation of the chemistry results of the Ballona Creek sediment sampling program.

Sediment samples were collected from the channel bottom of 17 drainages at their mouths, immediately upstream of their confluence with Ballona Creek. In addition, sediments were sampled from the main channel of Ballona Creek at 4 locations. Samples were collected towards the end of the annual low-flow period, on October 5 and 6, 1999 (Table 1). This list varies from that presented in the Sampling and Analysis Plan (CH2M HILL 1999) in that Overland North and the Jefferson area drains were not sampled due to a lack of sediment accumulation. In addition, two new drains were added, from the Holly Hills drains entering below Dauphin Ave. and from the main drains entering under Higuera Street. Sampling locations are shown on the map in the Sampling and Analysis Plan and summarized in Table 1.

TABLE 1
Sampling Locations for Deposited Sediment Quality Sampling in the Ballona Creek Drainage.

Mouth of Drain Location	Approximate miles upstream from mouth of Ballona Creek	L.A. County Drain Number
Centinela Channel	2.6	NA
Centinela Avenue	3.2	51
Inglewood Boulevard	3.5	503
Sepulveda Channel	3.8	NA
Ballona Creek at Sawtelle Boulevard	4.3	All upstream drains
Sepulveda Boulevard	4.5	NA
Westwood/Kingston	4.6	RDD 208
Saint Nicholas Avenue	4.7	2901
Overland (south side)	5.0	RDD 208
Ballona Creek below Madison	5.7	All upstream drains
Madison Avenue	5.7	Benedict Canyon Channel
Ince Boulevard	6.0	Ince Boulevard Drain
Higuera	6.5	NA
National Boulevard	7.0	84
S. La Cienega Boulevard	7.5	9408

TABLE 1
Sampling Locations for Deposited Sediment Quality Sampling in the Ballona Creek Drainage.

Mouth of Drain Location	Approximate miles upstream from mouth of Ballona Creek	L.A. County Drain Number
Dauphin Ave.	7.6	9408/Holly Hills Drain
Ballona Creek below Fairfax	8.0	All upstream drains
Fairfax	8.0	Holly Hills Drain
Marvin Avenue	8.5	494
Pickford Street	9.0	648
Ballona Creek at Pickford	9.0	All upstream drains

NA = Not applicable or not available.

Methods

Field Sampling Methods

Deposited sediments were collected from drainage channel mouths and the main channel of Ballona Creek from areas visually determined to be sediment accumulation areas. The sediment was scooped from the channel bottoms with stainless steel hand trowels. Three separate equal-volume samples were collected within an approximate 1-meter radius and mixed thoroughly by hand in a stainless steel bowl. The resulting composite sample was packed with no head space into chemically clean glass jars. Samples were chilled in the field, held chilled, and transported to the laboratory within two days of collection.

Sampling equipment was chemically decontaminated between sites. A single decontamination rinsate sample (water sample) was collected for each day of sediment sampling.

Sediment Quality Constituents of Concern

The sediments were analyzed for those constituents listed in the Sampling and Analysis Plan and shown in the Results Section, below. Major contaminant groups investigated included metals, PAHs, organochlorine compounds, and pesticides. Grain size analysis and total organic carbon analysis was performed on all samples. All samples were collected in chemically clean glass jars, kept in the dark, and refrigerated prior to analysis.

Normalization of Results

The raw, wet chemistry results expressed in concentration units per weight of wet sediment would not offer a particularly effective means of comparison among sites. In contrast, several types of standardizations were created to provide insights into the differences in contamination among sites. The techniques used were:

- Dry weight normalization; all results were presented as concentration units per dry weight (DW) of sediment.

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- TOC normalization; all results were presented as dry weight concentrations per weight of total organic carbon (TOC) in the sample.
- Silt/clay normalization; all results were presented as dry weight concentrations per proportion of silt and clay in the sample.

Sediment chemistry results are presented in the Appendix for all samples and analytes on a wet and dry weight basis. Sediment chemistry results are presented using the three normalization techniques in Tables 2 - 5 for all sampling locations. Sediment toxicity guidelines, presented as Effect Range Low (ERL) values, are shown in the first column of Table 2 as a basis of comparison to known toxic levels of individual contaminants as assessed on a dry weight basis. Tables 3 - 5 shows the ordering of sites by level of contamination in sediment based on selected Table 2 results. Table 6 shows the average ranks for each site by analyte class.

TABLE 2
Ballona Creek Bed Load Sediment Quality
October 5 - 6, 1999

Sediment Concentration by Site (Dry Weight Basis)

Parameters	Units	Reporting Limits	Effect Range Low (ERL)*	Ballona @ Pickford	Pickford	Marvin	Fairfax	Ballona @ Fairfax	Dauphin	La Cienega	National	Higuera	Ince	Madison	Ballona @ Madison	Overland	St. Nicholas	Westwood	Sepulveda Blvd.	Ballona @ Sawtelle	Sepulveda Channel	Inglewood	Centinela Ave	Centinela Channel
Total Organic Carbon	mg/kg	80		442	22400	177755	1423	285	438	1142	2700	817	494	1741	2975	11340	3269	1119	1327	1012	563	4862	25442	1190
Total Recoverable Hydrocarbons	mg/kg	100		942	1200	2510	724	200	224	225	353	573	1010	413	201	258	632	36	873	74	139	1954	786	171
Silt/clay	proportion	NA		0 000	0 007	0 035	0 073	0 007	0 012	0 022	0 031	0 126	0 007	0.619	0.545	0 596	0 238	0.036	0 536	0 006	0 087	0 66	0 084	0 04[illegible]
Metals:																								
Antimony	mg/kg	0 750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	1 208	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	2 762	BLD
Arsenic	mg/kg	0.750	8 2	BLD	BLD	BLD	4 862	1.277	1 017	2 564	2 900	1 842	2 399	10.544	9.004	8.341	3.409	BLD	7.585	1 180	8 170	11.251	6 973	1 75[illegible]
Barium	mg/kg	0 500		24.382	448 571	593 878	157 735	31 565	26 148	63 381	99 167	50 292	43 987	205 792	175 207	735 052	157.025	12 547	228 190	38.874	75 710	283 077	213 605	40 092
Beryllium	mg/kg	0.250		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Cadmium	mg/kg	0 500	1 2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	3.051	2.675	BLD	BLD	BLD	BLD	BLD	BLD	2.877	4.190	BLD
Chromium	mg/kg	0 250		3 527	30 571	28.735	35 083	5 822	6 984	9 112	12 483	17.251	13.578	25 251	23 967	40.103	31.281	2.870	37 415	7.721	9.779	38 000	29 628	7 250
Cobalt	mg/kg	0 250		1 497	18 029	10.408	6.188	2.427	2 028	2.579	3.983	3.275	2.302	7.915	7.300	12.474	5 950	0.793	14.218	2.279	3 139	13 308	10 918	2 388
Copper	mg/kg	0 500	34 0	15 313	614.296	310.204	74.243	75.349	9 324	39.255	32 833	29 366	49.515	213.960	173.275	600.000	220.579	3 827	283.672	7.976	28 076	233.846	242.867	21 659
Lead	mg/kg	0 500	46 7	53.628	224.714	406.735	127.348	12 719	3 929	27 937	72.500	270.468	28.907	81.390	72.448	117.526	67.353	0.928	400.000	11.126	17 192	150.462	244.965	25 197
Mercury	mg/kg	0 084	0 2	BLD	BLD	BLD	BLD	BLD	BLD	4.632	0 167	BLD	BLD	BLD	BLD	BLD	BLD	0.129	BLD	BLD	BLD	0.477	0.314	BLD
Molybdenum	mg/kg	0 250		BLD	BLD	14.755	1 677	5.758	BLD	0.841	1 227	0.830	1 178	5.135	2 383	2.907	2.928	BLD	2.357	BLD	0 923	3 846	7 517	BLD
Nickel	mg/kg	0 250	20 9	2.981	224.296	23.873	21.799	6 220	4.273	7.622	9.350	14 035	9.182	20.395	24.749	22.374	19.174	1 317	35.934	6.408	10 142	36.615	28.118	4 071
Selenium	mg/kg	0 750		1.392	BLD	BLD	4 862	1 923	1 352	2 292	2.333	1 974	1 498	7.761	5 234	11.753	4.086	BLD	4 320	2 091	3 659	4 477	BLD	1 843
Silver	mg/kg	0 250	1 0	BLD	BLD	BLD	6.000	1.277	BLD	BLD	1.160	BLD	BLD	1.102	1.455	3.330	BLD	BLD	BLD	BLD	BLD	4.769	1.153	BLD
Thallium	mg/kg	0.750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Vanadium	mg/kg	0 250		4 977	19.057	31.837	21 547	8 011	9 005	10 244	11 717	10 658	8.338	23 591	23 912	40 000	22.603	3.354	54 082	8.056	11.041	37 231	35 374	9 862
Zinc	mg/kg	1 000	150 0	54 408	1830.000	1280.000	483.425	149 867	87 092	187.679	208.333	185.673	235.784	457.181	398.127	1247.423	495.868	26.087	842.857	78 018	119 874	887.892	1840.138	86 329
Polynuclear Aromatic Hydrocarbons:																								
Acenaphthene	µg/kg	[illegible]	[illegible]	[illegible]	[illegible]	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Anthracene	µg/kg	[illegible]	[illegible]	[illegible]	[illegible]	2449	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	92	680	BLD
Benzo(a) anthracene	µg/kg	[illegible]	[illegible]	[illegible]	[illegible]	2246	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	4472	BLD
Benzo(a) pyrene	µg/kg	[illegible]	[illegible]	[illegible]	[illegible]	BLD	BLD	BLD	BLD	129	83	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	323	28231	BLD
Benzo(b) Fluoranthene	µg/kg	50		BLD	BLD	BLD	166	BLD	BLD	72	BLD	BLD	83	BLD	BLD	BLD	BLD	BLD	238	BLD	BLD	569	3741	BLD
Benzo(k) Fluoranthene	µg/kg	50		BLD	BLD	1020	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	246	1156	BLD
Benzo(g,h,i) Perylene	µg/kg	50		104	BLD	BLD	BLD	BLD	BLD	487	BLD	263	97	BLD	BLD	BLD	289	BLD	BLD	BLD	BLD	BLD	578	BLD
Chrysene	µg/kg	50	384 0	BLD	1744	BLD	138	BLD	BLD	143	BLD	88	69	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	431	4472	BLD
Dibenzo-a,h-anthracene	µg/kg	50	63 4	128	1429	BLD	470	BLD	BLD	244	100	292	139	BLD	BLD	BLD	BLD	BLD	BLD	BLD	126	308	680	BLD
Fluoranthene	µg/kg	50	600 0	BLD	BLD	BLD	249	80	BLD	401	BLD	278	166	BLD	136	BLD	BLD	BLD	BLD	BLD	128	882	8103	138
Fluorene	µg/kg	50	19 0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	146	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	108	BLD	BLD
Indeno(1,2,3-c,d) Pyrene	µg/kg	50		70	BLD	BLD	138	66	BLD	100	187	146	BLD	309	193	BLD	248	BLD	204	BLD	126	385	2449	123
2-Methylnaphthalene	µg/kg	50	70 0	BLD	BLD	BLD	BLD	80	BLD	201	BLD	BLD	111	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	748	BLD
Naphthalene	µg/kg	50	160 0	681	BLD	BLD	BLD	815	BLD	BLD	BLD	1155	416	BLD	BLD	BLD	BLD	BLD	1088	BLD	BLD	1442	1224	138
Phenanthrene	µg/kg	50	240 0	BLD	BLD	BLD	221	262	BLD	274	BLD	408	764	BLD	BLD	BLD	BLD	BLD	BLD	BLD	142	738	3102	92
Pyrene	µg/kg	50	665 0	BLD	2000	BLD	193	BLD	BLD	287	BLD	234	194	309	165	BLD	BLD	BLD	272	BLD	95	848	8163	138
Total PAHS	µg/kg	50	4022 0	974	6143	5714	1575	1393	BLD	2335	350	3012	1540	616	496	BLD	537	BLD	1803	BLD	615	6400	79702	630
Pesticides:																								
Aldrin	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Alpha-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Gamma-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	9	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Delta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Chlordane (Technical)	µg/kg	25	0 50	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDT	µg/kg	3	1 00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDD	µg/kg	3	2.00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDE	µg/kg	3	2 20	BLD	1743	BLD	12	BLD	BLD	BLD	8	8	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total DDTs	µg/kg	3	1 60	BLD	1743	BLD	12	BLD	BLD	BLD	8	8	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Dieldrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	8	BLD	BLD	7	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan I	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan II	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan Sulfate	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

Endrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endrin aldehyde	µg/kg	3	0.60	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor epoxide	µg/kg	3	0.20	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Methoxyclor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Toxaphene	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
PCBs:																								
Aroclor-1016	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1221	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1232	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1242	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1248	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1254	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1260	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1262	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total PCBs	µg/kg	25	22.7	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

BLD denotes not detected at indicated reportable limit
*Bold numbers exceed NOAA sediment guideline ERL toxicity values

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TABLE 3
Ranked Sites and Sediment Chemical Concentrations (Dry Weight Basis)
Concentrations are as Chemical (mg)/Sediment(kg) for metals and ug/kg for organics

Site Rank	Total Recoverable Hydrocarbons	Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno(1,2,3-c,d)Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHS
Marvin	2510	Pickford	[illegible]	Higuera	270	Pickford	224	Centinela Ave	1840	Centinela Ave	6163	Centinela Ave	2449	Centinela Ave	[illegible]	Centinela Ave	[illegible]	Centinela Ave	79762
Inglewood	1954	Overland	600	Pickford	222	Centinela Ave	[illegible]	Pickford	1830	Inglewood	862	Inglewood	385	Inglewood	[illegible]	Pickford	[illegible]	Inglewood	[illegible]
Pickford	1200	Marvin	310	Centinela [illegible]	[illegible]	Inglewood	37	Marvin	1260	LaCienega	401	Madison	309	Higuera	[illegible]	[illegible]	[illegible]	Marvin	5714
Ince	1010	Sepulveda Blvd	284	Inglewood	160	Sepulveda Blvd	[illegible]	Overland	1247	Higuera	278	St Nicholas	248	LaCienega	[illegible]	Madison	309	Pickford	6143
Ballona @ Pickford	942	Inglewood	[illegible]	Fairfax	127	Marvin	34	Inglewood	888	Fairfax	249	Sepulveda Blvd	204	Ince	[illegible]	LaCienega	287	Higuera	[illegible]
Centinela Ave	786	Centinela Ave	[illegible]	Overland	[illegible]	Overland	32	Sepulveda Blvd	843	Ince	156	Ballona @ Madison	193	Ballona @ Fairfax	[illegible]	Sepulveda Blvd	272	LaCienega	2335
Fairfax	724	St Nicholas	231	Marvin	107	Madison	30	St Nicholas	496	Ballona @ Madison	139	National	167	Fairfax	221	Higuera	234	Sepulveda Blvd	1803
Sepulveda Blvd	673	Madison	214	Sepulveda Blvd	100	Ballona @ Madison	27	Fairfax	483	Centinela Up	138	Higuera	146	Sepulveda Channel	142	Ince	194	Fairfax	1575
St Nicholas	632	Ballona @ Madison	173	Ballona @ Madison	77	Fairfax	22	Madison	487	Sepulveda Channel	126	Fairfax	138	Centinela Up	92	Fairfax	193	Ince	1540
Higuera	573	Ballona @ Fairfax	178	National	73	St Nicholas	19	Ballona @ Madison	358	Ballona @ Fairfax	80	Sepulveda Channel	126	Madison		Ballona @ Madison	165	Ballona @ Fairfax	1393
Madison	413	Fairfax	[illegible]	St Nicholas	67	Higuera	14	Ince	236	Pickford		Centinela Up	123	St Nicholas		Centinela Up	138	Ballona @ Pickford	974
National	353	Ince	150	Madison	61	Sepulveda Channel	10	National	208	Marvin		LaCienega	100	Sepulveda Blvd		Sepulveda Channel	95	Centinela Up	630
Overland	258	LaCienega	139	Ballona @ Pickford	54	National	9	LaCienega	188	Overland		Pickford	70	Ballona @ Madison		Ballona @ Fairfax		Madison	618
LaCienega	225	National	33	LaCienega	28	Ince	9	Higuera	186	Sepulveda Blvd		Ballona @ Fairfax	66	National		St. Nicholas		Sepulveda Channel	615
Dauphin	224	Higuera	29	Ince	27	LaCienega	8	Ballona @ Fairfax	150	St Nicholas		Ince		Ballona @ Pickford		National		St. Nicholas	537
Ballona @ Madison	201	Sepulveda Channel	28	Centinela Up	25	Ballona @ Sawtelle	6	Sepulveda Channel	120	Madison		Pickford		Pickford		Ballona @ Pickford		Ballona @ Madison	496
Ballona @ Fairfax	200	Centinela Up	22	Sepulveda Channel	17	Ballona @ Fairfax	6	Centinela Up	86	National		Marvin		Marvin		Marvin		National	350
Centinela Up	171	Ballona @ Pickford	15	Ballona @ Fairfax	13	Dauphin	4	Ballona @ Sawtelle	78	Ballona @ Sawtelle		Overland		Overland		Overland		Overland	
Sepulveda Channel	139	Dauphin	9	Ballona @ Sawtelle	11	Centinela Up	4	Dauphin	67	Dauphin		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle	
Ballona @ Sawtelle	74	Ballona @ Sawtelle	8	Dauphin	4	Ballona @ Pickford	3	Ballona @ Pickford	54	Ballona @ Pickford		Dauphin		Dauphin		Dauphin		Dauphin	
Westwood	36	Westwood	4	Westwood	1	Westwood	1	Westwood	26	Westwood		Westwood		Westwood		Westwood		Westwood	

Bold, shaded values indicate sites where sediment values exceeded NOAA ERL values (presented in Table 2)

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TABLE 4

Ranked Sites and Sediment Chemical Concentrations Normalized to the Proportion of Silt and Clay in the Sample

Concentrations are as Chemical (mg)/silt-clay(kg) for metals and ug/kg for organics (Dry Weight Basis)

Site Rank	Total Recoverable Hydrocarbons	Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Total PAHS
Marvin	2510	Pickford	91684	Pickford	33092	Pickford	33475	Pickford	273134	Centinela Ave.	954090
Inglewood	1954	Marvin	8788	Ince	3900	Ince	1331	Marvin	36261	Pickford	767591
Pickford	1200	Ince	7176	Marvin	3024	Ballona @ Sawtelle	1050	Ince	34172	Ince	223120
Ince	1010	Ballona @ Fairfax	1868	Centinela Ave.	2571	Marvin	954	Centinela Ave.	22011	Ballona @ Fairfax	193413
Ballona @ Pickford	942	La Cienega	1817	National	2377	Ballona @ Fairfax	864	Ballona @ Fairfax	20815	Marvin	1618[illegible]
Centinela Ave.	786	Centinela Up	535	Higuera	2155	Centinela Ave.	468	Ballona @ Sawtelle	12790	La Cienega	108113
Fairfax	724	Sepulveda Blvd.	529	Ballona @ Sawtelle	1824	Dauphin	372	La Cienega	8689	Higuera	23998
Sepulveda Blvd.	673	Inglewood	387	Ballona @ Fairfax	1767	La Cienega	353	National	6831	Fairfax	21718
St. Nicholas	632	Madison	346	Fairfax	1757	National	307	Fairfax	6668	Centinela Up	15551
Higuera	573	Sepulveda Channel	322	La Cienega	1293	Fairfax	301	Dauphin	5834	National	11475
Madison	413	Ballona @ Madison	318	Centinela Up	622	Sepulveda Channel	116	Centinela Up	2132	Inglewood	9768
National	353	Centinela Ave.	295	Dauphin	342	Higuera	112	Overland	2095	Sepulveda Channel	7054
Overland	258	Higuera	234	St. Nicholas	284	Centinela Up	101	St. Nicholas	2088	Sepulveda Blvd.	3365
La Cienega	225	National	177	Inglewood	230	St. Nicholas	81	Higuera	1479	St. Nicholas	2262

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Dauphin	224	Fairfax	152	Overland	197	Sepulveda Blvd.	65	Sepulveda Channel	1375	Madison	999
Ballona @ Madison	201	Ballona @ Sawtelle	138	Sepulveda Channel	197	Inglewood	56	Inglewood	1355	Ballona @ Madison	911
Ballona @ Fairfax	200	St. Nicholas	98	Sepulveda Blvd.	187	Overland	54	Sepulveda Blvd.	1200	Ballona @ Sawtelle	0
Centinela Up	171	Dauphin	82	Ballona @ Madison	142	Madison	49	Madison	755	Dauphin	0
Sepulveda Channel	139	Overland	18	Madison	99	Ballona @ Madison	49	Westwood	721	Overland	0
Ballona @ Sawtelle	74	Westwood	1	Westwood	26	Westwood	36	Ballona @ Madison	658	Westwood	0
Westwood	36			Ballona @ Pickford		Ballona @ Pickford		Ballona @ Pickford		Ballona @ Pickford	

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Table 6
Ranked Sites and Sediment Chemical Concentrations Normalized to Total Organic Carbon (TOC) content
Concentrations are as Chemical (mg)/TOC(kg) for metals and ug/kg for organics (Dry Weight Basis)

Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno (1,2,3 c,d) Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHS
Ballona @ Fairfax	274419	Higuera	330948	Sepulveda Blvd	26410	Ballona @ Fairfax	525581	La Cienega	351317	Ballona @ Fairfax	232558	Ballona @ Fairfax	883721	Ince	393258	Ballona @ Fairfax	4883[illegible]1
Sepulveda Blvd	213846	Ballona @ Pickford	121785	Ballona @ Fairfax	21814	Sepulveda Blvd	484615	Higuera	339893	Sepulveda Channel	224090	Ince	533708	Centinella Ave	320856	Higuera	36851[illegible]
Madison	122838	Fairfax	89515	Ince	18596	Ince	477528	Ince	337079	Higuera	178891	Higuera	500894	Higuera	285225	Centinella Ave	31350[illegible]
Ince	100281	Sepulveda Blvd	75385	Sepulveda Channel	18011	Fairfax	339806	Centinella Ave	320856	Madison	177384	Sepulveda Channel	252101	La Cienega	250941	Ince	311[illegible]
St Nicholas	70544	Ince	54494	Madison	17450	Madison	268293	Ballona @ Fairfax	279070	Ballona @ Pickford	157480	La Cienega	238394	Sepulveda Blvd	205128	Ballona @ Pickford	2204[illegible]
Ballona @ Madison	58241	Ballona @ Fairfax	44605	Higuera	17174	Higuera	227191	Sepulveda Channel	224090	Sepulveda Blvd	153846	Centinella Ave.	200535	Madison	177384	La Cienega	20451[illegible]
Fairfax	53592	Madison	35255	Fairfax	15320	Sepulveda Channel	212885	Inglewood	177215	Centinella Up	103226	Fairfax	155340	Inglewood	-174051	Sepulveda Blvd	13589[illegible]
Overland	52909	Inglewood	30949	Pickford	10013	Inglewood	182595	Fairfax	174757	Fairfax	97087	Inglewood	151899	Sepulveda Ch	168067	Inglewood	131645[illegible]
Inglewood	52215	Sepulveda Channel	30532	Dauphin	9767	La Cienega	164366	Centinella Up	116129	Centinella Ave	96257	Centinella Up	77419	Fairfax	135922	Fairfax	110679[illegible]
Sepulveda Channel	49860	National	26852	Ballona @ Madison	8991	Dauphin	153353	Ballona @ Madison	46296	La Cienega	87829	Madison	0	Centinella Up	116129	Sepulveda Channel	109241[illegible]
Higuera	3595[illegible]	Ballona @ [illegible]	[illegible]	Inglewood	7532	St Nicholas	151707	Sepulveda Blvd	0	Inglewood	79114	Ballona @ Pickford	0	Pickford	89286	Centinella Up	5290[illegible]
Ballona @ Pickford	34[illegible]	[illegible]	[illegible]	Ballona @ [illegible]	6745	Ballona @ Pickford	123097	Madison	0	St Nicholas	75853	Sepulveda Blvd	0	Ballona @ Madison	55556	Madison	354[illegible]
La Cienega	3437[illegible]	[illegible]	[illegible]	La Cienega	6675	Ballona @ Madison	120370	Dauphin	0	Ballona @ Madison	64815	St Nicholas	0	Ballona @ Fairfax	0	Pickford	2295[illegible]
Pickford	27423	St Nicholas	20607	Ballona @ Sawtelle	6331	Overland	110000	St Nicholas	0	National	61728	Ballona @ Madison	0	Ballona @ Pickford	0	Ballona @ Madison	1666[illegible]
Dauphin	21312	Ballona @ Sawtelle	10993	St Nicholas	5866	Pickford	81696	Ballona @ Pickford	0	Ince	0	National	0	St Nicholas	0	St Nicholas	164349
Centinella Up	18194	Overland S	10364	National	3463	National	77160	Overland	0	Dauphin	0	Dauphin	0	National	0	National	129[illegible]
National	12160	Pickford	9898	Centinella Up	3419	Ballona @ Sawtelle	77086	Pickford	0	Overland	0	Overland	0	Dauphin	0	Marvin	32147
Centinella Ave.	9545	Dauphin	8980	Overland S	2855	Centinella Up	72516	National	0	Pickford	0	Pickford	0	Overland	0	Dauphin	0
Ballona @ Sawtelle	7881	Centinella Ave	8449	Centinella Ave	1537	Centinella Ave.	72326	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Overland	0
Westwood	3241	Westwood	829	Westwood	1176	Westwood	23307	Westwood	0	Westwood	0	Westwood	0	Westwood	0	Ballona @ Sawtelle	0
Marvin	1745	Marvin	600	Marvin	189	Marvin	7201	Marvin	0	Marvin	0	Marvin	0	Marvin	0	Westwood	0

TABLE 6
Average Ranks of Sites as Measured by Contaminant Group

Sites	Average Ranks by Metals	Average Ranks by PAHs
Ballona @ Pickford	17.75	13
Pickford	1.5	6.5
Marvin	4.5	
Fairfax	8.25	7.5
Ballona @ Fairfax	15	10
Dauphin	19	
LaCienega	13.75	6
National	12.25	7
Higuera	10.25	5.5
Ince	13	6.33
Madison	9	3.5
Ballona @ Madison	9	7.667
Overland	4.5	
St. Nicholas	8.75	4
Westwood	21	
Sepulveda Blvd.	5.5	5.5
Ballona @ Sawtelle	18.25	
Sepulveda Channel	15.25	9.75
Inglewood	4.25	2.25
Centinela Ave.	3	1
Centinela Channel	17.25	9.75

Results

Comparisons Among Sites

The results are presented in several different ways as a means of elucidating differences among sites and to correct for biases in sediment chemistry associated with sediment deposition characteristics. Comparative toxicity information is available for sediment as assessed on a dry weight basis. Thus, dry weight results in Table 2 are presented in comparison to toxicity guidelines. The two additional normalization techniques (TOC and silt/clay) are useful in ranking sites by relative levels of contamination. In general, toxic constituents in sediments tend to be associated with fine particles and with organic compounds and the normalized results shown in Tables 3 and 4 provide a method of standardizing for variability in silt/clay and organic fractions in the samples. Depositing sediment is highly variable with respect to grain size and associated organic content that is associated with the physical process of site-specific deposition rather than sources of contaminants. Thus the normalized values, although not directly comparable to toxicity guidelines, were useful in ranking sites on the basis of the chemistry of the fine, organic fraction of the sediment.

The samples ranged from less than 1% silt plus clay fraction (Ballona Creek at Pickford) to 66% silt/clay (Inglewood Blvd.)(Table 2). Total organic carbon content ranged from 442 mg/kg (Ballona Creek at Pickford) to 17% of total sediment dry weight (Marvin Ave. drain). In general, many of the drains had only fine deposited sediment dominated by living and dead algal mats while the main Ballona Creek channel had relatively much more sand and gravel in the sediment. Locations with noticeable oil in the discharge were Ballona Creek below Pickford, Marvin Ave. (with tar included, as well), Ballona Creek below Fairfax, and Dauphin Ave (particularly heavy oil flow). In addition, the flow from Overland Ave. drain (north side, drain 9404) had no accumulated sediment to sample and appeared to be chronically toxic; no algae or plants occupied the area within the drainage flow or for several hundred feet downstream in Ballona Creek.

Only 4 of the 21 sites were without any chemical concentrations exceeding toxicity guidelines (ERLs); Dauphin Ave., Westwood St., Ballona Creek at Sawtelle, and Centinela Channel. The other sites most often exceeded ERLs for copper, lead, nickel, zinc, and anthracene. Four sites exceeded ERLs for total PAHs or total DDT compounds. With the exception of dieldrin, most pesticides and all PCBs were undetected in the samples (Table 2).

Site Rankings

The sites can be ranked on the basis of dry weight chemistry as presented in Table 2 and shown in rank order for selected constituents of concern. Table 3 shows that Pickford, Centinela Ave., Marvin, and Inglewood most consistently rank as the most contaminated sites with respect to metals and PAHs. The two areas of the main Ballona Channel ranked as most contaminated and exceeding ERLs were sites just downstream of Madison and Fairfax. Other main creek sites appeared relatively clean, probably as a result of dilution of the toxic fraction by gravel and sand.

Rankings based on silt/clay normalized results revealed that Ince Blvd. and Ballona Creek locations at Pickford and Sawtelle could be added to the list of more contaminated sites (Table 4). Marvin, Inglewood, Pickford, and Centinela Ave. remained in the ranks of more contaminated drains in this analysis.

When viewed as TOC normalized values, Ballona Creek sites at Pickford and Fairfax and Higuera, Centinela Ave., Sepulveda Blvd., and Ince drains appeared most contaminated (Table 5). These TOC-based rankings are particularly important in the case of organic contaminants (PAHs).

The summary of average ranks based on the dry weight values as shown in Tables 2 and 3 is shown in Table 6 for major groups of contaminants. For combined metals the 5 most contaminated sites (in order of most contaminated to least) were Pickford, Centinela Ave., Inglewood, and Marvin/Overland (tie). For combined PAHs, the 6 most contaminated sites (same ordering) were Centinela Ave., Inglewood, Madison, St. Nicholas, and Higuera/Sepulveda Blvd (tie). Centinela Ave and Pickford drains consistently rank as containing the most contaminated sediments for either metals or PAHs. The main Ballona Creek sites, Sepulveda Channel, and Centinela Channel consistently rank as among the cleanest sites.

Conclusions

The deposited sediment in the Ballona Creek drains, as sampled toward the end of the seasonal dry period in 1999, represented baseflow conditions incorporating an unknown degree of contaminant accumulation since the last stormwater flows. To the extent that the samples analyzed in this report represent an averaging of upstream sediment quality, results can be compared for relative sediment toxicity and overall levels of contamination. Presumably, the sediments analyzed here were washed out and replaced with stormflow bedload as part of the first rainfall flows in the fall of 1999. It is assumed that the relative contamination associated with suspended sediment in stormflows can be generally related to the sediment quality results as presented in this report.

As shown in Tables 3– 6, many drains into Ballona Creek possess sediments with potentially toxic concentrations of contaminants. The most upstream locations (Pickford and Ballona Creek below Pickford) rank among the most contaminated locations. Many of the drains along the length of Ballona Creek also contribute contaminated sediment. The rankings and comparisons to ERL values shown above point out those most contaminated sites. It is notable that the bedload sediment in the major tributary drains of Sepulveda and Centinela Channels are among the least contaminated samples. Upstream control measures focused on those most contaminated drainages would be likely to improve the quality of Ballona Creek bedload and suspended sediment, including sediment deposited at the mouth of Marina del Rey.

APPENDIX

Insert LabResults

DRAFT
Sediment Sampling Results: Ballona Creek Sediment Contaminants Source Study

Submitted to

U.S. Army Corps of Engineers

Submitted by

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Introduction

Twenty-one sites, including tributary drains and the main creek bed, were sampled for bedload sediment quality along Ballona Creek. The sediment sampling stations were designed to trace the upstream sources of contaminants of concern associated with sediment deposition at the mouth of Ballona Creek and the entrance to Marina del Rey Harbor. Deposited sediments were sampled from sediment accumulation areas representative of a variety of storm drain inputs into Ballona Creek. This report is a summary and evaluation of the chemistry results of the Ballona Creek sediment sampling program.

Sediment samples were collected from the channel bottom of 17 drainages at their mouths, immediately upstream of their confluence with Ballona Creek. In addition, sediments were sampled from the main channel of Ballona Creek at 4 locations. Samples were collected towards the end of the annual low-flow period, on October 5 and 6, 1999 (Table 1). This list varies from that presented in the Sampling and Analysis Plan (CH2M HILL 1999) in that Overland North and the Jefferson area drains were not sampled due to a lack of sediment accumulation. In addition, two new drains were added, from the Holly Hills drains entering below Dauphin Ave. and from the main drains entering under Higuera Street. Sampling locations are shown on the map in the Sampling and Analysis Plan and summarized in Table 1.

TABLE 1
Sampling Locations for Deposited Sediment Quality Sampling in the Ballona Creek Drainage.

Mouth of Drain Location	Approximate miles upstream from mouth of Ballona Creek	L.A. County Drain Number
Centinela Channel	2.6	NA
Centinela Avenue	3.2	51
Inglewood Boulevard	3.5	503
Sepulveda Channel	3.8	NA
Ballona Creek at Sawtelle Boulevard	4.3	All upstream drains
Sepulveda Boulevard	4.5	NA
Westwood/Kingston	4.6	RDD 208
Saint Nicholas Avenue	4.7	2901
Overland (south side)	5.0	RDD 208
Ballona Creek below Madison	5.7	All upstream drains
Madison Avenue	5.7	Benedict Canyon Channel
Ince Boulevard	6.0	Ince Boulevard Drain
Higuera	6.5	NA
National Boulevard	7.0	84
S. La Cienega Boulevard	7.5	9408

TABLE 1
Sampling Locations for Deposited Sediment Quality Sampling in the Ballona Creek Drainage.

Mouth of Drain Location	Approximate miles upstream from mouth of Ballona Creek	L.A. County Drain Number
Dauphin Ave.	7.6	9408/Holly Hills Drain
Ballona Creek below Fairfax	8.0	All upstream drains
Fairfax	8.0	Holly Hills Drain
Marvin Avenue	8.5	494
Pickford Street	9.0	648
Ballona Creek at Pickford	9.0	All upstream drains

NA = Not applicable or not available.

Methods

Field Sampling Methods

Deposited sediments were collected from drainage channel mouths and the main channel of Ballona Creek from areas visually determined to be sediment accumulation areas. The sediment was scooped from the channel bottoms with stainless steel hand trowels. Three separate equal-volume samples were collected within an approximate 1-meter radius and mixed thoroughly by hand in a stainless steel bowl. The resulting composite sample was packed with no head space into chemically clean glass jars. Samples were chilled in the field, held chilled, and transported to the laboratory within two days of collection.

Sampling equipment was chemically decontaminated between sites. A single decontamination rinsate sample (water sample) was collected for each day of sediment sampling.

Sediment Quality Constituents of Concern

The sediments were analyzed for those constituents listed in the Sampling and Analysis Plan and shown in the Results Section, below. Major contaminant groups investigated included metals, PAHs, organochlorine compounds, and pesticides. Grain size analysis and total organic carbon analysis was performed on all samples. All samples were collected in chemically clean glass jars, kept in the dark, and refrigerated prior to analysis.

Normalization of Results

The raw, wet chemistry results expressed in concentration units per weight of wet sediment would not offer a particularly effective means of comparison among sites. In contrast, several types of standardizations were created to provide insights into the differences in contamination among sites. The techniques used were:

- Dry weight normalization; all results were presented as concentration units per dry weight (DW) of sediment.

- TOC normalization; all results were presented as dry weight concentrations per weight of total organic carbon (TOC) in the sample.
- Silt/clay normalization; all results were presented as dry weight concentrations per proportion of silt and clay in the sample.

Sediment chemistry results are presented in the Appendix for all samples and analytes on a wet and dry weight basis. Sediment chemistry results are presented using the three normalization techniques in Tables 2 - 5 for all sampling locations. Sediment toxicity guidelines, presented as Effect Range Low (ERL) values, are shown in the first column of Table 2 as a basis of comparison to known toxic levels of individual contaminants as assessed on a dry weight basis. Tables 3 - 5 shows the ordering of sites by level of contamination in sediment based on selected Table 2 results. Table 6 shows the average ranks for each site by analyte class.

TABLE 2
Ballona Creek Bed Load Sediment Quality
October 5 - 6, 1999

Sediment Concentration by Site (Dry Weight Basis)

Parameters	Units	Reporting Limits	Effect Range Low (ERL)*	Ballona @ Pickford	Pickford	Marvin	Fairfax	Ballona @ Fairfax	Dauphin	La Cienega	National	Higuera	Ince	Madison	Ballona @ Madison	Overland	St Nicholas	Westwood	Sepulveda Blvd	Ballona @ Sawtelle	Sepulveda Channel	Inglewood	Centinela Ave	Centinela Channel
Total Organic Carbon	mg/kg	80		442	22400	177755	1423	285	438	1142	2700	817	494	1741	2975	11340	3269	1119	1327	1012	563	4882	25442	[illegible]
Total Recoverable Hydrocarbons	mg/kg	100		842	1200	2510	724	200	224	225	353	573	1010	413	201	258	632	38	673	74	139	1954	788	[illegible]
Silt/clay	proportion	NA		0.000	0.007	0.035	0.073	0.007	0.012	0.022	0.031	0.128	0.007	0.819	0.545	0.596	0.238	0.038	0.536	0.006	0.087	0.66	0.084	[illegible]
Metals:																								
Antimony	mg/kg	0.750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	1.208	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	2.782	BLD
Arsenic	mg/kg	0.750	8.2	BLD	BLD	BLD	4.882	1.277	1.017	2.564	2.900	1.842	2.399	10.598	8.008	8.345	3.409	BLD	7.585	1.180	8.170	17.231	6.973	[illegible]
Barium	mg/kg	0.500		24.362	448.571	593.878	157.735	31.585	26.148	83.381	99.167	50.282	43.987	205.792	175.207	735.052	157.025	12.547	226.190	38.874	75.710	283.077	213.605	[illegible]
Beryllium	mg/kg	0.250		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Cadmium	mg/kg	0.500	1.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	3.054	2.675	BLD	BLD	BLD	BLD	BLD	BLD	2.677	4.199	BLD
Chromium	mg/kg	0.250		3.527	30.571	28.735	35.083	5.822	6.984	9.112	12.483	17.251	13.578	25.251	23.967	40.103	31.281	2.870	37.415	7.721	9.779	36.000	29.626	7.250
Cobalt	mg/kg	0.250		1.497	16.029	10.408	6.188	2.427	2.028	2.579	3.983	3.275	2.302	7.815	7.300	12.474	5.950	0.793	14.218	2.279	3.139	13.308	10.918	2.366
Copper	mg/kg	0.500	34.0	15.313	614.396	310.204	76.243	78.249	9.324	38.259	32.833	29.386	49.516	212.900	173.278	600.000	220.579	3.627	243.817	7.976	28.076	243.846	242.857	21.659
Lead	mg/kg	0.500	46.7	53.626	224.719	106.735	127.348	12.719	3.929	27.937	72.500	270.468	28.907	81.390	77.410	147.576	67.359	0.928	400.000	11.126	17.192	150.462	244.966	25.192
Mercury	mg/kg	0.084	0.2	BLD	BLD	BLD	BLD	BLD	BLD	1.633	0.187	BLD	BLD	BLD	BLD	BLD	BLD	0.129	BLD	BLD	BLD	0.477	0.314	BLD
Molybdenum	mg/kg	0.250		BLD	BLD	14.755	1.677	5.758	BLD	0.841	1.227	0.830	1.178	5.135	2.383	2.907	2.928	BLD	2.357	BLD	0.923	3.846	7.517	BLD
Nickel	mg/kg	0.250	20.9	2.981	224.396	33.873	31.796	8.220	4.273	7.622	9.350	14.035	9.182	20.366	24.749	32.374	19.174	1.317	35.024	8.408	10.142	36.615	38.118	4.071
Selenium	mg/kg	0.750		1.392	BLD	BLD	4.882	1.923	1.352	2.292	2.333	1.974	1.498	7.761	5.234	11.753	4.066	BLD	4.320	2.091	3.659	4.477	BLD	1.643
Silver	mg/kg	0.250	1.0	BLD	BLD	BLD	6.000	1.277	BLD	BLD	1.100	BLD	BLD	1.152	1.455	3.330	BLD	BLD	BLD	BLD	BLD	4.769	1.133	BLD
Thallium	mg/kg	0.750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Vanadium	mg/kg	0.250		4.977	19.057	31.837	21.547	8.011	9.005	10.244	11.717	10.658	8.336	23.591	23.912	40.000	22.603	3.354	54.082	8.058	11.041	37.231	35.374	9.862
Zinc	mg/kg	1.000	150.0	54.408	1830.000	4280.000	483.425	149.867	67.092	187.678	208.333	185.673	235.784	467.181	398.127	1247.423	495.868	26.087	542.857	78.016	119.874	887.802	1840.530	86.324
Polynuclear Aromatic Hydrocarbons:																								
Acenaphthene	µg/kg	50	16.0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Anthracene	µg/kg	50	85.0	BLD	BLD	2449	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	92	690	BLD
Benzo(a) anthracene	µg/kg	50	261.0	BLD	BLD	2245	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	4472	BLD
Benzo(a) pyrene	µg/kg	50	430.0	BLD	BLD	BLD	BLD	BLD	BLD	129	83	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	323	20231	BLD
Benzo(b) Fluoranthene	µg/kg	50		BLD	BLD	BLD	166	BLD	BLD	72	BLD	BLD	83	BLD	BLD	BLD	BLD	BLD	238	BLD	BLD	569	3741	BLD
Benzo(k) Fluoranthene	µg/kg	50		BLD	BLD	1020	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	246	1156	BLD
Benzo(g,h,i) Perylene	µg/kg	50		104	BLD	BLD	BLD	BLD	BLD	487	BLD	263	97	BLD	BLD	BLD	289	BLD	BLD	BLD	BLD	BLD	578	BLD
Chrysene	µg/kg	50	384.0	BLD	1714	BLD	138	BLD	BLD	143	BLD	88	69	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	431	4472	BLD
Dibenzo-a,h-anthracene	µg/kg	50	63.4	128	1429	BLD	470	BLD	BLD	244	100	292	133	BLD	BLD	BLD	BLD	BLD	BLD	BLD	126	308	690	BLD
Fluoranthene	µg/kg	50	600.0	BLD	BLD	BLD	249	80	BLD	401	BLD	278	166	BLD	138	BLD	BLD	BLD	BLD	BLD	126	862	8103	138
Fluorene	µg/kg	50	19.0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	146	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	108	BLD	BLD
Indeno(1,2,3-c,d) Pyrene	µg/kg	50		70	BLD	BLD	138	68	BLD	100	187	146	BLD	309	183	BLD	246	BLD	204	BLD	126	385	2449	123
2-Methylnaphthalene	µg/kg	50	70.0	BLD	BLD	BLD	BLD	80	BLD	201	BLD	BLD	111	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	748	BLD
Naphthalene	µg/kg	50	160.0	681	BLD	BLD	BLD	815	BLD	BLD	BLD	1155	416	BLD	BLD	BLD	BLD	BLD	1088	BLD	BLD	1482	11224	138
Phenanthrene	µg/kg	50	240.0	BLD	BLD	BLD	221	262	BLD	272	BLD	409	261	BLD	BLD	BLD	BLD	BLD	BLD	BLD	142	738	5102	92
Pyrene	µg/kg	50	665.0	BLD	2000	BLD	193	BLD	BLD	287	BLD	234	194	309	165	BLD	BLD	BLD	272	BLD	95	846	8163	138
Total PAHS	µg/kg	50	4022.0	974	5143	5714	1575	1393	BLD	2335	350	3012	1540	618	496	BLD	537	BLD	1803	BLD	615	6400	79782	630
Pesticides:																								
Aldrin	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Alpha-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Gamma-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	9	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Delta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Chlordane (Technical)	µg/kg	25	0.50	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDT	µg/kg	3	1.00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDD	µg/kg	3	2.00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDE	µg/kg	3	2.20	BLD	1743	BLD	12	BLD	BLD	BLD	8	8	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total DDTs	µg/kg	3	1.60	BLD	1743	BLD	12	BLD	BLD	BLD	8	8	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Dieldrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	8	BLD	BLD	7	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan I	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan II	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan Sulfate	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

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Endrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endrin aldehyde	µg/kg	3	0.60	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor epoxide	µg/kg	3	0.20	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Methoxyclor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Toxaphene	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
PCBs:																								
Aroclor-1016	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1221	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1232	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1242	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1248	µg/kg	25		BLD	BLD	BLD	*BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1254	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1260	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1262	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total PCBs	µg/kg	25	22.7	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

BLD denotes not detected at indicated reportable limit.
*Bold numbers exceed NOAA sediment guideline ERL toxicity values.

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TABLE 3
Ranked Sites and Sediment Chemical Concentrations (Dry Weight Basis)
Concentrations are as Chemical (mg)/Sediment(kg) for metals and ug/kg for organics

Site Rank	Total Recoverable Hydrocarbons	Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno(1,2,3-c,d)Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHs
Marvin	2510	Pickford	614	Higuera	270	Pickford	224	Centinela Ave	1840	Centinela Ave	8163	Centinela Ave	2449	Centinela Ave	5102	Centinela Ave	6163	Centinela Ave	79762
Inglewood	1954	Overland	600	Pickford	222	Centinela Ave	39	Pickford	1830	Inglewood	862	Inglewood	385	Inglewood	739	Pickford	2000	Inglewood	8400
Pickford	1200	Marvin	310	Centinela Blvd	216	Inglewood	37	Marvin	1280	LaCienega	401	Madison	309	Higuera	[illegible]	Inglewood	[illegible]	Marvin	5714
Ince	1010	Sepulveda Blvd	284	Inglewood	160	Sepulveda Blvd	36	Overland	1247	Higuera	278	St. Nicholas	248	LaCienega	272	Madison	309	Pickford	6143
Ballona @ Pickford	942	Inglewood	284	Fairfax	127	Marvin	34	Inglewood	888	Fairfax	249	Sepulveda Blvd	204	Ince	264	LaCienega	287	Higuera	[illegible]
Centinela Ave	786	Centinela Ave	243	Overland	114	Overland	32	Sepulveda Blvd	643	Ince	166	Ballona @ Madison	193	Ballona @ Fairfax	252	Sepulveda Blvd	272	LaCienega	[illegible]
Fairfax	724	St Nicholas	231	Marvin	107	Madison	30	St Nicholas	496	Ballona @ Madison	138	National	167	Fairfax	221	Higuera	234	Sepulveda Blvd	[illegible]
Sepulveda Blvd	673	Madison	214	Sepulveda Blvd	100	Ballona @ Madison	27	Fairfax	483	Centinela Up	138	Higuera	146	Sepulveda Channel	142	Ince	194	Fairfax	[illegible]
St Nicholas	632	Ballona @ Madison	173	Ballona @ Madison	77	Fairfax	22	Madison	487	Sepulveda Channel	126	Fairfax	138	Centinela Up	92	Fairfax	193	Ince	[illegible]
Higuera	573	Ballona @ Fairfax	78	National	73	St Nicholas	19	Ballona @ Madison	356	Ballona @ Fairfax	80	Sepulveda Channel	126	Madison		Ballona @ Madison	165	Ballona @ Fairfax	[illegible]
Madison	413	Fairfax	76	St Nicholas	67	Higuera	14	Ince	236	Pickford		Centinela Up	123	St Nicholas		Centinela Up	138	Ballona @ Pickford	[illegible]
National	353	Ince	50	Madison	61	Sepulveda Channel	10	National	208	Marvin		LaCienega	100	Sepulveda Blvd		Sepulveda Channel	95	Centinela Up	[illegible]
Overland	258	LaCienega	39	Ballona @ Pickford	54	National	9	LaCienega	188	Overland		Ballona @ Pickford	70	Ballona @ Madison		Ballona @ Fairfax		Madison	[illegible]
LaCienega	225	National	33	LaCienega	28	Ince	9	Higuera	186	Sepulveda Blvd		Ballona @ Fairfax	66	National		St Nicholas		Sepulveda Channel	615
Dauphin	224	Higuera	29	Ince	27	LaCienega	8	Ballona @ Fairfax	150	St Nicholas		Ince		Ballona @ Pickford		National		St. Nicholas	537
Ballona @ Madison	201	Sepulveda Channel	28	Centinela Up	25	Ballona @ Sawtelle	6	Sepulveda Channel	120	Madison		Pickford		Pickford		Ballona @ Pickford		Ballona @ Madison	495
Ballona @ Fairfax	200	Centinela Up	22	Sepulveda Channel	17	Fairfax	6	Centinela Up	86	National		Marvin		Marvin		Marvin		National	350
Centinela Up	171	Ballona @ Pickford	15	Ballona @ Fairfax	13	Dauphin	4	Ballona @ Sawtelle	78	Ballona @ Sawtelle		Overland		Overland		Overland		Overland	
Sepulveda Channel	139	Dauphin	9	Sawtelle	11	Centinela Up	4	Dauphin	67	Dauphin		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle	
Ballona @ Sawtelle	74	Ballona @ Sawtelle	8	Dauphin	4	Ballona @ Pickford	3	Ballona @ Pickford	54	Ballona @ Pickford		Dauphin		Dauphin		Dauphin		Dauphin	
Westwood	36	Westwood	4	Westwood	1	Westwood	1	Westwood	26	Westwood		Westwood		Westwood		Westwood		Westwood	

Bold, shaded values indicate sites where sediment values exceeded NOAA ERL values (presented in Table 2)

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TABLE 4
Ranked Sites and Sediment Chemical Concentrations Normalized to the Proportion of Silt and Clay in the Sample
Concentrations are as Chemical (mg)/silt-clay(kg) for metals and ug/kg for organics (Dry Weight Basis)

Site Rank	Total Recoverable Hydrocarbons	Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Total PAHS
Marvin	2510	Pickford	91684	Pickford	33092	Pickford	33475	Pickford	273134	Centinela Ave.	954090
Inglewood	1954	Marvin	8788	Ince	3900	Ince	1331	Marvin	36261	Pickford	767591
Pickford	1200	Ince	7176	Marvin	3024	Ballona @ Sawtelle	1050	Ince	34172	Ince	223120
Ince	1010	Ballona @ Fairfax	1868	Centinela Ave.	2571	Marvin	954	Centinela Ave.	22011	Ballona @ Fairfax	193413
Ballona @ Pickford	942	La Cienega	1817	National	2377	Ballona @ Fairfax	864	Ballona @ Fairfax	20815	Marvin	161878
Centinela Ave.	786	Centinela Up	535	Higuera	2155	Centinela Ave.	468	Ballona @ Sawtelle	12790	La Cienega	108113
Fairfax	724	Sepulveda Blvd.	529	Ballona @ Sawtelle	1824	Dauphin	372	La Cienega	8689	Higuera	23998
Sepulveda Blvd.	673	Inglewood	387	Ballona @ Fairfax	1767	La Cienega	353	National	6831	Fairfax	21718
St. Nicholas	632	Madison	346	Fairfax	1757	National	307	Fairfax	6668	Centinela Up	15551
Higuera	573	Sepulveda Channel	322	La Cienega	1293	Fairfax	301	Dauphin	5834	National	11475
Madison	413	Ballona @ Madison	318	Centinela Up	622	Sepulveda Channel	116	Centinela Up	2132	Inglewood	9768
National	353	Centinela Ave.	295	Dauphin	342	Higuera	112	Overland	2095	Sepulveda Channel	7054
Overland	258	Higuera	234	St. Nicholas	284	Centinela Up	101	St. Nicholas	2088	Sepulveda Blvd.	3365
La Cienega	225	National	177	Inglewood	230	St. Nicholas	81	Higuera	1479	St. Nicholas	2262

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Dauphin	224	Fairfax	152	Overland	197	Sepulveda Blvd.	65	Sepulveda Channel	1375	Madison	999
Ballona @ Madison	201	Ballona @ Sawtelle	138	Sepulveda Channel	197	Inglewood	56	Inglewood	1355	Ballona @ Madison	911
Ballona @ Fairfax	200	St. Nicholas	98	Sepulveda Blvd.	187	Overland	54	Sepulveda Blvd.	1200	Ballona @ Sawtelle	0
Centinela Up	171	Dauphin	82	Ballona @ Madison	142	Madison	49	Madison	755	Dauphin	0
Sepulveda Channel	139	Overland	18	Madison	99	Ballona @ Madison	49	Westwood	721	Overland	0
Ballona @ Sawtelle	74	Westwood	1	Westwood	26	Westwood	36	Ballona @ Madison	658	Westwood	0
Westwood	36			Ballona @ Pickford		Ballona @ Pickford		Ballona @ Pickford		Ballona @ Pickford	

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Table 6

Ranked Sites and Sediment Chemical Concentrations Normalized to Total Organic Carbon (TOC) content

Concentrations are as Chemical (mg)/TOC(kg) for metals and ug/kg for organics (Dry Weight Basis)

Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno (1,2,3-c,d) Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHS
Ballona @ Fairfax	274419	Higuera	330948	Sepulveda Blvd.	26410	Ballona @ Fairfax	525581	La Cienega	351317	Ballona @ Fairfax	232558	Ballona @ Fairfax	883721	Ince	393258	Ballona @ Fairfax	4883721
Sepulveda Blvd.	213846	Ballona @ Pickford	121785	Ballona @ Fairfax	21814	Sepulveda Blvd	484615	Higuera	339893	Sepulveda Channel	224090	Ince	533708	Centinella Ave.	320856	Higuera	3685152
Madison	122838	Fairfax	89515	Ince	18596	Ince	477528	Ince	337079	Higuera	178891	Higuera	500894	Higuera	286225	Centinella Ave.	3135027
Ince	100281	Sepulveda Blvd	75385	Sepulveda Channel	18011	Fairfax	339806	Centinella Ave	320856	Madison	177384	Sepulveda Channel	252101	La Cienega	250941	Ince	3117978
St. Nicholas	70544	Ince	54494	Madison	17450	Madison	268293	Ballona @ Fairfax	279070	Ballona @ Pickford	157480	La Cienega	238394	Sepulveda Blvd.	205128	Ballona @ Pickford	2204724
Ballona @ Madison	58241	Ballona @ Fairfax	44605	Higuera	17174	Higuera	227191	Sepulveda Channel	224090	Sepulveda Blvd.	153846	Centinella Ave.	200535	Madison	177384	La Cienega	2045169
Fairfax	53592	Madison	35255	Fairfax	15320	Sepulveda Channel	212885	Inglewood	177215	Centinella Up	103226	Fairfax	155340	Inglewood	174051	Sepulveda Blvd.	1358974
Overland	52909	Inglewood	30949	Pickford	10013	Inglewood	182595	Fairfax	174757	Fairfax	97087	Inglewood	151899	Sepulveda Ch	168067	Inglewood	1316456
Inglewood	52215	Sepulveda Channel	30532	Dauphin	9767	La Cienega	164366	Centinella Up	116129	Centinella Ave.	96257	Centinella Up	77419	Fairfax	135922	Fairfax	1106796
Sepulveda Channel	49860	National	26852	Ballona @ Madison	8991	Dauphin	153353	Ballona @ Madison	46296	La Cienega	87829	Madison	0	Centinella Up	116129	Sepulveda Channel	1092437
Higuera	35957	Ballona @ Madison	26019	Inglewood	7532	St. Nicholas	151707	Sepulveda Blvd	0	Inglewood	79114	Ballona @ Pickford	0	Pickford	89286	Centinella Up	529032
Ballona @ Pickford	34646	La Cienega	24467	Ballona @ Pickford	6745	Ballona @ Pickford	123097	Madison	0	St. Nicholas	75853	Sepulveda Blvd.	0	Ballona @ Madison	55556	Madison	354767
La Cienega	34379	Centinella Up	21161	La Cienega	6675	Ballona @ Madison	120370	Dauphin	0	Ballona @ Madison	64815	St. Nicholas	0	Ballona @ Fairfax	0	Pickford	229592
Pickford	27423	St. Nicholas	20607	Ballona @ Sawtelle	6331	Overland	110000	St. Nicholas	0	National	61728	Ballona @ Madison	0	Ballona @ Pickford	0	Ballona @ Madison	166667
Dauphin	21312	Ballona @ Sawtelle	10993	St. Nicholas	5866	Pickford	81696	Ballona @ Pickford	0	Ince	0	National	0	St. Nicholas	0	St. Nicholas	164349
Centinella Up	18194	Overland S	10364	National	3463	National	77160	Overland	0	Dauphin	0	Dauphin	0	National	0	National	129630
National	12160	Pickford	9898	Centinella Up	3419	Ballona @ Sawtelle	77086	Pickford	0	Overland	0	Overland	0	Dauphin	0	Marvin	32147
Centinella Ave.	9545	Dauphin	8980	Overland S	2855	Centinella Up	72516	National	0	Pickford	0	Pickford	0	Overland	0	Dauphin	0
Ballona @ Sawtelle	7881	Centinella Ave.	8449	Centinella Ave.	1537	Centinella Ave.	72326	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Overland	0
Westwood	3241	Westwood	829	Westwood	1176	Westwood	23307	Westwood	0	Westwood	0	Westwood	0	Westwood	0	Ballona @ Sawtelle	0
Marvin	1745	Marvin	600	Marvin	189	Marvin	7201	Marvin	0	Marvin	0	Marvin	0	Marvin	0	Westwood	0

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TABLE 6
Average Ranks of Sites as Measured by Contaminant Group

Sites	Average Ranks by Metals	Average Ranks by PAHs
Ballona @ Pickford	17.75	13
Pickford	1.5	6.5
Marvin	4.5	
Fairfax	8.25	7.5
Ballona @ Fairfax	15	10
Dauphin	19	
LaCienega	13.75	6
National	12.25	7
Higuera	10.25	5.5
Ince	13	6.33
Madison	9	3.5
Ballona @ Madison	9	7.667
Overland	4.5	
St. Nicholas	8.75	4
Westwood	21	
Sepulveda Blvd.	5.5	5.5
Ballona @ Sawtelle	18.25	
Sepulveda Channel	15.25	9.75
Inglewood	4.25	2.25
Centinela Ave.	3	1
Centinela Channel	17.25	9.75

Results

Comparisons Among Sites

The results are presented in several different ways as a means of elucidating differences among sites and to correct for biases in sediment chemistry associated with sediment deposition characteristics. Comparative toxicity information is available for sediment as assessed on a dry weight basis. Thus, dry weight results in Table 2 are presented in comparison to toxicity guidelines. The two additional normalization techniques (TOC and silt/clay) are useful in ranking sites by relative levels of contamination. In general, toxic constituents in sediments tend to be associated with fine particles and with organic compounds and the normalized results shown in Tables 3 and 4 provide a method of standardizing for variability in silt/clay and organic fractions in the samples. Depositing sediment is highly variable with respect to grain size and associated organic content that is associated with the physical process of site-specific deposition rather than sources of contaminants. Thus the normalized values, although not directly comparable to toxicity guidelines, were useful in ranking sites on the basis of the chemistry of the fine, organic fraction of the sediment.

The samples ranged from less than 1% silt plus clay fraction (Ballona Creek at Pickford) to 66% silt/clay (Inglewood Blvd.)(Table 2). Total organic carbon content ranged from 442 mg/kg (Ballona Creek at Pickford) to 17% of total sediment dry weight (Marvin Ave. drain). In general, many of the drains had only fine deposited sediment dominated by living and dead algal mats while the main Ballona Creek channel had relatively much more sand and gravel in the sediment. Locations with noticeable oil in the discharge were Ballona Creek below Pickford, Marvin Ave. (with tar included, as well), Ballona Creek below Fairfax, and Dauphin Ave (particularly heavy oil flow). In addition, the flow from Overland Ave. drain (north side, drain 9404) had no accumulated sediment to sample and appeared to be chronically toxic; no algae or plants occupied the area within the drainage flow or for several hundred feet downstream in Ballona Creek.

Only 4 of the 21 sites were without any chemical concentrations exceeding toxicity guidelines (ERLs); Dauphin Ave., Westwood St., Ballona Creek at Sawtelle, and Centinela Channel. The other sites most often exceeded ERLs for copper, lead, nickel, zinc, and anthracene. Four sites exceeded ERLs for total PAHs or total DDT compounds. With the exception of dieldrin, most pesticides and all PCBs were undetected in the samples (Table 2).

Site Rankings

The sites can be ranked on the basis of dry weight chemistry as presented in Table 2 and shown in rank order for selected constituents of concern. Table 3 shows that Pickford, Centinela Ave., Marvin, and Inglewood most consistently rank as the most contaminated sites with respect to metals and PAHs. The two areas of the main Ballona Channel ranked as most contaminated and exceeding ERLs were sites just downstream of Madison and Fairfax. Other main creek sites appeared relatively clean, probably as a result of dilution of the toxic fraction by gravel and sand.

Rankings based on silt/clay normalized results revealed that Ince Blvd. and Ballona Creek locations at Pickford and Sawtelle could be added to the list of more contaminated sites (Table 4). Marvin, Inglewood, Pickford, and Centinela Ave. remained in the ranks of more contaminated drains in this analysis.

When viewed as TOC normalized values, Ballona Creek sites at Pickford and Fairfax and Higuera, Centinela Ave., Sepulveda Blvd., and Ince drains appeared most contaminated (Table 5). These TOC-based rankings are particularly important in the case of organic contaminants (PAHs).

The summary of average ranks based on the dry weight values as shown in Tables 2 and 3 is shown in Table 6 for major groups of contaminants. For combined metals the 5 most contaminated sites (in order of most contaminated to least) were Pickford, Centinela Ave., Inglewood, and Marvin/Overland (tie). For combined PAHs, the 6 most contaminated sites (same ordering) were Centinela Ave., Inglewood, Madison, St. Nicholas, and Higuera/Sepulveda Blvd (tie). Centinela Ave and Pickford drains consistently rank as containing the most contaminated sediments for either metals or PAHs. The main Ballona Creek sites, Sepulveda Channel, and Centinela Channel consistently rank as among the cleanest sites.

Conclusions

The deposited sediment in the Ballona Creek drains, as sampled toward the end of the seasonal dry period in 1999, represented baseflow conditions incorporating an unknown degree of contaminant accumulation since the last stormwater flows. To the extent that the samples analyzed in this report represent an averaging of upstream sediment quality, results can be compared for relative sediment toxicity and overall levels of contamination. Presumably, the sediments analyzed here were washed out and replaced with stormflow bedload as part of the first rainfall flows in the fall of 1999. It is assumed that the relative contamination associated with suspended sediment in stormflows can be generally related to the sediment quality results as presented in this report.

As shown in Tables 3 - 6, many drains into Ballona Creek possess sediments with potentially toxic concentrations of contaminants. The most upstream locations (Pickford and Ballona Creek below Pickford) rank among the most contaminated locations. Many of the drains along the length of Ballona Creek also contribute contaminated sediment. The rankings and comparisons to ERL values shown above point out those most contaminated sites. It is notable that the bedload sediment in the major tributary drains of Sepulveda and Centinela Channels are among the least contaminated samples. Upstream control measures focused on those most contaminated drainages would be likely to improve the quality of Ballona Creek bedload and suspended sediment, including sediment deposited at the mouth of Marina del Rey.

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APPENDIX

Insert LabResults

1999-2000

LOS ANGELES COUNTY

GRAND JURY

Final Report

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INTRODUCTION

COMMITTEE REPORTS

REDUCING THE HEALTH RISKS OF SWIMMING AT LOS ANGELES COUNTY BEACHES

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LIST OF ACRONYMS

BMP	Best Management Practice
CDS	Continuous Deflective Separation
DBH	Los Angeles County Department of Beaches and Harbors
DHS	Los Angeles County Department of Health Services
NPDES	National Pollutant Discharge Elimination System
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SCAQMD	South Coast Air Quality Management District
SIC	Standard Industrial Classification
SMURRF	Santa Monica Urban Runoff Recycling Facility
SMBRP	Santa Monica Bay Restoration Project
TMDL	Total Maximum Daily Load
TWC	Topanga Watershed Committee
WDR	Waste Discharge Requirements
WHO	World Health Organization

SUMMARY

This report examines the health risks of swimming (and water-contact recreation more generally) at the beaches in Los Angeles County and the policies and programs in place to reduce these risks. Health risks are of concern first because of the negative effects on the swimmers who contract illnesses. They are also of concern because the perception or reality that beach waters are not safe for swimming has negative effects on the economies of beach communities and perhaps even on the economy of the county as a whole. Finally, health risks are of concern because they limit an important recreational opportunity and reduce the well-being of the citizens of L.A. County.

Based on the findings of our investigation, we believe there are important areas where policies and programs to clean up beach waters can be improved. Therefore, we make recommendations to the Los Angeles County Board of Supervisors, various departments in the County and in the cities within the County, that address:

- the process for monitoring water quality at the beaches, assessing swimming risks, and communicating these risks to the public.
- efforts to improve the water quality during dry weather at seven problem beaches.
- policies and procedures for improving the quality of rivers, creeks and storm drains that flow into the ocean.

The objectives of our recommendations are to reduce the health risks of swimming at beaches in L.A. County and to ensure that the programs in place to reduce risks are sensible in terms of cost. Our recommendations also aim to establish programs that accurately communicate the health risks of swimming at L.A. beaches to the citizens of the County. Many of our recommendations are addressed to government entities other than the Board of Supervisors or County departments. However, in the interests of the residents of L.A. County, the Board of Supervisors should take an aggressive leadership role to ensure that all these recommendations are carried out.

In the remainder of this summary, we present our key findings and recommendations on (1) water quality at Los Angeles County beaches; (2) health risks of swimming at the beach; (3) improving the public understanding of beach water quality; (4) improving water quality at seven problem beaches in L.A. County; and (5) improving the water quality in the rivers, creeks, and storm drains that flow into the ocean. We conclude with a table listing the government agencies responsible for key recommendations.

WATER QUALITY AT LOS ANGELES COUNTY BEACHES DURING DRY AND WET WEATHER

Most of the beaches in L.A. County meet health standards during dry weather. Heal the Bay, an environmental group based in Santa Monica, grades beaches based on water quality data provided by city and county agencies. Over the last five years, slightly over two-thirds of the beaches monitored received annual grades of A or better during dry weather. Roughly speaking, an A grade means that water quality meets health standards in more than 90 percent of the samples taken during the year. Even during dry weather, however, there are a number of beaches in the County with persistent pollution problems. The water at Cabrillo Beach, considered the dirtiest in the County, exceeded health standards in more than two-thirds of dry-weather samples over the last year.

Water quality is poor at almost all L.A. County beaches during wet weather--defined as periods during and for the three days following rain. It rains more than 0.01 inches an average of 36 days per year in Los Angeles. Over the last 5 years, less than 20 percent of beaches on average received grades of A or better during wet weather.

HEALTH RISKS OF SWIMMING AT THE BEACH

Studies have shown higher rates of fever, chills, ear discharge, vomiting, phlegm, highly credible gastroenteritis, and significant respiratory disease among those swimming in beach waters that do not meet health standards. The increases in illness rates are not large, however, rising to roughly 4 percent in people swimming in water with elevated pollutant levels from 2 percent in those swimming in clean water.

Severity of these illnesses has not been well studied, either in L.A. County or marine water elsewhere, but there have not been reports of life threatening illness associated with swimming in the County, despite the large number of beachgoers. There has also been little study of long-term health effects of repeated exposure to elevated pollution levels in beach waters. But again, the lack of reports of chronic effects suggests that such risks are not substantial.

Even though demonstrated health effects of swimming in L.A. County beach water do not appear substantial, uncertainties remain both about health effects and how well current water-quality monitoring techniques protect the public. We thus recommend additional research on health risks and on the most effective way to detect water quality problems (see Section 3.1).

IMPROVING THE PUBLIC UNDERSTANDING OF BEACH WATER QUALITY

We are concerned that the public has an inaccurate and overly negative impression of beach water quality. Beach attendance fell by 32 percent between 1983 and 1997. This decline could have been due to many factors, but increasing concern about water quality may have played a role. Ongoing research on perceptions about L.A. County beaches suggests that people think that some beaches are dirtier than others but are confused about which ones have the worst water quality. We also suspect that the public has very little understanding of the types of illnesses that are associated with swimming in polluted water.

We make two recommendations aimed at improving the public's understanding of water quality at County beaches. (The recommendation numbers correspond to section numbers in the full report.)

Recommendations

3.2-A **The L.A. County Department of Health Services should develop a grading system for beaches similar to that used at L.A. County restaurants and post these grades at sampling locations and in other highly visible locations at the beaches.**

3.2-B **The L.A. County Department of Health Services should initiate a public information campaign to accurately communicate to L.A. County residents the health risks of swimming at L.A. County beaches. The message should be that:**

- **Beaches in L.A. County are among the best monitored in the nation.**
- **Swimming is safe during dry weather at the vast majority of beaches, although a few problem areas remain.**
- **Water quality standards are typically exceeded during rainstorms and beachgoers should not swim during or in the three days following significant rain (i.e. greater than 0.1 inch).**

The campaign should also provide accurate information on the types of illnesses and the chances of contracting them from swimming at beaches that violate health standards.

IMPROVING WATER QUALITY AT SEVEN PROBLEM BEACHES IN L.A. COUNTY

We examined the specific problems at seven beaches: Surfrider, Topanga Canyon, Santa Monica Canyon, Santa Monica Pier, Pico-Kenter, Mother's Beach in Marina del Rey, and Cabrillo Beach (See Figure 4.1 for a map of their locations). The beaches were chosen based on their consistently poor water quality. With only a few exceptions, these beaches are the only beaches in the County with consistent dry-weather problems.

Our investigation of these seven beaches uncovered two major issues. The first is what should be done about the septic systems in Malibu. The second is how to handle conflicting uses at some beaches.

Septic Systems in Malibu

Most of the stakeholders we interviewed outside the City of Malibu think that septic systems are a major source of pollution in the Malibu Lagoon and Surfrider Beach and think that a sewer system should be installed. Most in Malibu think that there is not clear evidence that septic tanks are a problem and vigorously resist sewers. We see the need for independent, objective information on the scope of the problem and, given the power of vested interests, believe that Malibu cannot be left to resolve this issue on its own. We thus recommend that the Regional Board take the lead to resolve this issue.

Recommendations

4.1-A **Commercial and multi-family residential septic system owners in Malibu should obtain waste discharge permits from the Regional Board and comply with the terms of those permits.**

This type of permit is required of anyone discharging waste that could affect the quality of water resources in the State of California. Septic system owners in Malibu should not be exempted from this requirement. The groundwater monitoring information collected under the terms of these permits is needed to resolve the issue of whether or not septic systems are a problem.

4.1-B Groundwater levels in residential areas with a high water table, especially residential properties near the Malibu lagoon, should be monitored.

The City of Malibu has found it difficult to access private residential properties for monitoring.

Competing Uses

The second major issue we found is the existence of competing uses at three of the seven problem beaches investigated. The minimal success of the City of Santa Monica's substantial efforts to improve water quality south of Santa Monica Pier raises the concern that a heavily-visited pier and an adjacent swimming area are not compatible uses. Similarly, swimming may not be an appropriate use at Mother's Beach, a beach that has limited water circulation, is populated by birds, and that is located adjacent to a marina. Cabrillo has limited circulation, is located adjacent to a wildlife refuge, and is heavily populated with birds. The competing uses at Cabrillo Beach are swimming and bird habitat.

Society's resources are scarce, and there is no point in spending money to try to meet health standards for swimming when the efforts will be frustrated by other uses. At each of these three beaches, we thus recommend that the responsible authorities (the City of Santa Monica for the Santa Monica Pier, the County of Los Angeles for Mother's Beach, and the City of Los Angeles for Cabrillo Beach) regularly reassess their water quality goals for these beaches. It may not make sense to spend large amounts of money to meet the swimming standards at these beaches.

Recommendations

4.4-E, 4.6-C, 4.7-C The responsible authorities at Santa Monica Pier, Mother's Beach, and Cabrillo Beach should continue with some of the modest programs that are in place or planned to improve water quality. However, before moving on to very expensive solutions they should reconsider the water quality goals for these beaches.

Given the relatively modest health risks of swimming at these beaches, we do not believe that they should be closed if water quality does not improve. Rather we make the following recommendations:

Recommendations

4.4-D, 4.6-B, 4.7-B Until water quality improves, the responsible authorities should permanently post signs at Santa Monica Pier, Mother's Beach and Cabrillo Beach that warn beachgoers of consistently poor water quality and briefly describe the health risks associated with swimming in polluted waters.

IMPROVING THE QUALITY OF URBAN RUNOFF

The water in the rivers, creeks, and storm drains that flow into the ocean carries pollution that causes a large majority of beaches to exceed health standards during wet weather and that causes violations at some beaches during dry weather. The Regional Board has ambitious plans to improve the water quality of these watercourses in L.A. County. However, we are concerned that the institutions, programs, and resources in place may not be up to the job. We make recommendations for improving the system in seven different areas (numbered according to where they appear in the full report):

- 5.1 - Setting goals for the uses of rivers, creeks, estuaries, and beach waters.
- 5.2 - Identifying pollution sources.
- 5.4 - Enhancing incentives to improve water quality.
- 5.5 - Matching authority with responsibility.
- 5.6 - Policies for diverting urban runoff into the sewer system.
- 5.7 - Monitoring and enforcement.
- 5.8 - Funding for water quality programs.

Here we discuss the four most important.

Setting Goals for the Uses of Rivers, Creeks, Estuaries, and Beach Waters

The Regional Board has designated beneficial uses for specific water bodies in L.A. County. These designated beneficial uses drive the water quality goals for these water bodies and thus the cleanup costs. There is a great deal of controversy over these beneficial uses. Several important stakeholders feel that some of the designated beneficial uses are inappropriate and that the process through which beneficial uses were designated (mainly in the 1970s) was inadequate. Their lack of support stops many of them from fully supporting and contributing to efforts to improve the quality of urban runoff and may lead to lawsuits that can further slow the process.

Our examination of the beneficial uses in L.A. County also suggests that there are conflicts among the beneficial uses that have been designated for some water bodies. Examples include the three beaches discussed above. The inconsistencies between some beneficial uses and the lack of support for others lead us to the following recommendation.

Recommendation

5.1 A meaningful process to prioritize the beneficial uses for the water bodies in L.A. County should be created. Near-term water quality programs should attempt to achieve the high-priority beneficial uses. Programs required to achieve lower priority beneficial uses should be deferred.

Matching Authority with Responsibility

There are several important sources of pollution in urban runoff that neither the Regional Board nor the cities, County, and businesses it regulates have the power to reduce at the source. For example, automobile and truck brake pads are thought to be a significant source of the copper that winds up in urban runoff, but neither the Board nor the regulated entities can require that brake pads contain less copper. Current institutional boundaries also restrict the types of remediation strategies that can be considered. Natural attenuation of some pollutants in stream beds and wetlands may make a lot of sense and create multiple benefits, but the Regional Board and regulated entities often do not have the authority to restore stream channels that are encased in concrete to more natural states or to build or restore wetlands.

The lack of authority over important sources of pollution or the ability to implement certain treatment strategies means that certain types of solutions are not even considered, and even if considered, are quickly taken off the table. As a consequence, cities and others may be forced into expensive end-of-the-pipe treatment when other approaches are more sensible. This is not a desirable outcome. We as a society should not let institutional boundaries get in the way of the best solutions.

Recommendation

5.5 The County should lead an effort to identify what additional powers are needed by the Regional Board, the cities, and the County pertaining to water quality control, determine who should have these powers, and then obtain them.

Monitoring and Enforcement

No matter how good they may look on paper, efforts to clean up the rivers, creeks, and ocean in L.A. County are only effective to the extent that the responsible organizations translate the words into action. To make sure that our pollution control system is more than a paper tiger, additional resources need to be spent on auditing the activities that actually reduce pollution. In addition, our investigation found overlap and lack of coordination between enforcement efforts of the Regional Board and the county and the cities in the County. We also found that current requirements in most jurisdictions to prosecute violations of urban runoff ordinances as criminal violations hinders the enforcement process. These findings led us to the following recommendations.

Recommendations

5.7-A Programmatic audits of city and County storm water programs should be conducted. These audits should verify whether programs outlined in the permits are being implemented and assess their adequacy and effectiveness.

5.7-B The cities and County should coordinate and consolidate as appropriate their inspection programs of industrial and construction sites, with the Regional Board. This program should increasingly focus on the adequacy of the storm water management plans and the extent to which they are being implemented.

5.7-C More generally, the cities and County should clarify the division of enforcement responsibilities between them and the Regional Board. Enforcement should be delegated to the cities and County, whenever possible.

5.7-D The County of Los Angeles Department of Public Works should investigate the advantages and disadvantages of ticketing authority for runoff violations. Based on a review of experiences in the City of Los Angeles and other jurisdictions that have the ability to issue tickets for infractions, the Department should make a recommendation to the Board of Supervisors on whether the County code should be amended to allow such ticketing.

Funding for Water-Quality Programs

To be effective, there must have adequate resources to carry out the permitting, monitoring, and enforcement responsibilities. Recommending additional funding for a public agency is often not popular, but we believe that the benefits from potential improvements in programs and enforcement are likely to outweigh the costs.

Recommendation

5.8 The Board of Supervisors should lead an effort to increase funding for the Regional Board.

Potential funding sources include increased permit fees from the municipalities and businesses in L.A. County and the State General Fund. The Supervisors should appeal to the governor and the State Water Resources Control Board directly as well as enlist the support of the L.A. delegation to the State legislature.

AGENCIES RESPONSIBLE FOR KEY RECOMMENDATIONS

Table S.1 summarizes the most important recommendations by the government entity responsible for implementation.

Table S.1
Agencies Responsible for Key Recommendations

Number	Recommendation to:
Los Angeles County	
3.2-A	Department of Health Services should develop a grading system for beaches.
3.2-B	Department of Health Services should initiate a public information campaign to communicate health risks of swimming.
4.6-B,C	Department of Beaches and Harbors should continue modest programs to improve water quality at Mother's Beach, but reconsider water quality goals before moving on to expensive solutions. Permanently post Mother's Beach until water quality improves.
5.7-D	Department of Public Works should investigate advantages and disadvantages of ticketing authority for runoff violations.
5.8	Board of Supervisors should lead an effort to increase funding for the Regional Board.
City of Los Angeles	
4.7-B,C	Continue with modest programs to improve water quality at Cabrillo Beach, but reconsider water quality goals before moving on to expensive solutions. Permanently post Cabrillo Beach until water quality improves.

City of Santa Monica

4.4-D,E Continue with modest programs to improve water quality at Santa Monica Pier, but reconsider water quality goals before moving on to expensive solutions. Permanently post Santa Monica Pier until water quality improves.

Regional Water Quality Control Board –

As a State agency, the Board is beyond the purview of the Grand Jury; however, it is an integral part of waste water control in Los Angeles County, and may want to consider the following:

4.1-A Issue waste discharge permits for commercial and multi-family residential septic systems in Malibu.

4.1-B Require monitoring of groundwater levels in residential areas in Malibu.

5.1 Create a meaningful process to prioritize beneficial uses and defer programs required to achieve lower priority uses.

5.3 Focus more on setting limits on contaminants than on requiring implementation of prescribed programs.

5.5 Lead efforts to identify what additional powers are needed by the Regional Board, the cities, and the County and to obtain them.

5.7-A Conduct programmatic audit of city and County storm-water programs.

5.7-B Coordinate and consolidate inspection programs with the County and cities; increasingly focus inspections on adequacy of storm-water management plans.

5.7-C Clarify division of enforcement responsibilities between Regional Board, cities, and County.

SECTION 1. INTRODUCTION

This report examines the health risks of swimming (and water-contact recreation more generally) at the beaches in Los Angeles County and examines the policies and programs in place to reduce these risks. Health risks are of concern first because of the negative effects on the swimmers who contract illnesses. They are also of concern because the perception or reality that beach waters are not safe for swimming has negative effects on the economies of beach communities and perhaps even on the economy of the county as a whole. And finally, health risks are of concern because they limit an important recreational opportunity and reduce the well-being of the citizens of L.A. County.

Improving water quality at L.A. beaches is part of a larger effort to clean up the rivers, creeks, groundwater basins, and ocean in the region. Substantial resources have been spent on this effort, and significantly greater amounts would be required by some additional programs under consideration. The scope of this effort has been likened to the long-running campaign to clean up the region's air. We in the county need to make sure that the resources spent on this effort are spent wisely, both because society's resources are limited and because there are many benefits to be gained by cleaning up the county's beaches and waters.

1.1 SCOPE OF THIS REPORT

We examine the policies and procedures in place for monitoring water quality at beaches in L.A. County and assessing the health risks of swimming. We also assess programs to communicate these risks to the public. We examine the sources of and efforts to reduce pollution at seven of the beaches in the county with the worst pollution problems. As will be discussed below, one of the major sources of beach water pollution is polluted discharge from the rivers, creeks and storm drains that flow into the ocean. We thus also examine policies and programs to improve the quality of waters that discharge to the ocean.

We investigate efforts to improve water quality both during dry weather and during wet weather. Water quality and health risks are of primary concern during the dry, summer months when beach attendance is highest. However, even though beach attendance is lower during wet weather, there are still some who swim at the beach (e.g., surfers). Water quality during wet weather may also affect overall perceptions about the attractiveness of the beaches and their use during dry weather. Investigation of policies to improve water quality during wet weather is also important because of the large amount of resources that will potentially be required by the programs currently under consideration.

We use the information gathered in our investigation to make recommendations on:

- The process for monitoring water quality at beaches, assessing swimming risks, and communicating these risks to the public;
- Efforts to improve water quality during dry weather at seven problem beaches;
- Policies and procedures for improving the quality of rivers, creeks and storm drains flowing to the beach.

The objectives of our recommendations are to reduce the health risks of swimming at beaches in L.A. County and to ensure that the programs in place to reduce risks are sensible in terms of cost. Our recommendations also aim to put in place programs to accurately communicate the health risks of swimming at the beaches to the citizens of the county.

1.2 EVALUATION APPROACH

Our evaluation and recommendations are based on a review of relevant literature and interviews with 26 experts on water quality programs and policies in L.A. County. The experts interviewed spanned the many agencies and organizations involved in water quality issues in L.A. County. Appendix A lists the organizational affiliations of those interviewed.

Most of the interviews were conducted in person, although a few were done over the telephone. Interviews typically lasted two to three hours and were usually done at the interviewee's place of employment. The interviews were conducted between October and December 1999. To encourage candor, interviews were conducted on a confidential basis. Thus, we do not identify the people interviewed nor attribute statements to them in this report. A semi-structured interview format was used. Questions were prepared in advance, but both the interviewers and interviewees were free to pursue topics not on the list.

1.3 ORGANIZATION OF THE REPORT

Section 2 sets the stage for our review of beach water pollution issues. It provides background on water quality at the beaches in L.A. County, the health risks of swimming, and the potential sources of pollution. It also provides an overview of the roles and responsibilities of the agencies and organizations involved in beach water quality issues. Sections 3, 4, and 5 each examine a different set of issues surrounding beach water quality. For each issue area, we first define the issue and why it is important. We then present the findings of our investigation of the issue and conclude with recommendations to improve policies in the issue area. Section 3 examines the policies and procedures in place to assess the risks of swimming at the beaches in L.A. County and the procedures for communicating these risks to the public. Section 4 assesses efforts to reduce pollution at seven of the most polluted beaches in the county and makes suggestions for improvements. Section 5 evaluates and makes recommendations about efforts to improve the water quality of the rivers, creeks and storm drains that flow into the ocean. A review of the literature on the health risks of swimming in marine water is contained in Appendix B.

SECTION 2. BACKGROUND

Most beaches in L.A. County are considered safe for swimming and other forms of water recreation when the weather is dry. Unfortunately, there are several beaches with persistent pollution problems even when the weather is dry, and almost all beaches have high pollution levels when it rains. In this section we characterize the water quality at L.A. County beaches and review the health risks of swimming. We also provide brief overviews of the potential sources of pollution and of the agencies and organizations involved in beach water quality issues.

2.1 WATER QUALITY AT LOS ANGELES COUNTY BEACHES

The California Department of Health Services has established water quality standards for swimming at public beaches. The standards are based on three indicator bacteria: total coliform, a group of bacteria that can originate from soil, plants, and human and animal waste; fecal coliform, a group of bacteria found in the intestinal tracts of humans, mammals, and birds; and Enterococcus, a bacterium that is part of the normal flora found in human and animal waste. These bacteria do not necessarily cause illness in humans themselves, but are thought to be good indicators of the presence of human pathogens (see Section 3.1 for a discussion of their effectiveness as indicators). The single-sample water quality standards for bacteria established by state are:

- 10,000 or fewer total coliforms per 100 ml.
- 400 or fewer fecal coliforms per 100 ml.
- 104 or fewer enterococci per 100 ml.
- 1,000 total coliforms per 100 ml, if the ratio of fecal to total coliforms exceeds 0.1.

Heal the Bay, an environmental group based in Santa Monica, provides readily accessible information on beach water quality. It develops annual grades for 61 beaches throughout the county based on weekly or daily water quality monitoring data provided by the Los Angeles County Department of Health Services (DHS), the City of Los Angeles, and the County Sanitation Districts of Los Angeles County.[1] Grades run from A+ through F. A grade of A or better means that (1) Enterococcus exceeded 104 per 100 ml in less than 10 percent of samples taken during the year, (2) total coliform exceeded 10,000 per 100 ml in less than 1 percent of samples, and (3) the ratio of fecal to total coliform exceeded 0.1 (when total coliform were greater than 1,000 per 100 ml) in less than 5 percent of samples. The beaches monitored by the City and County of Los Angeles are not randomly selected along the coast and, if anything, are more likely to be in areas with the greatest pollution problems. Factors including beach attendance, distance from storm drains or sewage outfalls, and the existence of known pollution problems were used to select the beaches monitored. (See the Heal the Bay website for the locations of the 61 beaches in L.A. County for which it issues grades.)

Most of the beaches in L.A. County meet health standards during dry weather. Over the last five years, slightly over two-thirds of the 61 beaches monitored received grades of A or better during dry weather. In contrast, water quality is poor during wet weather which is defined as

[1] More detailed information regarding California's sampling requirements can be found in Title 17 of the California Code of Regulations, Group 10, Sanitation, Healthfulness, and Safety of Ocean Water-Contact Sports Areas.

periods during and for the three days following rain. Over the last five years, less than 20 percent of beaches on average received grades of A or better during wet weather.

Even during dry weather there are a number of beaches throughout the county with persistent pollution problems. Figure 2.1 shows the percent of sampling days during which three water-quality thresholds were exceeded during the 1998-1999 monitoring year at seven problem beaches (a map with the location of these beaches is included in Section 4). At least one of the bacterial indicators was exceeded in more than 10 percent of the dry-weather samples at each of the beaches, and the Enterococcus standard was exceeded over two-thirds of the time at Cabrillo Beach.

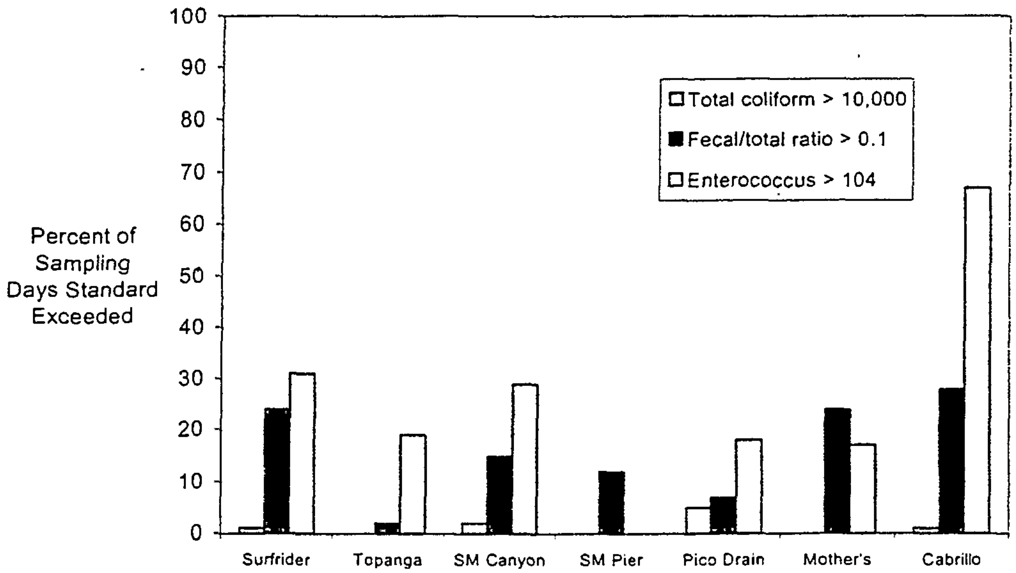

Figure 2.1—Percent Sampling Days That Water Quality Standards Were Exceeded At Seven Problem Beaches During Dry Weather in 1998-1999

The State Water Resources Control Board has established water quality requirements for discharges to the ocean for a number of contaminants other then bacteria. Many of the requirements are aimed at protecting human health and include restrictions on heavy metals and organic chemicals. Public health officials have paid the most attention to bacteria levels, however, in part because their main concerns historically have been about the spread of infectious diseases in waters contaminated with human sewage. Monitoring data on bacteria are much more extensive for bacteria than other contaminants, and we focus our characterization of beach water quality in L.A. County on them. We discuss the health risks imposed by contaminants other than bacteria below.

2.2 EXTENT OF HEALTH RISKS OF SWIMMING AT THE BEACH

A large number of people are exposed to the waters at L.A. County beaches every year (see Figure 2.2 for annual beach attendance). The most extensive study of the health risks of swimming in the beach waters of L.A. County was released by the Santa Monica Bay Restoration Project (SMBRP) in 1996. The study compared the incidence of illness among people who swam at various distances from three flowing storm drains and correlated illness rates with bacteria levels. It found that illness was higher among people who swam right in front of storm drains (where the pollution levels are the highest) than among people who swam 400 yards away. They also found that illness rates were correlated with bacteria levels in the water. This study provided the first scientifically-documented evidence that swimming at L.A. County beaches increases illness rates when bacteria levels are high.

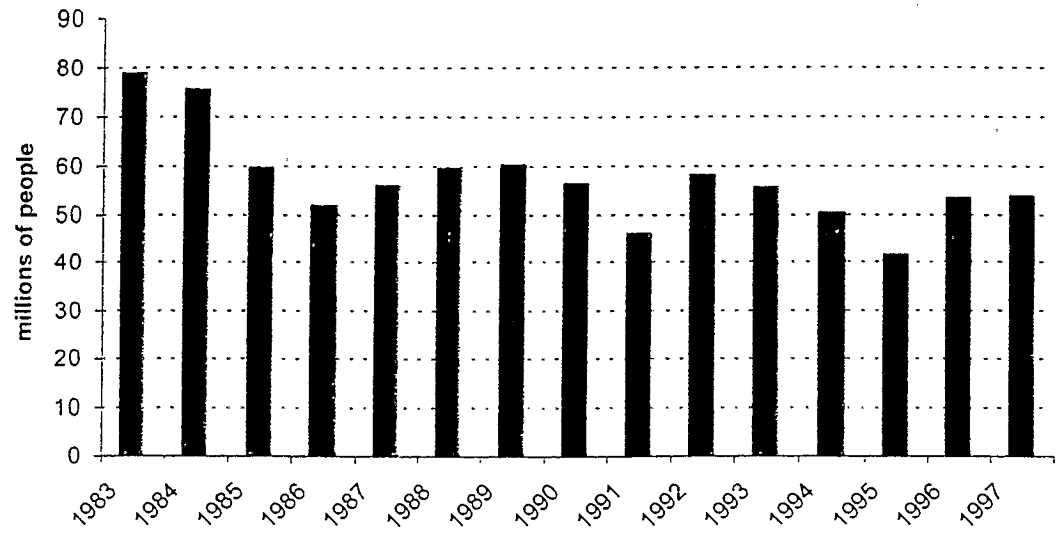

Figure 2.2—Annual Attendance at Beaches in Los Angeles County, 1983-1997
Source: Compiled by Linwood Pendelton and Miwa Tamanaha, Department of Economics, USC, based on data provided by Los Angeles County Lifeguards.

The SMBRP study found higher rates of fever, chills, ear discharge, vomiting, phlegm, highly credible gastroenteritis, and significant respiratory disease among those swimming in front of storm drains than those swimming 400 yards away.[2] Even though the differences were statistically significant, the increase in illness rates was not large. Illness rates were generally one to two percentage points higher among those who swam in front of the drain than those who swam 400 yards away. Rates for the individual illnesses named above ranged from one to five percent for those farthest from the drain versus two to seven percent for those swimming in front of the drain.

[2] Highly credible gastroenteritis is defined in the SMBRP study as (1) vomiting, (2) diarrhea and fever, or (3) stomach pain and fever. Significant respiratory disease is defined as a complex of symptoms that include (1) fever and nasal congestion, (2) fever and sore throat, and (3) cough with sputum.

The SMBRP also found higher rates for some illnesses when bacteria levels exceeded the standards listed above than when bacterial levels met the standards. Again, the increases were not large, ranging from one to two percentage points from the same low baseline levels.

The SMBRP study is part of a larger literature on the health effects of swimming in beach waters. Our review of this literature (see Appendix B) reveals that a great deal of uncertainty about the health effects of swimming remains. But given what is known, we make the following observations. First, the acute illnesses (those coming on quickly and lasting a short time) associated with swimming in beach waters contaminated at the levels found in L.A. County do not appear very severe (see list of illnesses found by SMBRP study above). We did not hear of or find studies reporting life threatening or other serious illnesses from swimming at L.A. County beaches. Given the large number of beachgoers, one would expect some such reports if serious illnesses were occurring.

Second, most of the studies on risks of swimming in marine waters focus on acute illnesses. The SMBRP study focused on illnesses coming within one or two weeks of swimming. It also restricted its attention to one-time exposure to water, and did not examine the effects of repeated exposure. This opens up the possibility that there may be chronic effects of repeated exposure to the heavy metals and organic chemicals sometimes found in ocean water. However the lack of reports again suggests that these risks are not substantial.

Finally, while there is evidence that exposure to human sewage causes illnesses, there is little information on whether exposure to water contaminated with the feces of other animals (such as birds) causes problems. Most studies that have found increased illness rates have supposed human fecal contamination. The storm drains in the SMBRP study were found to contain human viruses (indicating the presence of human sewage). It is unknown whether there are similar health effects at other beaches where the source of contamination in not human sewage but, say, bird feces.

2.3 CAUSES OF BEACH WATER POLLUTION

This section provides an overview of the many potential sources of bacteria and other pollutants that sometimes contaminate the beaches in L.A. County. As we will see in subsequent sections, there is a great deal of controversy over which of these sources are most important.

Point Sources

Twenty years ago, discharges from municipal sewage treatment plants and industrial facilities were the largest sources of water pollution in the beaches and ocean off L.A. County. Much progress has been made since then in reducing pollutants from these so-called point sources, although occasional problems crop up. Now that emissions from these point sources have been reduced greatly, pollutant loads from diffuse, non-point sources have become the focus of attention.

Non-Point Sources

Urban runoff. Urban runoff refers to the water that collects on hard, impermeable surfaces, such as streets and rooftops and flow into the county's storm drain system. Runoff is caused by rain and dry-weather sources such as over-irrigating landscaping. As runoff flows through urban areas it picks up pollutants and becomes contaminated with high levels of bacteria, metals and chemicals. Pet waste (including cats, dogs, and horses) and the homeless are potential sources of bacteria, as are restaurants that wash floor mats covered with food into the gutter. Oil and grease from trucks and cars, copper from brake pads, and the components of tail-pipe exhaust that have settled to the ground can be picked up by rain and other flows. Sediment may erode from construction sites, and fertilizers and other nutrients can be carried from residential yards, parks and commercial landscaping. Section 5.2 discusses the sources of pollution in urban runoff in greater detail.

Sewage spills and leaks. Blockages in sewers or very high flow levels can cause sewage to rise up through manhole covers and then flow into the storm drain system and out to the ocean.[3] Some also believe that leaks in the sewer pipes allow sewage to migrate underground into the storm drain system.

Illegal connections and discharges to the storm drain system. Sewage lines can be mistakenly hooked up to the storm drain system or pollutants can be illegally discharged to the storm drain system. Discharges of recreational vehicle sewage tanks or used engine oil into the storm drain system are examples of illegal discharges.

Septic systems. Septic systems that are not properly functioning may be the source of bacteria and high nutrient levels in groundwater, rivers, creeks, and the ocean.

Direct sources of beach pollution. Excrement from birds and other wildlife at beaches can cause high bacteria levels. Litter can create a medium for the growth of bacteria and can attract birds and other wildlife that leave droppings. High nutrient levels near storm drain outfalls can attract aquatic wildlife, which can also attract birds. Bathers may also use the ocean as a toilet (sometimes referred to as bather loading).

Natural sources. Runoff from undeveloped land can also contain substantial levels of bacteria (from the wildlife that live there), nutrients, and other contaminants.

2.4 OVERVIEW OF THE MAJOR AGENCIES AND ORGANIZATIONS INVOLVED IN WATER QUALITY ISSUES

A complex web of agencies and organizations is involved in water quality issues in L.A. County. Brief descriptions of the most important local agencies and organizations follow.

The California Regional Water Quality Control Board, Los Angeles Region (Regional Board). The Regional Board develops and implements water quality control plans that specify beneficial uses for the water bodies (which include the oceans, rivers, creeks, lakes, and groundwater) in the Los Angeles region, the water quality objectives that must be achieved to protect the beneficial uses, and describe implementation programs to protect all waters in the

[3] The sewer and storm drain systems are separate in L.A. County. Sewers flow to sewage treatment plants that then discharge treated effluent to the ocean (or in some cases to rivers). The storm drain system discharges to the ocean without treatment. Rainwater is not supposed to enter the sewer system, and sewage is not supposed to enter the storm drain system.

Region. The Regional Board is the regulator for water quality issues in the region with broad powers to achieve its goals.

The Regional Board is governed by nine board members who are appointed by the governor and confirmed by the State Senate. Members serve part-time for staggered four-year terms and represent the following interest groups: water quality (two members); irrigated agriculture; industrial water use; public; county government; municipal government; recreation, fish and wildlife; and water supply. Currently, one of the water quality positions and the industrial water use position are vacant. As of October 1999, the Regional Board staff included 112 positions – 92 technical, 5 administrative support, and 14 clerical. The technical staff consists primarily of engineers, geologists and biologists.

The primary mechanism used by the Regional board to regulate water quality is the National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued to both point and non-point dischargers. Point discharges, such as the City of Los Angeles Hyperion wastewater treatment plan, are issued NPDES permits that set effluent standards and require monitoring. Non-point dischargers, such as the County of Los Angeles, are issued municipal storm water NPDES permits that require the permittee to implement various programs designed to improve water quality.

Los Angeles County and the Cities in Los Angeles County. The Regional Board regulates local government agencies in Los Angeles County in a number of different ways. The sewage treatment plants of the City of Los Angeles and the County Sanitation Districts of L.A. County are regulated by point-source permits. Both these agencies are required under the terms of their permits to monitor water quality at many different locations in San Pedro and Santa Monica Bays.

The county and the cities in Los Angeles County are responsible for the urban runoff that originates in their jurisdictions and are subject to Regional Board regulations on storm water quality. Responsibility for urban runoff usually falls in public works departments, which, in the case of the County and the City of Los Angeles, also have responsibility for parts of the sewer system.

Independent of Regional Board requirements, the Los Angeles County Department of Health Services collects water quality data, sets health standards for swimming in beach waters and issues beach closures and warnings when pollution levels are high.

There are four cities in L.A. County whose jurisdiction abut the coast: Los Angeles, Long Beach, Malibu, and Santa Monica. These four, in addition to L.A. County which also controls areas that abut the coast, have particular interest in and enhanced roles in beach pollution issues.

Businesses. Businesses are required to have permits from the Regional Board to discharge "process water" (water from manufacturing or other business activity) into the waters of L.A. County. Certain types of industrial facilities and construction sites must also have storm water permits. Several business groups are involved in the policy debate over water quality in Southern California. Examples include the Southern California Coalition for Pollution Prevention.and the Western States Petroleum Association.

Environmental Groups. A number of environmental groups are active in water quality issues in the region. Located in Santa Monica, Heal the Bay has been a strong advocate of efforts to clean up Santa Monica Bay. The Natural Resources Defense Council and Santa Monica Baykeeper have also been very involved in the policy debates and have initiated, and won, several lawsuits against the Regional Board, the county, cities, and businesses to implement clean water programs.

Joint Powers Research and Planning Organizations. The Santa Monica Bay Restoration Project was formed in 1988 under the National Estuary Program and charged with assessing the Bay's problems, developing solutions and putting them into action. It is funded by the state and federal governments and views itself as a partnership of governments, environmentalists, scientists, industry, and the general public. The Southern California Coastal Water Research Program is a joint powers agency focused on conducting research and gathering information necessary to protect the Southern California marine environment. Its commission includes representatives of city, county, state and federal agencies with authority over and responsibility for coastal waters.

University Researchers. There are several researchers at UCLA and USC who have worked on water quality issues and been involved in the policy debate to varying degrees.

SECTION 3. IMPROVING WATER QUALITY MONITORING AND RISK COMMUNICATION

In this section we first evaluate and make recommendations about policies and procedures in place to assess the risks of swimming at the beaches in L.A. County. We then turn to the policies and procedures for communicating these risks to the public.

3.1 BEACH MONITORING AND RISK ASSESSMENT

Issue

As discussed in Section 2, the levels of three different types of bacteria are used to indicate the health risks of swimming at L.A. County Beaches. These bacteria are not necessarily harmful to humans in themselves but are presumed to indicate the presence of pathogens that are harmful to humans. How effectively do the current bacterial tests indicate human health risks? How might monitoring procedures be improved?

Findings

Water quality standards for swimming at the beach are based on the levels of three indicator bacteria (total coliform, fecal coliform, and Enterococcus) because it is too difficult, time-consuming, and expensive to test for the huge array of potential pathogens themselves. Although numerous studies have shown various degrees of correlation between these bacterial indicators and illnesses such as gastroenteritis, use of such indicators immediately raises the question of how closely associated the indicators are with the actual health risks of swimming. (See Appendix B for a review of studies that address the correlation between indicator bacteria and illness.)

High bacteria levels may overstate health risks to humans in some cases. As discussed in Section 2.2, the health effects of fecal contamination from non-human sources are unknown. The bacteria tests used to monitor beach water do not distinguish between bacteria from different types of animals. Thus, high bacteria levels may be due to birds, for example, but not cause increased illness in humans.

The bacterial indicators may also miss some important human pathogens. There is a great deal of uncertainty in the scientific community over how well the indicators predict the presence of human viruses and illness due to viruses. Several studies have shown that certain types of viruses are not well correlated with bacterial indicators, and what is more, no studies show that bacterial indicators are well correlated with particular viruses. This raises the possibility that harmful viruses may be in the water even when bacterial levels are low.

Of course, the possibility that viruses may be present when bacterial indicators are low does not mean that viruses are actually a problem. For example, viruses may not be present or the viruses that are present may be dead. More information is needed to determine whether the bacterial indicators fail to capture an important human health risk.

Also, the bacterial indicators may not be well correlated with heavy metals and organic compounds that could possibly result in chronic illness. As discussed in Section 2.2, there is currently no evidence of such effects, but more information is needed to make sure the risks are small and to better understand how bacterial indicators are correlated with any risks should they exist.

The lag between taking a water sample and the availability of test results raises some public health concerns. At present, testing for the bacterial indicators takes about 24 hours. The turnaround time from water sampling to reporting a violation to health officials and notifying the public is about 30 hours. The process in L.A. County is smooth and as timely as possible given existing monitoring technology. However, it means that the public cannot be assured at any given moment that the water at a given beach meets health standards. Public health officials and researchers are interested in finding testing methods that would drastically reduce the turnaround time for results. Some promising methods are being tried in other parts of the country and the world, but their usefulness in Southern California waters is yet to be determined.

Water quality monitoring along the beaches is done by three different agencies: the County Department of Health Services (DHS), the County Sanitation Districts of L.A. County, and the City of Los Angeles. The latter two agencies are required to do monitoring as part of their permits to discharge from waste sewage treatment plants into the Bay. Different laboratory procedures for measuring bacteria levels are used by these agencies, and results from the different procedures are not well correlated in wet weather (in dry weather the correlation is strong). Several of the experts we interviewed thought it important to understand the discrepancies between the two procedures and to understand which procedure, or combination of procedures, gives the most accurate count of bacterial levels.

Uncertainties in how well the current bacterial tests measure the risks of swimming at L.A. County beaches lead us to the following recommendations.

Recommendation

3.1 **The Board of Supervisors should direct the L.A. County Department of Health Services to assemble a panel of experts to evaluate the efficacy of current procedures for assessing the health risks of swimming at L.A. County beaches. The panel should include representatives of the L.A. County Department of Health Services, the City of Los Angeles, the Regional Board, the Southern California Coastal Water Research Project, the Santa Monica Bay Restoration Project, and experts within the academic and environmental communities.**

The panel should be charged to assess and recommend research to better understand the effectiveness of current bacterial tests and to ultimately suggest, as appropriate, changes in tests and testing procedures. In particular, the panel should examine:

- **The extent to which viruses pose a threat to swimmers.**
- **The extent to which bacterial indicators can be used to indicate the presence or absence of viruses.**

- The threat of non-human bacteria, viruses and other organisms to humans.
- The long-term health risks of regular swimming or surfing at L.A. County beaches and the relationship of near term-indicators to chronic diseases, if any.
- The availability of tests that more rapidly indicate the presence of pathogens in beach waters.
- Inconsistencies between the different bacterial measurement procedures currently used.

The panel should leverage ongoing work by the Santa Monica Bay Restoration Project on several of these topics.

3.2 RISK COMMUNICATION

Issue

The citizens of L.A. County and the region more broadly will be best served if they can make informed decisions about whether or not to swim at the beach. To make informed decisions, they need to have an accurate picture of the water quality and health risks of beach waters. They need to know if the water is contaminated and where it is contaminated. If water quality is indeed good, they need to know it is good.

How effective are current programs and policies for communicating the health risks of swimming at L.A. County beaches to the public? How might risk communication be improved?

Findings

Currently there are two main sources of information on water quality at the beaches. As discussed in Section 2.1, Heal the Bay issues grades that are posted on its web site as well as at some surf shops. Grades are updated weekly, are up-to-date, and are based on samples taken during the most recent four-week period. A history of weekly grades, in some cases going back over a year, is available for each beach. The Heal the Bay web site and grading system is a useful resource, but does not reach people who do not have internet access or who do not frequent the participating surf shops. Some of the public may also distrust or discount Heal the Bay grades because they are not government sanctioned.

The DHS is the second main source of information available to the public. DHS alerts the public of beach warnings and closures through warning signs posted at affected beaches, news releases to the media, and a telephone information hotline (800.525.5662). DHS posts warnings when bacterial levels exceed state health standards and closes beaches if there is a sewage spill that is known to have reached beach waters. The DHS is a useful and important source of information, but its public notification protocols have some shortcomings. First, the presence, or absence, of warnings may not provide an accurate picture of current water quality. People will have swum at a beach for one or two days (or longer if the beach is sampled weekly) before a test sample comes back from the lab showing that the bacterial levels are high. And, by the time the sample comes back, water quality may have improved. Second, the information hotline has not been adequately publicized so that it is well known by all potential beach-goers. Third, it is not clear how much attention people pay to posted warning signs, or really understand what they mean.

We are concerned that the public has an inaccurate and overly negative impression of beach water quality. Beach attendance fell by 32 percent between 1983 and 1997 (see Figure 2.2). This decline could have been due to many factors, including increasing traffic congestion, more limited or expensive parking, or growing concern about skin cancer, but increasing concern about water quality may have also played a role. The Los Angeles Times ran a series of articles on beach and ocean pollution last November that focused on beaches where there are pollution problems. Missing from the article was the message that the water quality at most beaches in L.A. County is good the vast majority of the time. One of the experts we interviewed who is doing work on public perceptions of water quality in Southern California said that his research shows that people generally think that water quality is poor and getting worse. (No studies have shown that water quality is in fact getting worse in recent years.) People think that some beaches are dirtier than others, but most are confused about which ones have the worst water quality. For example, most think the water in Malibu is clean, even though some beaches in Malibu (e.g., Surfrider) have poor water quality.

We also suspect that the public has very little understanding of the types of illnesses that are associated with the high bacterial levels found at some beaches (refer to Section 2.2 and Appendix B). Before our inquiry began, we at the Grand Jury had little idea of what types of illnesses are associated with swimming at the most polluted beaches in L.A. County. The public likely does not know that demonstrated risks are not life-threatening diseases, but rather an increase in earaches, runny noses, and gastrointestinal problems from a background rate of 2 percent when swimming in clean water to 4 percent.

We make two recommendations aimed at improving the public's understanding of water quality at County beaches. The first attempts to create a more accurate, visible method for communicating water quality conditions at individual beaches. The second is aimed at better informing the public about water quality at L.A. County beaches more generally.

Recommendations

3.2-A The L.A. County Department of Health Services should develop a grading system for beaches similar to that used at L.A. County restaurants and post these grades at sampling locations and in other highly visible locations at the beaches.

The current Heal the Bay grading system provides a good model for the new program. The new grading system would be most effective if groups such as Heal the Bay participate in developing it and endorse it.

Because of uncontrollable delays in the testing process, the best such grades can do is measure the likelihood, or probability, that the water is clean. Accordingly, the grades should be based on average water quality over the past several months to one year, although a second grade based on the most recent weekly sample might also be posted.

Grades should be posted at locations where sampling occurred (e.g., near storm drain outlets) and beach entrance points as well as on a county web site and telephone information line (the current County environmental phone line might be expanded to include the beach grades). The grading system and the type of health risks associated with each grade should also be posted and clearly explained.

3.2-B The L.A. County Department of Health Services should initiate a public information campaign to accurately communicate to L.A. County residents the health risks of swimming at L.A. County Beaches. The message should be that:

- **Beaches in L.A. County are among the best monitored in the nation.**
- **Swimming is safe during dry weather at the vast majority of beaches, although a few problem areas remain.**
- **Water quality standards are typically exceeded during rainstorms and beachgoers should not swim during or in the three days following significant rain (i.e. greater than 0.1 inch).**

The campaign should also provide accurate information on the types of illnesses and the chances of contracting them from swimming at beaches that violate health standards.

An effective way to engage the public in water quality issues might be to develop and publicize an overall measure of beach water quality. A weekly report on the percent of beaches meeting water quality standards is one possible method.

The media should be used to convey the message as appropriate, and the information should be available in written form and on a county web site. The campaign will be most effective if it is developed in partnership with and endorsed by local environmental groups.

SECTION 4. RECOMMENDATIONS FOR IMPROVING WATER QUALITY DURING DRY WEATHER AT SEVEN PROBLEM BEACHES

In addition to looking at regional issues related to water quality in Los Angeles County, we examined the specific problems at seven beaches: Surfrider, Topanga Canyon, Santa Monica Canyon, Santa Monica Pier, Pico-Kenter, Mother's Beach in Marina del Rey, and Cabrillo Beach. (see Figure 4.1) The beaches were chosen based on their consistently poor water quality, according to the Heal the Bay grading system.

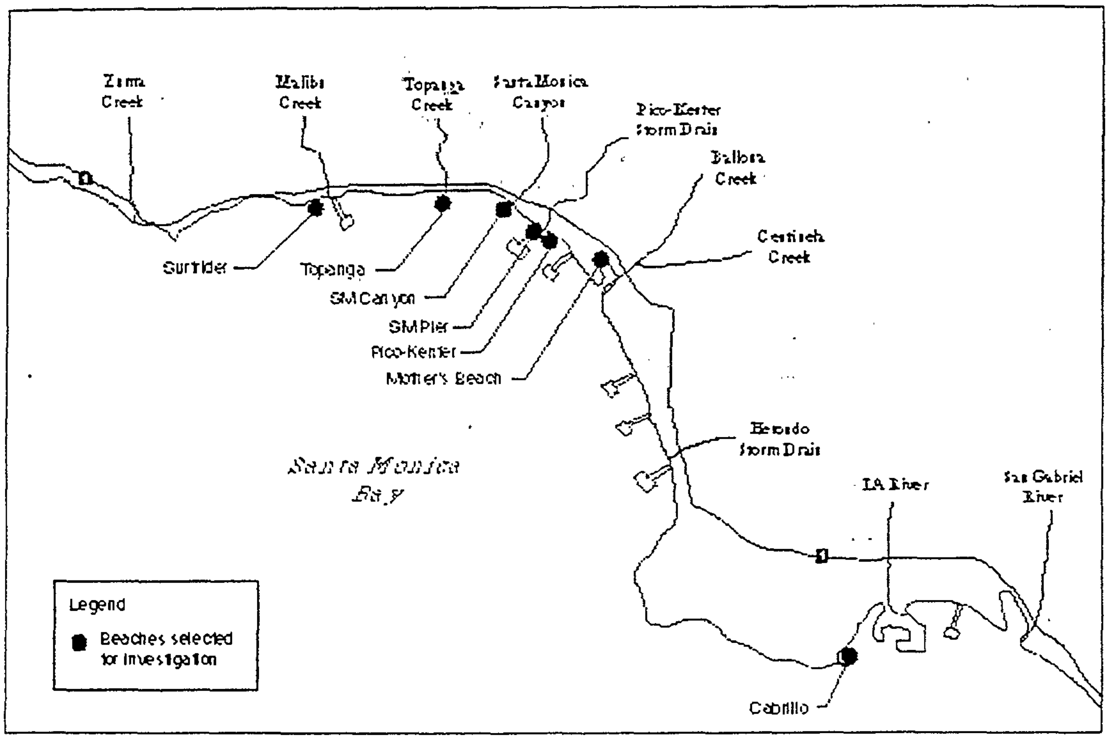

Figure 4.1 Location of the Seven Problem Beaches Chosen for Individual Examination

With only a few exceptions, these seven beaches are the only beaches in the county with consistent dry-weather problems. The exceptions include other beaches that face similar problems as the ones selected, but which have generally better water quality. For example, the beach in front of the Ashland Avenue storm drain in Santa Monica has had water quality problems similar to, but not as extensive as, those experienced at the beach in front of Pico-Kenter.

Some of the beaches have unique problems, such as low tidal circulation, and some have problems similar to beaches throughout the county, such as receiving urban runoff. In this section we focus on the specific problems at these beaches and examine local solutions. Solutions to the regional urban runoff problem are discussed in the following section. This approach allows us to get away from generalities and better understand the real-world problems and potential solutions. Studying individual beaches provides the opportunity to see which pollution-reduction strategies have worked, and which have not.

The issue addressed in this section is what progress has been made in making these beaches safer for swimming and what further should be done. We focus on bacterial indicators only in this section. We do not consider metals or toxic substances or other materials that might be harmful to the ecosystem, but not acutely harmful to humans. *Clean water* in this context thus means low levels of bacterial indicators. In this section, we also focus only on attempts to improve water quality during *dry* weather. In addition to being much more difficult to address, wet weather causes problems at most beaches in the county, not just the seven studied here. Wet weather problems are primarily caused by contaminated urban runoff, which we consider in Section 5.

4.1 SURFRIDER

Findings

Surfrider is a popular surfing beach located in front of Malibu Lagoon in the City of Malibu. Malibu Lagoon is an estuary at the bottom of Malibu Creek, the second largest watershed draining to Santa Monica Bay, after Ballona Creek. The watershed drained by Malibu Creek is 110 square miles, 88 percent of which is undeveloped.

Malibu Lagoon is usually separated from Surfrider Beach during dry weather by a sand berm. However, when water levels in the lagoon rise, either due to increased flows from Malibu Creek or other sources, the berm can breach. When the lagoon is closed, the water quality at Surfrider is very good. But when the lagoon is breached, the water quality at Surfrider quickly degrades as polluted lagoon water spills out into the ocean. As shown in Table 4.1, the water quality grades at Surfrider have been consistently Ds and Fs over the last 6 years.

There are numerous potential sources of pollution to Malibu Creek and lagoon. Wildlife, including birds, and urban runoff, including runoff from areas inhabited by horses, are two important sources. The most contentious potential sources of pollution to the lagoon are the city's commercial and residential septic systems.

In the late 1980s, before Malibu was incorporated, the County of Los Angeles decided that the area should be connected to a regional sewer because of septic system failures observed during county surveys. Locals disagreed and fought to keep the regional sewer out of Malibu. The residents finally won when they incorporated in 1991 and gained control over their wastewater systems. A consent decree between the City of Malibu and the County Board of Supervisors was signed in 1993. This document required that the County "stop work towards constructing a regional sewer system and to relinquish jurisdiction of wastewater disposal and management to the City of Malibu" (Los Angeles County Department of Public Works, 1993). The consent decree required that Malibu assume responsibility for the city's wastewater disposal practices. Thus the city took over the problem and the county stepped out of the picture.

Table 4.1
Heal the Bay Annual Grades
for Seven L.A. County Problem Beaches

Beach	Weather	1994	1995	1996	1997	1998	1999
Surfrider – breach location	Dry	D	F	F	F	D	F
	Wet	F	F	F	F	F	F
Topanga Canyon	Dry	A	B	F	C	C	C
	Wet	F	F	F	F	F	F
Santa Monica Canyon	Dry	C	F	C	B	D	D
	Wet	D	F	D	F	D	F
Santa Monica Pier	Dry	B	F	F	F	F	F
	Wet	D	F	F	F	F	F
Santa Monica Pico-Kenter	Dry	B	F	D	C	D	C
	Wet	F	F	F	F	F	F
Mother's Beach, Marina del Rey	Dry	A	A	A	C	C	F
	Wet	A	F	F	F	F	F
Cabrillo –harborside at lifeguard tower	Dry	*	F	D	F	F	F
	Wet	*	F	F	F	F	F

Source: Heal the Bay's Ninth Annual Beach Report Card, May 26, 1999, Tables 6 and 6a.
* Data not available

Since the City took over responsibility for the management of septic systems, a number of studies and reports have been prepared which address, in various ways, the pollution in the lagoon, possible causes of pollution, and the possible contamination from septic systems. Most of the stakeholders we interviewed outside the City of Malibu think that the studies have not provided convincing evidence that septic systems are not a source of pollution in the lagoon. Most in Malibu think that the studies have provided no solid evidence that septic systems are a problem.

In June of 1998, the Regional Water Quality Control Board (Regional Board) ordered the City of Malibu to develop a plan to assess whether the septic systems were contributing to contamination of the groundwater and/or lagoon. After a year of extended deadlines, lack of agreement on strategy, and issued and subsequently rescinded fines, the city and the Regional Board agreed upon a comprehensive monitoring investigation that was begun in the latter part of 1999. Although the results of this study have not yet been released, some stakeholders in the county are already skeptical about the reliability of the results.

The concern stems from the way the monitoring locations were chosen, especially those in front of the Malibu Colony. The city monitored at eleven locations, at every sixth lot along the coast (resulting in monitoring locations separated by distances of 300 to 800 feet). Because the city was not able to access public property in front of the Colony, the monitoring was conducted along the beach at the mean high tide line, on public property. Distances from the monitoring locations to homes ranged from 40 feet to 200 feet.

Critics of the study think that the monitoring locations should have been placed closer to individual leach fields, thus providing a better indication of whether individual septic systems are contaminating groundwater. Not having access to the study or the results, we cannot assess whether or not the monitoring locations were appropriate. This disagreement, however, illustrates the ongoing battle surrounding the septic system issue in Malibu, and the difficulty of coming to a consensus about what should be done. The dispute also touches on another relevant item: the city cannot monitor in many important locations because it cannot gain access to private property.

Groundwater levels are a critical issue in Malibu. A report prepared in 1999 indicated that when the groundwater level in the Malibu lagoon area is at least two feet below the bottom of a septic tank's leach field, pathogen transport to the Creek or lagoon is unlikely. However, when the groundwater rises closer to the leach field, pathogen transport is possible, though it is not known how far the pathogens can travel. One study found that groundwater levels in the Cross Creek Plaza commercial area, located adjacent to the lagoon, were 1.5 to 4 feet below the bottom of the leach fields, suggesting there may be problems in portions of this area. Groundwater levels in most residential areas of the City are not known; it is known, however, that the groundwater level in the Malibu Colony area is very shallow during periods of extended lagoon closure.

The Regional Board is responsible for regulating septic systems (Single family residences are specifically excluded from Regional Board septic system regulations). Owners of commercial and multi-family residences are required to apply for coverage under either an individual permit or the Regional Board's general Waste Discharge Requirement (WDR) for Domestic Wastewater Treatment Systems. Single family residences are excluded from the general WDRs. However, according to the Basin Plan, "the Regional Board retains jurisdiction over ... any situation where septic systems are creating or have the potential to create a water quality problem."

In 1999, the Regional Board began sending letters to commercial and multi-family residential septic system owners in Malibu requiring them to file for coverage under either an individual permit or a general WDR for septic systems. Coverage under both an individual permit and a general WDR would require complying with numerous requirements relating to proper maintenance and operation of the septic system, including groundwater monitoring requirements.

A confounding element in the Malibu lagoon pollution problem is the Tapia wastewater treatment plant. Tapia discharges tertiary-treated water to Malibu Creek. A 1999 UCLA study found Giardia and Cryptosporidium in Tapia effluent, but not at levels which are considered hazardous. More importantly, Tapia's effluent affects the water level of the lagoon, causing it to breach more frequently than under natural conditions. Last year the Regional Water Quality Control Board prohibited Tapia from discharging to the Creek during the summer. Without the Tapia effluent (and without rain) the lagoon did not breach this summer, and the water quality at Surfrider was good. The City of Malibu has been very active in pursuing strategies to reduce pollution in the lagoon that do not involve eliminating septic systems or monitoring existing septic systems. In addition, when failing septic systems are brought to its attention, the city takes action to ensure that the problems are remedied. A handful of the city's proposed solutions to the pollution problem include the following:

- Pumping water from Malibu Creek to a constructed wetlands to provide dry-weather flows with biological treatment.
- Construction of a spillway to control lagoon water levels in dry weather.

- Installation of disinfection equipment at storm drains discharging into the lagoon.
- Requiring that new developments and remodels have advanced treatment septic systems and maintenance contracts.

The septic system issue is enmeshed in politics. The Regional Board has been accused of backing down from issuing fines to Malibu in the face of strong political and financial support for the city. The predominant response the Regional Board has received to letters requesting application for WDRs has been letters from attorneys asking for extensions, although some commercial dischargers have been cooperating and are supportive of the Regional Board's efforts. The mixed response to the Regional Board's action foreshadows the fight that lies ahead if the Board pursues requiring these permits. A by-product of the struggle between the county and Malibu is the deterioration of the relationship between the city and county. Because Malibu does not have its own health department, the County Department of Health Services (DHS) is responsible for protecting the health of the citizens of Malibu. Therefore, residents reporting septic system failures in Malibu might call either the DHS or an agency within the city. Currently, the city notifies the county when it responds to a septic system complaint, but the city does not hear about problems attended to by the county.

Given the contentious nature of the septic system problem in Malibu and given that the city is pursuing several strategies to curtail pollution from other sources, the following recommendations focus only on reducing contamination from septic systems.

Recommendations

4.1-A Commercial and multi-family residential septic system owners in Malibu should obtain waste discharge permits from the Regional Board and comply with the terms of those permits.

This type of permit is required of anyone discharging waste that could affect the quality of water resources in the State of California. Septic systems operators in Malibu should not be exempted from this requirement. The monitoring information is needed to resolve the issue of whether or not septic systems are a problem.

4.1-B Groundwater levels in residential areas with a high water table, especially residential properties near the Malibu lagoon, should be monitored.

Everyone agrees that in order for septic systems to function properly, there needs to be adequate distance between the bottom of the leach field and the water table. Therefore, establishing the height of the water table is the first step in determining whether or not there may be septic system problems. Because of the difficulty the City of Malibu has gaining access to residential properties, the Regional Board should be requested to take the lead in this effort.

Although single family residences are generally exempted from Regional Board regulation, the unique situation in Malibu deserves a unique response. If problems are found with single-family septic systems, the Regional Board should be asked to re-examine this exemption. Los Angeles County should assist this effort. The County could provide technical and laboratory assistance to the Regional Board such as help with groundwater sampling and laboratory analysis of water samples.

4.1-C The Los Angeles County Department of Health Services should inform the City of Malibu when it responds to a septic system complaint.

In addition to allowing Malibu to keep better track of septic system problems within the city, such notification would facilitate coordination and communication between the two agencies.

4.2 TOPANGA CANYON BEACH

Findings

Topanga Beach is at the foot of Topanga Creek, which drains a watershed covering approximately 18 square miles. The Topanga watershed consists of predominantly undeveloped lands, much of which is held by state and federal park agencies as part of the Santa Monica Mountains National Recreation Area.

Water quality at the Topanga Canyon Beach is generally mediocre in dry weather and poor in wet weather, earning Fs in wet weather for the last six years in a row. Recent annual dry weather grades have been mixed, ranging A to F in the past six years (See Table 4.1).

Possible sources of pollutants within the Topanga watershed include wildlife, horses, urban runoff and septic systems. However, a lack of baseline data prevents further speculation about the extent of the contributions of each.

The water quality at Topanga Beach and sources of contamination have not received much scrutiny from environmental groups and government agencies. A group called the Topanga Watershed Committee (TWC) is taking the lead at addressing the problem. The TWC is an all-volunteer, community-based, coordinated resource management and planning group, established through a grant from the California Department of Conservation. Participants in the TWC include community members, landowners, government agencies, environmental groups, and other interested parties.

One of the goals of the TWC is to improve water quality in Topanga Canyon. To achieve that goal, TWC has developed the following actions designed to identify the degree and extent of the water quality problem:

- Monitor sites, identify existing regulations and possible solutions.
- Assess septic system function and impacts.
- Assess livestock waste/corral impacts
- Assess homeless encampment impacts
- Assess graywater disposal impacts
- Determine water quality in drinking water wells.
- Assess impacts due to use of fertilizers, pesticides, herbicides, etc.
- Assess source standards.

Another group with a role in the Topanga watershed is the Santa Monica Mountains Resource Conservation District (RCD), which oversees natural resource conservation within the Santa Monica Mountains, and is closely linked with the TWC. The RCD received a grant from the State Water Resources Control Board to fund a two-year study designed to examine the relationship between water quality and land use in the Topanga watershed. Working with the TWC, the RCD began work on the study in July 1999. The study involves water quality sampling at various locations along the creek in order to establish baseline water quality data. Results of the study will be used by the TWC and RCD to identify strategies for pollution reduction in the creek and at the beach. For example, data collected during the study could help identify where along the stream pollutants are introduced. This information would be used to narrow down the possible sources of pollutants to the water body.

Recommendation

4.2 **The County Board of Supervisors should ensure that the county continues to participate in and have an active voice in the Topanga Watershed Committee. The Board of Supervisors should require that representatives of appropriate departments (e.g., Department of Beaches and Harbors, Department of Health Services, Department of Public Works) regularly attend TWC meetings and facilitate TWC's goal of improving water quality in the canyon. The county should continue to make available to the TWC the skills, expertise and experience of its staff to provide, as appropriate and as requested by the TWC, technical assistance, advice and guidance.**

4.3 SANTA MONICA CANYON

Findings

The Los Angeles County-owned storm drain at Santa Monica Canyon discharges at Will Rogers Beach in the City of Los Angeles. The watershed contributing to this storm drain includes primarily residential and open space land uses. Roughly half of the watershed is open space owned by the state. The annual dry weather grades at Santa Monica Canyon for the last six years have been poor (see Table 4.1).

The City of Los Angeles, County and Heal the Bay conducted a study to determine the sources of pollution in the Santa Monica Canyon storm drain. The study identified no primary source. Instead, the study pointed to many different sources, including horses and septic systems. Other potential sources include wildlife and pet droppings. A study conducted in 1991 found live viruses in Santa Monica Canyon, indicating that other possible sources of pollution in this drain are leaks or spills from the sewage system, private septic systems, or homeless populations.

A plan for diverting low flows at Santa Monica Canyon into the sewer system between April and September is currently under consideration by the Los Angeles City Council. This would solve the summer pollution problem at the Santa Monica Canyon beach. A year-round diversion is not under consideration at this time because the receiving wastewater treatment plant could not accommodate flows resulting from heavy rains, and the problem of ensuring that the diversion would be by-passed during storms has not yet been resolved. Most people we interviewed believe that this project will go forward, but a decision has not yet been finalized. Many issues have arisen in the debate over whether to proceed:

- The pros and cons of diversion as compared with source reduction.
- Liability associated with flows directed to the Hyperion wastewater treatment plant.
- Cost sharing.
- Prioritizing which flows to divert.

The City and County of Los Angeles would share the costs of the diversion. Funds from Proposition A in the amount of one million dollars have been earmarked for this project.

Recommendation

4.3 The County and City of Los Angeles should proceed with the planned construction of a seasonal diversion project.

Although there are some unresolved issues related to diversion policy more generally, we believe that it makes sense to go ahead with the diversion at this beach. It is a popular beach and the dry-weather urban runoff is substantial. A source investigation has been done, and no particular sources stood out. It is almost certain that efforts to reduce pollution sources will not yield results any time soon. Small-scale, local treatment is a conceivable alternative to diversion, but the real-world feasibility and cost-effectiveness of these systems has yet to be demonstrated. Diversion is the only way to ensure that water quality at this beach will be good in the near future. Issues relating to low-flow diversions are discussed in more detail in Section 5.6 of this report.

4.4 SANTA MONICA PIER

Findings

Santa Monica Pier is a recreational destination attracting large numbers of tourists with its amusement park rides, games and food, as well as nearby parking and hotels. It is also a popular destination for recreational fishermen.

A storm drain located under Santa Monica Pier discharges runoff from a small drainage area of 0.13 square miles. The predominant land uses are commercial and retail; other land uses include restaurants, hotels and high-density apartments. The Los Angeles County Department of Public Works monitors the water quality in the Santa Monica Pier storm drain as part of its Municipal Stormwater Permit. Monitoring data reveal that water in this drain contains minerals, solids, metals, and pesticides. Tests were not done for hydrocarbons or bacteria.

The beach monitoring station is located 50 yards south of the pier. Both dry and wet weather annual grades at the pier have been almost exclusively Fs over the past 6 years, with the exception of 1994, when the location received a B in dry weather and a D in wet weather (See Table 4.1). Fortunately, the water quality problems at Santa Monica Pier are not characteristic of the other piers in L.A. County. Water quality near these other piers is not consistently poor.

The pollution problem at this location has received much attention over the past several years. Attempts at eliminating sources of pollution have thus far been unsuccessful. The first attempt at reducing pollution was when the City of Santa Monica diverted low flows from the storm drain under the pier to the Hyperion treatment plant during summer months. Flow from the pier storm drain was periodically diverted to Hyperion in 1996. In 1997, a permanent diversion system was installed.

The City of Santa Monica, with funding from the City of Los Angeles and Proposition A, is constructing the Santa Monica Urban Runoff Recycling Facility (SMURRF) just south of the pier and north of the Pico-Kenter storm drain. When the SMURRF is operational, flows from both the pier and the Pico-Kenter storm drains will be diverted to this treatment facility. Low flows from both storm drains will be treated year round. During storm events, flows over the facility's capacity will be discharged to the ocean.

Roughly a year ago, a City of Santa Monica investigation of the sewer lines running underneath the pier resulted in the discovery of several leaks that were subsequently repaired. Birds were also suspected to be a large part of the problem, so a bird entrapment program was launched by the city, resulting in a perceived decrease of the bird population. None of these actions has significantly improved grades south of the pier.

The most recent strategy to reduce pollution has been the placement of signs along the pier warning visitors to avoid littering and improperly disposing of food waste. Mostly by process of elimination, it is thought that littering by pier visitors (including improper disposal of fishing waste), is the primary source of pollution – both the litter itself, and waste from the birds it attracts.

The attempt to track down and eliminate sources of pollution at the pier is ongoing. Recent strategies have focused on ensuring that garbage cans are not leaking polluted water into the ocean.

A Continuous Deflective Separation (CDS) unit was recently installed in the pier storm drain. This device filters out trash and sediment thereby reducing the amount of pollution reaching the beach (when the drain is not diverted). Visual inspections of the unit have revealed that it is operating properly and has been effective at removing most trash and sediment from the storm drain flow.

Recommendation

4.4-A The City of Santa Monica should regularly inspect the sewer lines under the pier.

4.4-B The City of Santa Monica should continue to educate pier visitors about the harmful effects of littering, feeding the birds, and improper disposal of fishing waste.

4.4-C The City of Santa Monica should continue to scrutinize the water quality monitoring data at this location.

4.4-D Until water quality improves, the City of Santa Monica should place permanent warning signs along the beach within 50 yards south of the pier. The signs should

warn swimmers that this beach has consistently poor water quality and they should briefly describe the health risks associated with swimming in polluted water.

4.4-E **Before moving on to very expensive solutions, the City of Santa Monica should reconsider the water quality goals for this beach.**

The minimal success of the city's substantial efforts to improve water quality south of the pier raises the concern that a heavily-visited pier and an adjacent swimming area are not compatible uses. Therefore, if the recent educational efforts do not result in improved water quality, the City of Santa Monica should reconsider its water quality goals for this beach and evaluate whether further efforts to meet the bacteria standards make sense. If the city does decide to relax its water quality goals at this beach, it should make sure that the public is adequately warned about the poor quality of the water and associated health risks. Issues relating to conflicting uses are further discussed in Section 5.1.

A more cautious alternative to posting warning signs would be to close the beach immediately south of the pier altogether. We do not think this is warranted. As discussed in Section 2.2, the demonstrated health risks of swimming in water contaminated at the levels observed are not severe (incidence rates of gastrointestinal problems, earaches, etc. rose from two to four percent), and the risks of swimming in water contaminated with bacteria coming from birds rather than human sewage may be even less. We do think, however, that the persistent nature of the problem south of the pier and the lag time between monitoring and posting discussed in Section 3.1 does warrant permanent posting.

There are a number of strategies that could be considered by the city if current efforts fail and it decides to make further efforts to improve water quality south of the pier. One suggestion is to eliminate bird roosting nests under the pier. Another strategy would be to hire personnel to walk the pier and enforce anti-littering policies. However these approaches are costly, and there is no guarantee that they will work.

4.5 PICO-KENTER

Findings

The Pico-Kenter storm drain is located in the City of Santa Monica, one half mile south of the Santa Monica Pier. This facility drains portions of Santa Monica and Los Angeles. This drain has been diverted in summer months to the Hyperion wastewater treatment facility since the early 1990s. Instances of problems with the diversion system, including leaks and breaks, have prevented this beach from receiving good grades even when the diversion has been in place.

The beach at the foot of this storm drain has received Fs for the past six years during wet weather. During dry weather, the annual grades for the past six years have been poor (see Table 4.1). It is important to remember that the dry weather annual grade takes into account months in the winter when the drain is not being diverted, as well as summer low flows that are diverted. A closer look at the Pico-Kenter monitoring data reveals that when the diversion is in place and functioning properly, the water quality at this beach is very good.

Human enteric viruses have been found in the runoff from Pico-Kenter storm drain, indicating that sewage has infiltrated the storm drain system. Other potential sources of pollution include those typical of most storm drains such as illicit connections, homeless and pet droppings. The City of Santa Monica and the City of Los Angeles share ownership of and maintenance responsibilities for the storm drain.

As discussed above, the City of Santa Monica is constructing a water treatment facility (SMURRF) just south of the pier and north of the Pico-Kenter storm drain. When the SMURRF is operational, flows from the Pico-Kenter storm drain will be diverted to this treatment facility year round. A CDS unit is being installed at Pico-Kenter; flows from the storm drain will be routed through the CDS before being diverted to the SMURRF. Once the SMURRF is operational, dry weather water quality is expected to be good year round.

Recommendation

4.5 No recommendation is required. This storm drain is currently being diverted in the summer and will be diverted year round (low flows only) to the SMURRF.

4.6 MOTHER'S BEACH, MARINA DEL REY

Findings

Mother's Beach is a popular family beach located at the end of one of Marina del Rey's eight basins. Marina del Rey is a man-made marina, housing 6,000 boat slips, numerous restaurants and over 10,000 residents. It is maintained by the Los Angeles County Department of Beaches and Harbors (DBH).

Water quality at Mother's Beach is inconsistent and often very poor. Wet weather grades at the playground monitoring station have been poor during the past six years while annual dry weather grades have been mixed (See Table 4.1).

A major cause of poor water quality at this beach is limited tidal circulation. The breakwater that protects the marina from potentially damaging waves also inhibits tidal flushing in the entire marina. The far reaches of the marina, such as the end of Basin D, are subject to very little flushing action at all. Therefore, when pollutants are introduced into the water at Mother's Beach, they are likely to remain.

Speculation about and investigation into the sources of pollution at Mother's Beach have been ongoing since the 1970s. In the past few years, attention has been directed towards the large bird population that frequents Mother's Beach. The DBH has made several improvements aimed at reducing the bird population. A grid of thin braided nylon lines (often inaccurately referred to as mono-filament lines) has been strung above the beach and is thought to interfere with the birds' flight patterns, thus deterring them from landing at the beach.

Another improvement directed towards bird reduction was the installation of roost-proof buoys. The previous buoys proved an attractive roosting location for birds as they are adequately sized (roughly 36 inches in diameter) and constructed from a black neoprene which absorbs the sun's heat and becomes enticingly warm. The birds would roost and pollute the buoy and surrounding water with bird feces. The new buoys are small on the top and lighter weight and tip over when birds land on them.

The new buoys were installed in the beginning of last summer and the braided nylon grid was upgraded in the spring. The grades at Mother's Beach last summer were much better than in the previous summer, suggesting that the recent strategies may be working. Grades at the beach from April through early November of 1999 were As and A+s. However, the beach has received Fs since the end of November, so it is not clear that the problem has been solved.

Other possible sources of pollution at Mother's Beach are the Oxford Creek storm drain, which discharges to the basin adjacent to Basin D, pollution from the boats in the marina, and improper urban runoff practices by restaurants in the marina. It is not known to what degree these sources contribute to the pollution problem at Mother's Beach.

The DBH has considered other options for Mother's Beach which have been put on the back burner both in light of the recently improved grades and due to cost and technological constraints. One such option is the installation of a filter technology at Mother's Beach to reduce pathogen flow from sources outside the beach. The filter allows water to flow through, but prevents particles larger than 20 microns from passing. Pathogens attached to larger particles could not pass through the screen. The filter would be installed in the water between Mother's Beach and the remainder of Basin D. The drawbacks of the filter technology are that: 1) it is expensive; 2) it would further hinder circulation; 3) whether the pollution is coming from the marina as opposed to the shore is unknown; and 4) even if the pollution is coming from the marina, its effectiveness is uncertain.

Another option that has been considered but is not currently being pursued is the construction of a swimming-pool-like structure, similar to the plunge in Redondo Beach. The facility would be carved out of the beach, enclosed with a sand bottom and filled with salt water. Construction of a bathing pool would allow control of the water quality, thus reducing health risks to swimmers.

Recommendations

4.6-A The County Department of Health Services (DHS) and County Department of Beaches and Harbors (DBH) should continue monitoring to determine whether the recent improvements (additional braided nylon lines, roost-proof buoys) are effective at reducing pollution at Mother's Beach.

4.6-B Until water quality improves, the DBH should place permanent warning signs along this limited-circulation beach. The signs should warn swimmers that this beach has inconsistent and often poor water quality and they should briefly describe the health risks associated with swimming in polluted water

4.6-C Before moving on to very expensive solutions, the DBH should reconsider the water quality goals for this beach.

This beach may be another example of inconsistent land uses. Perhaps a limited circulation beach located adjacent to a marina is not an appropriate swimming beach. The issues at this beach are similar to those discussed under Recommendation 4.4 (Santa Monica Pier). Again, the responsible agency, in this case, Los Angeles County, needs to decide how much money it wants to spend to ensure low bacterial indicator levels at this beach.

If the DBH decides that getting high grades at Mother's Beach is a fiscal priority, options that have been put on the back burner because they are prohibitively expensive or because of technological barriers could be reconsidered. In addition to the options mentioned above, the DBH could consider engineering solutions to improve tidal circulation, such as pumping water into the beach from other, cleaner areas of the marina or ocean. Such enormous expenditures would require a strong mandate that safe swimming at Mother's Beach is a priority to be achieved at even high cost.

4.7 CABRILLO BEACH

Findings

Cabrillo Beach is located on the east side of the Palos Verdes Peninsula, within the San Pedro Breakwater. This is a limited circulation beach, protected from ocean currents by the breakwater and bordered by two jetties. Circulation is also inhibited by eelgrass growing in the water in front of the beach. A portion of the beach is marked by buoys as a swimming beach. Cabrillo Beach is heavily used by an economically diverse population.

Cabrillo Beach is considered the most polluted beach in the county. It has received annual grades of Fs for both dry and wet weather for the past five years (with one exception – it received a dry weather grade of D in 1996).

In November of last year, the City of Los Angeles launched an intensive investigation at Cabrillo Beach to determine the source of the pollution. Possible sources considered were leaks from the sewer lines running to the restrooms on the beach, storm drains, the adjacent marina and pier, the Dominguez Channel, bather loading, and birds.

The study allowed the city to eliminate several possible sources and come to the conclusion that the problem is the birds. Off-shore sources (such as pollution from the marina) were eliminated because bacteria levels were higher at ankle depth than at knee and chest depths. Leaks from the restroom were ruled out by groundwater sampling between the shore and the facilities. Storm drains were eliminated because they do not flow unless it rains, and the problem persists in dry weather. Also, groundwater sampling along a line between the beach and the storm drain outlet did not reveal that the storm drain was a source of contamination. The Dominguez Channel was excluded because bacterial levels were not high in water samples taken at the mouth of the Dominguez Channel.

Humans are not thought to be the primary cause of the problem because bacteria levels are higher in the winter, when there are fewer people and more birds. That is not to say that humans do not contribute to the problem. People leave trash and even diapers along the beach.

To ensure that humans are not the source of the problem, human virus testing will be done by the City of Los Angeles on low-use and high-use days.

The eelgrass contributes to the problem both because it inhibits tidal circulation and because it washes up on the beach and captures organic matter such as bird feces.

The city's options at this beach are limited. They sweep the beach daily to remove eelgrass and all the ensnared organic matter. They are planning on replacing the buoys marking the swim area with a roost-proof model. Installation of a braided nylon grid, such as that the one at Mother's Beach in Marina del Rey, is not an attractive option because this beach is considered a bird habitat.

One option suggested in the city's review is to install a fence between the area where the birds tend to sit and the swimming area. Some believe this might inhibit the birds' movement into the bathing area, reducing pollution in this area.

This issue is currently under consideration by the Los Angeles City Council.

Recommendations

4.7-A The City of Los Angeles should take the measures to limit seagull use of the beach in front of the swimming area (including the fence solution) identified in their recent investigation of Cabrillo Beach.

4.7-B Until water quality improves, the City of Los Angeles should place permanent warning signs along this limited-circulation beach. The signs should warn swimmers that this beach has consistently poor water quality and they should briefly describe the health risks associated with swimming in polluted water.

4.7-C Before moving on to very expensive solutions, the City of Los Angeles should reconsider the water quality goals for this beach.

This beach, again, brings up the question of having two competing uses at one beach – in this case, bird habitat and swimming. Therefore, if measures to limit seagull use of the beach are ineffective, the City of Los Angeles should reconsider its water quality goals for this beach and evaluate whether further efforts to meet the bacteria standards make sense. If the city does decide to relax its water quality goals at this beach, it should post permanent warning signs about the poor water quality and the risks of swimming. Again, the issues discussed for Santa Monica Pier (see Section 4.4) apply also at this beach. How important is it to us as a society to ensure low bacteria levels at this beach? A costly solution could include running a pipe from outer Cabrillo Beach (outside of the breakwater) to inner Cabrillo Beach to improve tidal circulation.

Cabrillo is one of the few beaches in L.A. County in close proximity to lower income neighborhoods. It thus provides an easily accessible recreation opportunity for low-income families. This feature should be kept in mind when determining how much to spend to reduce bacteria levels at this beach.

SECTION 5. RECOMMENDATIONS FOR IMPROVING THE QUALITY OF URBAN RUNOFF

This section evaluates and makes recommendations about efforts in Los Angeles County to improve the water in the rivers, creeks, and storm drains that flow into the ocean. Urban runoff and other non-point sources cause bacteria levels to exceed health standards at almost all L.A. County beaches during wet weather (defined as the period during and the 3 days following rain). Urban runoff also causes high bacteria levels at some beaches during dry weather. In addition, urban runoff contains other contaminants such as metals and organic chemicals (e.g., pesticides) that may pose health risks to swimmers.

As previously mentioned, the Grand Jury cannot investigate nor make recommendations to the Los Angeles Regional Water Quality Control Board; however, recommendations to Los Angeles cities and Los Angeles County must be viewed within the context of Regional Board public programs and policies.

The Los Angeles Regional Water Quality Control Board is responsible for setting water quality standards and issuing permits aimed at reducing pollution in L.A. County's rivers, creeks, and beach waters. Thus, this section is largely about the Regional Board's programs and policies. It also addresses the policies and programs of the County and the cities in L.A. County.

The Regional Board, prodded by several lawsuits by environmental groups, has ambitious plans to improve the water quality of urban runoff in L.A. County. However, we are concerned that the institutions, programs, and resources in place may not be up to the job. Below we make several recommendations for improving the system and urge the Board of Supervisors and city governments to take steps necessary to implement them. At stake is both the speed with which the benefits of cleaner rivers, creeks, and beach waters will be realized and the effectiveness of the billions of dollars that may well be spent by public and private organizations in the cleanup effort.

The following issue areas are examined in this section:

5.1 Setting goals for the uses of rivers, creeks, estuaries, and beach waters.
5.2 Identifying pollution sources.
5.3 The Regional Board's role in designing programs.
5.4 Enhancing incentives to improve water quality.
5.5 Matching authority with responsibility.
5.6 Policies for diverting urban runoff into the sewer system.
5.7 Monitoring and enforcement.
5.8 Funding for water quality programs.

5.1 SETTING GOALS FOR THE USES OF RIVERS, CREEKS, ESTUARIES, AND OCEAN

Issue

The Regional Board specifies beneficial uses for the rivers, creeks, estuaries, and beach waters in L.A. County. Different beneficial uses imply very different water quality objectives and potentially very different compliance costs. What should these beneficial uses be? Are the currently listed beneficial uses appropriate?

Findings

The Regional Board has designated beneficial uses for specific water bodies in L.A. County. These water bodies include rivers, creeks, estuaries, lakes, and beach waters. There are 24 possible beneficial uses, ranging from water-contact recreation, shellfish harvesting, and freshwater habitat to uses of water for municipal drinking water systems. Varying combinations of the 24 beneficial uses have been designated for each of the water bodies in the county.

Many experts we talked to feel that some of the designated beneficial uses are inappropriate. For example, contact recreation is listed as a beneficial use in many of the channelized sections of the L.A. River, even though access to the concrete-lined channels is prohibited. Cleaning water up in Ballona Creek so that shellfish at the mouth of Ballona Creek are safe for human consumption does not seem like a sensible goal to many. And many feel that reducing pollution in the L.A. River so that it can be used in domestic water systems (after standard treatment) is a poor use of society's resources when it is not clear that the State Department of Health Services would ever allow flow in many reaches of the L.A. River to be used directly for drinking water.

Some stakeholders feel that the process through which beneficial uses were designated (mainly in the 1970s) was inadequate. They think that the designations were done haphazardly, without proper quality control on the data and analysis. We have not been able to assess whether the process was really lacking, but regardless of the answer, it is clear that there is not widespread support among the experts we interviewed for many of the beneficial uses. This lack of support stops many from fully supporting and contributing to efforts to improve the quality of urban runoff and may lead to lawsuits that can further slow the process.

Others, mainly from environmental groups, that we talked to feel that most beneficial uses are appropriate. They criticized efforts by the County Sanitation Districts of L.A. County that used taxpayer dollars to try to "delist" drinking water as a beneficial use in several rivers and creeks. Even those that supported most beneficial uses, however, think there are probably some situations where the designated uses do not make sense.

It is very difficult to delist a beneficial use once it has been listed. By design, the barriers are high to discourage backsliding on water quality goals. Supporting the County Sanitation Districts' efforts, the Regional Board submitted a petition to delist drinking water on several reaches, but the petition was denied by California's Office of Administrative Law (the agency responsible for ensuring that proposed regulations comply with required formats and legal standards) in the summer of 1998 as insufficiently documented. We observe that while it may make a great deal of sense to create high barriers to delisting thoughtfully listed beneficial uses, it may not make sense to impose such high barriers if the original listing process was flawed.

Our examination of the beneficial uses in L.A. County also suggests that there may be conflicts among the beneficial uses that have been designated for some water bodies. For example, both water-contact recreation and wildlife are designated as beneficial uses in Malibu Lagoon, but the presence of birds may make it very difficult to meet the bacteria standards for swimming. Similarly, contact recreation and wildlife are listed at Cabrillo Beach, and we have seen how these two uses may not be compatible.

Recommendation

5.1 A meaningful process to prioritize the beneficial uses for the water bodies in L.A. County should be created. Near-term water quality programs should attempt to achieve the high-priority beneficial uses. Programs required to achieve lower priority beneficial uses should be deferred.

The resource costs of the process itself and likely legal challenges make delisting an unattractive way at this point to resolve the inconsistencies between some listed beneficial uses and the lack of support for others. A phased approach leaves the beneficial uses in place, but focuses attention on the most important beneficial uses first. It means that instead of installing treatment technologies or developing pollution prevention strategies that meet the most stringent water quality objectives all at once, goals would at least initially be less ambitious. Decisions to pursue lower-priority beneficial uses would be made once there is more real-world experience with the costs and effectiveness of different pollution reduction technologies and when spending on the high-priority beneficial uses begins to wind down. It may ultimately make sense to delist some beneficial uses if certain water quality objectives are unattainable or attainable only at very high cost. However, we do not need to make the decision to delist now.

When prioritizing, it may make sense to consider beneficial uses separately during wet and dry weather. For example, water-contact recreation may be sensible in dry weather when flows in rivers and creeks are low, but not in the relatively few days of wet weather in Southern California. High flows during wet weather are dangerous, and it will likely be very expensive to reduce the contaminant levels in such large runoff volumes.

The Regional Board is beginning to issue so-called Total Maximum Daily Loads (TMDLs). TMDLs allocate pollutant loads to the different sources on a particular water body and provide the basis for pollution reduction requirements from the various sources. Leaving all beneficial uses on the books will likely mean that Total Maximum Daily Loads (TMDLs) will have to satisfy all beneficial uses, but the decisions to implement the load reductions can still be phased.

A meaningful process to prioritize beneficial uses would involve the participation of the various stakeholders—the county, the cities, industry, and environmental groups—and would create a process and decision-making criteria that all can support and abide by.

5.2 IDENTIFYING POLLUTION SOURCES

Issue

An effective and cost-conscious program for reducing pollution in urban runoff must be based on a solid understanding of the sources of pollution. Without this understanding, the right activities may not be targeted and resources may not be spent in the most effective manner. For example, if leaking sewers are the main source of the bacteria in urban runoff, resources should focus on detecting and fixing leaks. If sewers were not a major problem, investing resources on leak detection would not yield many payoffs. Do we have a good understanding of the sources of pollution in urban runoff?

Findings

Measurements show that urban runoff contains high levels of bacteria and other contaminants both in wet and dry weather. But there is little agreement on the relative importance of the potential sources of pollutants (see Section 2.3 for discussion of possible sources).

There is particular controversy over the source of bacteria. Some (often the people responsible for the city and county storm water programs) put the majority of the blame on the sewer system. Noting that much of the sewer system in the City of Los Angeles is over 50 years old and, in their view, poorly maintained, they believe that blockages or capacity limits frequently cause sewage to come up through manhole covers and then flow into storm drains. Some also believe that leaks in the sewer pipes allow sewage to migrate underground into the storm drain system.

Others (usually people responsible for the sewer system) put the blame for high bacteria levels on contaminants picked up by water running over the surface on its way to storm drains and on illegal discharges and connections to the storm drain system. In their minds, sewers are not the main problem, and resources should be spent reducing these other sources of pollution. Sources of bacteria in surface runoff include pet and bird droppings, the homeless, and food waste washed off restaurant mats. Fertilizers and food from restaurant mats in surface runoff can also provide nutrients that allow the bacteria to multiply.

The lack of agreement reflects a lack of solid information on pollution sources. Even basic characteristics of the system are not well understood. For example, many experts think that there is a "first-flush" effect, that is, that pollution is highest during the first rainfall of the season. However, recent monitoring data suggest that the first-flush effect does not apply to bacteria: bacteria densities observed during the first storm of each rainy season were not necessarily higher than during consecutive storms.

While the beaches and Bay are extensively monitored, there has not been much monitoring inland. L.A. County is required by its storm water permit to collect water quality data at a number of inland sites, but the scope of this effort is limited.[4] Several cities in L.A. County, researchers at UCLA and other organizations, and some environmental groups have analyzed inland water samples, but the efforts are scattered.

There does not appear to be much communication or coordination among the organizations that are doing sampling. There is no well-thought-out division of responsibilities or allocation of costs. Indeed, some organizations are not aware of the sampling other organizations are doing. Sampling procedures and test protocols are not always consistent, making it difficult to compare results (see Section 3.1). There is no central inventory or repository of existing data, making it difficult to know what has been done or learn from the experience of others either in L.A. County or in other parts of the state.

The importance of solid information in designing cost-effective pollution control strategies leads us to recommend that inland monitoring efforts be expanded and coordinated.

Recommendation

5.2 Efforts to identify the sources of the pollution in urban runoff should be coordinated and expanded. In particular:

- **An inventory and assessment of the comprehensiveness and quality of existing water quality data should be compiled.**
- **Water quality monitoring should be expanded to fill gaps in our understanding of pollution sources.**
- **Monitoring efforts should be coordinated and sampling procedures and testing protocols standardized.**
- **A rational formula for sharing costs between the county the cities in the county, and other involved parties should be developed.**

Because human sewage is thought to pose the greatest threat to swimmers, particular attention should be paid to the contribution of the sewer system, the homeless, and illegal connections and discharges to the high bacteria levels in urban runoff. A joint powers authority whose mission is to collect standardized monitoring data both inland and along the shore should be considered. The mission of the Southern California Coastal Water Research Project (SCCWRP), which has been involved in evaluating shoreline monitoring procedures, might be expanded to take on these responsibilities.

[4] During the 1998-99 storm season, L.A. County collected wet weather data at 5 "mass"-monitoring stations, 8 land-use sites, and 9 critical source sites (along with 9 control sites). The mass-monitoring stations sample water that drains from large, or massive, drainage areas; the land-use sites are chosen to be representative of particular land uses; and the critical source sites are chosen to test the effectiveness of BMP implementation at industrial sites thought to generate substantial pollution. Some dry-weather sampling is also done at the mass-monitoring sites.

5.3 THE REGIONAL BOARD'S ROLE IN DESIGNING PROGRAMS

Issue

The Regional Board can take two fundamentally different approaches to reducing the pollution in urban runoff. It can specify performance standards, say in terms of the concentrations of bacteria and other contaminants in discharges to surface waters, and then leave it to the cities, county, and businesses responsible to figure out how to meet them. Or it can require the cities, counties, and businesses to adopt particular pollution reduction programs, the implementation of which will satisfy their responsibilities to reduce pollution. What mix of approaches should L.A. County support?

Findings

As far as urban runoff is concerned, the Regional Board is very much in the business of requiring permittees to develop programs to reduce pollution, approving them and then requiring that they be implemented. It does not write permits in terms of the concentrations or pollutant loads that permittees are allowed to discharge to the storm water system.[5] The Board requires the county and cities to develop storm water management programs and submit them to the Board for approval. The Board reviews and may modify the proposed programs. Once approved by the Board, the programs are then incorporated into NPDES permits.

The current urban runoff permit for the county and cities requires them to develop and implement programs to:

- Eliminate illicit connections and illicit discharges to the storm drain system.
- Control pollution both during and after construction from new development.
- Reduce the impact of public agency activities on urban runoff quality.
- Raise public awareness of urban runoff quality issues.

In all but a few instances, the county and cities are not held directly accountable for the quality of the urban runoff that flows from their jurisdictions into the rivers, creeks, and ocean of L.A. County. Rather, implementation of the Board-approved programs satisfies their responsibilities.

The recently adopted requirement to restrict runoff from new development is an example of a program developed to control pollution. As principal permittee for the municipal urban runoff permit, L.A. County developed (and has implemented in its own jurisdiction) a program that requires certain categories of new development to retain or treat runoff from the first three-quarters of an inch of rainfall on their properties. The county developed the requirement as part of a legal settlement with environmental groups, and the program is very contentious. Even though the county considered a wide range of input in developing the program, many cities and developers think it much too costly. The Regional Board approved the rule with some

[5] The L.A. County urban runoff permit says "Timely and complete implementation by a Permittee of the storm water management programs prescribed in this Order shall satisfy the requirements of this section and constitute compliance with receiving water limitations." If the programs are inadequate to achieve water quality objectives, the permittees "shall submit revised storm water management programs ... that will increase the likelihood of preventing future exceedances of water quality objectives".

modifications, and the program is now mandatory for all the cities and unincorporated areas of the county.

Requiring programs has some advantages. It creates an even playing field across the county and consistency of regulations. It also eliminates the need for water-quality monitoring to measure compliance with a performance-based permit.

The Board's focus on requiring programs rather than setting performance standards raises several concerns, however. First, because the cities, county, and industrial sources do not have direct responsibility for meeting water quality standards, their focus becomes designing and implementing approvable programs, whether or not they are effective. While some agencies and businesses will undoubtedly take their responsibilities very seriously, others will likely try to get by with the least effort possible. Second, the structure and condition of the economy, the types of pollution sources, and geography vary a great deal across the county, and region-wide programs are unlikely to work equally well in all areas. For example, it may be that treatment makes much more sense in some areas, while prevention is the best approach in another. Third, as discussed more below, the Regional Board is very resource constrained. Reviewing, modifying as necessary, and then approving these programs is staff-intensive, as is monitoring whether the programs are actually being implemented as designed.[6] Finally, we are concerned with the focus on programs rather than standards because there seems to be little attention being paid among the regulated as to how well the programs that are approved and implemented really work. This does not bode well for a cost-effective pollution reduction strategy.

These concerns motivate our recommendation that the cities and County agencies focus more on setting limits on the contaminants in effluent and fixing responsibility for meeting them rather than designing programs.

Recommendation

5.3 Los Angeles cities and the County should focus more on setting limits on the contaminants in discharges to surface waters and fix responsibility for meeting them.

Holding cities, the county, and certain types of businesses responsible for numerical water quality objectives will make them very much interested in the design and implementation of water quality programs in their areas. Setting goals will allow regulated entities to design the programs that best fit their situation and encourage them to carefully evaluate the programs' effectiveness.

[6] U.S. EPA has criticized the Regional Board for delays in reviewing the model programs submitted under the L.A. County municipal storm water report. EPA has noted that there was a significant lack of overall progress in implementing the terms and conditions of this storm water permit. The Board had not reviewed and approved the model program components submitted by Los Angeles County, the lead permittee. Five major model programs had been submitted by the county but had not been reviewed and or approved by the Board. EPA's concern was so great that it recommended that neither it nor the Regional Board issue permits which rely on actions by a regulatory agency before requirements can go into effect.

As discussed above, requiring programs has certain advantages, but, particularly in the coming world of TMDLs, we believe that defining compliance in terms of effluent limits is the better approach.

A focus on meeting water quality objectives requires comprehensive monitoring of the water that leaves each regulated entity (the cities, the county and regulated businesses). The intermittent and variable nature of urban runoff creates some difficulties in monitoring, but we are confident that modern automated sampling equipment can be effectively used. Increased monitoring will mean increased costs, but savings from a more efficient program will offset these increased costs.

Because of uncertainties in the sources of pollution and in the cost and effectiveness of different control strategies, some cities will undoubtedly prefer that compliance be defined in terms of implementation of a set of programs rather then in terms of meeting water quality objectives. However, the Regional Board can set or phase in water quality objectives taking into account these uncertainties.[7] There is a movement away from centralized, command-and-control regulations in the United States and toward policies with more flexibility and dispersed responsibility. While some may be comfortable with the old system, the new system promises better results at lower costs.

5.4 ENHANCING INCENTIVES TO IMPROVE WATER QUALITY

Issue

The previous section urged the responsible agencies broad discretion in designing programs to achieve objectives. This section addresses the character of these programs. In particular, it examines the role of incentives for voluntary actions to improve water quality. What mix of incentives versus required programs makes sense in L.A. County?

Findings

The current system relies very little on financial, market, or other incentives to improve water quality. Programs adopted by the cities, county, and Regional Board are in the form of regulatory programs with penalties (at least in principle) for noncompliance. Programs that rely on voluntary response to individual or organizational incentives are being used to address many other resource and environmental problems and could be applied here.

Some incentives that have been used are financial: for example, financial incentives to install low-flow toilets or energy-efficient refrigerators. Sometimes the incentives are reputational. EPA's Green Star program, for example, acknowledges businesses with model environmental programs. These awards can help improve perceptions of the companies in the communities in which they operate or with regulators or consumers. Market incentives have also been used in several areas. The South Coast Air Quality Management District's RECLAIM

[7] By determining what sets of programs are adequate to meet water quality responsibilities, the Regional Board in effect sets interim water quality objectives in the current system.

program assigns rights to emit certain amounts of pollutants which can then be bought and sold on the open market. Such markets provide incentives for firms to reduce emissions beyond their assigned limit (by allowing them to sell their unused emission rights) and encourage the firms that can reduce emissions most cheaply to make the greatest emissions reductions. Incentive-based programs have been successful in other areas and may well make sense in the water-quality area.

Recommendations

5.4-A The L.A. County Department of Public Works and the appropriate city departments should explore programs that rely on incentives for voluntary actions that improve the quality of urban runoff. Approaches that should be explored include:

- **Financial incentives for businesses and homeowners to reduce runoff flows or improve runoff quality. The cities and county should consider imposing storm water fees that could fund such programs.**
- **A county-wide awards program that acknowledges business or government agencies that have adopted exemplary programs to improve urban runoff.**

The City of Los Angeles already has a storm water fee in place that could be used to fund incentive programs. This fee system should serve as a starting point for discussions in other cities and the county for adopting storm water fees.

5.4-B The setting up a market for water quality pollutants should be explored. Dischargers would be assigned pollution limits and could buy rights to emit pollutants if it were too difficult to reduce their own pollutants or sell rights if they reduced pollutants below their cap.

The participants in a market for pollutants would include the cities and county responsible for controlling discharges of urban runoff into the rivers, creeks, and oceans. Businesses with point-source discharge permits or general industrial storm water permits and publicly owned treatment plants would also be included.

There are several important issues that need to be investigated before setting up a market for water pollutants. First, trading raises the concern that pollutants will be concentrated in certain areas. Trading may thus have to be restricted to certain zones (e.g., within defined drainage basins). Second, systematic monitoring will be required to verify that emissions do not exceed the rights to discharge held by the firm. Highly variable urban runoff flows make this a challenge. It is not obvious that a market system will work in the water quality area, but the potential benefits of such a system warrant its consideration.

5.5 MATCHING AUTHORITY WITH RESPONSIBILITY

Issue

The Regional Board is embarking on an ambitious effort to clean up urban runoff. It is unclear, however, that it or the cities, county, and businesses that it regulates have the authority to control some significant pollution sources or adopt some of the more innovative types of treatment technologies, such as in-stream bio-remediation. The result may be reliance on end-of-the-pipe treatment solutions that are more expensive than necessary. Are the authorities of the Regional Board and the entities it regulates properly matched with their responsibilities? Are additional authorities needed? Who should have them?

Findings

There are several important sources of pollution in urban runoff that neither the Regional Board nor the cities, county, and businesses it regulates have the power to reduce at the source. For example, automobile and truck brake pads are thought to be a significant source of the copper that winds up in urban runoff, but neither the Board nor the regulated entities can require that brake pads contain less copper. Likewise, oil leaks and grease drippings from cars and trucks are likely a significant source of the oil and grease that ends up in urban runoff, but the Board, cities, County, or Caltrans (which has its own urban runoff permit) do not have the power to require that oil systems be checked for leaks during vehicle inspection programs or to set standards for the formulation and application of grease on tractor-trailer bearings. Pollutants from vehicle exhaust (which then settle out of the atmosphere) are another example of a potentially important source of pollution over which the water-quality regulators and regulated have no direct control. Chain link fences may be the major source of the zinc that shows up in urban runoff, but controlling the zinc-content of chain link fences is out of reach of the agencies responsible for pollution reduction programs.

Current institutional boundaries restrict the types of remediation strategies that can be considered. Natural attenuation of some pollutants in stream beds and wetlands may make a lot of sense and create multiple benefits, but the Regional Board and regulated entities often do not have the authority to restore to more natural states stream channels that are encased in concrete or to build or restore wetlands.

The lack of authority over important sources of pollution or the ability to implement certain treatment strategies means that certain types of solutions are not even considered, and even if considered, are quickly taken off the table because of the inability to implement them. As a consequence, cities and others may be forced into expensive end-of-the-pipe treatment when other approaches are more sensible.[8] This is not a desirable outcome. We as a society should not let institutional boundaries get in the way of the best solutions.

Recommendation

5.5 **The County should lead an effort to identify what additional powers are needed by the Regional Board, the cities, and the County pertaining to water quality control, determine who should have these powers, and then obtain them.**

It may make sense for the Regional Board to be the lead agency for regulations on consumer products such as brake pads or chain link fences. The South Coast Air Quality

[8] The Regional Board acknowledges that certain pollutants present in storm water and/or urban runoff may be contributed by activities which the Permittees cannot control but Permittees can implement measures to minimize entry of these pollutants into storm water.

Management District (SCAQMD) might provide a model to follow. SCAQMD regulates many consumer products sold in its jurisdiction (paint and barbecue lighter fluid, for example) in an effort to reduce air pollution.

The authorities that result from such a process should be well aligned with the responsibility for reducing particular pollution sources. For example, if the Regional Board has authority and takes responsibility for the copper in brake pads and the zinc in chain-link fences, then removing the pollutants from these sources should not be the responsibility of the cities, the county, or Caltrans. Such exemptions are analogous to current exemptions for runoff from agricultural lands or exemptions for runoff from public schools and universities, which are outside the jurisdiction of cities and the county.

5.6 POLICIES FOR DIVERTING URBAN RUNOFF INTO THE SEWER SYSTEM

Issue

Diversion of low volumes of urban runoff into the sewer system is one of the many policy options being considered as a solution to the beach water pollution problem. Many of those involved in water quality issues consider diversions to be the best way to guarantee clean water in the short term. Others have reservations about the costs and potential liability for failure of sewage treatment plants. Does the current diversion policy in the county make sense? What improvements might be made?

Findings

We first present some background on the advantages and disadvantages of diversions. We then describe current diversion programs in the City of Los Angeles, where the debate over diversions is perhaps the most intense, and in Los Angeles County. We conclude by describing the issues that remain unresolved in developing a sensible diversion policy for the county.

Background. Diversions send polluted urban runoff into the municipal sewer system. Sewer system capacity constraints limit the amount of runoff that can be diverted to the sewers. The chief benefit of diversions is that they immediately eliminate polluted urban runoff from beaches, at least when flows are sufficiently low.

Source reduction is an alternative to diversions, but as we have seen (see discussion of Santa Monica Canyon in Section 4.3), eliminating the causes of the pollution in urban runoff is difficult. Source identification is costly and often unsuccessful. There is not much evidence so far that regulations (Best Management Practices) to reduce pollution in urban runoff are very effective. Public education campaigns that focus on changing people's behavior may ultimately have an effect, but it is likely that this is a long-term solution that may take a generation to yield tangible results.

Small treatment devices are also an alternative to diversions in some locations. We have not been able to compare their costs with those of diversions, but the innovative approaches that have recently been developed are still largely untested in the real world. Siting such facilities

The County and the City of Los Angeles should continue their efforts to develop a cost-sharing formula that considers both the area of origin of the runoff and the incidence of the benefits from the diversion. The state and other cities that contribute to flows in the drains subject to diversion should be also be pulled into the discussions.

Efforts should be made to reduce the possible impacts of the diversion on sewage treatment plants and to clearly assign (and share as appropriate) liability for violations that do occur. One approach that should be considered is to install automatic monitoring stations just upstream of diversions. Readings from the stations could be used when treatment plant permit limits are exceeded to determine the appropriate fine and its allocation.

5.7 MONITORING AND ENFORCEMENT

Issue

No matter how good they may look on paper, efforts to clean up the rivers, creeks, and oceans in L.A. County are only effective to the extent that the responsible organizations translate the words into action. Many of the experts we interviewed are concerned that the Regional Board is not adequately monitoring whether the cities, county, and industries that contribute to pollution in urban runoff are complying with their permit requirements and that the Regional Board does not issue strong enough penalties when they fail to comply. Many are similarly concerned about efforts by the cities and county to enforce municipal ordinances related to urban runoff. How effective are the compliance monitoring and enforcement programs in the county? How might they be improved?

Findings

The L.A. Regional Board regulates urban runoff in L.A. County through a municipal storm water permit (L.A. County is the principal permittee with 86 cities as co-permittees) and approximately 2,600 industrial and 600 construction permits. Regional Board enforcement programs are in four areas: the industrial storm water program, the municipal storm water program, spills, and point source permits. We then examine the monitoring and enforcement programs in the City and County of Los Angeles and their coordination with Regional Board programs.

Industrial Storm Water Program. Some analysts believe that there are many industrial facilities that are required to obtain storm water permits but have failed to do so. For example, based on its own research and that done by UCLA, a report by Heal the Bay concludes that there are 5,000 to 10,000 facilities in the region that have failed to obtain the required permits. While recognizing that increased efforts are underway, U.S. EPA also believes that non-filing is an important issue.

In response to this concern, the Regional Board has mounted an intensive effort to identify non-filing facilities. Preliminary results show that there are fewer non-filing facilities than previous estimates suggested and that the non-filing issue is well on its way to being resolved.

Monitoring for compliance with existing industrial storm water permits consists, first, of checking whether the required annual reports have been submitted and, second, of conducting about 100 or so inspections per year.[10] Compliance with the reporting requirement is not very good. One report states that 29 percent of the firms required to submit annual reports under the terms of their storm water permit failed to do so in 1995/96 and that roughly three-quarters of these were more than one year late. The results of inspections also do not suggest a very effective program. There is evidence that many firms are not doing what is in their storm water plan. Also, at this point, there has been very little assessment of the efficacy and appropriateness of the storm water management plans themselves.

Municipal Storm Water Program. As principal permittee, L.A. County coordinates the annual reporting required of the county and the 86 cities that are co-permittees. Problems with reporting did not come up during our investigation. There is, however, little in-field monitoring of compliance with the terms of the permit or the efficacy and appropriateness of the programs in the various cities. There have been no substantive audits of city programs, and that the review that does exist focuses on reporting and procedural requirements. Programmatic audits of the city and county programs are necessary to ensure that the municipal storm water program is more than a paper program.

Spills. Every day in L.A. County there are several sewage spills. Most of these are small and probably do not reach the storm drain system. A system of permits and reporting requirements enables the Regional Board to monitor the performance of the system at a basic level and provides incentives for system maintenance through fines. It also allows the County Department of Health Services to issue swimming health advisories as appropriate. There is an important gap in this system, however. The county and the cities that have permits with the Board to operate sewage treatment facilities or that hire the county to run their sewage collection systems are required to report spills to the Regional Board, the County Department of Health Services, and the State Office of Emergency Services. The cities that run their own sewage collection systems[11] are required by their municipal storm water permits to report spills to the County DHS, but DHS receives no such reports. There is thus a general lack of information on the performance of these systems and no mechanism in place to issue beach closures if the spills are a threat to public health.

Environmental and public interest groups have raised concerns that the Regional Board is not tough enough on the cities, county, and businesses that spill sewage or water tainted with other contaminants. CalPirg reports that of the 1,857 spills in the L.A. Region in 1997 and 1998, only 46 triggered formal action and only 10 resulted in fines.

According to Heal the Bay, only 4 of the 2,194 spills between 1992 and 1997 resulted in penalties or referrals to the attorney general. Many of these spills do not reach waterways and the Board has a progressive enforcement policy that starts with warnings and culminates with fines for repeat violators. Over the last two years or so the frequency and size of fines for spills,

[10] EPA reports that 50 sites were inspected in 1996/97. Regional Board staff confirmed that inspections were currently running about 100 a year.

[11] About one-half of the cities in L.A. County are not members of the county's consolidated maintenance district and either run their own sewage collection systems or hire private vendors to maintain their sewage collection systems.

particularly on municipal sewage systems, have increased. This may have been in part due to increased spills during wet El Niño winters, but it also suggests that the Board decided that its past enforcement policies were too lax and is moving to remedy the situation.

A state law that took effect on January 1 indicates more general dissatisfaction with the enforcement policies of water quality regulations across the state. SB709 requires mandatory penalties for serious and chronic violations. For better or worse, it severely limits discretion in imposing fines.

Point Sources. We have focused on monitoring and enforcement for urban runoff policies in this section, but one issue of concern arose during our investigation of the water quality monitoring associated with point source permits—permits that regulate discharges from municipal sewage and industrial process-water treatment plants. There is general satisfaction among those we interviewed with the frequency of inspections of the 44 major dischargers and 260 minor dischargers throughout the region. However there is concern that the water samples used to monitor compliance with the permit are not representative of the flows from the facilities. Dischargers are required to collect samples and report results of lab analyses to the Board. Some we interviewed felt that dischargers "game" the system, taking samples during periods when the treatment plant is known to be working well or when inflows into the plant are low or have low pollution levels.

Enforcement in the City and County of Los Angeles. The County visits all restaurants and other businesses in selected Standard Industrial Classification (SIC) codes to inform them of their responsibilities related to urban runoff under municipal codes and the county's municipal storm water permit. Under the terms of the county permit, two such educational visits per site are required between 1996 and 2001. The County has responsibility for businesses in unincorporated areas and in cities that have contracted with the county for this service. Consistent with the education mission, not a large number of citations for runoff-related violations have been issued since the program began.

The City of Los Angeles is also conducting educational visits at approximately 15,000 businesses under its jurisdiction. The city is currently finishing up the second round of visits. In recent months, it has been issuing 10 to 15 notices to comply with urban runoff regulations a month and is gearing up for a greater emphasis on enforcement.

Several issues arose in our investigation of city and county enforcement programs. First, we found little coordination between county and city programs and the Regional Board's industrial storm water permit enforcement program (see above). The county or city staff also separately visits most firms visited by Regional Board staff. There is also an overlap at construction sites. The City and County of Los Angeles inspect construction sites for compliance with runoff requirements. There do not appear to be plans to coordinate visits by the city and county with the Regional Board. Duplication between the cities and county and state programs increases the regulatory burden on the businesses in the county and wastes scarce enforcement resources.

Second, we found that there is an ongoing debate over the division of enforcement responsibilities between the Regional Board and the cities and the county. Negotiations during the last renewal of the municipal storm water permit (which went into effect in 1996), illustrate this tension. The Regional Board wanted the local agencies to enforce the runoff provisions. The cities balked, and the requirement for educational visits, without inspection and enforcement responsibilities, was the compromise. The allocation of enforcement responsibilities will undoubtedly be a topic of debate during the 2001 permit renewal negotiations.

The third issue that arose in our investigation of the enforcement programs of L.A. City and County is whether local agencies should have the power to issue non-criminal infractions or tickets, with associated fines, for urban runoff violations. The city and county have the power to issue notices of noncompliance and notices of violation but have to submit these to the district or city attorney for enforcement. The violations fall under criminal codes and are usually prosecuted as misdemeanors, but can be felonies. The City of Los Angeles has recently approved non-criminal fines for runoff violations. The details are currently being worked out, but plans are for fines to start at $50 for the first violation, increase to $100 for the second, and rise to $250 for the third, along with a notice to comply. Failure to comply can lead to criminal referral to the city attorney at any step of the process. The city plans to start issuing tickets within the next six months. Los Angeles County currently does not have ticketing authority.

Some we interviewed thought that ticketing authority is an important addition to the enforcement tool chest. City and district attorneys are very busy and usually do not view runoff violations as a high priority. Evidentiary requirements for criminal prosecutions are high, increasing the cost of enforcement. Criminal prosecution also seems inappropriate for all but the most flagrant violations. The result, advocates for ticketing authority argue, is not much enforcement. Others we interviewed were leery of ticketing authority. They worry that it would be abused as a way to generate revenue and that it would turn inspections into a much more adversarial process. They worry that the educational element of inspections would be compromised and that voluntary compliance with runoff regulations will decline.

Recommendations

5.7-A **Programmatic audits of city and County storm water programs should be conducted. These audits should verify whether programs outlined in the permits are being implemented and assess their adequacy and effectiveness.**

5.7-B **The cities and County should coordinate and consolidate as appropriate their inspection programs of industrial and construction sites, with the Regional Board. This program should increasingly focus on the adequacy of the storm water management plans and the extent to which they are being implemented.**

5.7-C **More generally, the cities and County should clarify the division of enforcement responsibilities between them and the Regional Board. Enforcement should be delegated to the cities and County, whenever possible.**

5.7-D **The County of Los Angeles Department of Public Works should investigate the advantages and disadvantages of ticketing authority for runoff violations. Based on a review of experiences in the City of Los Angeles and other jurisdictions that have the ability to issue tickets for infractions, the Department should make a** recommendation to the Board of Supervisors on whether the county code should be amended to allow such ticketing.

5.7-E **The Board of Supervisors should insist that cities that operate their own sewage collection facilities should report spills to the Regional Board and the County Department of Health Services.**

To make sure that our pollution control system is more than a paper tiger, additional resources need to be spent on auditing the activities that actually reduce pollution.

5.8 FUNDING FOR WATER QUALITY PROGRAMS

Issue

Many believe that the Regional Board is severely underbudgeted and, as a result, progress in cleaning up the waters in the County has lagged.

Recommendation

5.8 ***The Board of Supervisors should lead an effort to increase funding for the Regional Board.***

Potential funding sources include increased permit fees from the municipalities and businesses in L.A. County and the State General Fund. The Supervisors should appeal to the governor and the State Water Resources Control Board directly as well as enlist the support of the L.A. delegation to the state legislature. While increased funding for the Regional Board means more outlays for a public agency, the savings from better-designed and more effective water quality programs will far outweigh the costs.

RAND

September 25, 2000

Mr. Xavier Swamikannu
California Regional Water Quality Board
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Dear Xavier:

Attached is the copy of the L.A. Country Grand Jury report on reducing the health risks of swimming at L.A. County beaches.

The Grand Jury report closely follows the draft report we provided them except in one important area—recommendations concerning the Regional Water Quality Control Board. Toward the end of the Grand Jury's term, L.A. County counsel ruled that, because the Board is a state agency, it is beyond the purview of the Grand Jury. Thus, recommendations that were initially directed at the Board were modified to omit reference to the Board (see for example Recommendations 5.3). The Grand Jury report still does ask the Board to consider several recommendations, however (see p. 200). The report also still recommends that funding for the Board be increased, but the discussion in the draft report on what areas are most in need of funding was dropped.

Thank you again for generously contributing your time and expertise to this project. We hope this report has assembled useful information on some of the critical water quality issues in Los Angeles County and has helped move the debate forward. Please feel free to call if you have any questions or comments about the report.

Sincerely,

Lloyd

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United States
Environmental Protection
Agency

Office of Water (4503F)
Washington, DC 20460

EPA841-S-00-001
June 2000

The Quality of Our Nation's Waters

A Summary of the National Water Quality Inventory: 1998 Report to Congress

overview

States, territories, tribes, and interstate commissions assessed 23% of the nation's 3.6 million miles of rivers and streams for their 1998 water quality assessment reports to EPA. Of the assessed stream miles, 55% are rated as good, 10% good but threatened, and 35% impaired. States and other jurisdictions assessed 42% of the nation's 41.6 million acres of lakes, reservoirs, and ponds and reported that 46% of assessed lake acres are rated as good, 9% good but threatened, and 45% impaired. States and other jurisdictions assessed 32% of the nation's 90,500 square miles of estuaries and reported that 47% of assessed estuary square miles are rated as good, 9% as good but threatened, and 44% as impaired. Principal pollutants causing water quality problems include nutrients, siltation, metals, and pathogens.

Why Do States and Other Jurisdictions Assess Water Quality?

Section 305(b) of the Clean Water Act requires states, territories, tribes, and interstate commissions to assess the health of their waters and the extent to which their waters support state water quality standards and the basic goals of the Clean Water Act. The goals of the Clean Water Act are to achieve and maintain water quality that provides for healthy communities of fish and shellfish and that allows for recreation in and on the water. States collect data and information that allow them to characterize whether water quality meets these and other uses for their waters which are expressed in standards that each state sets.

States and other jurisdictions such as territories, tribes, and interstate commissions submit their water quality assessments to the U.S. Environmental Protection Agency (EPA) every 2 years. EPA summarizes this information in a biennial report to Congress. The *National Water Quality Inventory: 1998 Report to Congress* is the twelfth biennial report to Congress and the public about the quality of our nation's rivers, streams, lakes, ponds, reservoirs, wetlands, estuaries, coastal waters, and ground water.

States' Section 305(b) assessments are an important component of their water resource management programs. These assessments help states:

✓ **Implement** their water quality standards by identifying healthy waters that need to be maintained and impaired waters that need to be restored

✓ **Prepare** their lists of impaired waters under Section 303(d) of the Clean Water Act

✓ **Identify** priority watersheds for protection and restoration using their Watershed Restoration Action Strategies, total maximum daily loads, and pollutant source controls

✓ **Evaluate** the effectiveness of activities undertaken to restore impaired waters and protect healthy waters.

The 305(b)/ 303(d) Connection

Under Section 303(d), the Clean Water Act includes a second reporting requirement—that states provide a prioritized list of all their impaired waters. Current requirements are that states submit these 303(d) lists to EPA every 2 years. The most recent set of 303(d) lists were submitted to EPA in April 1998.

These lists of impaired waters are then used to prioritize state restoration activities. One of the most important restoration tools is the development of Total Maximum Daily Loads (TMDLs)—calculations of the amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL is the sum of all available loads of a single pollutant from all contributing point and nonpoint sources. It includes reductions needed to meet water quality standards and allocates these reductions among sources in the watershed.

The 305(b) and 303(d) reporting processes are connected. State 305(b) data is used to assist in the identification and priority ranking of 303(d) waters, although for their 303(d) listings, states may supplement the 305(b) information with other assessments or choose only that data in which they have the highest confidence. As a result, the findings on impaired waters reported by the states in their 303(d) lists build on, and are, in general, consistent with their 305(b) reports to EPA. Both sources find similar amounts of impaired waters and conclude that siltation, nutrients, bacteria, and metals are among the top pollutants causing impairments.

EPA and the states continue to work to improve and harmonize both these assessments through better and more extensive monitoring. Our goal is comprehensive monitoring of all waters for all applicable water quality standards—a challenging task given the demands placed on limited state, tribal, and federal resources, but a particularly vital one because of the important and costly water resource management decisions that depend on high quality water data.

This National Water Quality Inventory report reflects incremental progress toward the goal of comprehensive assessment. It includes information submitted by all 50 states, the District of Columbia, and 5 territories, 4 interstate commissions, and 9 Indian tribes. In addition, the amount of waters assessed for this report has increased slightly since the previous report. States assessed 150,000 more river and stream miles and 600,000 more lake acres in 1998 than in 1996.

How Do States and Other Jurisdictions Assess Water Quality?

Water quality assessment begins with setting goals through water quality standards adopted by states, tribes, and other jurisdictions such as territories. These standards must then be approved by EPA before they become effective under the Clean Water Act.

Water quality standards have three elements:

1. **Designated uses.** The Clean Water Act envisions that all waters be able to provide for recreation and the protection and propagation of aquatic life. Additional uses described in the Act that can be adopted in standards by states and tribes include drinking water supply and fish consumption.

2. **Criteria.** Criteria help protect designated uses. For example, criteria include chemical-specific thresholds that protect fish and humans from exposure to levels that may cause adverse effects. They may also include descriptions of the best possible biological condition of aquatic communities such as fish and insects.

3. **Antidegradation policy.** This policy is intended to prevent waters that do meet standards from deteriorating from their current condition.

After setting water quality standards, states then assess their waters to determine the degree to which these standards are being met and report this information in their 305(b) reports.

Currently states use two categories of data to assess water quality. The first and most desirable category is monitored data. This refers to field measurements, not more than 5 years old, of biological, habitat, toxicity, and physical/chemical conditions in water, sediments, and fish tissue. The second category, frequently used to fill information gaps, is evaluated data. Evaluated data includes field measurements that are more than 5 years old and estimates generated using land use and source information, predictive models, and surveys of fish and game biologists. This type of data provides an indicator of potential water quality.

Because evaluated data varies in quality and confidence, it is used for different purposes by different states. Most states use evaluated data to supplement monitoring data for their 305(b) reports. This information helps states identify waters that need additional monitoring.

After comparing water quality data to standards, states, tribes, and jurisdictions classify their waters into the following general categories:

Attaining Water Quality Standards

- **Good/Fully Supporting**: These waters meet applicable water quality standards, both criteria and designated uses.
- **Good/Threatened**: These waters currently meet water quality standards, but water quality may degrade in the near future.

Not Attaining Water Quality Standards/Impaired

- **Fair/Partially Supporting**: These waters meet water quality standards most of the time but exhibit occasional exceedances.
- **Poor/Not Supporting**: These waters do not meet water quality standards.

Water Quality Standards Not Attainable

- **Not Attainable**: The state has performed a use-attainability analysis and demonstrated that support of one or more designated uses is not attainable due to specific biological, chemical, physical, or economic/social conditions.

How Many of Our Waters Were Assessed for 1998?

This report does not describe the health of all U.S. waters because states and other jurisdictions have not yet achieved comprehensive assessment of all their waters (see Figure 1). Therefore, this report summarizes the health of only the subset of waters that states assessed in their individual 1998 water quality inventories: 23% of river and stream miles, 42% of lake acres, 32% of estuary square miles, 5% of ocean shoreline miles, and 90% of Great Lakes shoreline miles.

Oceans, coral reefs, wetlands, and ground water quality are poorly represented in state monitoring programs. In part, this is due to the fact that few states have adopted water quality standards for these resources. EPA's wetlands and ground water protection programs continue to work with states to develop assessment methods and water quality standards and to improve monitoring coverage. EPA is initiating a coastal monitoring program, Coastal 2000, that will provide a national baseline characterization of coastal waters and data needed to assist in development of water quality standards (particularly biological and nutrient criteria) for these waters.

Figure 1

Percentage of Waters Assessed for the 1998 Report

Rivers and Streams
842,426 miles = 23% assessed
Total miles: 3,662,255 (of which 35% are perennial, excluding Alaska)

Lakes, Ponds, and Reservoirs
17,390,370 acres = 42% assessed
Total acres: 41,593,748

Estuaries
28,687 square miles = 32% assessed
Total square miles: 90,465

Ocean Shoreline Waters
3,130 miles = 5% assessed
Total miles: 66,645, including Alaska's 44,000 miles of shoreline

Great Lakes Shoreline
4,950 miles = 90% assessed
Total miles: 5,521

Source: 1998 Section 305(b) reports submitted by states, tribes, territories, and commissions.

What Is the Status of Our Assessed Waters?

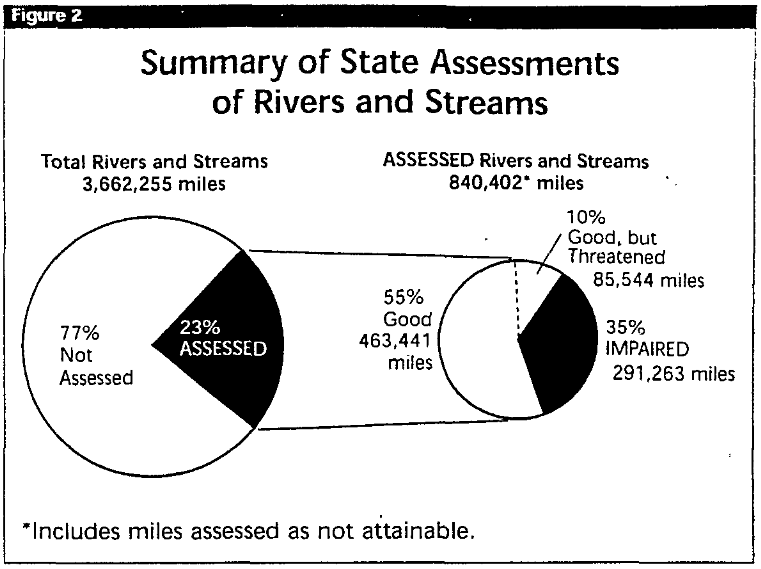
Rivers and Streams

The United States has a total of 3,662,255 miles of rivers and streams. States and other jurisdictions assessed 23% of these river and stream miles, focusing primarily on perennial streams (i.e., those that flow year round). Altogether, the states and other jurisdictions reported that of the 23% of assessed stream miles, 65% fully support designated uses and 35% are impaired. They also report that 10% of the assessed rivers and streams are fully supporting but are threatened for one or more uses (Figure 2). Aquatic life use is the most frequently impaired individual use in assessed rivers and streams (Figure 3).

According to the states and other jurisdictions, siltation and bacteria are the most common pollutants affecting assessed rivers and streams (Figure 4). Siltation alters aquatic habitat and suffocates fish eggs and other bottom-dwelling organisms. Excessive siltation can also interfere with drinking water treatment processes and recreational use of a river. Bacteria provide evidence of possible fecal contamination that may cause waters to be unsafe for swimming and other recreational activities. Both pollutants raise the costs of drinking water treatment to remove them.

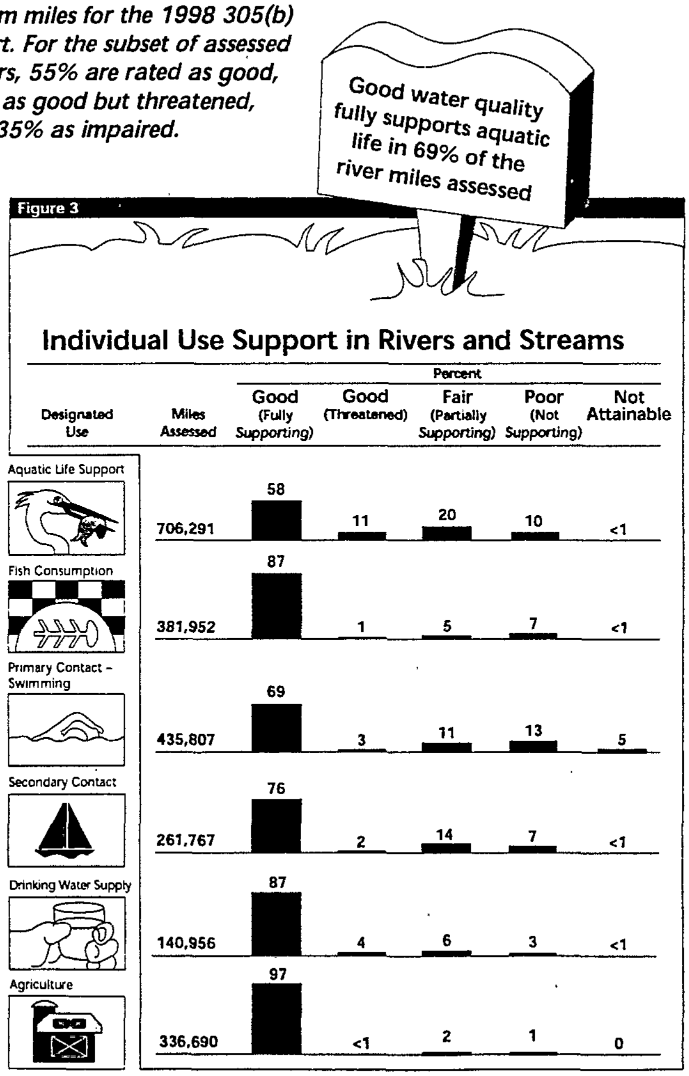
States and other jurisdictions reported agriculture as the most widespread

Figure 2



States assessed 23% of river and stream miles for the 1998 305(b) report. For the subset of assessed waters, 55% are rated as good, 10% as good but threatened, and 35% as impaired.

Figure 3



This figure presents a tally of the river and stream miles for each key designated use. For each use, the figure presents the percentage of assessed waters in each water quality category.

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source of pollution in assessed rivers and streams. Agricultural activities may introduce siltation, nutrients, pesticides, and organic matter that deplete oxygen in surface water. Nutrients and pesticides can also leach into and contaminate ground water. While the impact of agricultural activities is significant, it should be considered in context of the amount of land supporting agricultural activities. According to the 1997 Census of Agriculture, 41% of the continental United States, about 900 million acres, is used for agricultural production.

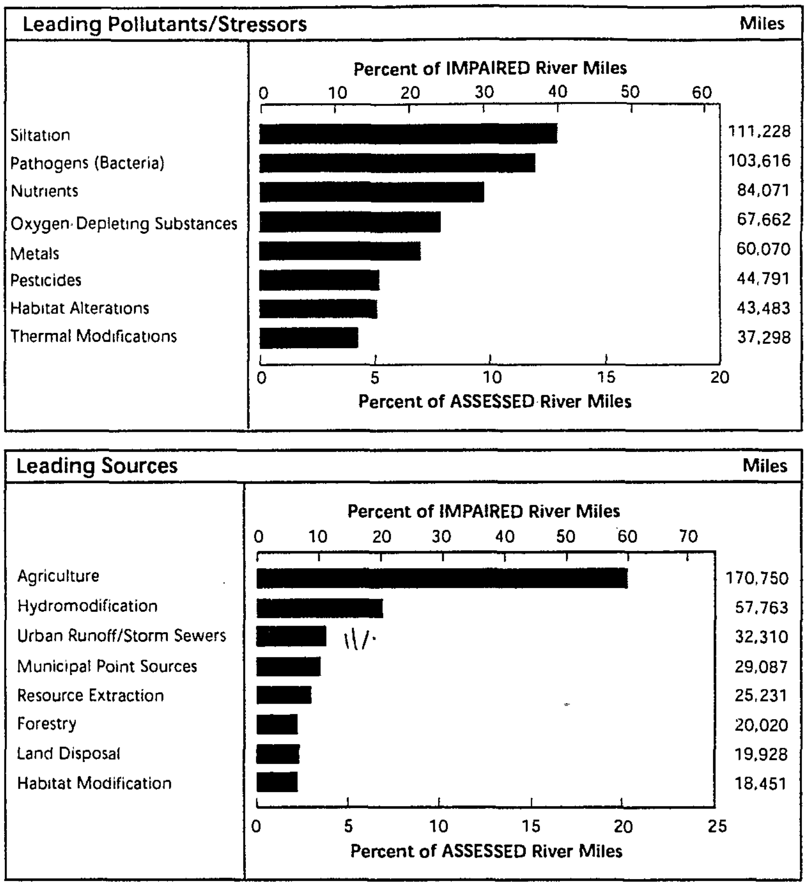
Other leading sources of pollution in assessed rivers and streams include hydromodifications such as flow regulation and modification, channelization, dredging, and construction of dams—which may alter a river's habitat in such a way that it becomes less suitable for aquatic life—and urban area runoff and storm sewer discharges.

Lakes, Reservoirs, and Ponds

There are a total of 41,593,748 acres of lakes, reservoirs and ponds in the United States. In 1998, states and other jurisdictions assessed 42%, or about 17.4 million acres. Altogether, states and jurisdictions reported that of the 42% of lake acres assessed, 55% fully support all of their uses and 45% are impaired. They also reported that 9% of the assessed acres are fully supporting but threatened for one or more uses (Figure 5).

Figure 4

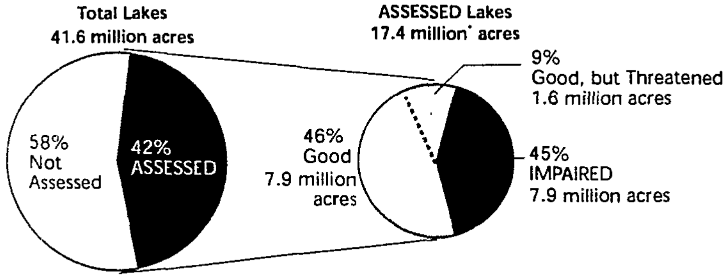
Leading Pollutants and Sources Impairing Assessed Rivers and Streams



These bar charts present the leading pollutants and sources reported by the states. The percent scale on the lower axis compares the miles impacted to the total ASSESSED miles. The upper axis compares the miles impacted to the total IMPAIRED miles.

Figure 5

Summary of State Assessments of Lakes, Reservoirs, and Ponds



*Includes acres assessed as not attainable.

States assessed 42% of lake, reservoir, and pond acres for the 1998 305(b) report. For the subset of assessed waters, 45% are rated as good, 9% as good but threatened, and 45% as impaired.

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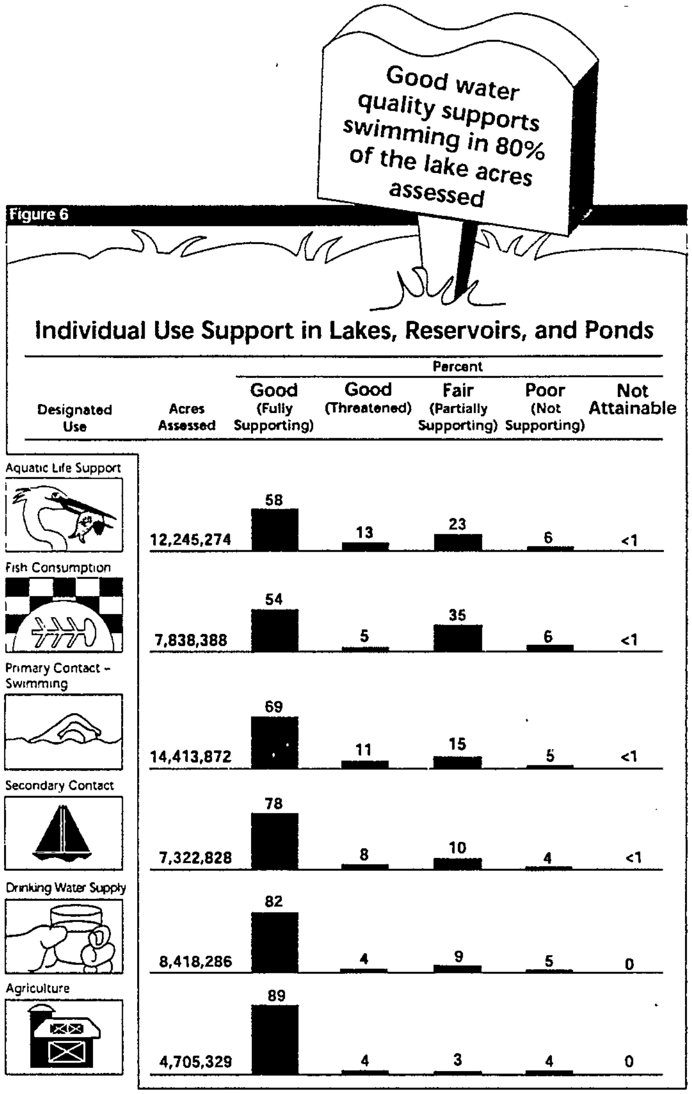
More lake, reservoir, and pond acres were reported as impaired for aquatic life use support than any other assessed use (Figure 6). However, where fish consumption use was assessed, it was responsible for a higher percentage of impaired acres. (Many states did not evaluate fish consumption use support in lakes because they have not included this use in their water quality standards.) Through separate tracking of state fish consumption advisories, EPA estimates that about 6.5 million lake acres were under fish consumption advisories in 1998.

According to the states and other jurisdictions, nutrients are the most common pollutant affecting assessed lakes, reservoirs, and ponds (Figure 7). While healthy lake ecosystems contain nutrients in small quantities from natural sources, too many nutrients disrupt the balance of lake ecosystems. Nutrient overenrichment can initiate a chain of impacts that includes algal blooms, low dissolved oxygen conditions, fish kills, foul odors, and excessive aquatic weed growth that can interfere with recreational activities.

Metals are the second most common pollutants in assessed lake acres, mainly due to the widespread detection of mercury in fish tissue samples. The mercury problem is especially complex because it often includes atmospheric transport from power-generating facilities, waste incinerators, and other sources.

The most widespread source of pollution reported for assessed lakes is agriculture, followed by hydrologic modification, urban runoff and storm sewers, municipal point sources, and atmospheric deposition (Figure 7).



This figure presents a tally of the lake, pond, and reservoir acres assessed for each key designated use. For each use, the figure presents the percentage of assessed waters in each water quality category.

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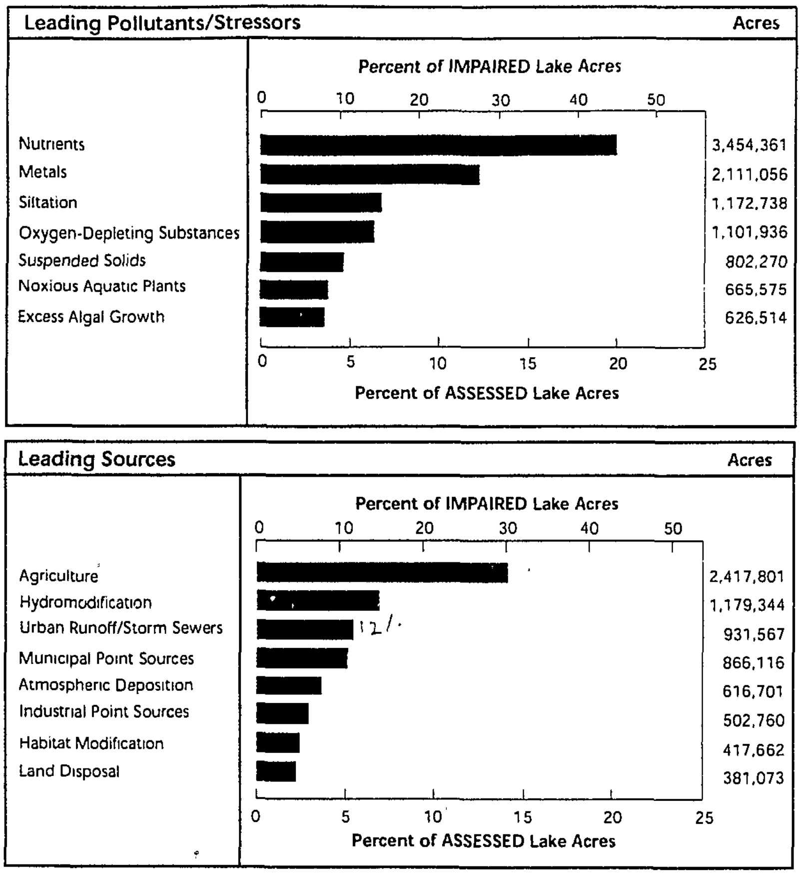
Figure 7

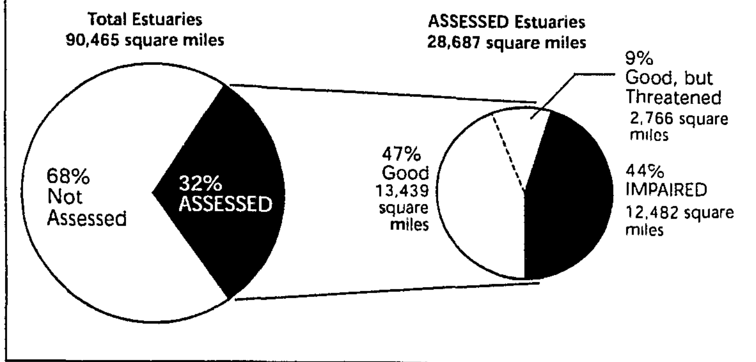
Leading Pollutants and Sources Impairing Assessed Lakes, Reservoirs, and Ponds



These bar charts present the leading pollutants and sources reported by the states. The percent scale on the lower axis compares the acres impacted to the total ASSESSED acres. The upper axis compares the acres impacted to the total IMPAIRED acres.

Figure 8

Summary of State Assessments of Estuaries



States assessed 32% of estuary square miles for the 1998 305(b) report. For the subset of assessed waters, 56% are rated as good, 9% as good but threatened, and 44% as impaired.

Coastal Resources—

Estuaries, The Great Lakes, Ocean Shoreline Waters, and Coral Reefs

The United States' extensive coastal resources include nearly 67,000 miles of ocean shoreline, more than 5,500 miles of Great Lakes shoreline, about 90,500 square miles of tidal estuaries, and extensive coral reef areas.

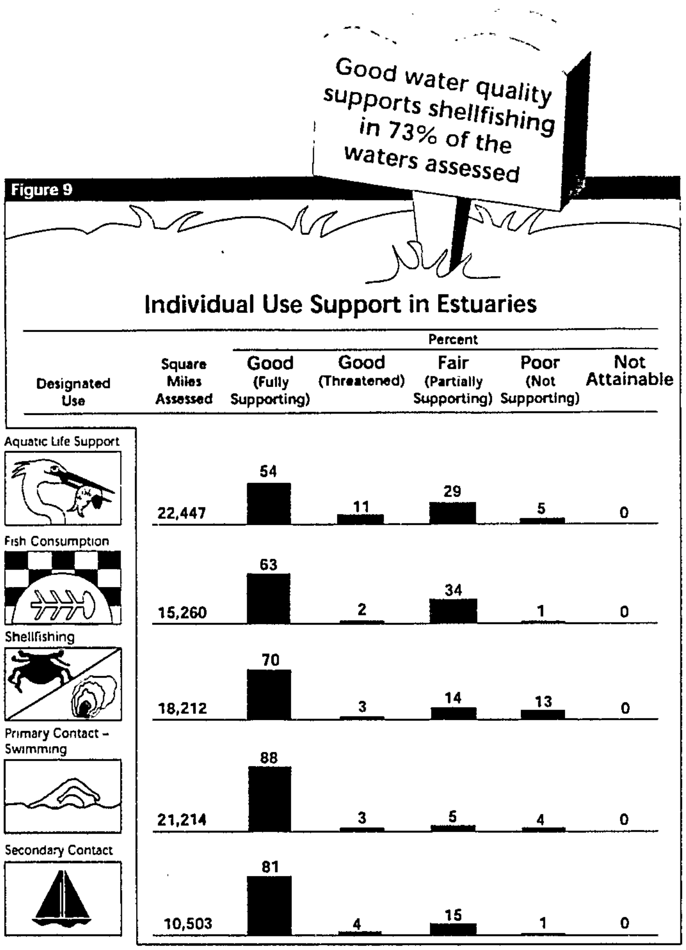
Estuaries

There are 90,465 square miles of estuaries in the United States. Estuaries are where rivers meet oceans, and they include bays and tidal rivers. They serve as nursery areas for many commercial fish and most shellfish populations, including shrimp, oysters, crabs, and scallops. States and other jurisdictions assessed 32% of the total square miles of estuaries in the country (Figure 8). Altogether, states and other jurisdictions reported that of the 32% of estuarine square miles assessed, 56% fully support designated uses and 44% are impaired. They reported that 9% of the assessed square miles are fully supporting but threatened for one or more uses. Aquatic life use is the most frequently impaired individual use in assessed estuaries (Figure 9).

States reported that bacteria (pathogens) are the most common pollutants affecting assessed estuaries. Most states monitor indicator bacteria, such as *Esherichia coli*, which provide evidence that an estuary is contaminated with sewage that may contain numerous viruses and bacteria that cause illness in people. Humans can become exposed to these pathogens by consuming contaminated fish and shellfish or contacting or ingesting contaminated water during swimming.

In addition to pathogens, the states also reported that oxygen depletion from organic wastes, metals, nutrients, thermal modifications, PCBs, and priority toxic chemicals impacts more square miles of estuarine waters than other pollutants and stressors.

Municipal point sources and urban runoff and storm sewers are cited as the most widespread sources of pollution in assessed estuaries (Figure 10). These urban sources are significant contributors to the degradation of estuarine waters because large cities are located near most U.S. estuaries.



This figure presents a tally of the estuary square miles assessed for each key designated use. For each use, the figure presents the percentage of assessed waters in each water quality category.

The Great Lakes

There are 5,521miles of Great Lakes shoreline in the United States. The Great Lakes contain nearly one-fifth of the fresh surface water on earth. Despite their large size, the Great Lakes are sensitive to the effects of a broad range of contaminants that enter the Lakes from polluted air, ground water, surface water, wastewater discharges, and overland runoff. For the 1998 report, five of the eight Great Lakes states assessed conditions of 90% of the nation's total Great Lakes shoreline miles (Figure 11). The states reported that of the 90% of assessed shoreline miles, 4% fully support designated uses and 96% are impaired. They also report that 2% of the assessed waters are fully supporting but threatened for one more uses.

The reporting states indicated that the greatest impacts to Great Lakes shoreline are on fishing activities (Figure 12). The states bordering the Great Lakes have issued advisories to restrict consumption of fish caught along their entire shorelines. Depending upon the location, mercury, PCBs, pesticides, or dioxins are found in fish tissues

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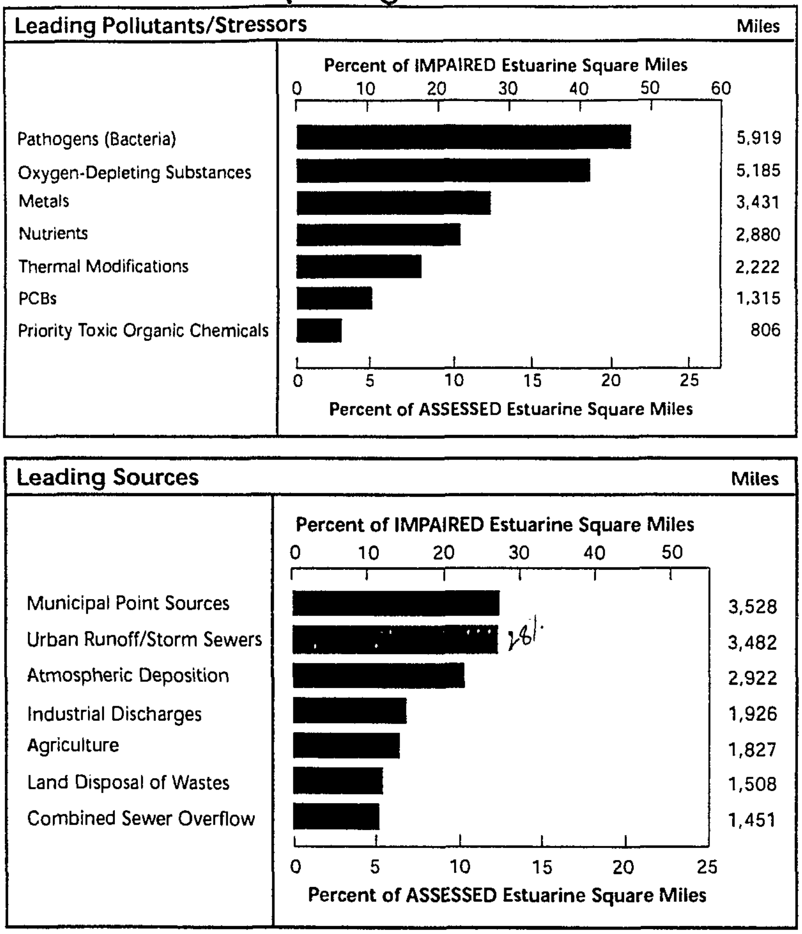
Figure 10

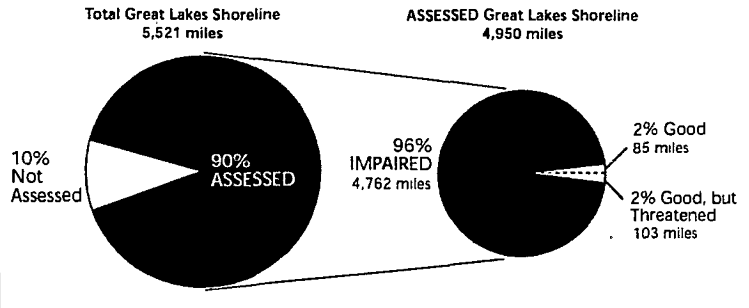
Leading Pollutants and Sources Impairing Estuaries



These bar charts present the leading pollutants and sources reported by the states. The percent scale on the lower axis compares the square miles impacted to the total ASSESSED square miles. The upper axis compares the square miles impacted to the total IMPAIRED square miles.

Figure 11

Summary of State Assessments of Great Lakes Shoreline



States assessed 90% of Great Lake shoreline miles for the 1998 305(b) report. For the subset of assessed waters, 2% are rated as good, 2% as good but threatened, and 96% as impaired.

at levels that exceed standards set to protect human health.

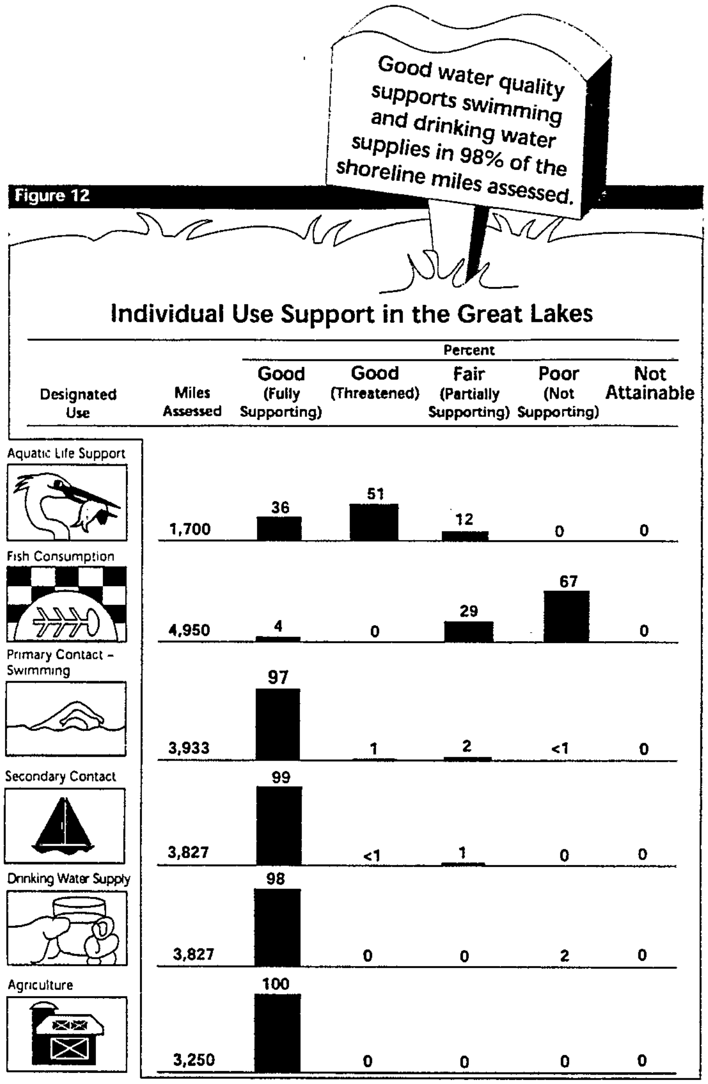
Priority organic chemicals, pesticides, and nonpriority organic chemicals are the most common pollutants affecting the waters along the Great Lakes shoreline, according to the three states that reported on pollutants and sources (Figure 13). These states reported that atmospheric deposition, discontinued discharges from factories that no longer operate, and contaminated sediments are the primary sources of these pollutants.

Ocean Shoreline Waters

There are 66,645 miles of ocean shoreline in the United States, including Alaska. Our ocean shoreline waters provide critical habitat for various life stages of commercial fish and shellfish (such as shrimp), provide habitat for endangered species (such as sea turtles), and support popular recreational activities, including sport fishing and swimming. Despite their vast size and volume, oceans are vulnerable to impacts from pollutants, especially in nearshore waters that receive inputs from adjoining surface waters, ground water, wastewater discharges, and nonpoint source runoff.

Fifteen of the 27 coastal states and territories assessed conditions in 5% of the nation's total ocean shoreline miles (Figure 14). The states and territories reported that of the 5% assessed, 88% of ocean shoreline miles fully support designated uses and 12% are impaired. They report that 8% of the assessed miles are threatened for one or more uses.

Figure 12



This figure presents a tally of the Great Lakes shoreline miles assessed for each key designated use. For each use, the figure presents the percentage of assessed waters in each water quality category.

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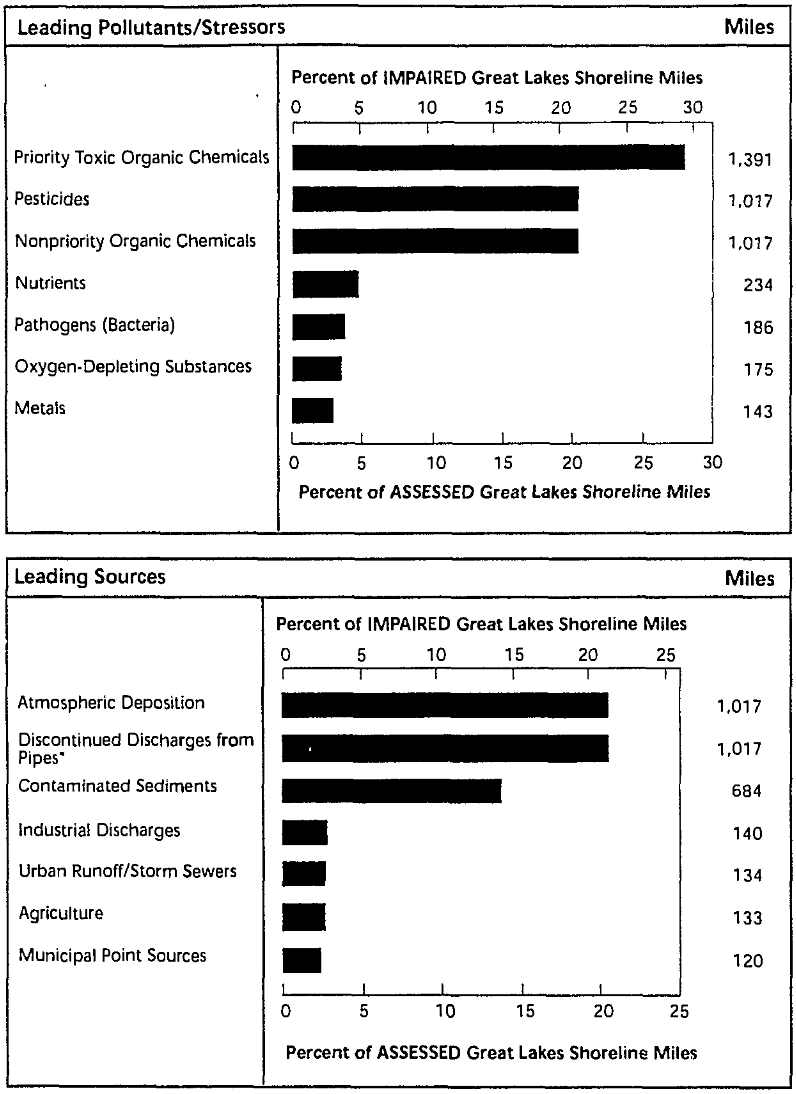
Figure 13

Leading Pollutants and Sources Impairing Great Lakes Shoreline

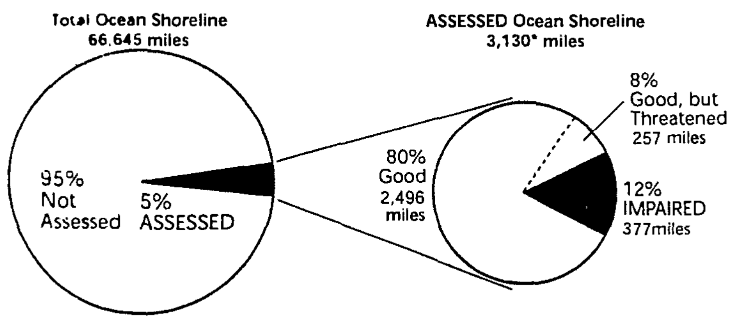


These bar charts present the leading pollutants and sources reported by the states. The percent scale on the lower axis compares the miles impacted to the total ASSESSED miles. The upper axis compares the miles impacted to the total IMPAIRED miles.

States assessed 5% of ocean shoreline miles for the 1998 305(b) report. For the subset of assessed waters, 80% are rated as good, 8% as good but threatened, and 12% as impaired.

Figure 14

Summary of State Assessments of Ocean Shoreline



*Includes miles assessed as not attainable.

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Swimming was the most frequently assessed use in ocean shoreline waters (Figure 15).

Bacteria (pathogens), turbidity, and excess nutrients are the most common pollutants affecting the assessed ocean shoreline. The primary sources of pollution to assessed shoreline miles include urban runoff and storm sewers and land disposal of wastes (Figure 16).

Coral Reefs

Coral reefs are among the most productive ecosystems in the ocean. They are inhabited by a wide variety of fish, invertebrates, and plant species and provide important economic opportunities, primarily in terms of fishing and tourism. Coral reefs are found in three states—Hawaii, Florida, and Texas, and five U.S. territories—American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands (Figure 17).

Recent evidence indicates that coral reefs are deteriorating worldwide. To prevent further deterioration of coral ecosystems, President Clinton signed Executive Order 13089 on Coral Reef Protection. This order created the U.S. Coral Reef Task Force, composed of representatives from the states and territories with coral resources. In response, these areas have initiated or increased efforts to identify the causes of coral reef degradation and approaches to prevent further loss.

Efforts are under way in Hawaii, Florida, and American Samoa to assess the status of coral reefs and identify pollutants and stressors to coral reef ecosystems.

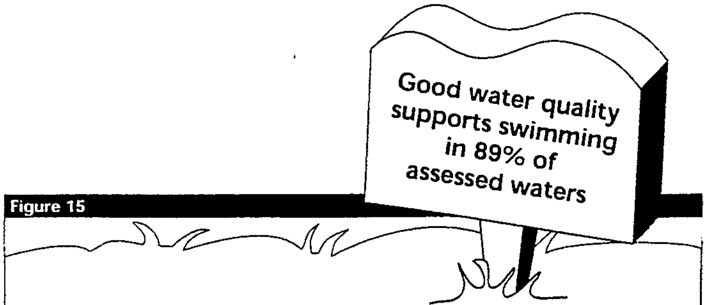

Figure 15

Individual Use Support in Ocean Shoreline Waters

Designated Use	Miles Assessed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Not Attainable
Aquatic Life Support	1,707	87	7	4	2	0
Fish Consumption	780	84	2	10	4	0
Shellfishing	1,141	89	0	11	<1	0
Primary Contact - Swimming	2,138	80	9	8	2	0
Secondary Contact	1,646	93	1	5	1	0

This figure presents a tally of the ocean shoreline miles assessed for each key designated use. For each use, the figure presents the percentage of assessed waters in each water quality category.

R0011734

Figure 16

Leading Pollutants and Sources Impairing Ocean Shoreline

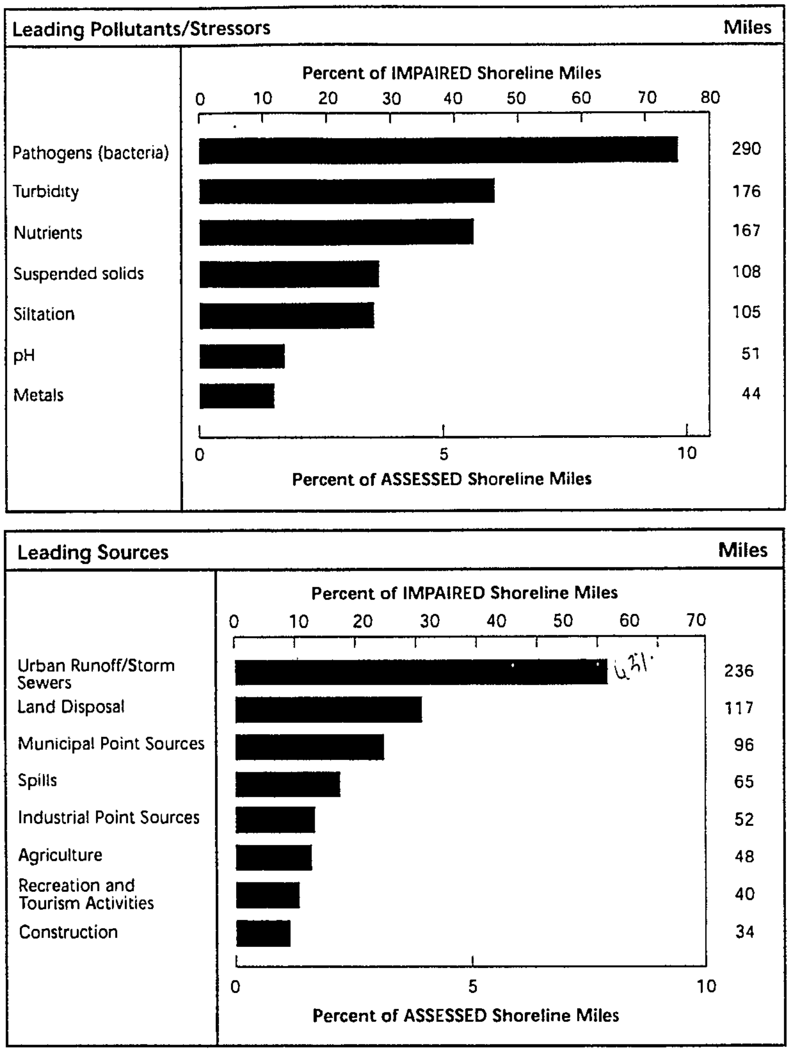

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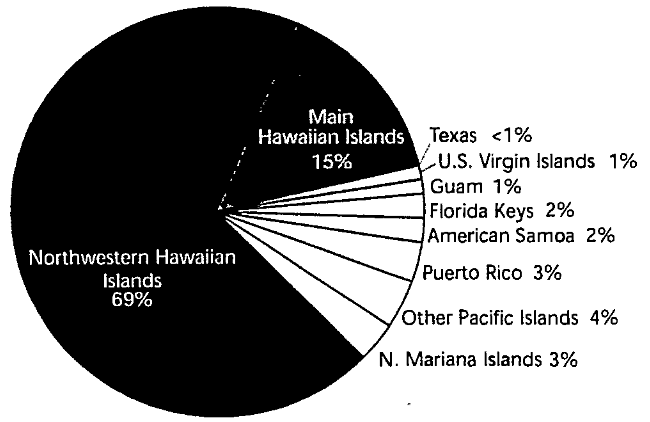
Figure 17

United States Coral Reef Areas



The findings will be used to develop management actions to protect coral reefs in these areas. Coral reef stressors identified to date include invasive species, marine debris, petroleum spills, nutrient runoff, and septic discharges.

Wetlands

Wetlands are intermittently or permanently flooded areas that are the link between land and water. The functions and values of healthy wetlands include the following:

- **Storage of water –** Wetlands help prevent flooding by storing and slowing the flow of water through a watershed.
- **Storage of sediment and nutrients –** Wetlands act like filters that purify water in a watershed.
- **Growth and reproduction of plants and animals –** Wetlands produce a wealth of natural products, including fish and shellfish, wildlife, timber, and wild rice.
- **Diversity of plants and animals –** Wetlands are critical to the survival of a wide variety of plants and animals, including numerous rare or endangered species as well as many species of great commercial value to man.

It is estimated that over 200 million acres of wetlands existed in the lower 48 states at the time of European settlement. Since then, extensive wetlands acreage has been lost, with many of the original wetlands drained and converted to farmland and urban areas. Today, less than half of our nation's original wetlands remain. Recent federal studies estimate an average net loss of wetlands around 100,000 acres per year in the contiguous United States. Although losses continue to decline, we still have to make progress toward our Administration's goal of an annual net gain of 100,000 wetland acres per year by the year 2005 and every year thereafter.

Eleven states and tribes listed sources of recent wetlands loss in their 1998 305(b) reports. Eight states cited agriculture as a leading source of current losses. Other losses were due to construction of roads, highways, and bridges; residential growth and urban development; filling and/or draining; construction; industrial development; commercial development; and channelization.

The states and tribes are making progress in incorporating wetlands into water quality standards and developing designated uses and criteria specifically for wetlands. But many states and tribes still lack wetland-specific designated uses, criteria, and monitoring programs for wetlands. Without criteria and monitoring data, most states and tribes cannot evaluate use support.

Ground Water

Ground water—water found in natural underground formations called aquifers—is an important component of our nation's fresh water resources. About 77,500 million gallons of the nation's ground water are withdrawn daily for use in drinking and bathing, irrigation of crop lands, livestock watering, mining, industrial and commercial uses, and thermoelectric cooling applications (Figure 18). Unfortunately, this valuable resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the country. Ground water contamination can occur through relatively well defined, localized pollution plumes emanating from specific sources such as leaking underground storage tanks, or it can occur as a general deterioration of ground water quality over a wide area due to diffuse nonpoint sources such as agricultural fertilizer and pesticide applications, septic systems, and urban runoff.

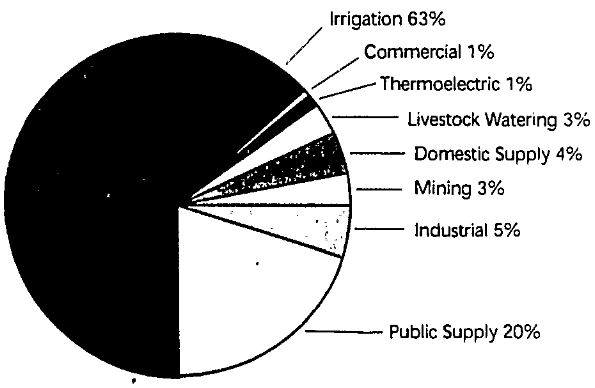
Based on results reported by states in their 1998 305(b) reports, ground water quality in the nation is good and can support the many different uses of this resource. However, despite these positive results, measurable negative impacts to aquifers across the nation have been detected, and they are usually traced back to human activities.

States identified leaking underground storage tanks as an important potential threat to our nation's ground water resources. This was based on the sheer number of underground storage tanks and the risk posed to human health and the environment from releases. States also report that the organic chemicals found in petroleum products such as gasoline are common ground water contaminants. Other potential sources of ground water contamination include septic systems, landfills, industrial facilities, fertilizer and pesticide applications, accidental spills, surface impoundments, and animal feedlots. Contaminants occur in the form of organic compounds, metals, and nitrate.

Assessing the quality of our nation's ground water resources is no easy task. An accurate and representative assessment of ambient ground water quality requires a well-planned and well-executed monitoring plan. Although the 305(b) ground water program is improving, there is still much to be done. States need to increase their monitoring coverage and focus on collecting ground water data that are most representative of the resource.

Figure 18

National Ground Water Use



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

How Does Impaired Water Quality Impact Public Health and Aquatic Life?

Water pollution threatens both public health and aquatic life. Public health may be threatened directly through the consumption of contaminated food or drinking water or indirectly through skin exposure to contaminants present in recreational and boating waters. Aquatic organisms can be affected by the presence of toxic chemicals in their environment and are also particularly susceptible to changes in the physical quality of their environments, such as changes in pH, temperature, dissolved oxygen, and habitat.

Public Health Concerns

The 1998 EPA Listing of Fish and Wildlife Advisories listed 2,506 advisories in effect in 47 states, the District of Columbia, and American Samoa (Figure 19). Mercury, PCBs, chlordane, dioxins, and DDT (with its byproducts) caused 99% of all the fish consumption advisories in effect in 1998.

In their 1998 305(b) reports, 11 of the 27 coastal states and jurisdictions reported shellfish harvesting restrictions in over 2,300 square miles of estuarine waters. These areas are monitored for bacteria as part of the National Shellfish Sanitation Program.

Advisories were also issued to warn the public about health risks from water-based recreation. Sixteen states and tribes identified 240 sites where recreation was restricted at least once during the reporting cycle. The states and tribes identified sewage treatment plant bypasses and malfunctions, urban runoff and storm sewers, and faulty septic systems as the most common sources of elevated bacteria concentrations in bathing areas.

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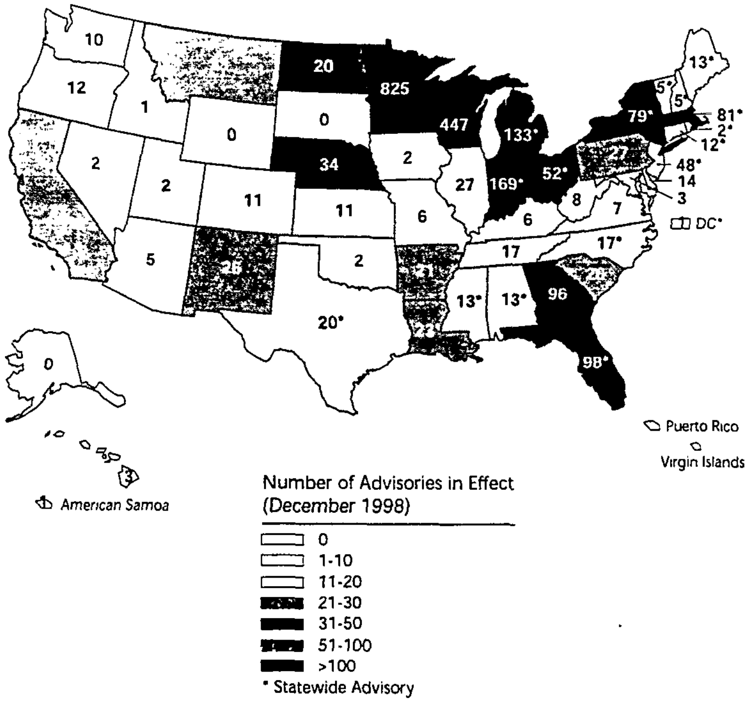
Thirty-eight states, tribes, and other jurisdictions provided information about the degree to which drinking water use is met. Of the 23% of river and stream miles assessed, only 3% do not support drinking water where it is a designated use; of the 42% of lake and reservoir acres assessed, 5% do not support drinking water use.

Increasingly, states are coordinating their efforts under the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA) to assess sources of drinking water. SDWA requires states to determine the susceptibility to contamination of drinking water sources, while the CWA calls for them to assess the ability of waters to support drinking water use. Assessments under both laws will provide the information necessary for states to develop tailored monitoring programs and for water systems to work with states and local governments to protect drinking water sources.

Figure 19

Fish and Wildlife Consumption Advisories in the United States



Note: States that perform routine fish tissue analysis (such as the Great Lakes states) will detect more cases of fish contamination and issue more advisories than states with less rigorous fish sampling programs. In many cases, the states with the most fish advisories support the best monitoring programs for measuring toxic contamination in fish, and their water quality may be no worse than the water quality in other states.

Aquatic Ecosystem Concerns

A fish kill is one of the most obvious effects of pollution on aquatic life. This phenomenon is normally attributed to exceptionally low dissolved oxygen levels—usually due to excessive nutrients in the water—or to the discharge of toxic contaminants to the water column. A more insidious impact of pollution on aquatic organisms is the development of growths, lesions, and eroded fins, or increased body burden of toxic chemicals.

The most common impact of pollution on aquatic life is the shift of a waterbody's naturally occurring and self-sustaining population from one type of aquatic community to another. An example is the shift of a cold water trout stream to a warm water carp-dominated stream. Changes in aquatic community structure and function may occur due to a variety of reasons, but the most common are an elevation of temperature, a lowering of available dissolved oxygen, and an increase in sedimentation due to land use practices within the watershed.

The persistence of chemicals in bottom sediment poses risks to both aquatic life and humans. These chemicals may be toxic to bottom-dwelling aquatic organisms. Some of these chemicals, like mercury and PCBs, bioaccumulate in fish tissue and pose a potential threat to humans and other organisms that consume the fish. In their 1998 305(b) reports, 11 states and tribes listed 115 separate sites with contaminated sediments. These states and tribes most frequently listed metals, PCBs, pesticides, PAHs, and other priority organic chemicals as the source of contamination. They identified industrial and municipal discharges (both past and present), landfills, resource extraction, and abandoned hazardous waste disposal sites as the primary sources of contamination.

What Is Being Done to Restore and Maintain Water Quality?

Public polls consistently document that Americans value water quality. In addition to its economic benefits, clean water provides recreational and aesthetic benefits. As a result, local, state, and federal agencies, the private sector, and other organizations are working to improve water quality. According to President Clinton's *Clean Water Act Initiative: Analysis of Costs and Benefits*, these partners spend between $63 billion and $65 billion dollars each year to improve and protect water quality.

This study estimated that private sources spend a combined total of about $30 billion per year on pollution prevention and control efforts. Agriculture spends another $500 million per year on activities that reduce its impact on water quality, including implementation of best management practices to control the effects of nonpoint source runoff. Municipalities spend a total of $23 billion per year, primarily on wastewater treatment plants, drinking water treatment, and storm water pollution control.

State governments dedicate almost $500 million and federal governments dedicate almost $10 billion to water resource protection and restoration efforts each year. These efforts include developing and revising water quality standards, monitoring and assessing water quality, characterizing causes and sources of impairment, developing total maximum daily loads and allocating these loads to point and nonpoint sources, implementing permitting programs to address point sources, and developing and implementing best management practices to control nonpoint source pollution.

Significant resources are dedicated to restoring and maintaining water quality. Water quality monitoring and assessment is a critical tool to help ensure that these resources are used effectively to achieve water quality goals. EPA and state environmental agencies recognize that water quality monitoring and assessment programs need continued strengthening to be able to evaluate the effectiveness of water quality protection and restoration efforts.

EPA continues to work with states and other partners to increase the quality and comprehensiveness of water quality monitoring and assessment programs. This is achieved through data sharing and development of consistent monitoring designs and assessment criteria. EPA provides technical assistance, guidance, and resources for monitoring design and implementation. EPA and its partners including states, tribes, other federal agencies, and other public and private monitoring organizations are developing a Consolidated Assessment and Listing Methodology (CALM) that will provide a consistent approach for characterizing water quality under both Sections 305(b) and 303(d) of the Clean Water Act.

For more information on CALM, visit EPA's website at **www.epa.gov/owow/monitoring/wqreport.html.**

For More Information

For more information about the *National Water Quality Inventory: 1998 Report to Congress*, visit EPA's Office of Water 305(b) website at http://www.epa.gov/305b, call EPA's Assessment and Watershed Protection Division at (202) 260-7040, or contact:

U.S. EPA (4503F)
Assessment and Watershed Protection Division
401 M Street, SW
Washington, DC 20460

For a copy of the *National Water Quality Inventory: 1998 Report to Congress* (EPA-841-R-00-001) or related materials, call 1-800-490-9198, fax your order to EPA's National Service Center for Environmental Publications at (513) 489-8695 (include EPA number and document title), or send your order to:

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- ❑ *National Water Quality Inventory: 1998 Report to Congress* (434 pages) (EPA841-R-00-001)
- ❑ *National Water Quality Inventory: 1998 Report to Congress Appendixes* (diskette) (EPA841-C-00-001)
- ❑ *Water Quality Conditions in the United States: A Profile from the National Water Quality Inventory: 1998 Report to Congress* (2 pages) (EPA841-F-00-006)

EPA United States Environmental Protection Agency

Office of Water

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Washington, DC 20460

EPA-841-F-00-006
June 2000

Water Quality Conditions in the United States: A Profile from the 1998 National Water Quality Inventory Report to Congress

States, tribes, territories and interstate commissions report that, in 1998, about 40% of U.S. streams, lakes and estuaries that were assessed were not clean enough to support uses such as fishing and swimming. About 32% of U.S. waters were assessed for this national inventory of water quality. Leading pollutants in impaired waters include siltation, bacteria, nutrients and metals. Runoff from agricultural lands and urban areas are the primary sources of these pollutants. Although the U.S. has made significant progress in cleaning up polluted waters over the past 30 years, much remains to be done to restore and protect the Nation's waters.

Findings

Recent water quality data finds that more than 291,000 miles of assessed rivers and streams do not meet water quality standards. Across all types of waterbodies, states, territories, tribes and other jurisdictions report that poor water quality affects aquatic life, fish consumption, swimming, and drinking water. In their 1998 reports, states assessed 840,000 miles of rivers and 17.4 million acres of lakes, including 150,000 more river miles and 600,000 more lake acres than in their previous reports in 1996.

Summary of Quality of Assessed Rivers, Lakes, and Estuaries

Waterbody Type	Total Size	Amount Assessed* (% of Total)	Good (% of Assessed)	Good but Threatened (% of Assessed)	Polluted (% of Assessed)
Rivers (miles)	3,662,255	842,426 (23%)	463,441 (55%)	85,544 (10%)	291,264 (35%)
Lakes (acres)	41,593,748	17,390,370 (42%)	7,927,486 (46%)	1,565,175 (9%)	7,897,110 (45%)
Estuaries (sq. miles)	90,465	28,687 (32%)	13,439 (47%)	2,766 (10%)	12,482 (44%)

*Includes waterbodies assessed as not attainable for one or more uses.

Note: percentages may not add up to 100% due to rounding.

Of the assessed ocean shoreline miles, 12% are impaired, primarily because of bacteria, turbidity and excess nutrients. Primary sources of pollution include urban runoff, storm sewers and land disposal of wastes. States assessed only 5% of the Nation's ocean shoreline miles.

States also found that 96% of assessed Great Lakes shoreline miles are impaired, primarily due to pollutants in fish tissue at levels that exceed standards to protect human health. States assessed 90% of Great Lakes shoreline miles.

Leading Pollutants and Sources* Causing Impairment in Assessed Rivers, Lakes, and Estuaries

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Pollutants	Siltation	Nutrients	Pathogens (Bacteria)
	Pathogens (Bacteria)	Metals	Organic Enrichment/ Low Dissolved Oxygen
	Nutrients	Siltation	Metals
Sources	Agriculture	Agriculture	Municipal Point Sources
	Hydromodification	Hydromodification	Urban Runoff/Storm Sewers
	Urban Runoff/Storm Sewers	Urban Runoff/Storm Sewers	Atmospheric Deposition

*Excluding unknown, natural, and "other" sources

Wetlands are being lost in the United States at a rate of about 100,000 acres per year in the contiguous United States. Eleven states and tribes listed sources of recent wetland loss; conversion for agricultural uses, road construction, and residential development are leading reasons for loss.

The states found that ground water quality is good and can support many different uses. However, measurable negative impacts have been detected and are commonly traced back to sources such as leaking underground storage tanks, septic systems, and landfills.

Reporting Under the Clean Water Act

This *National Water Quality Inventory* is the twelfth biennial report to Congress prepared under Section 305(b) of the Clean Water Act. It contains information from each state on the quality of our nation's rivers, lakes, wetlands, estuaries, coastal waters, and ground water, along with information on public health and aquatic life concerns. It serves as a snapshot of water quality conditions across the country.

To assess water quality, states and other jurisdictions compare their monitoring results to the water quality standards they have set for their waters. These standards consist of designated uses (such as drinking, swimming, or fishing), criteria to protect those uses (such as chemical-specific thresholds that should not be exceeded), and an antidegradation policy intended to keep waters that do meet standards from deteriorating from their current condition.

Under Section 303(d) of the Clean Water Act, there is a second reporting requirement -- that states provide lists of all of their impaired waters. These lists are then used to prioritize state restoration activities. This is accomplished through the development of Total Maximum Daily Loads (TMDLs), calculations of the amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL is the sum of all allowable loads of a single pollutant from all contributing point and nonpoint sources. It includes reductions needed to meet water quality standards and allocates those reductions among sources in the watershed.

Information reported by the states under the two Clean Water Act reporting requirements is generally consistent, although the 303(d) lists often include specific information from more targeted monitoring activities. This information clearly points to the need to restore polluted waters and maintain the quality of waters that currently meet standards. In August 1999, EPA announced a new proposal for a strengthened TMDL program. Since August, EPA has workec to incorporate comments from stakeholders and to refine the proposal to be an effective, common-sense approach to water restoration led by states, territories, and tribes in partnershir with federal and local governments, and local communities.

For Further Information

For a copy of the *National Water Quality Inventory: 1998 Report to Congress* (EPA 841-R-00-001), visit www.epa.gov/305b/ or call the EPA's National Service Center for Environmental Publications at 800-490-9198.

National Water Quality Inventory: 1998 Report Home

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United States
Environmental Protection
Agency

Office of Water (4503F)
Washington, DC 20460

EPA841-F-00-006
June 2000

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Water Quality Conditions in the United States

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Recent water quality data find that more than 291,000 miles of assessed rivers and streams do not meet water quality standards. Across all types of waterbodies, states, territories, tribes, and other jurisdictions report that poor water quality affects aquatic life, fish consumption, swimming, and drinking water. In their 1998 reports, states assessed 840,000 miles of rivers and 17.4 million acres of lakes, including 150,000 more river miles and 600,000 more lake acres than in their previous reports in 1996.

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Note: percentages may not add up to 100% due to rounding.

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Leading Pollutants and Sources* Causing Impairment in Assessed Rivers, Lakes, and Estuaries

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Pollutants	Siltation	Nutrients	Pathogens (Bacteria)
	Pathogens (Bacteria)	Metals	Organic Enrichment/ Low Dissolved Oxygen
	Nutrients	Siltation	Metals
Sources	Agriculture	Agriculture	Municipal Point Sources
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	Urban Runoff/Storm Sewers	Urban Runoff/Storm Sewers	Atmospheric Deposition

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This *National Water Quality Inventory* is the twelfth biennial report to Congress prepared under Section 305(b) of the Clean Water Act. It contains information from each state on the quality of our nation's rivers, lakes, wetlands, estuaries, coastal waters, and ground water, along with information on public health and aquatic life concerns. It serves as a snapshot of water quality conditions across the country.

To assess water quality, states and other jurisdictions compare their monitoring results to the water quality standards they have set for their waters. These standards consist of designated uses (such as drinking, swimming, or fishing), criteria to protect those uses (such as chemical-specific thresholds that should not be exceeded), and an antidegradation policy intended to keep waters that do meet standards from deteriorating from their current condition.

Under Section 303(d) of the Clean Water Act, there is a second reporting requirement—that states provide lists of all of their impaired waters. These lists are then used to prioritize state restoration activities. This is accomplished through the development of Total Maximum Daily Loads (TMDLs), calculations of the amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL is the sum of all available loads of a single pollutant from all contributing point and nonpoint sources. It includes reductions needed to meet water quality standards and allocates these reductions among sources in the watershed.

Information reported by the states under the two Clean Water Act reporting requirements is generally consistent, although the 303(d) lists often include specific information from more targeted monitoring activities. This information clearly points to the need to restore polluted waters and maintain the quality of waters that currently meet standards. In August 1999, EPA announced a new proposal for a strengthened TMDL program. Since August, EPA has worked to incorporate comments from stakeholders and to refine the proposal to be an effective, common-sense approach to water restoration led by states, territories, and tribes in partnership with federal and local governments and local communities.

For Further Information

For a copy of the *National Water Quality Inventory: 1998 Report to Congress* (EPA841-R-00-001), visit *www.epa.gov/305b* or call EPA's National Service Center for Environmental Publications at 1-800-490-9198.

Executive Summary

The Quality of Our Nation's Water

Background

The *National Water Quality Inventory Report to Congress* is the twelfth biennial report to Congress and the public about the quality of our nation's rivers, streams, lakes, ponds, reservoirs, wetlands, estuaries, coastal waters, and ground water. This report is prepared under Section 305(b) of the Clean Water Act. Section 305(b) requires states and other jurisdictions to assess the health of their waters and the extent to which water quality supports state water quality standards and the basic goals of the Clean Water Act. This information is submitted to the U.S. Environmental Protection Agency (EPA) every 2 years and summarized in the biennial report to Congress.

States' Section 305(b) assessments are an important component of their water resource management programs. These assessments help states

- Implement their water quality standards by identifying healthy waters that need to be maintained and impaired waters that need to be restored
- Prepare their Section 303(d) lists of impaired waters
- Develop restoration strategies such as total maximum daily loads and source controls
- Evaluate the effectiveness of activities undertaken to restore impaired waters and protect healthy waters.

EPA and the states continue to work to improve these assessments through better and more extensive monitoring. Our goal is comprehensive monitoring of all waters. This is a challenging task given the demands placed on limited state and federal resources. However, this is a vital goal given the important, and costly, water resource management decisions based on state water quality monitoring data. This report reflects incremental progress toward the goal of comprehensive assessment. It includes information submitted by all 50 states and the District of Columbia and 5 territories, 4 interstate commissions, and 9 Indian tribes.


Beverly Manifold, Okeefenoke Swamp, GA

How Do States and Other Jurisdictions Assess Water Quality?

Water quality assessment begins with water quality standards. States and other jurisdictions adopt water quality standards for their waters. These standards must then be approved by EPA before they become effective under the Clean Water Act.

Water quality standards have three elements. First are the designated uses assigned to waters. The Clean Water Act envisions that all waters be able to provide for swimming and the protection and propagation of aquatic life. Additional uses described in the Act and adopted by states include drinking water and fish consumption. Second are the criteria. Criteria help protect designated uses. For example, criteria include chemical-specific thresholds that protect fish and humans from exposure to levels that may cause adverse effects. The third element is called the antidegradation policy. This policy is intended to prevent waters from deteriorating from their current condition.

After setting standards, states assess their waters to determine the degree to which these standards are being met. Currently, states use two categories of data to assess water quality. The first and most desirable category is monitored data. These data are field measurements that are not more than 5 years old. They include field measurements of biological, habitat, toxicity, and/or physical/chemical conditions in waterbodies, sediments, and fish tissue. The other category frequently used to fill information gaps is evaluated data. Evaluated data include field measurements that are more than 5 years old and estimates generated using land use and source information, predictive models, and surveys of fish and game biologists.

How Many of Our Waters Were Assessed for 1998?

This report does not describe the health of all waters of the United States because states have not yet achieved comprehensive assessment of all their waters. States assessed almost 25% of the nation's total river and stream miles; 40% of its lake, pond, and reservoir acres; and 30% of its estuarine square miles for this edition of the biennial report.

Therefore, this report summarizes the health of only that portion of waters that states reported on in their individual 1998 water quality inventories.

States reported fairly significant increases in the amount of rivers and streams assessed between 1996 and 1998. Assessed river and stream miles increased by 21% from 694,000 to over 842,000 miles. This is considerable when you realize that only 1.3 million river and stream miles are perennial waters that flow year round. The remaining 2.3 million miles or so are intermittent or ephemeral, which means they are dry for some or most of the year.

EPA and states recognize that, in spite of the progress made toward comprehensive assessment, we still have a long way to go. Oceans, wetlands, and ground water quality are poorly represented in state monitoring programs. EPA's wetland and ground water protection programs continue to work with states to develop assessment methods and improve monitoring coverage. EPA is initiating a coastal monitoring program, Coastal 2000, that will provide a baseline characterization of coastal waters and data needed to develop water quality standards for these waters.

What Is the Status of Our Assessed Waters?

States focused the majority of their assessment activities on rivers and streams; lakes, ponds, and reservoirs; and estuaries. States reported that 65% of assessed river and stream miles, 55% of assessed lake acres, and 56% of assessed estuarine square miles fully support the water quality standards states evaluated. The remaining assessed waters are impaired to varying degrees. The amount of assessed waters identified as impaired changed somewhat between 1996 and 1998. However, states indicated that these differences more likely reflect changes in monitoring design, assessment methodology, and water quality standards than actual water quality changes.

The states bordering the Great Lakes report on almost 90% of their Great Lake shoreline. The assessments indicate that one or more uses is impaired for about 4,700 shoreline miles. Much of this impairment is due to historic contamination by persistent pollutants that still impact fish consumption.

States assessed very small amounts of ocean and marine resources, wetlands, and ground water. This is due in part to a lack of water quality standards and other assessment tools for these resources. EPA and states are working to develop water quality standards and improve characterization of these resources.

What Do States Identify as the Leading Causes and Sources Affecting Impaired Waters?

For the subset of assessed waters identified as impaired, the report presents the leading pollutants and sources of pollution reported by states, territories, commissions, and tribes. In terms of the nature of impairment, the bottom line did not change significantly from 1996 to 1998. For example, across all waterbody types, states and other jurisdictions reported that

- Aquatic life, swimming, and fish consumption are among the top impaired uses.
- Siltation, nutrients, bacteria, and metals are among the top pollutants causing impairment.
- Pollution from urban and agricultural land that is transported by precipitation and runoff (called nonpoint source pollution) is the leading source of impairment.

It is important to understand the difficulties in identifying causes and, in particular, sources of pollution in impaired waters. For many waters, states and other jurisdictions classify the causes and sources as unknown. EPA and states are working to develop methodologies for both determining the causes and sources of impairment and describing the level of confidence in the classification.

How Does Impaired Water Quality Impact Public Health and Aquatic Life?

Water quality standards are adopted to protect public health and aquatic life. Specifically, water quality standards establish conditions designed to ensure that

- Water quality supports a balanced population of fish, shellfish, and wildlife
- Water is safe to use for drinking water, fish consumption, swimming and recreation, and other beneficial uses.

When waters do not meet water quality standards, one or more of these uses are impaired. Depending on the nature of the impairment, this may mean that certain public uses must be restricted. For example, fish consumption may be prohibited or restricted, beaches may be closed to swimming, and drinking water utilities may have to install more costly treatment devices. Toxic chemicals, as well as viruses and bacteria, threaten human health through the consumption of contaminated fish and shellfish or through contact with contaminated waters.

Toxic chemicals, bacteria, and viruses may also impact aquatic life. In fact, aquatic organisms are more sensitive than humans are to some chemicals. In severe cases, exposure can kill aquatic organisms. Lower levels of exposure can cause deformities and sores and can reduce the reproductive success of organisms. Aquatic life is often impaired by loss of in-stream habitat for organisms and by conventional problems such as low dissolved oxygen, siltation, and excess nutrients. While extremely low dissolved oxygen can result in fish kills, these problems usually exhibit less dramatic, but more long-term, impacts on aquatic life. These stressors result in alteration or loss of the biological integrity of aquatic communities.

What Is Being Done To Restore and Maintain Water Quality?

Public polls consistently document that Americans value water quality. In addition to its economic benefits, clean water provides recreational and aesthetic benefits. As a result, local, state, and federal agencies; the private sector; and other organizations are working to improve water quality. According to President Clinton's *Clean Water Act Initiative: Analysis of Costs and Benefits* (EPA800-S-94-001, 1994), these partners spend between $63 billion and $65 billion dollars each year to improve and protect water quality.

This study estimated that private sources spend a combined total of about $30 billion per year on pollution prevention and control efforts. Agriculture spends another $500 million per year on activities that reduce its impact on water quality including implementation of best management practices to control the effects of nonpoint source runoff. Municipalities spend a total of $23 billion per year, primarily on wastewater treatment plants, drinking water treatment, and storm water pollution control.

State and federal governments dedicate almost $500 million and $10 billion, respectively, to water resource protection and restoration efforts each year. These efforts include developing and revising water quality standards, monitoring and assessing water quality, characterizing causes and sources of impairment, developing total maximum daily loads and allocating these loads to point and nonpoint sources, implementing permitting programs to address point sources, and developing and implementing best management practices to control nonpoint source pollution.

Significant resources are dedicated to restoring and maintaining water quality. Water quality monitoring and assessment is a critical tool to help ensure that these resources are used effectively to achieve water quality goals. EPA and state environmental agencies recognize that water quality monitoring and assessment programs need continued strengthening to be able to evaluate the effectiveness of water quality protection and restoration efforts.


John H. McShane, Buttermilk Falls State Park, NY

California

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Surface Water Quality

Siltation, metals, nutrients, bacteria, and pesticides impair the most river miles in California. The leading sources of degradation in California's rivers and streams are agriculture, forestry activities, urban runoff and storm sewers, and municipal point sources. In lakes, siltation, metals, and nutrients are the most common pollutants. Hydrologic and habitat modifications, along with urban runoff/ storm sewers, construction, highway maintenance and runoff, and atmospheric deposition pose the greatest threat to lake water quality.

Metals, pesticides, PCBs, and priority organics are the most frequently identified pollutants in estuaries, harbors, and bays. Urban runoff and storm sewers are the leading source of pollution in California's coastal waters, followed by spills, agriculture, resource extraction, and septage disposal.

Ground Water Quality

Salinity, total dissolved solids, and chlorides are the most frequently identified pollutants impairing use of ground water in California, followed by priority organic chemicals, nutrients, non-priority organic chemicals, and pesticides. Leading sources are septage disposal, agriculture, and dairies. Potential sources of ground water contamination include leaking underground storage tanks, septage disposal, agriculture, and industrial point sources.

Programs to Restore Water Quality

Through California's stormwater permit program, two statewide general permits have been adopted addressing stormwater discharges associated with industrial activities. Dischargers are required to eliminate most nonstormwater discharges, develop a stormwater pollution prevention plan to identify and implement control measures to minimize pollutants in stormwater runoff, and monitor their discharges.

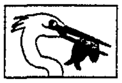
The State Water Resources Control Board and Regional Water Quality Control Boards are implementing a Watershed Management Initiative to better coordinate and focus limited public and private resources to address both point and nonpoint source water quality problems especially in high-priority targeted watersheds.

Programs to Assess Water Quality

California has developed a number of programs to monitor water quality in fresh, estuarine, and marine waters of the state. These include a Toxic Substances Monitoring Program that focuses on areas with known or suspected impairment; the Toxicity Testing Program for the identification of high-risk areas as well as the spatial and temporal extent of water quality problems and their causes and sources; an underground storage tank program to study the cleanup of leaking tanks; and volunteer monitoring.

Programs that focus on saltwater monitoring include the California State Mussel Watch Program to detect toxic substances in bays, harbors, and estuaries and the Bay Protection and Toxic Cleanup Program to identify toxic hot spots in enclosed bays and estuaries. California is also developing a comprehensive program for monitoring and reducing pollution in California's coastal zone.

Individual Use Support in California

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Not Attainable
Rivers and Streams (Total Miles = 211,513)[b]	Total Miles Assessed					
	12,289	24	12	49	16	-
	8,075	29	9	59	2	-
	12,066	24	11	48	17	-
Lakes (Total Acres = 1,672,684)	Total Acres Assessed					
	683,248	25	8	48	19	-
	490,343	28	12	35	26	-
	675,736	25	11	46	19	-
Estuaries (Total Square Miles = 1,008)[c]	Total Square Miles Assessed					
	870	27	<1	67	5	-
	880	30	2	65	3	-
	749	36	3	60	1	-
	785	34	<1	65	1	-
Wetlands (Total Acres = 275,812)	Total Acres Assessed					
	27,117	55	1	43	<1	-
	338	51	0	0	49	-
	24,869	61	2	36	1	-

- Not reported in a quantifiable format or unknown.
[a] A subset of California's designated uses appear in this figure. Refer to the state's 305(b) report for a full description of the state's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Includes bays and harbors.

Note: Figures may not add to 100% due to rounding.

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USGS
science for a changing world

Selected Findings and Current Perspectives on Urban and Agricultural Water Quality by the National Water-Quality Assessment Program

Studies by the USGS National Water-Quality Assessment (NAWQA) program in the last decade describe water-quality conditions in nearly 120 agricultural and 35 urban watersheds ("urban" primarily refers to residential and commercial development over the last 50 years). The findings show that for both urban and agricultural areas, nonpoint chemical contamination is an issue. Much work still needs to be done in urban areas with point source contamination as well, including infrastructure improvements. Appreciable improvements in overall water quality, however, will depend upon effective management of point and nonpoint sources. The findings also show that water-quality conditions and aquatic health reflect a complex combination of land and chemical use, land-management practices, population density and watershed development, and natural features, such as soils, geology, hydrology, and climate. Contaminant concentrations vary from season to season and from watershed to watershed. Even among seemingly similar land uses and sources of contamination, different areas can have very different degrees of vulnerability and, therefore, have different rates at which improved treatment or management can lead to water-quality improvements.

Water Quality in Agricultural Watersheds

- Nitrogen and phosphorus in surface water commonly exceed levels that contribute to excessive algae. For example, average annual concentrations of phosphorus in nearly 80 percent of streams sampled in agricultural areas were greater than the U. S. Environmental Protection Agency (USEPA) desired goal for preventing nuisance plant growth in streams. Excessive plant growth can lead to low dissolved oxygen, which can be harmful to fish and other aquatic life.
- Nitrate is often elevated above background levels in shallow ground water underlying farmland. Concentrations in about 20 percent of shallow wells sampled in agricultural areas exceeded the USEPA drinking water standard. This result is a concern in rural areas where shallow ground water is used for domestic supply; these domestic wells are not regulated and owners often do not know the quality of their well water or whether their wells are vulnerable to contamination. Nitrate is most often elevated in karst (carbonate) areas or where soils and aquifers consist of sand and gravel. These natural features enable rapid infiltration and downward movement of water and chemicals. Some of the more vulnerable areas are the Central Valley of California, and parts of the Pacific Northwest, the Great Plains, and the Mid-Atlantic region. In contrast, ground-water contaminants underlying farmland in parts of the upper Midwest are barely detectable, despite similar high rates of chemical use. In these areas ground-water contamination may be limited because of relatively impermeable, poorly drained soils and glacial till that cover much of the region, and because tile drains provide quick pathways for runoff to streams.
- Pesticides are widespread. At least one pesticide was detected in more than 95 percent of stream samples. Pesticides were detected in more than 60 percent of shallow wells sampled in agricultural areas.
- Pesticides commonly occur in mixtures. Two-thirds of stream samples collected in agricultural areas contained 5 or more pesticides, and more than one-quarter of the samples contained 10 or more. Ground water contained fewer pesticides; about 30 percent of the wells sampled contained 2 or more.
- Concentrations of pesticides generally are low and below drinking-water standards. However, the risk to humans and the environment from present-day low levels of contaminant exposure remains unclear. For example, current standards and guidelines do not yet account for exposure to mixtures, and many pesticides and their breakdown products do not have standards or guidelines.
- Herbicides—most commonly atrazine and its breakdown product desethylatrazine, and metolachlor, cyanazine, and alachlor—occur more frequently and usually at higher concentrations in agricultural streams and ground water than in urban waters. Their occurrence is linked to their use; they rank in the top five in national herbicide use for agriculture.
- Insecticides that were used in the past still persist in agricultural streams and sediment. DDT was the most commonly detected organochlorine compound, followed by dieldrin and chlordane. Their uses were restricted in the 1970s and 1980s and, yet, more than 20 years later, one or more sediment-quality guidelines were exceeded at more than 20 percent of agricultural sites.

U.S. Geological Survey
U.S. Department of the Interior

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- Concentrations of fecal coliform bacteria commonly exceed recommended standards for water-contact recreation.
- Concentrations of total phosphorus are generally as high in urban streams as in agricultural streams. More than 70 percent of sampled urban streams exceeded the USEPA desired goal for preventing nuisance plant growth.
- Insecticides, such as diazinon, carbaryl, chlorpyrifos, and malathion, occur more frequently, and usually at higher concentrations in urban streams than in agricultural streams. Concentrations are low in urban streams, rarely exceeding USEPA drinking-water standards. However, effects on aquatic life may be more of a concern. Concentrations of insecticides exceeded at least one guideline established to protect aquatic life in every sampled urban stream.
- Herbicides are widespread in surface water (detected in 99 percent of urban stream samples) and ground water (detected in more than 50 percent of sampled wells). Most common are those applied to lawns, golf courses, and road right-of-ways, such as atrazine, simazine, and prometon.
- Similar to agricultural areas, pesticides in urban waters commonly occur in mixtures; nearly 80 percent of stream samples contained 5 or more pesticides. Two of the most commonly detected insecticides in mixtures were diazinon and chlorpyrifos; common herbicides detected were simazine and prometon.
- Sediment in urban streams is associated with higher frequencies of occurrence of DDT, chlordane, and dieldrin and higher concentrations of chlordane and dieldrin than sediment in agricultural streams. Sediment-quality guidelines for organochlorine pesticides were exceeded at 36 percent of sampled urban sites.
- Volatile organic compounds, which are used in plastics, cleaning solvents, gasoline, and industrial operations, occur widely in shallow urban ground water. Some of the most frequently detected of the 60 analyzed compounds were the commercial and industrial solvents trichloroethene (TCE), tetrachloroethene (PCE), and methylene chloride; the gasoline additive methyl tert-butyl ether (MTBE); and the solvent and disinfection by-product of water treatment, trichloromethane (also known as chloroform).
- Concentrations of selected trace elements, such as cadmium, lead, zinc, and mercury, are elevated above background levels in populated urban settings, most likely caused by emissions from industrial and municipal activities and motor vehicles. Sediment cores from streambeds and reservoirs, which can be used to track changes over long time periods, indicate that lead increased from 1940s to the 1970s, and began to decrease after it was removed from gasoline. Concentrations are not yet down to background levels. Decreases also are noted for DDT and chlordane.
- In contrast to lead, DDT, and chlordane, sediment cores indicate that zinc and polycyclic aromatic hydrocarbons (PAHs, which result from fossil fuel combustion) are increasing. These increases most likely relate to increasing motor vehicle traffic in watersheds. Sediment-quality guidelines for PAHs were exceeded at more than 40 percent of urban sites.
- Toxic compounds in streambed sediment in urban areas, such as DDT, chlordane, dieldrin, and PCBs, also were found in fish tissue, often at higher concentrations than in the sediment. One or more organochlorine compounds were detected in 97 percent of whole fish samples collected at urban sites, and PCBs were detected in more than 80 percent of whole fish samples. Concentrations of organochlorine compounds exceeded guidelines to protect wildlife at more than 10 percent of urban sites; wildlife guidelines for PCBs were exceeded at nearly 70 percent of urban sites. These findings have contributed to decisions by some states to issue fish-consumption advisories.
- Deteriorated water quality and sediment, as well as habitat disturbances, contribute to degraded biological communities in urban streams. The greatest effects are seen in areas with the highest human population densities and watershed development. Pollution-tolerant algae and aquatic invertebrates (such as worms and midges), as well as omnivorous fish communities, prevail at the affected sites.

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For Internet access to NAWQA publications, data, and maps:

http://water.usgs.gov/nawqa

Marine Pollution in the United States

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Contents

Abstract

Direct discharges of pollutants into the ocean and coastal waters from sewage treatment plants, industrial facilities, ships, and the at-sea dumping of sewage sludge and other wastes have been greatly reduced over the past 30 years as a result of the Clean Water Act and other federal statutes. Advances in waste treatment have kept ahead of increases in the volume of wastes, and that trend is likely to continue. Some persistent toxic pollutants, such as DDT and PCBs, were banned for manufacture or use in the United States, and ambient levels of these pollutants have been decreasing in most U.S. marine environments. On the other hand, pollution from land runoff went largely unabated during this period; in some cases it has increased. As a result, diffuse sources now contribute a larger portion of many kinds of pollutants than the more thoroughly regulated direct discharges.

Toxic pollutants, including pesticides, industrial organic chemicals and trace metals, are widespread contaminants of the marine environment. But they produce discernible adverse effects on ecosystems only in limited areas around population centers and ports. Some of these chemicals are known through experimental studies to affect the reproductive, immune, or endocrine systems of marine organisms at low concentrations, and may have subtle effects on marine organisms and populations over a broader area. While some of the most toxic substances have been banned for manufacture and use, material previously released may remain in the environment for decades to centuries. High

Nutrient Overenrichment

The dominant form of plant life in the world's oceans is free-floating, single-celled algae known as **phytoplankton.** Like all plants, phytoplankton need **nutrients—nitrogen, phosphorus,** and other minerals—and light to grow and reproduce. Most of the needed nutrients either wash into the ocean from the land or move from the deeper waters to the surface through upwelling.

The growth of phytoplankton is usually limited by the availability of nutrients. Nitrogen is the nutrient that is usually in the shortest supply. But if nitrogen becomes abundant, the growth of phytoplankton can increase dramatically. An explosive increase in the population of phytoplankton is known as an **algal bloom.** A bloom often contains more phytoplankton than can be eaten by marine animals. The uneaten algae—and wastes from animals that eat the algae—sink to the ocean bottom, and decompose.

Through the process of decomposition, the dissolved oxygen levels in the water near the bottom can decrease substantially.

The long-term increase in the supply of organic matter to an ecosystem—often as a result of excess nutrients, or nutrient overenrichment—is called **eutrophication.**

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concentrations of persistent contaminants in bottom sediments require careful consideration when removed by dredging or managed in place.

Overenrichment of coastal ecosystems by nutrients, particularly nitrogen, has emerged as the most widespread and measurable effect of pollution on living marine resources and biodiversity in U.S. coastal waters. Excessive nutrient levels (overenrichment or eutrophication; see sidebar on these pages) may result in serious depletion of the dissolved oxygen supplies needed by marine animals, loss of habitat (e.g., seagrasses and coral reefs), and algal blooms. Two-thirds of the surface area of estuaries and bays in the conterminous U.S. suffers one or more symptoms of overenrichment. Because a majority of the nutrients in most regions now come from diffuse sources rather than direct discharges, reversing coastal eutrophication will require management strategies for watersheds reaching far inland from the coastal environment. Feasible measures include advanced treatment of municipal wastewaters, reduction of nitrogen oxide emissions from power plants and vehicles, control of ammonia emissions from animal feedlots, more efficient use of fertilizers and manure, and restoration of wetlands and floodplains that act as nutrient traps.

Eutrophication creates two harmful effects: oxygen depletion and reduced water clarity. When dissolved oxygen levels drop to levels that equal two milligrams per liter or less, a condition called **hypoxia** occurs.

Anoxia refers to a complete absence of dissolved oxygen in the water.

More mobile marine animals, like fish and crabs, can often migrate out of hypoxic areas. Other animals—such as oysters and marine snails—that lack mobility or cannot move quickly enough to escape hypoxia may suffocate. When water clarity is reduced by greater concentrations of algae, less light can penetrate to the ocean bottom where seagrasses and seaweeds live. As a result, these plants may sicken and die.

Increased nutrient levels in surface water (rivers and streams) and in groundwater from the land can be attributed to human activity. Major sources of nitrogen, phosphorus, and other nutrients delivered to the oceans include discharges from wastewater-treatment plants, runoff and groundwater from cropland, urban and suburban stormwater (runoff from paved surfaces), farm animal wastes, and even nutrients found in airborne emissions from power plants, automobile exhaust, and industrial smokestacks.

I. Introduction

"Pollution occurs when a substance, an organism, or energy (e.g., sound or heat) is released into the environment by human activities and produces an adverse effect on organisms or the environmental processes on which they depend."

This report provides background on the effects of pollution on life in the ocean and coastal waters of the United States for the Pew Oceans Commission, which is conducting a national dialogue on policies needed to restore and protect living marine resources. Pollution occurs when a substance, an organism, or energy (e.g., sound or heat) is released into the environment by human activities and produces an adverse effect on organisms or the environmental processes on which they depend.

Marine pollution comes in many forms and from many sources (Table 1). Some pollutants in sufficient concentrations are toxic to marine organisms. These include both naturally occurring chemicals present in much higher concentrations as a result of human activities (e.g., trace metals and oil) as well as compounds that did not exist in nature until manufactured by humans (e.g., pesticides such as DDT).

Other pollutants are harmful not because they are toxic but because they stimulate biological activity or alter habitats. The addition of large amounts of organic matter in the form of sewage or fish-processing wastes, for example, supports the growth of decomposer microbes that can exhaust the available oxygen supply. Inputs of nutrients (particularly forms of nitrogen and phosphorus), while responsible for the rich biological productivity of many coastal waters, can stimulate the production of more organic matter than an ecosystem can assimilate. Turbid waters, depletion of oxygen, and blooms of noxious algae may result. Sediments from land runoff or from dredging can decrease water clarity and smother sensitive bottom habitats such as reefs and seagrass beds.

Pollution emanates from either direct discharges or diffuse sources. Land-based industrial and municipal outfalls discharge wastewater into coastal waters or rivers that drain to the coast. Other direct discharges include those from vessel operations and at-sea waste disposal. Pollutants from diffuse sources include those released into the atmosphere by fossil-fuel and waste combustion; and land runoff of pesticides, toxic-waste products, nutrients, and sediments. Although chemical contaminants—released as a result of human activities—can now be found throughout the world's oceans, most demonstrable effects on living resources occur in coastal waters and are the result of pollution from land.

Table 1

Forms of Marine Pollution

Form	Sources	Effects and Trends
Toxins (e.g., biocides, PCBs, trace metals)	Industrial and municipal wastewaters; runoff from farms, forests, urban areas and landfills; erosion of contaminated soils and sediments; vessels; atmospheric deposition	Poison and cause disease and reproductive failure; fat-soluble toxins may biocencentrate, particularly in birds and mammals, and pose human health risks. Inputs into U.S. waters have declined, but remaining inputs and contaminated sediments in urban and industrial areas pose threats to living resources.
Biostimulants (organic wastes, plant nutrients)	Sewage and industrial wastes; runoff from farms and urban areas; airborne nitrogen from combustion of fossil fuels	Organic wastes overload bottom habitats and deplete oxygen; nutrient inputs stimulate algal blooms (some harmful), which reduce water clarity, cause loss of seagrasses and coral reefs, and alter food chains supporting fisheries. While organic waste loadings have decreased, nutrient loadings have increased (NRC, 1993a, 2000a).
Oil	Runoff and atmospheric deposition from land activities; shipping and tanker operations; accidental spills; coastal and offshore oil and gas production activities; natural seepage	Petroleum hydrocarbons can affect bottom organisms and larvae; spills affect birds, mammals and nearshore marine life. While oil pollution from ships, accidental spills, and production activities has decreased, diffuse inputs from land-based activities have not (NRC, 1985).
Radioactive isotopes	Atmospheric fallout, industrial and military activities	Few known effects on marine life; bioaccumulation may pose human health risks where contamination is heavy.
Sediments	Erosion from farming, forestry, mining, and development; river diversions; coastal dredging and mining	Reduce water clarity and change bottom habitats; carry toxins and nutrients. Sediment delivery by many rivers has decreased, but sedimentation poses problems in some areas; erosion from coastal development and sea-level rise is a future concern.
Plastics and other debris	Ships, fishing nets, containers	Entangles marine life or is ingested; degrades beaches, wetlands and nearshore habitats
Thermal	Cooling water from power plants and industry	Kills some temperature-sensitive species; displaces others. Generally, less a risk to marine life than thought 20 years ago.
Noise	Vessel propulsion, sonar, seismic prospecting, low-frequency sound used in defense and research	May disturb marine mammals and other organisms that use sound for communication.
Human pathogens	Sewage, urban runoff, livestock, wildlife	Pose health risks to swimmers and consumers of seafood. Sanitation has improved, but standards have been raised (NRC, 1999a).
Alien species	Ships and ballast water, fishery stocking, aquarists	Displace native species, introduce new diseases; growing worldwide problem (NRC, 1996).

Adapted from Weber 1993

The report first reviews accomplishments in reducing marine pollution, and then highlights the need for further reductions in the effects of toxic substances and nutrients as remaining major challenges. Diffuse sources of pollution via land runoff and atmospheric deposition are particularly important and have proved difficult to control. To provide grounding for policies needed to restore and protect living marine resources, the report: describes the forms, sources, movements, and effects of pollutants; assesses past and future trends of pollution in the U.S.; considers additional steps that could reduce pollution; and places pollution threats into a broader context of other threats to living resources.

II. Reductions of **Pollution**

Municipal and Industrial Discharges

In 1972, Congress passed the landmark Federal Water Pollution Control Act, which was reauthorized in 1977, 1981, and 1987 as the Clean Water Act (CWA). The goal of the law is to eliminate pollution in the nation's waters. It imposes uniform minimum federal standards for municipal and industrial wastewater treatment based on best available technology. Facilities discharging wastes at discernible points are required to obtain permits from the U.S. Environmental Protection Agency (EPA) or from state pollution-control agencies. Permits include enforceable limits on pollutants in the discharges, and require dischargers to conduct monitoring and to file reports when limits are violated.

Most publicly owned treatment works (POTWs) handle industrial wastes as well as domestic sewage. Because discharges of untreated organic wastes had degraded many rivers, lakes, and coastal waters by depleting dissolved oxygen and causing fish kills, the Clean Water Act required POTWs to achieve at least "secondary" treatment. Secondary treatment adds biodegradation of the organic matter in the wastewater to the solids (sludge) removal and disinfection included in "primary" treatment. Consequently, it significantly reduces the biological oxygen demand (BOD) of wastewater effluent. The CWA provided substantial amounts of money to help pay for the required POTW improvements. About 125 billion dollars have been spent in constructing or expanding POTWs, mainly between 1972 and 1992 when federal grants provided three-quarters of the costs (NRC, 1993a). Waivers to this requirement were allowed for several deep ocean outfalls where it could be demonstrated that the organic wastes would not harm the environment. Additional waste treatment, such as reduction of suspended solids, was often required.

Technology-based standards and the National Pollutant Discharge Elimination System (NPDES) have resulted in a dramatic reduction in the amount of pollutants entering U.S. waters, including coastal waters. Reductions in discharges of organic matter improved conditions in the Delaware River estuary near Philadelphia to the point that low oxygen levels no longer prevent the upriver migration of juvenile striped bass and American shad (Weisberg et al., 1996). Oxygen levels in New York Harbor are approximately 50 percent higher (NRC, 1993a). The most thoroughly documented example of the benefits of improved treatment may be the Southern California Bight, off Los Angeles and San Diego (Box 1), where inputs of many pollutants have been reduced 90 percent or more over a 25-year period. Kelp beds, fish and invertebrate communities, and certain seabird populations have greatly, if not completely, recovered. These improvements have been accomplished despite a steady increase in population and in the volume of wastewater discharged.

Another long-term effort to restore water quality has recently come to fruition with the completion in September 2000 of a new deepwater outfall for treated effluents from the Boston region. The offshore discharge into Massachusetts Bay will result in improvements in environmental quality in Boston Harbor beyond those already achieved as a result of the cessation of sludge disposal, reductions in combined sewer overflow, and secondary treatment of

Box 1
Southern California Bight Ocean Discharges

Wastes from the nation's largest metropolitan center (17 million people) are discharged into a bight of the Pacific Ocean via deepwater (about 200 feet) outfalls. Pollution from publicly owned treatment works (POTWs) has been reduced significantly since the 1970s even though the population served and wastewater volumes grew steadily (Schiff et al., 2000, Figure 1). This reduction was accomplished through source control, pretreatment of industrial wastes, reclamation, and treatment-plant upgrades, including secondary or other advanced treatment (concentrating on chemical removal of suspended solids). Capital improvements to POTWs throughout the Southern California Bight cost more than five billion dollars.

Discharges from POTWs of most pollutants into the bight have decreased: 50 percent for suspended solids and biological oxygen demand, 90 percent for combined trace metals, and more than 99 percent for chlorinated hydrocarbons. Bight sediments show a record of decreasing contamination. Concentrations of contaminants in fish and marine mammals have declined. Kelp beds near the POTWs have returned. The extent of degraded bottom communities has contracted by about two-thirds; and the incidence of tumors and other maladies in bottom fish has returned to background levels.

A unique problem for the bight is the fact that large quantities of the pesticide DDT were previously discharged, particularly through the Los Angeles County's POTW. This facility received wastes from the world's largest DDT manufacturer. In 1971 an estimated 440,000 pounds of DDT were discharged via an outfall off Palos Verdes. Today, only 3 pounds of DDT are discharged from all Southern California POTWs combined (Schiff et al., 2000). Concentrations of DDT and its degradation products have declined greatly in fish and marine mammals. Populations of brown pelicans, which were decimated by the eggshell thinning induced by DDT contamination, have rebounded. However, brown pelicans, bald eagles, and peregrine falcons are still being affected by the residual DDT contamination in the bottom sediments of the bight. Although this "legacy" contamination is slowly being buried, some DDT is still remobilized into the food chain.

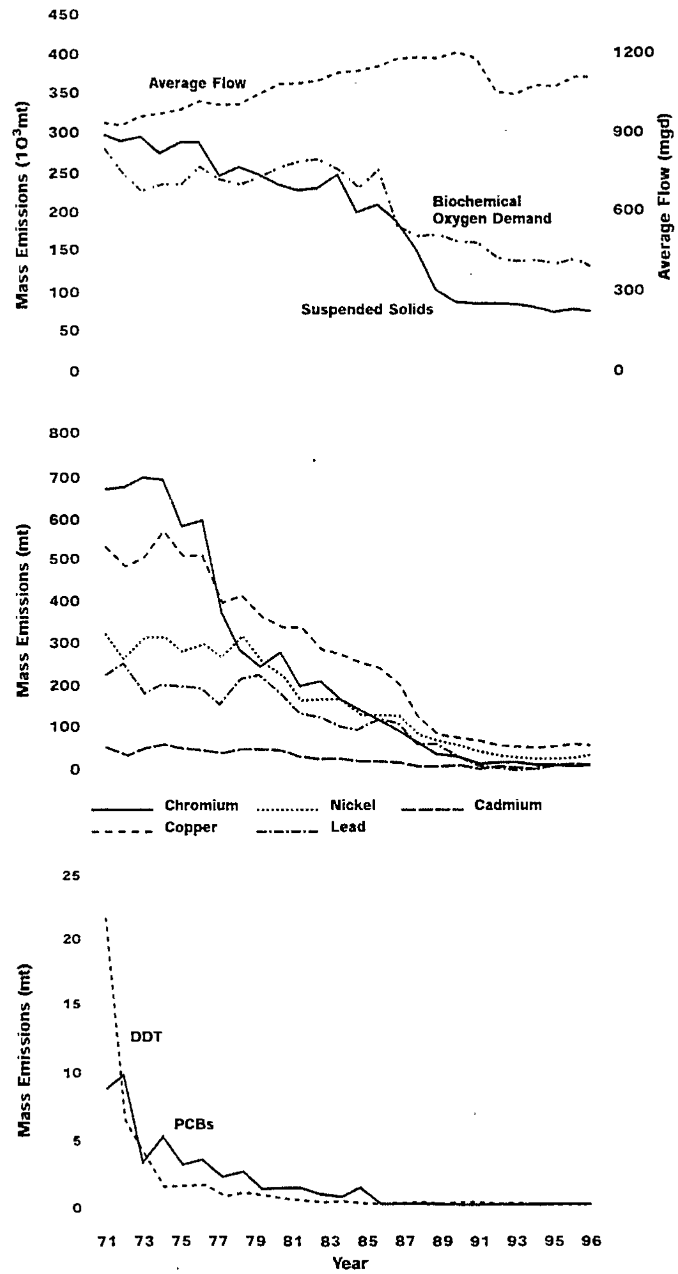
wastes. Although recovery is far from complete, liver tumors in flounder are less common, mussels accumulate lower levels of organic contaminants, and bottom invertebrate communities are recovering in the harbor (Rex, 2000). Field studies and computer models predict that moving the discharge offshore to deeper waters will not increase concentrations of pollutants, including nutrients, in Massachusetts Bay.

Although secondary treatment of municipal sewage removes at least 85 percent of the organic material and suspended solids in wastewater, only one-third of the nitrogen and phosphorus is eliminated (NRC, 1993a; NRC, 2000a). These two nutrients are the principal causes of eutrophication of receiving waters (see Section IV). Advanced treatment technologies, capable of eliminating up to 97 percent of the nitrogen and 99 percent of the phosphorus (NRC, 2000a), are being implemented in regions susceptible to nutrient overenrichment from direct discharges.

Pollutant levels have also been reduced in discharges from industries, including oil and gas production, refineries, chemical manufacturing, electric-power generation, and food processing. Although regionally important, industrial discharges contribute a relatively small portion of pollutant

Figure 1

Flow Volume and Pollutant Emissions from Four Largest Publicly Owned Treatment Works in the Southern California Bight, 1971 through 1996.



Source: Raco-Rands 1999, Schiff et al. 2000

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loadings on a national scale. Industrial discharges often have specific waste-reduction requirements that necessitate pollution prevention (elimination or reduction of the source in the industrial process), recycling and reuse, and advanced waste treatment.

Pollution from aquaculture—effluents from ponds or holding tanks on land and materials released from net pens and shellfish racks or rafts—is receiving new regulatory attention with the expansion of aquaculture in coastal waters. Pollutants include uneaten food, fecal and excretory material, and releases of antibiotics, pesticides, hormones, anesthetics, pigments, vitamins, and minerals. Organic deposits under net pens and shellfish rafts often alter the bottom habitat and affect seabed communities in the immediate vicinity. Extensive aquaculture operations can constitute a major source of nutrient inputs to the smaller bays and estuaries in which they are located. Antibiotic, pesticide, and hormone releases can also affect wild organisms in the region (Goldburg and Triplett, 1997).

Additional reductions of pollution from direct discharges will undoubtedly be required and more effective source controls and treatment technologies developed to meet those requirements. Two forces are driving these reductions. First, the Clean Water Act requires dischargers to implement advanced pollution controls where conventional technology is not sufficient to protect aquatic life and the human uses assigned to the water body receiving the discharge. Standards for designated uses are not currently met for one-third of U.S. waters (EPA 2000a). In such cases, the Clean Water Act specifies that total maximum daily loads (TMDLs) be determined and allocated among point and nonpoint sources. Second, ever-closer scrutiny is given to the inputs of chemicals that induce toxicity at very low concentrations, persist in the environment for long periods, and reach high levels of accumulation in the tissues of fish and wildlife.

Vessel Discharges

Pollutants are discharged to the ocean from the routine operations of ships and boats (including discharges of sewage and industrial-processing wastes and the release of petroleum hydrocarbons from engine exhausts and bilge and ballast waters). Vessel-related pollution may also occur as a result of accidental spills and solid-waste disposals.

At-sea release of oily water has been an international issue over the past 30 years and is regulated under the International Convention for the Prevention of Pollution from Ships. Compartments of oil tankers are typically filled with seawater for ballast when emptied of their cargo. Some ports, such as Port Valdez, Alaska, have ballast-water treatment facilities. Although ballast-water discharges may cause problems along some tanker routes and are responsible for tar balls that contaminate the surface of high seas, they comprise a relatively small percentage of oil pollution in the marine environment (NRC, 1985). Exhaust emissions into the water from smaller vessels may be a significant source of petroleum hydrocarbons in more confined coastal waters.

Atmospheric emissions from ships are being recognized as a significant source of global air pollution (Corbett and Fischbeck, 1997), yet they are not subject to the same restrictions for protection of air quality as are land-based power plants and manufacturers. Seagoing vessels are responsible for an estimated 14 percent of emissions of nitrogen from fossil fuels and 16 percent of the emissions of sulfur from petroleum uses into the atmosphere (Corbett and Fischbeck, 1997).

Cruise ships, although not a major source of pollution to U.S. coastal waters as a whole, can cause problems in areas such as Caribbean island harbors, which accommodate intense cruise-ship activity, or relatively pristine areas such as the inland passages of Alaska. Cruise ships generate sewage, gray water, solid wastes, oily wastes, and waste from photo processors, swimming pools and dry cleaners. (EPA, 2000b).

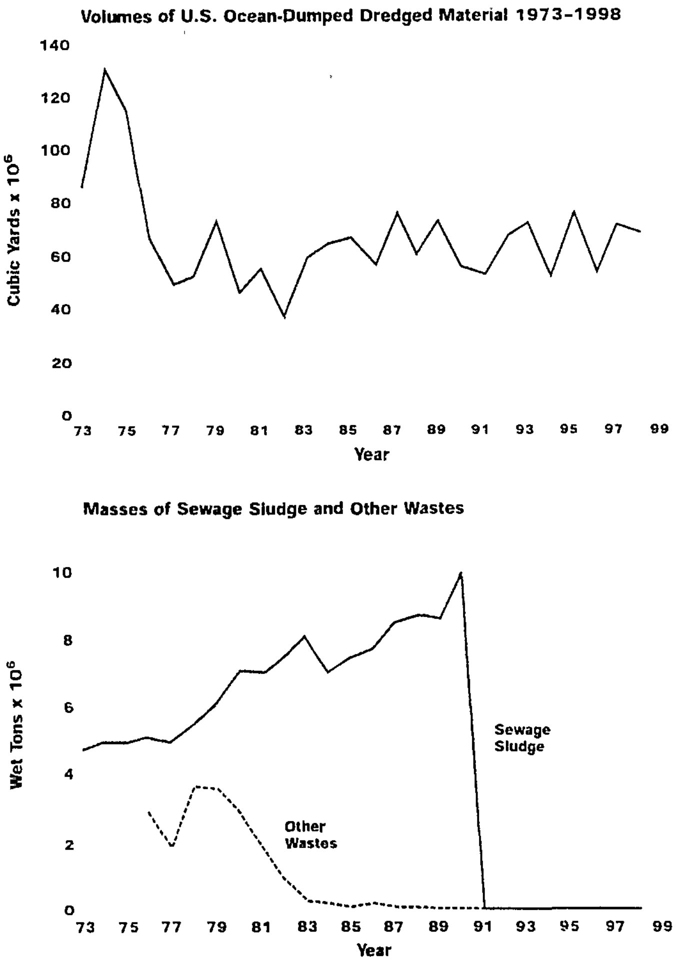
Ocean Dumping

The practice of transporting wastes for disposal in the ocean became a cause for national and international concern in the 1970s (CEQ, 1970). The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, or the London Dumping Convention, came into force in 1975, acknowledging through its regulatory framework that different materials have vastly different impacts on the marine environment. Nationally, ocean disposal in U.S. waters has been regulated under the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) by a permit procedure that prohibits dumping of some materials, establishes criteria to authorize dumping of others, and identifies sites for disposal. The Clean Water Act also regulates discharges into the territorial sea and navigable waters of the United States. In the ten years following passage of the MPRSA, dumping of industrial waste, construction debris, solid waste, and incineration of chemicals remained low, but dumping of sewage sludge doubled (Burroughs, 1988). Although the amount of dredged sediment disposed in coastal waters remained constant, it was approximately an order of magnitude greater in volume than the sludge dumped (Figure 2).

During the 1980s, public apprehension about ocean dumping grew. Sewage sludge dumped in the New York Bight was blamed for an apparent decline in water quality and health risks to bathers. Controversy also erupted over ocean incineration of chemical wastes in the Gulf of Mexico. In 1988,

Figure 2

Amounts of Dredged Material and Other Wastes Dumped in U.S. Waters, 1973 through 1998



Source: U.S. Army Corps of Engineers 1999; EPA 1991

Congress enacted the Ocean Dumping Ban Act that prohibited ocean dumping of sewage sludge and industrial chemicals. Sewage sludge must now be incinerated, disposed of on land, or reused—alternatives that have their own set of environmental impacts, including pollution of the marine environment via land runoff and atmospheric deposition.

Today, virtually all the material dumped into coastal and marine waters is bottom sediment removed by dredging (Figure 2). Under the Clean Water Act, the U.S. Army Corps of Engineers issues permits for disposal of dredged material, subject to guidelines established by EPA. Protocols have been developed to determine whether dredged sediments are suitable for placement in the ocean or coastal environment. These protocols involve an assessment based on the sediment characteristics, contaminant levels, the toxicity of contaminants present, and the potential for the contaminants to accumulate in the tissues of organisms (EPA, 1991). Based on these criteria, dredging may not be permitted at all or the dredged sediments may be deemed unacceptable for overboard disposal. Placement in a landfill, in a confined disposal facility, or in a contained underwater disposal site is then required. Approximately five to ten percent of the sediments dredged require management as contaminated sediments (NRC, 1997).

Although the federal laws governing dredged material disposal have eliminated the practice of discarding heavily contaminated harbor sediments in the marine environment, they have not eliminated controversies. Despite the protections afforded by regulatory requirements and testing

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protocols, significant controversies surround the overboard disposal of dredged sediments that are deemed acceptably "clean." These controversies are related in part to the physical impacts of dredged sediment placement, including increased turbidity, siltation, burial of bottom organisms, and permanent changes in the quality of bottom habitat. In addition, the public, resource users, and environmental managers are concerned that contaminants in the dredged sediment will be mobilized and made more bioavailable by overboard disposal. As a result, many ports struggled to resolve impasses in selecting and permitting alternatives for dredged sediment placement (Box 2). On one side, there is an aversion to placing wastes of any kind into the ocean and coastal waters; on the other, there are constraints related to costs, limits in the feasibility of beneficial uses, and opposition to disposal alternatives outside of the marine environment.

The volume of commerce moving through U.S. ports is increasing and will continue to do so because of increased world trade and dependence on foreign

Box 2
San Francisco Bay: Long-Term Strategy for Dredged Material

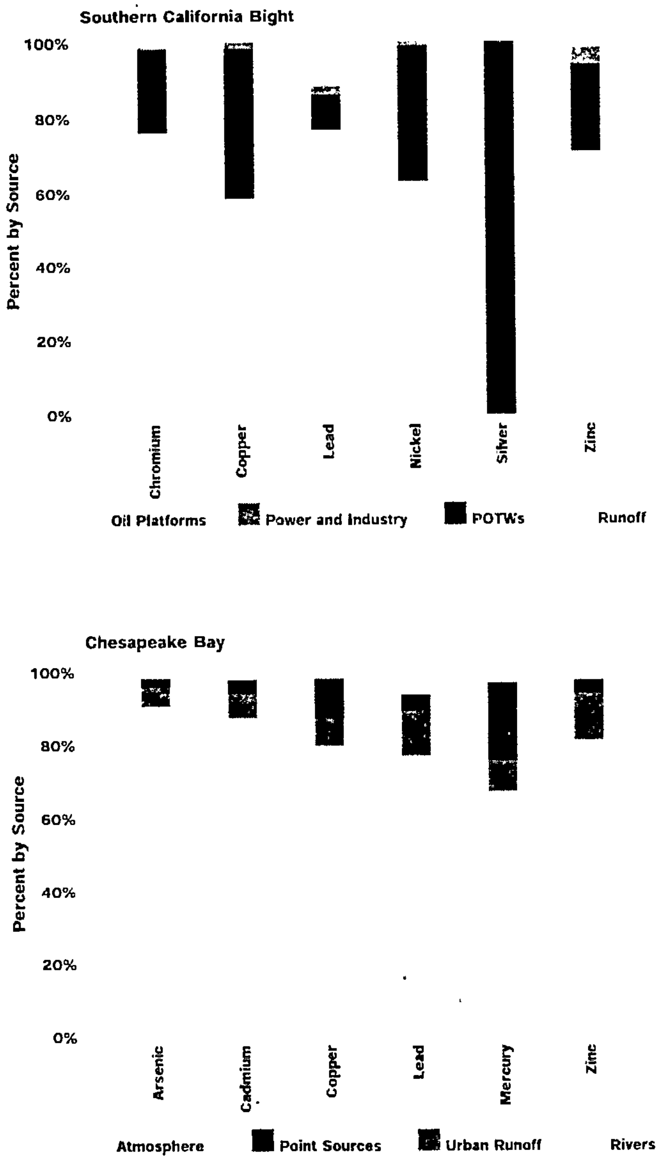
Navigation channels and berths in San Francisco Bay tend to fill in rapidly because of the large amount of mobile sediments in the bay—a legacy of placer mining following the California Gold Rush—and strong tidal currents. Dredged sediments were typically placed back into the bay, mostly at a site near Alcatraz Island, where strong tidal currents dispersed them. However, disposal of large quantities of sediments generated from channel deepening changed the current patterns at the Alcatraz site so that sediments placed there no longer dispersed.

The limitations of this site, the lack of readily available alternatives, public concerns, lawsuits, and fragmented agency management coalesced to create an impasse, or so-called mudlock, that halted most dredging. This caused significant problems for both commercial and military shipping. The U.S. Navy, citing national security requirements, broke the impasse by dumping dredged sediments at a deepwater site in the ocean. Subsequently, EPA designated an ocean disposal site to receive sandy sediments dredged by federally funded projects.

In 1990, federal, state, and regional agencies joined with navigation interest groups, fishing groups, environmental organizations, and the public to develop a Long-Term Management Strategy for Bay Area dredged material (U.S. Army Corps of Engineers, 1998). The strategy emphasizes a balance between ocean disposal and beneficial reuse at upland/wetland sites with limited in-bay disposal. During a transitional period, the amount of dredged material deposited at in-bay sites would be reduced from 80 percent to 20 percent, while upland sites, reuses, and wetland restoration are developed. Toxicity testing and monitoring would be bolstered. Nonetheless, environmental interest groups are calling for the elimination of in-bay disposal altogether.

Figure 3

Sources of Loadings of Trace Metals to the Southern California Bight



Source: Schiff et al. 2000, Chesapeake Bay Program, 1999

energy resources (Bureau of Transportation Statistics, 2000). This is driving a trend toward larger ships with deeper drafts and, thus, continued pressure for deeper channels. Although there has been an effort to develop a national policy for screening dredged material and evaluating disposal options (Maritime Administration, 1994). the U.S. lacks a coherent port development policy that is compatible with the environmental quality objectives articulated in federal environmental statutes.

Diffuse Sources of Pollution

In most U.S. coastal regions, diffuse sources of pollution—including land runoff and atmospheric deposition—are now responsible for most serious water-quality problems (EPA and USDA, 1998). Because of the reduced loadings of many contaminants achieved by point-source controls, land runoff is currently the dominant source of many contaminants in both the Southern California Bight and Chesapeake Bay (Figure 3).

Except where the manufacture or use of a contaminant has ceased or changed dramatically—such as for DDT and some other pesticides, PCBs, or lead additives in gasoline—the contribution of diffuse sources of pollution in coastal and ocean waters has not been significantly reduced by the programs implemented over the last 30 years. Moreover, loadings of some pollutants from diffuse sources, such as nitrogen (Howarth et al., 1996; Goolsby et al., 2000) and mercury

(Swain et al., 1992), appear to have increased during that time period.

The importance of diffuse sources of pollutants has long been recognized. There are provisions in the Clean Water Act and Coastal Zone Management Act intended to achieve reductions in pollution of coastal waters from diffuse sources. Nonetheless, improvements have been slow and difficult. This is due to the diversity of diffuse sources, resistance to regulatory solutions, and the multiple pathways through which the pollutants may reach coastal and ocean environments.

Fallout from the atmosphere is an important and previously under-appreciated source of a number of important pollutants, including nitrogen, lead, mercury, and organochlorine compounds such as DDT and PCBs (Box 3). Some of these pollutants can be transported over long distances before falling onto the ocean or on watersheds draining to the coast. Atmospheric transport is the primary mechanism for contamination of oceanic regions remote from human activities, such as polar seas and the open ocean. In a recent report to Congress, the EPA (2000c) indicated that atmospheric deposition of PCBs, banned and restricted pesticides, and lead has been declining in recent years for the Great Lakes and some coastal waters, but that deposition of other pollutants such as nitrogen has not fallen off.

Contaminants and nutrients in runoff are influenced by: (1) land uses, i.e., whether the land is forested, agricultural, industrial or urban; (2) human activities that involve the purposeful or unintended placement of fertilizers, pesticides, atmospheric contaminants, and wastes on the land surface; and (3) natural phenomena and land-use decisions that affect water infiltration, retention, groundwater movement, runoff, and transport in streams and rivers.

Sediments that erode from the land and reach the coast in runoff carry various contaminants bound to sediment particles, including trace metals, organic compounds, and phosphorus. The sediments themselves can constitute a serious form of pollution, silting up shallow water environments, increasing the need for dredging, altering benthic habitats, and decreasing water clarity. Alternatively, improved soil conservation practices and the entrapment of riverine sediments behind dams have resulted in decreased delivery of sediments to many U.S. coastal environments over the last half century (Meade, 1982). For some coastal environments, this has improved the conditions for living resources by increasing water clarity and decreasing sedimentation; however, other coastal ecosystems, such as sandy beaches and subsiding deltas (Milliman, 1997), are experiencing problems because a continued supply of sediments is needed to sustain them. *(Continued on page 14)*

Box 3
The Atmosphere: An Important Pathway for Some Pollutants

Atmospheric deposition of pollutants involves a variety of physical processes that transport chemicals to the Earth's surface (Baker, 1997; Figure 4). Wet deposition involves processes by which gases and airborne particles are washed from the atmosphere during precipitation. Dry deposition results from the impact of fine particles (aerosols) on surfaces and on gas exchange at terrestrial and aquatic surfaces. The magnitude of atmospheric deposition depends directly on the concentration of pollutants in the atmosphere, the form of each chemical (gas or particulate), the size of the aerosol particles, and the extent of precipitation and physical mixing.

Pollutants are introduced into the atmosphere from a variety of sources, travel through several pathways, and reach various fates. Materials such as soot, NO_X, and SO_2, are released from natural sources (forests, volcanoes, and fires) as well as from human activities (anthropogenic sources) However, many atmospheric pollutants (e.g., PCBs, CFCs) are only derived from anthropogenic sources. Sources of air pollutants are commonly categorized as stationary (e.g., power plants, refineries, and incinerators), mobile (vehicles, aircraft, locomotives, and ships), or area (e.g., volatilization of ammonia from manure).

The lifetime of a pollutant in the atmosphere is dependent on its chemical reactivity and its partitioning among gas, liquid, and solid phases. In general, chemicals on particles or in liquid water have a shorter lifetime in the atmosphere and are not transported far from their source, while gaseous chemicals may remain in the atmosphere a long time and travel great distances. Persistent chemicals that are revolatilized after being deposited can travel like a grasshopper over great distances. Because these chemicals are more prone to evaporation under warmer temperatures, they tend to be redistributed to higher latitudes (Wania and Mackay, 1996).

Atmospheric deposition is an important source of nitrogen, some trace metals (e.g., lead and mercury), and organochlorine compounds (e.g., DDT and PCBs) to coastal and ocean environments:

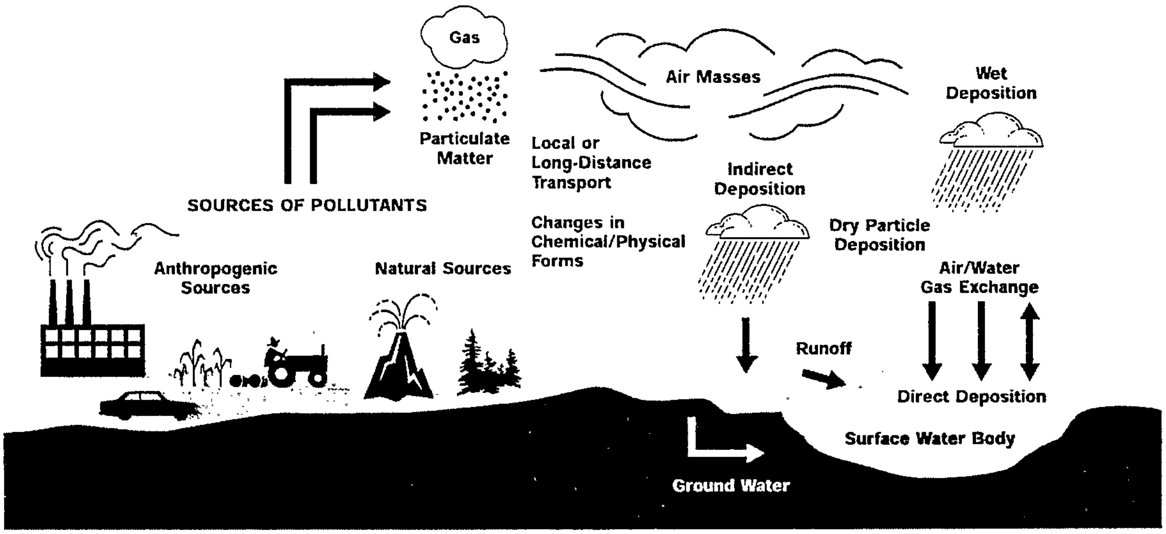
- Lead emissions to the atmosphere in the U.S. and Europe are now orders of magnitude lower than in the early 1970s due to ending the use of leaded additives to gasoline. The impact can be seen in the reduction of lead concentrations in surface waters of the open ocean (Wu and Boyle, 1997), coastal sediments (Bricker, 1993; Cochran et al., 1998; Hornberger et al., 1999), and shellfish tissues (Lauenstein and Daskalakis, 1998).
- The global reservoir of atmospheric mercury has increased by a factor of two to five since the beginning of industrialization (Boening, 2000) and is dominated by anthropogenic emissions (Mason et al., 1994). Principal sources (>80 percent) are combustion processes, primarily coal burning and municipal and medical-waste incineration (EPA, 1997). Higher mercury concentrations in wet deposition are found in urban areas, reflecting local power plant and incinerator sources (Mason et al., 2000). Surface waters of the North Atlantic have higher mercury concentrations compared to the equatorial Pacific (Mason and Fitzgerald, 1996), probably as a result of long-distance transport of gaseous forms of mercury from sources in North America.
- The discovery of organochlorine pesticides such as DDT and industrial chemicals such as PCBs in the waters and biota of the Arctic and Antarctic ecosystems fundamentally altered our view of the role of the atmosphere in distributing pollutants on a global scale (Wania and Mackay, 1996).

Conversion of lands to urban and suburban uses has been proceeding at a rate far greater than the rate of population growth in many coastal communities as a result of the U.S. tendency for low-density residential development (sprawl). The conversion of previously undisturbed land surfaces that allowed the infiltration and slow release of water to impervious surfaces such as roofs, driveways, roads, and parking lots results in higher peak runoff, which carries greater pollution loads and alters the salinity balance in bays and estuaries during both wet and dry weather periods.

While direct discharges still contribute significant toxic contaminants and nutrients to coastal waters, it is clear that protecting the marine environment from the many adverse effects of pollution will require more effective control of land runoff and atmospheric deposition—now the principal sources of the most damaging pollutants in many coastal ecosystems.

Figure 4

Atmospheric Release, Transport, and Deposition Processes



Source: EPA 2000c.

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III. The Challenge of **Toxic Contaminants**

"The historic use of some compounds no longer manufactured or used in the United States—like DDT, PCBs, and lead additives in gasoline—has left a legacy of contamination."

Nature of Toxic Contaminants

Toxic pollutants include trace metals (e.g., cadmium, copper, lead, and mercury), a variety of biocides (e.g., DDT, tributyl tin) and their by-products, industrial organic chemicals (e.g., PCBs and tetrachlorobenzene), and by-products of industrial processes and combustion (e.g., polycyclic aromatic hydrocarbons, or PAHs, and dioxins). Those pollutants meriting greatest attention are widespread and persistent in the environment, have a propensity to accumulate in biological tissues, or induce biological effects at extremely low concentrations.

The historic use of some compounds no longer manufactured or used in the United States—like DDT, PCBs, and lead additives in gasoline—has left a legacy of contamination. Generally, legacy contaminants in U.S. coastal environments have declined. However, these compounds are still in use in other countries and they continue to run off the land. For example, it has been estimated that less than 10 percent of the total lead deposited from the atmosphere onto the Sacramento and San Joaquin river basins has yet been delivered to San Francisco Bay (Steding et al., 2000). As the concentrations of some heavy metals and organochlorine compounds decrease in the marine environment, other contaminants are still being released and do not show a clear downward trend. Some may even be increasing. For example, analyses of lake and reservoir sediments show increasing levels of PAHs associated with suburban development (Van Metre et al., 2000). PAHs come from multiple sources, including petroleum and the combustion of fossil fuels and biomass, some of which have been reduced (e.g., coal coking) and some of which continue (e.g., urban runoff and atmospheric deposition of combustion by-products).

Humankind will be dealing with legacy contaminants of the marine environment well into the future. Repositories of persistent contaminants in marine sediments can be sources of long-term exposure to marine life well after the inputs of these contaminants have largely ceased. Examples of this include DDT in the Southern California Bight (Box 1) and PCBs in San Francisco Bay (San Francisco Estuary Institute, 1996). The deep sea may be the final sink for some persistent organic pollutants (Looser et al., 2000).

Biological Effects

Toxic effects, both lethal and sublethal, have been extensively documented in laboratory experiments, but concrete examples of contaminant effects on populations of marine organisms are limited (McDowell et al., 1999). Key issues considered here include the potential for bioaccumulation of toxicants by marine life; the effects of disruptions of organisms' immune, endocrine, and reproductive systems on their populations; and the effects on marine communities of chronic exposure to the high concentrations of contaminants found in coastal sediments.

Organisms may accumulate contaminants from water, sediments, or food in their tissues. This can result in concentrations of the contaminant many times higher than those found in the environment. The degree of bioaccumulation depends on the level of exposure and the mechanisms by which the organism expels, stores, or metabolically breaks down the contaminant. Compounds such as organochlorine pesticides and PCBs tend to accumulate in fatty tissues (lipophilic compounds), where they may remain for long periods of time. Animals in the upper levels of the food web may accumulate these compounds from prey until lipid storage sites are saturated. Their metabolism is then challenged to degrade and excrete the contaminants or their metabolic by-products, some of which are much more toxic than the original form. In this way, highly persistent and bioaccumulative compounds can magnify through the food web, having little noticeable toxic effect except at the highest trophic levels. Trace metals are also subject to bioaccumulation, but except for metal-containing organic compounds (e.g., methyl mercury) do not biomagnify in marine organisms.

Bioconcentration and biomagnification of toxicants pose particular risks to predators of fish, including birds, marine mammals, and humans. High concentrations of toxicants, such as PCBs and mercury, necessitate health advisories for frequent consumers of fish in some regions (EPA, 1999). Perhaps the most widely recognized effect of persistent contaminants on marine populations is the decline of populations of bald eagles and brown pelicans during the 1960s and 1970s. DDT and its breakdown products accumulated in adult birds from their prey, leading to changes in calcium metabolism in breeding females. The birds produced abnormally thin eggshells and ultimately experienced reproductive failures (Hickey and Anderson, 1968; Blus et al., 1971).

Extensive evidence demonstrates that toxicants can disrupt the metabolic, regulatory, or disease defense systems of an organism, eventually compromising its survival or reproduction. For example, genetic damage, malformations, and reduced growth and mobility were observed in Pacific herring embryos exposed to PAH (from weathered oil) levels as low as 0.7 ppb (Carls et al., 1999). Mollusks exposed to PCBs in New Bedford Harbor, Massachusetts, experienced both a loss of reproductive output and increased susceptibility to disease (McDowell et al., 1999). Accumulation of PCBs and PAHs in Puget Sound rock sole has been correlated with reductions in spawning success (Johnson et al., 1998). Bioconcentration of PCBs has also been linked with impaired immune defenses that lead to disease and death in marine mammals, including seals and dolphins (Kuehl and Haebler, 1995).

Particular attention is currently being devoted to the disruption of endocrine systems by toxic contaminants. Some organochlorine pesticides, PCBs, dioxins, and other compounds functionally mimic or alter the production of hormones (NRC, 1999b). Tributyl tin (TBT), a biocide used in antifouling paints, has been shown to disrupt hormones controlling sexual development in mollusks exposed to concentrations as low as 10 parts per trillion, leading to irreversible reproductive abnormalities (e.g., females developing male sex organs) and reproductive failures (NRC, 1999b). Significant declines in marine snail populations have been documented in regions of North America and Europe where use of TBT was intense (Matthiessen and Gibbs, 1998; Nehring, 2000). Most uses of TBT paints in the U.S. were discontinued as a result of these findings. Feminization of males due to exposure to estrogen mimics and masculinization of females exposed to estrogen blockers have been observed in various animals, including mollusks, fish, reptiles, birds, and mammals (NRC, 1999b; Royal Society, 2000). For example, endocrine-disrupting chemicals have been implicated in the incidence of hermaphroditism in Norwegian polar bears and St. Lawrence beluga whales (De Guise et al., 1994).

Toxic substances in sediments appear to have localized effects in U.S. bays and estuaries and in certain offshore regions that received wastes, such as the New York and Southern California Bights. In the past decade, EPA's Environmental Monitoring and Assessment Program (EMAP) and National Sediment Quality Survey and NOAA's National Status and Trends Program have extensively measured the concentrations of contaminants in bottom sediments in the nation's bays and estuaries, collected collateral data on the communities of benthic organisms living in those sediments, and assayed toxicity of sediments to sensitive amphipod crustaceans. Using these three components—contaminant concentrations (and their probable effects based on an extensive database), the health of the communities living in the sediments, and experimental toxicity—Long (2000) concluded that biologically significant chemical contamination and toxic responses occurred throughout the nation's coastal waters, especially in the most urbanized and industrialized regions. Chemical concentrations exceeding guidelines for probable effects occurred in 26 percent of samples, representing 7.5 percent of the bays and estuaries surveyed. Generally, sediments proved toxic to the crustaceans where contaminant concentrations were high and benthic communities degraded.

This three-pronged approach involving field studies does not fully resolve which contaminants and other factors are actually responsible for the toxicity and community degradation. The synergistic, additive, or antagonistic interactions among contaminants are poorly understood and challenging to assess, thus making it difficult to predict biological responses simply based on knowledge of the types and concentrations of contaminants present in a given area (Yang, 1998).

Pollution Abatement and Remediation

The most effective way to reduce the harmful impacts of toxic contaminants on marine ecosystems is to eliminate or restrict their use or production. The experiences with lead additives in gasoline, DDT, and PCBs show that in the long term this approach can reduce environmental concentrations and exposure for marine organisms. In addition to discontinuing the use or production of these substances, source controls, recycling and reuse, and other forms of "pollution prevention" provide the first line of defense (NRC, 1993a). Treatment and removal of pollutants from effluents and atmospheric emissions provide a second line of defense. Improved knowledge of the fate and effects of various classes of compounds and screening processes for new chemical products have reduced, but not totally eliminated, the risk of "surprises" such as DDT, PCBs, and TBT.

Legacy contaminants must be managed for decades to centuries into the future. Options include control of losses from waste sites and contaminated soils on land, treatment of urban stormwater, and remediation of contaminated sediments. Contaminated sediments exist in many ports, where they pose a risk of reintroduction of toxicants into the water column by physical disturbance of sediments or transferal through the food chain. Options for managing contaminated sediments include: leaving them in place to allow recovery to proceed through degradation and burial, capping them with clean sediments, treating them in place, and removing them for containment or treatment (NRC, 1997).

In the case of the pesticide kepone in the James River estuary, Virginia, the decision was to leave the contaminated sediments in place, and subsequent reductions of contaminants levels in the ecosystem and organisms were observed (NRC, 1997). However, when contaminant levels are high and the risks of reintroduction are great, capping may speed recovery of the ecosystem. The EPA has proposed placing clean sediments atop portions of the DDT deposits off Palos Verdes, California, in order to test the feasibility and effectiveness of this remediation method. Representatives of the DDT manufacturer have criticized this method because DDT concentrations in surface sediments have been declining and the process may expose heavily contaminated sediment below the surface (Whitaker, 2000). A similar controversy surrounds proposals to cap the dredged sediment disposal site in the apex of the New York Bight. These cases exemplify the dilemma faced in making decisions regarding remediation of contaminated sediments.

IV. The Challenge of **Nutrient Pollution**

Nutrient Overenrichment

An increase in the supply of organic matter in a water body is termed eutrophication (Nixon, 1995; see sidebar in Abstract). Over the last 30 years the discharge of organic wastes from municipal and industrial sources declined as a result of improved treatment. At the same time, eutrophication in many areas became more extensive due to increased loadings of mineral nutrients, particularly nitrogen and phosphorus, which stimulate the production of organic matter within the marine ecosystem. There are many consequences of this increased organic production, both beneficial and harmful. The latter include hypoxia, or stressfully low dissolved oxygen, reductions of seagrass beds and corals, and, potentially, noxious or toxic blooms of algae.

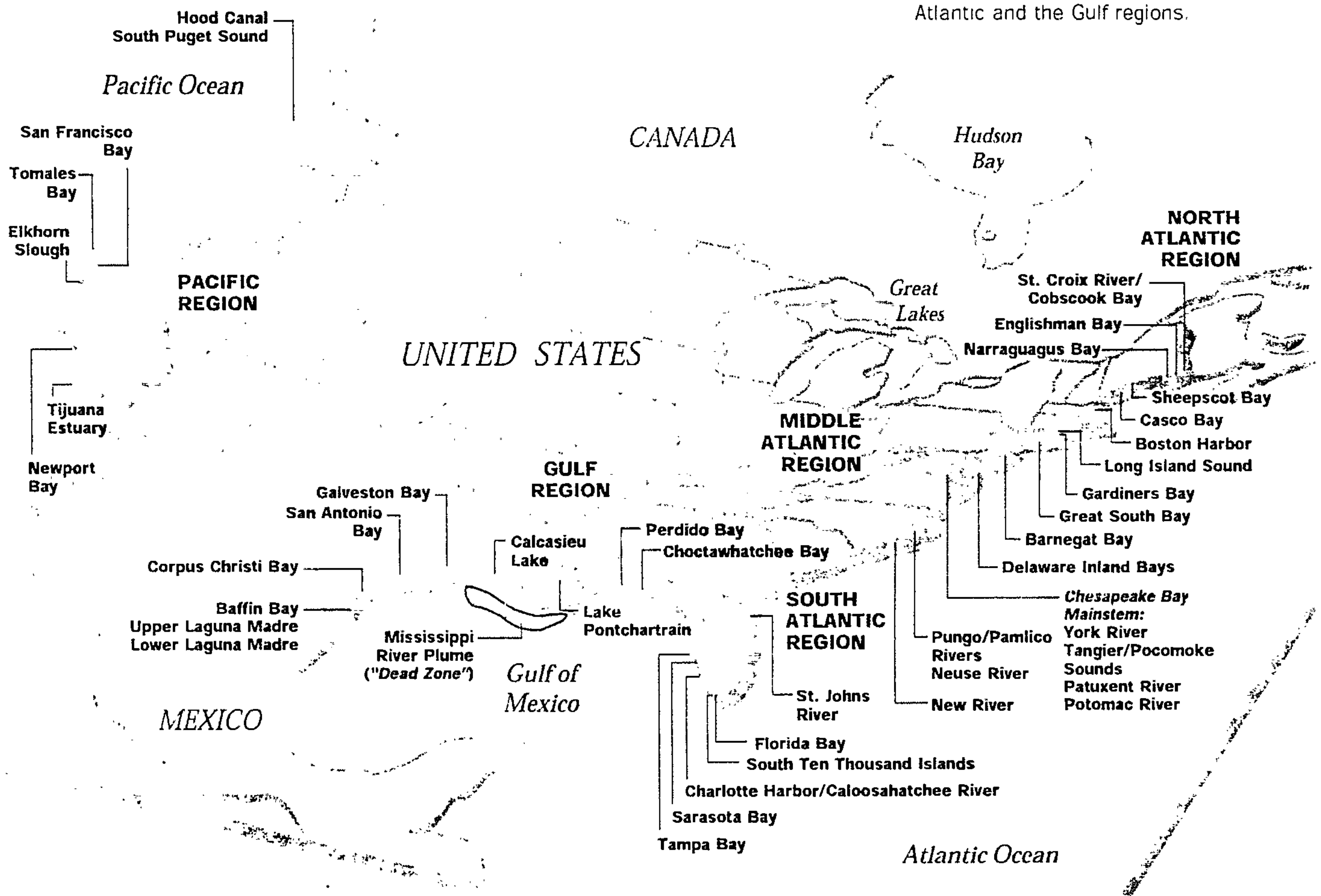
Nutrient pollution has been increasingly recognized as a key threat to coastal environments over the past 20 years because of both new scientific understanding and declining trends in water quality (Nixon, 1995). Loadings of nitrogen flowing in rivers to the Atlantic and Gulf coasts of the United States have increased four to eight fold from the time of European colonization (Howarth et al., 1996). Most of that increase came in the last half of the 20th century. Scientific research has demonstrated that nutrient overenrichment was a major contributor to the extensive changes observed in coastal ecosystems during that period. Three recent scientific assessments addressed nutrient pollution in U.S. coastal waters.

The National Oceanic and Atmospheric Administration characterized the symptoms of eutrophication for 138 bays and estuaries around the U.S. coast based on data review and expert consultations (Bricker et al., 1999). Approximately one-third of the water bodies had high expressions of eutrophic conditions (Figure 5). Altogether, 82 water bodies, representing 67 percent of the combined surface area of these bays and estuaries exhibited moderate to high degrees of depleted dissolved oxygen, loss of seagrasses, or harmful algal blooms. Moreover, it was predicted that eutrophic conditions would become more severe in 86 of these ecosystems by 2020. Systems having low inflow, poor flushing, or strong stratification are particularly susceptible to eutrophication. While this assessment was limited to estuaries and bays in the conterminous states, nutrient pollution has also resulted in loss of coral reef habitat and seagrasses in U.S. tropical regions (Bell, 1992; Lapointe, 1999). *(Continued on page 22)*

Figure 5

Areas of Significant Eutrophication in U.S. Coastal Waters

A recent National Oceanic and Atmospheric Administration (NOAA) study examined 138 estuaries along the coasts of the conterminous United States. A group of experts identified 44 estuaries and coastal areas (labeled on the map below) with high levels of eutrophication and found an additional 40 estuaries (not shown) with moderate symptoms of eutrophication. The highest percentage of estuaries with high levels of eutrophication occurs in waters along the coasts of the Middle Atlantic and the Gulf regions.



Map design by Robert Cronan, Lucidity Information Design, LLC

Eutrophication is the long-term increase in the supply of organic material to an ecosystem, often as a result of excess nutrients. Signs of eutrophication in coastal waters include increased phytoplankton growth, increased growth of macroalgae and epiphytes (plants that overgrow other plants), low dissolved oxygen, harmful algal blooms, and loss of seagrasses. Typically one or more of these symptoms is seen over large areas and/or persistently within the estuary. The "Dead Zone" in the Gulf of Mexico refers to an extensive area of seasonal hypoxia, or depletion of dissolved oxygen, in the bottom waters.

Adapted from Bricker et al., 1999

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Box 4
Gulf of Mexico's "Dead Zone"

In a large region of the inner continental shelf off the coast of Louisiana and Texas, the bottom water oxygen levels fall too low (<2 mg/L) to support fish, crustaceans, and many other invertebrates during the warmer months of April to September. This hypoxic zone, or Dead Zone, has been as large as 12,000 square miles (20,000 km^2) but varies in dimensions from year to year and within years, depending on river runoff, and meteorological and oceanographic factors. A recently completed integrated assessment conducted under the auspices of the President's National Science and Technology Council (CENR, 2000) concluded that:

1. the hypoxia is caused primarily by excess nutrient runoff (particularly of nitrogen) from the Mississippi-Atchafalaya River Basin in combination with stratification of Gulf waters;
2. landscape alterations and river channelization during the late 19th century and first half of the 20th century reduced the river basin's hydrologic buffering capacity;
3. eutrophication and hypoxia increased during the latter half of the 20th century during which the flux of nitrate-nitrogen almost tripled (between 1955–1970 and 1980–1996), concomitant with the rapid increase in the use of chemical fertilizers;
4. about 90 percent of the nitrate load comes from diffuse sources, particularly from agricultural lands along the upper Mississippi and Ohio rivers, nearly 1000 miles upstream from the river's mouth; and
5. Gulf ecosystems and fisheries are affected by hypoxia, but economic impacts are difficult to quantify.

Models predicted significant reductions in hypoxia would occur with a 20 to 30 percent nitrogen load reduction. Two approaches are required to achieve that level of reduction: (1) improved agronomic practices that reduce nitrogen losses from farm fields and (2) trapping nitrogen lost from fields in restored wetlands, vegetated buffers, reconnected floodplains, and coastal wetlands. These recommendations have been met with considerable controversy regarding both the certainty of the science and the costs and impacts on food production among midwestern states and agricultural interests. In October 2000, a task force including senior policymakers from eight federal agencies, nine states, and two tribal governments set a general goal to reduce the average area experiencing hypoxia to less than 5,000 km^2 (1,930 square miles or about 40 percent of its average dimensions during the 1990s), which the task force recognized would probably require the reduction of nitrogen inputs by 30 percent.

The President's National Science and Technology Council produced an integrated assessment of large-scale hypoxia in the northern Gulf of Mexico (CENR, 2000) (Box 4). The assessment concluded that diffuse sources of nutrient pollution have caused more extensive hypoxia, covering up to 12,000 square miles of the northern Gulf continental shelf, since the 1950s. It identified more efficient use of fertilizers and restoration of wetlands in the river basin as effective means to reduce the extent and severity of hypoxia in the Gulf.

Finally, the National Research Council (2000a) recently published an in-depth evaluation of the causes and effects of overenrichment in coastal waters and of abatement strategies, including monitoring and modeling, goal setting, and source reduction and control. Noting the substantial adverse impacts of nutrient pollution and the likelihood that nutrient loads will increase as human populations grow, the NRC calls for a nationwide strategy for reducing impairment by nutrient pollution and protecting unimpaired waters. One goal suggests a 10 percent reduction by the year 2010 in the number of coastal water bodies demonstrating severe impacts and a 25 percent reduction by 2020.

Large-scale eutrophication has also occurred in seas around other developed nations, including the Baltic Sea, eastern North Sea, northern Adriatic Sea, northwestern Black Sea, and Japan's Seto Inland Sea. As in the U.S., these problems also developed during the last half of the 20th century with expanded use of chemical fertilizers and combustion of fossil fuels. Coastal eutrophication is but one dimension of the significant modification of the nitrogen cycle (Vitousek et al., 1997). Globally, the amount of biologically available nitrogen added to the biosphere each year has more than doubled the amount made available by the natural sources of plant fixation and lightning. In addition to impacts on marine ecosystems, acid rain, loss of forest soil fertility, emissions of nitrous oxide (a greenhouse gas), and reduction of plant biodiversity are other consequences of the increasing flow of biologically available nitrogen in the biosphere.

Consequences for Living Marine Resources

Nutrients are generally in short supply in most ecosystems and microscopic and macroscopic plants have adapted mechanisms to assimilate them and grow when they are available. The addition of nutrients to an ecosystem affects not only how fast plants grow but also which plants grow most rapidly. These responses are affected by many factors, including light, temperature, mixing and stratification of the water column, the ratio of the various nutrients, and grazing by animals. In marine ecosystems, the rate at which plants create new organic matter (primary production) is closely related to nitrogen inputs (NRC, 2000a). Primary production doubled from the beginning of the 1960s to 1990 in the southern Kattegat between Denmark and Sweden (Richardson and Heilman, 1995), one of the few areas where primary production has been consistently measured. Similar dramatic increases in primary production in the Chesapeake Bay (Cooper, 1995) and the northern Gulf of Mexico (Rabalais et al., 1996) have been inferred based on chemicals and fossils laid down in bottom sediments.

Although much of the increased organic matter is consumed by zooplankton, bacteria, and bottom filter feeders, the amount of organic matter that falls to the bottom in the form of dead plant cells and fecal matter from grazing organisms is also increased. This changes the food regime of organisms living on the bottom or within bottom sediments, initially increasing the abundance of animals and microorganisms that consume the rich organic deposits. However, the respiration of these decomposer organisms consumes oxygen. At first oxygen is depleted in bottom sediments and, if organic loading is heavy enough, the deficit of oxygen reaches into the water column above the seabed. The severity and persistence of resulting hypoxia depend on the stratification of the water column. Less dense (warmer or fresher) surface waters overlying more dense (colder or saltier) bottom waters, with little mixing between the layers, prevents supplies of oxygen from surface waters from replenishing the oxygen consumed by decomposers.

Severe hypoxia near the bottom has become a more regular and extensive seasonal phenomenon in ecosystems such as the Louisiana continental shelf (Rabalais et al., 1996), Chesapeake Bay (Boesch et al., in press), the western basin of Long Island Sound (Long Island Sound Study, 1998), and many other parts of the world (Diaz and Rosenberg, 1995).

As bottom oxygen is depleted, many organisms unable to swim away succumb. Crustaceans, echinoderms, and mollusks are particularly sensitive to the lack of oxygen and the hydrogen sulfide that emanates from putrefying sediments. Consequently, benthic communities experiencing eutrophication and hypoxic stress are altered and have less species diversity. Substantial changes in the production and composition of benthic communities may be evident well before severe hypoxic conditions occur in overlying waters (Diaz and Rosenberg, 1995).

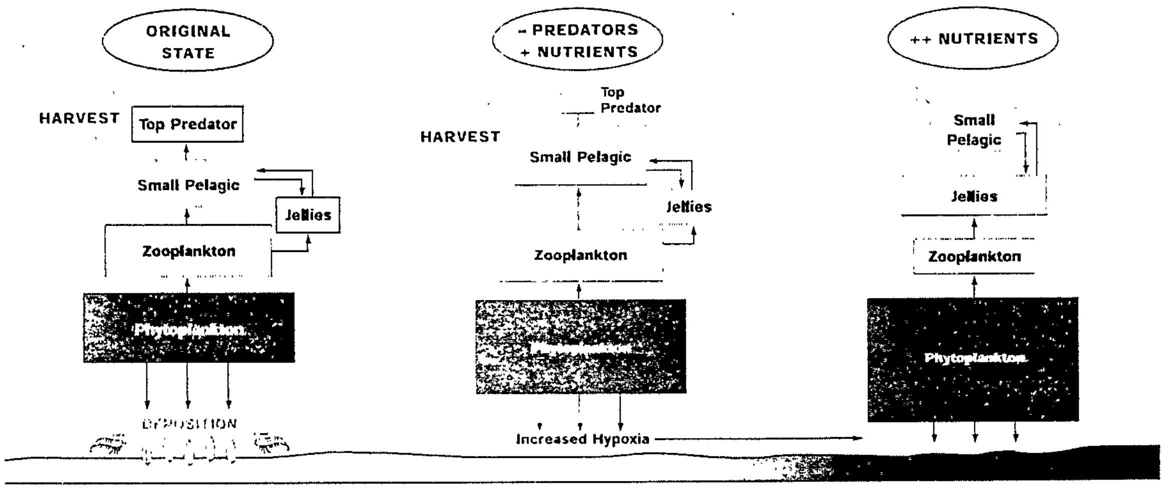
Hypoxic conditions in waters above the seabed force fish and swimming invertebrates to avoid the stressful conditions. Catches of fish and shrimp in bottom trawls in the Gulf of Mexico are dramatically lower or nonexistent where bottom dissolved oxygen levels fall below 2 mg/L (CENR, 2000). Fish and crustaceans often move up in the water column, where they are more susceptible to predation. Hypoxia can also block normal onshore-offshore migration. Despite these apparent obstacles to survival, large-scale hypoxia has not decimated the important shrimp fisheries of the northern Gulf of Mexico (CENR, 2000), although it may have reduced the catch of brown shrimp (Zimmerman and Nance, in press). Many other [illegible] affect shrimp populations, [illegible] less-than-catastrophic effects due [illegible] difficult to detect. Bottom hypoxia has [illegible] in declines in the catches in de[illegible] (living near the bottom) fisheries in Europe and Japan (Caddy, 1993, 2000).

Nutrients are necessary to support the productivity of marine food webs. Across the full range of marine ecosystems, the supply of nutrients—particularly nitrogen—is positively correlated with fisheries yield (Nixon et al., 1986). Although the general relationship is undeniable, the strength of coupling between nutrients and the production of animals within a given ecosystem has been called into question (Micheli, 1999). Nonetheless, increases in the catch of some fisheries have been observed in the North and Baltic Seas and Seto Inland Sea in Japan, concurrent with increases in nutrient loading (Caddy, 1993). While some increases are attributable to increased fishing pressure or more efficient fishing paralleling increased nutrient loadings, greater yields appear to be at least in part due to nutrient stimulation of the food chains supporting the fisheries. Other factors can affect fisheries yield, however, including climatic variation and the effects of fishing itself on the food chain. There is a strong global trend of "fishing down the food chain," wherein fishing is targeted on smaller species once stocks of higher predators are depleted (Pauly et al., 1998). Under these conditions there is less predation on mid-trophic level species, allowing them to become more abundant. These factors may result in increased yields measured as biomass, but the economic value of the fishery is typically smaller.

Eutrophication combined with increased fishing intensity, results in higher yields of small pelagic (living in the water column) species and reduced yields of top

Figure 6

imultaneous Effects of Eutrophication and Fishery Harvest on Marine Food Chains



ource Caddy, 2000

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predators and demersal (living near the bottom) species (Figure 6). In the extreme case, severe hypoxia and highly enriched food chains favor gelatinous predators (jellyfish and comb jellies) and result in the virtual elimination of demersal resources and reduction in small pelagic fish stocks (e.g., anchovies in the Black Sea). European seas can be ordered based on relative harvests of demersal and pelagic fisheries from the Irish Sea, with low nutrient inputs and proportionally greater demersal fisheries, to the Adriatic and Black Seas, with high nutrient inputs and predominantly pelagic fisheries (Caddy, 2000). In the U.S., enriched systems such as the Chesapeake Bay and northern Gulf of Mexico exhibit high yields of a small pelagic fish (menhaden). These systems have also experienced overharvesting of top predators such as striped bass, red snapper, and red drum and face current management problems for demersal crustaceans such as blue crabs and penaeid shrimp. The interactions between fishing pressure and eutrophication require that fisheries resources be managed not only in a multispecies context but also within an ecosystem framework. That framework may need to take into account human activities and natural processes extending even into the watersheds that deliver fresh water and nutrients to the sea (Caddy, 2000).

Seagrasses, seaweeds, and coral reefs create important habitats that provide food and shelter for a rich diversity of marine organisms, but are very sensitive to nutrient pollution. High nutrient levels in the water column can stimulate luxuriant growth of seagrass leaves, but there is insufficient rhizome growth to tide the plants over during periods of reduced photosynthesis. Reductions in available light caused by increased phytoplankton density and the proliferation of microscopic and macroscopic algae growing on seagrass blades also adversely affect the plants (Duarte, 1995). Seagrasses sometimes give way to fast growing macroalgae. Ultimately, conditions may become too turbid to support any macroscopic plants. As seagrass beds are lost, sediments are more easily eroded, causing the pace of loss to accelerate. Significant seagrass losses caused by excessive nutrient loadings have been observed in bays and coastal lagoons in New England, the mid-Atlantic region, Florida, Texas, and California (Bricker et al., 1999), as well as in Europe, Australia, and Japan (Duarte, 1995). On the other hand, partial recovery of seagrass beds in Sarasota, Tampa, and Chesapeake Bays has been observed as a result of efforts to abate nutrient pollution.

In the Baltic Sea, shallow rocky areas once covered with brown seaweeds that provide important spawning sites for fishes changed to a plant community dominated by rapidly growing green algae of little habitat value (Jansson and Dahlberg, 1999).

In the northwestern Black Sea, an extensive meadow of red algae covering 4,000 square miles in the 1950s was reduced to 200 square miles by the 1990s, causing a loss of a harvested resource, the disappearance of a unique fauna, and reduction in an important source of oxygen (Zaitsev, 1999).

Reef-building corals have a symbiotic relationship with algae (zooxanthellae) that live in coral tissue and efficiently recycle available nutrients. This relationship allows corals to build reefs in clear waters with low nutrient levels. Even small increases in nutrient loads can stimulate phytoplankton and reduce light availability for zooxanthellae in the deeper parts of the reef. Elevated nutrient levels or reduced light availability may make already temperature-stressed corals more prone to expelling zooxanthellae, producing a "bleaching" effect (Brown, 2000).

Increased availability of nutrients can shift an ecosystem dominated by corals and coralline algae toward dominance by algal turf and macroalgae (Bell, 1992; Lapointe, 1999). Nutrient stimulation due to sewage additions was responsible for overgrowth of coral reefs by macroalgae in Kaneohe Bay, Hawaii, during the 1960s. Redirecting sewage out of the bay reversed this situation (Smith et al., 1981). Grazing animals normally prevent algal overgrowth, so when overfishing reduces grazers, reefs may be particularly susceptible to nutrient pollution (Lapointe, 1999). Overenrichment may also contribute to environmental stresses that make corals susceptible to diseases that appear to be increasing in distribution and virulence (Harvell et al., 1999). Finally, a recent study in Barbados found that boring sponges, which weaken coral structures, were more common in reefs experiencing eutrophication (Holmes, 2000).

Probably no effect of nutrient pollution has captured more public attention than harmful algal blooms, though, in fact, the causes of these blooms are complex and incompletely understood. Harmful blooms involve a variety of unicellular organisms that create nuisance conditions in high concentrations, cause mass mortalities of marine organisms, or illness—or even death—in humans (Smayda, 1997). Included are microscopic organisms (including red tides, brown tides, and the notorious phantom dinoflagellate, *Pfiesteria piscicida*) that result in shellfish poisoning of humans, cause fish kills, and jeopardize aquaculture operations. The distribution, incidence, and severity of harmful algal blooms have been rising in recent decades, not only in the United States but also in Europe, Japan, and China (Hallegraeff, 1993). While nutrient pollution is clearly not the cause of some blooms, in other cases there is evidence that changes in nutrient supplies and ratios are a contributing factor (NRC, 2000a).

The chemical form and relative ratios of available plant nutrients can cause shifts

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in phytoplankton composition and unusual algal blooms. Organic nitrogen seems to favor the organism causing brown tides and possibly *Pfiesteria* in mid-Atlantic bays. A shortage of silicon, a nutrient needed for diatom growth, relative to the supplies of nitrogen and phosphorus favors the growth of flagellated phytoplankton, some species of which are toxic (NRC, 2000a). Even if the species favored are not toxic, changes in the proportions of various nutrients delivered to coastal waters could change the type as well as the amount of phytoplankton that grows, with significant consequences throughout the food web. Inputs of silicon from land have declined in many regions as a result of sediment entrapment behind dams, while phosphorus inputs have remained steady and nitrogen inputs have increased (Justić et al., 1995; CENR, 2000).

Eutrophication usually results in reductions in species diversity of the affected ecosystems and, if extensive and severe, can impact biodiversity on a regional scale. In the northwestern shelf of the Black Sea, for example, only one-third as many benthic animal species could be found within a given depth zone in the 1980s as were found in the 1960s (Diaz and Rosenberg, 1995). There is at this point no evidence that eutrophication is threatening the global extinction of any species. However, by isolating distinct subpopulations, local extinction of a species in one or two estuaries along a coast could affect the genetic flow within the regional population (NRC, 1995).

Eutrophication can also adversely affect the services provided by marine ecosystems. Nutrient removal by denitrification and burial in bottom sediments may be one of the most important services provided by coastal ecosystems (Costanza et al., 1997). However, when severe seasonal hypoxia occurs, both phosphorus and ammonia are released from bottom sediments, turning an important sink for nutrient pollution into a source—thereby fueling more hypoxia (Boesch et al., in press). Through this and other feedback mechanisms, eutrophic ecosystems appear to be less resilient, i.e., they have less capacity to buffer changes and recover from disturbances more slowly.

Sources and Trends

Human activities have increased the flow of phosphorus to the world's ocean by a factor of three over natural rates and the flow of nitrogen to U.S. coastal waters by four to eight times (NRC, 2000a). The largest human-controlled addition of nitrogen to the environment is the manufacture of inorganic nitrogen fertilizer. However, other activities, including the combustion of fossil fuels and cultivation of nitrogen-fixing crops, also convert atmospheric nitrogen into reduced, oxidized, or organic forms that are more biologically available than the gaseous nitrogen that comprises most of the air we breathe. About 20 percent of the fertilizer nitrogen applied in North America leaches into waters and 65 percent is removed in crops (NRC, 2000a). Most of the crops (70 percent) are fed to animals rather than humans; thus the amount of nitrogen reaching water bodies from animal wastes probably exceeds that from fertilizer runoff. Ammonia released into the air from animal wastes can be an important pathway though which nitrogen reaches coastal waters (Box 5). Human sewage is also an important avenue for nitrogen originally contained in crops or meat to reach coastal waters.

The relative importance of the sources of nutrients varies greatly among U.S. coastal regions, depending on the characteristics of their drainage basins, human populations, intensity of agricultural activities, and amount of atmospheric deposition. The percentages in Figure 7 are based on relating source estimates to fluxes measured through stream monitoring. Other statistical analyses across many watersheds (NRC, 2000a) suggest that atmospheric sources are a somewhat more significant contributor to diffuse source inputs than shown here, but the interregional differences depicted are in any case similar. Direct discharges of sewage dominate nitrogen inputs in northeastern bays; otherwise diffuse sources predominate. Agricultural sources generally are

Box 5
Ammonia Emissions: An Emerging Issue

Atmospheric deposition of nitrogen has been considered primarily in terms of the nitrogen oxides (NO_X) produced by fossil-fuel combustion. However, recent evidence shows that ammonia emissions from agricultural operations can be a significant pathway for nitrogen inputs to coastal waters, accounting for as much as half of the total nitrogen deposition in regions with extensive livestock production (Walker et al., 2000).

In the Chesapeake Bay watershed, agriculture and livestock contribute an estimated 81 percent of the total atmospheric burden of ammonia (Chimka et al., 1997). Ammonia volatilizes from animal wastes in feeding operations, waste-storage facilities, and application of manure. Increases in deposition of ammonia have occurred with expanding animal production. For example, a 60 percent increase in ammonia wet deposition was observed on the Delmarva Peninsula during the past two decades when this region experienced a 20-fold increase in poultry production (Scudlark and Church, 1999). In eastern North Carolina, ammonia wet deposition more than doubled over the same time period (Paerl and Whitall, 1999) in a region in which swine production tripled during the last ten years (Mallin, 2000).

Ammonia emissions also occur from various urban sources, including combustion, POTWs, and chemical plants. Recent modifications to gasoline-powered vehicles designed to reduce NO_X emissions (i.e., three-way catalytic converters running rich air-fuel conditions) actually increase ammonia emission rates (Fraser and Cass, 1998).

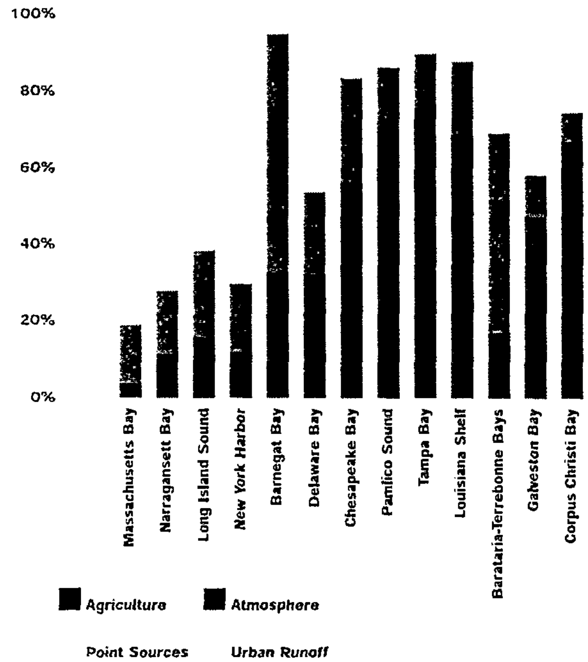
most important from the Chesapeake Bay south, while atmospheric sources are greater than agricultural sources in the Northeast.

Although global additions of nitrogen to the biosphere are continuing to increase rapidly (Vitousek et al., 1997), current trends in nitrogen loadings to U.S. coastal waters are in aggregate generally stable or growing slowly (NRC, 2000a), while inputs of phosphorus are stable or declining. Although the worldwide use of chemical fertilizers is growing and projected to increase substantially to support an expanding world population and increased meat consumption (Forsberg, 1998), the use of chemical fertilizers in the U.S. nearly plateaued in the 1980s (NRC, 2000a). However, increased inputs of both nitrogen and phosphorus have occurred in regions of the country experiencing an expansion and intensification of animal-feeding operations or human population growth. Future consumption of fertilizers and generation of animal wastes in the U.S. could increase, depending on global market forces. Atmospheric deposition of nitrogen from combustion of fossil fuels in vehicles and power plants has stabilized over much of the country as a result of pollution controls imposed under the Clean Air Act, and future efforts to improve air quality should result in reductions (EPA, 2000c).

Population growth increases the amount of sewage generated—a problem for rapidly growing parts of the country.

Figure 7

Estimated Nitrogen Loadings to Selected Atlantic and Gulf Coast Bays and Estuaries and Their Sources



Source: Castro et al., 2000

However, where eutrophication is a recognized problem, implementation of advanced nitrogen removal technologies in POTWs can keep pace with population increases. In many coastal regions of the U.S., however, the rate at which land that produces relatively little nutrient runoff is converted into suburban development, roads, and parking lots, [illegible] increase water and nutrient [illegible] has been progressing much faster [illegible] population growth.

[illegible] NOAA national eutrophication assessment estimated that eutrophic conditions are likely to worsen in two-thirds of the bays and estuaries examined

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(Bricker et al., 1999). However, the prospect that emerges from the preceding analysis is not one of runaway increases in nutrient loading such as the nation experienced between 1960 and 1990, but one of stability or slower growth. This offers the real potential for substantial reductions with aggressive application of technologies. This outlook varies, of course, among regions, and coastal population growth near presently unaffected but susceptible bays and estuaries could greatly increase nutrient pollution in those areas. One should not infer from this that nutrient pollution is no longer a serious problem. The effects of eutrophication on coastal ecosystems are severe and widespread, making its abatement worthwhile, while at the same time challenging.

Pollution Abatement

Significant reduction in nutrient pollution may be achieved by approaches that: (1) reduce the use of the nutrients in the first place; (2) control losses to the environment at the point of release (e.g., farm field, animal feeding operation, lawn or subdivision, vehicle, power plant, or POTW); and (3) sequester or remove pollutants as they are transported to the sea.

Phosphorus can be almost completely removed from wastewaters by additional chemical and biological treatment. Phosphorus removal from discharges into the Potomac estuary below Washington, D.C., produced substantial improvements in water quality and living resources (Jaworski, 1990). Significant nitrogen removal has been achieved in Chesapeake, Tampa, and Sarasota Bays by biological nutrient removal—a process in which one group of microorganisms convert wastewater ammonia to nitrate and another converts nitrate to nitrogen gas (NRC, 1993a, 2000a).

Reductions in nitrogen oxide (NO_X) emissions to the atmosphere have been driven by air quality considerations generally outside the influence of water quality or coastal ecosystem managers. For example, in 1987 the Chesapeake Bay Program established a goal to reduce the controllable nitrogen inputs by 40 percent, but specifically excluded atmospheric deposition from the sources considered "controllable." Nitrogen oxide emissions from power plants and vehicles are regulated under the Clean Air Act (CAA); a key goal of the 1990 amendments of the act is to reduce ground-level ozone that poses human health risks and stresses forests and crops. Significant reductions in NO_X emissions from stationary and mobile sources are in the offing to meet CAA requirements. The EPA estimates that a 40 percent reduction in NO_X emissions can ultimately be achieved as a result of new standards, technologies, and efficiencies being pursued under the Clean Air Act. Atmospheric deposition of nitrogen may be far more "controllable" than previously thought.

Abatement of agricultural sources of nutrient pollution may prove to be a more difficult challenge. To be practical, abatement of agricultural sources of nutrients must focus not only on reducing fertilizer use but also on plugging the many leaks in agricultural nutrient cycles. Efficiencies in fertilizer use in U.S. agriculture, measured by the ratio of nitrogen in harvested crops to nitrogen in fertilizer applied, have been slowly but steadily increasing since the mid-1970s (Frink et al., 1999). Nevertheless, about one-third of the nitrogen applied is not recovered in harvested crops (NRC, 2000a). Not all of the missing nitrogen contributes to eutrophication of coastal waters. Much is denitrified in soils or aquatic systems en route to the sea or is stored in soils or groundwater. In addition to increasing the efficiency of nitrogen uptake by crops, the return of nitrogen gas to the atmosphere can be enhanced through management practices.

Various agricultural practices affect nitrogen and phosphorus runoff and losses to groundwater (which ultimately seeps into surface waters). Practices employed to reduce soil erosion, such as contour plowing, timing of cultivation, conservation tillage (little or no tilling), stream-bank protection, grazing management, and grassed waterways also reduce nutrient pollution. Other practices are more specifically targeted to the efficient use and retention of nutrients: (1) soil testing to precisely match fertilizer applications to crop nutritional needs (many farmers still overapply to ensure maximum crop yields); (2) applying fertilizer only at the time the crop needs it; (3) crop rotation; (4) planting cover crops in the fall; (5) using soil and manure amendments; and (6) specialized methods of application (NRC, 1993b, 2000a). Landscape practices such as maintaining buffer strips between cultivated fields and nearby streams, moderating excessive drainage by ditches and tile lines, and maintaining wooded riparian areas can further reduce the leakage of agricultural nutrients to surface waters. By combining these approaches a significant portion of the edge-of-field nitrogen losses can be reduced (Boesch and Brinsfield, 2000).

Often, animal wastes are the most significant source of nutrient pollution from agriculture. Although the total production of livestock in the U.S. has not dramatically increased in recent years, the number and size of concentrated animal feeding operations have. Enclosures or trapping devices may eventually be required to stem ammonia emissions from animal wastes. Manure management also presents a risk of pollution if holding facilities fail or do not function properly (Mallin, 2000). Finally, frequently too much manure is produced within a geographic area for it to be applied to nearby land without overloading soils with nutrients (NRC, 2000a).

Urban runoff can also be an important diffuse source of nutrients. Reduction and control of urban and suburban diffuse sources can be achieved through: (1) reductions in the use of fertilizers; (2) effective and well-maintained stormwater collection systems (retention ponds can remove 30 to 40 percent of the total nitrogen and 50 to 60 percent of the total phosphorus); and (3) improved septic systems that promote denitrification (NRC, 2000a). Preservation and restoration of riparian zones and streams within urban and suburban areas is also an important aspect of effective nutrient control. However, the ability of streams to function effectively in nutrient removal is compromised when a significant portion of their watersheds is covered by impervious surfaces and the amplified runoff scours the streambeds (Booth and Jackson, 1997).

Removing or sequestering pollutants as they are transported downstream can also abate nutrient pollution. Many American watersheds were once sponge-like, containing extensive floodplains and wetlands that slowed the flow of water and served as sinks for dissolved and suspended nutrients. However, well over half of the wetlands present in the conterminous United States at the time of European settlement have been converted to other land uses and the percentage of inland swamps and riparian wetlands lost is even greater (Mitsch and Gosselink, 2000). Many floodplains have been disconnected from their rivers by flood-control projects or agricultural conversion and no longer serve as nutrient sinks.

Reducing and controlling diffuse sources of land runoff must involve large-scale landscape management, including restoration of riparian zones and wetlands (NRC, 1999c). The integrated assessment of hypoxia in the Gulf of Mexico estimated that 5 million acres of restored wetlands in the Mississippi River Basin would reduce nitrogen loading to the Gulf by 20 percent. Coupled with feasible controls in agriculture, this would achieve a nearly 40 percent reduction in nitrogen delivered to the Gulf. Similarly, the Chesapeake Bay Program is striving to reforest 2,000 miles of riparian zones and restore 25,000 acres of wetlands by 2010 in order to achieve nutrient-reduction goals (Boesch et al., in press).

Geographically targeting riparian and wetland restoration is critical to its effectiveness in nutrient control. Statistical models based on water quality measurements throughout the Mississippi River Basin show that the percentage of nitrogen leached from a field that reaches the Gulf of Mexico depends greatly on its proximity to larger streams and rivers (Alexander et al., 2000). Biological uptake and denitrification are already effective in small watercourses; therefore restoration of riparian and wetland habitats along moderate to large streams should be more cost-effective. However, because of equity considerations, both incentives (subsidies and cost sharing, technical assistance, and insurance) and disincentives (regulatory controls, taxes, and fees) for abatement tend to be applied uniformly.

Watershed Approaches

A given body of coastal water (bay, estuary, or continental shelf region) receives nutrients from numerous sources; thus an integrated strategy for effective abatement of nutrient pollution is required. Because of the importance of diffuse sources, the strategy should encompass the catchment basin, or watershed, draining into the coastal waters. Moreover, it may have to consider nutrients originating outside the watershed but

Box 6
Nonpoint Sources: Acts and Actions

Provisions of both the Clean Water Act (CWA) and Coastal Zone Management Act (CZMA) address diffuse, or nonpoint, sources of nutrient pollution; however, neither law has been very effective in controlling these sources. The implementation of provisions has been poorly funded, and arguably too much discretion is granted to states and local authorities (Adler, 1995; Johnson, 1999) A central programmatic shortcoming is the fundamental difficulty of influencing local land uses in order to obtain water-quality objectives. Under Section 208 of the 1972 CWA amendments, states were provided support and wide latitude in developing regional plans that identified point and nonpoint sources of pollution and methods, including land-use requirements, to control the sources (Anderson, 1999). However, the plans developed proved difficult to implement (Adler, 1995).

Section 319 of the 1987 CWA amendments requires the states to report on waters where nonpoint sources are problematic and identify best management practices and programs for source control. Section 319 moved toward, if not fully embraced, a watershed approach. State participation remained voluntary and EPA did not require states to penalize nonpoint-source polluters failing to adopt best management practices (Johnson, 1999). Lack of authority, enforcement, and monitoring clearly limited the effectiveness of the 319 efforts (Ruhl, 2000; Anderson, 1999).

In 1990 the reauthorized CZMA included Section 6217, under which states were required to implement enforceable policies to control nonpoint sources affecting coastal waters. Plans were originally required by 1995, but difficulties in implementation and coordination arose. Greater flexibility in plans was allowed and the period of implementation was extended to 15 years (NOAA, 2000).

Section 303 of the CWA requires the determination of a total maximum daily load (TMDL) of pollutants, including those from nonpoint sources, that can be accommodated by an impaired water body in order for it to meet water-quality standards for its designated use (Healy, 1997). A waste-load allocation then apportions the TMDL among the sources. This provision was not applied until lawsuits in the 1990s mandated EPA to establish TMDLs. Technical difficulties in determining TMDLs, legal issues regarding allocating loads among the sources, and the weak authority to regulate nonpoint sources remain serious barriers (Ruhl, 2000). Meanwhile, Congress prohibited EPA expenditures on further implementation of TMDLs during Fiscal Year 2001 (Copeland, 2000).

transported into it through the atmosphere. These are nonconventional units for ocean and coastal resource management and pose numerous challenges.

Recognition of the importance of diffuse-source pollution within a watershed is not new. Federal water-quality and coastal-management statutes include provisions for the assessment and control of nonpoint source pollution (Box 6), but to date they have been largely ineffective in limiting or reversing nutrient pollution of coastal waters. Their implementation has been long on planning and short on actions needed to control diffuse sources. In addition to the difficulties in determining management goals, acceptable nutrient loads, and efficient and equitable allocations among sources, substantial reliance on voluntary rather than mandatory reductions of diffuse sources has constrained the effectiveness of source-reduction efforts (NRC, 2000a).

These shortcomings are evidenced by the fact that 44 percent of the estuarine area assessed in 1998 did not fully meet the standards to support the designated uses (EPA, 2000a). Pathogens, organic enrichment, low dissolved oxygen, municipal point sources, urban runoff, and atmospheric [illegible] were the primary reasons, and [illegible] source pollution was a common [illegible]

Concerted efforts to reverse [illegible] pollution have been undertaken in some watersheds. In 1987 Pennsylvania, Maryland, Virginia, the District of Columbia, and the federal government committed to a 40 percent reduction in the "controllable" inputs of both nitrogen and phosphorus into the Chesapeake Bay by the year 2000. At about that same time, commitments were also being made for reductions of 50 percent of nutrient inputs into the North and Baltic Seas (Boesch and Brinsfield, 2000). Current estimates for the Chesapeake are that a 34 percent reduction in controllable phosphorus and a 28 percent reduction in controllable nitrogen will have been achieved by the end of 2000 (equivalent to 31 and 15 percent of the total loads, respectively; Blankenship, 2000). These are model simulations, but significant reductions in nutrient concentrations in rivers flowing into the Chesapeake Bay and in point-source discharges have been documented (Boesch et al., in press). These gains for the Chesapeake and European waters indicate that a watershed approach to reducing nutrient pollution can work, but so far successes have relied disproportionately on point-source controls. Under a new Chesapeake Bay agreement, more significant load reductions necessary to attain water-quality goals are being determined through a TMDL process (Box 6). Achieving these reductions will require a more rigorous effort to control diffuse sources.

Nitrogen inputs to Tampa Bay have also been reduced, again largely as a result of advanced treatment of sewage. Seagrass beds showed some recovery as a result (Lewis et al., 1998). A decrease in anthropogenic nitrogen inputs of 58.5 percent is the management goal for Long Island Sound (Long Island Sound Study, 1998). Direct discharges dominate nutrient sources there, thus biological nutrient removal at POTWs—at an estimated capital cost of more than 300 million dollars—is being counted on for most of this reduction.

Watershed approaches are being pursued in controlling diffuse sources of nutrients and other pollutants in many other U.S. bays and estuaries. In most, voluntary approaches to the pollution abatement are preferred; however, regulatory approaches are becoming more necessary, particularly as a result of the TMDL process (NRC, 2000a).

Watershed approaches place a premium on environmental modeling and monitoring (NRC, 2000a) in an adaptive management framework (Lee, 1993; CENR, 2000). Models are needed to track sources through the watershed, target abatement, and relate pollutant inputs to marine ecosystem responses. Monitoring is critical in determining the effectiveness of abatement strategies, evaluating responses of the ecosystem, and placing these responses in the context of ecosystem variability.

V. Implications for **National Ocean Policy**

Pollution in Context

Determining the degree to which pollution affects marine living resources, biodiversity, and ecosystem services and comparing these effects to those due to fishing, habitat modification, and global climate change are extremely difficult. Effects of pollution must be separated from those due to natural variability and other human activities. Furthermore, the broader consequences of sublethal or localized effects for populations and ecosystems are seldom clear. The ramifications for biodiversity and living resource production of localized toxic effects or even the more extensive effects of nutrient pollution are difficult to quantify.

For the most part, the effects of pollution are reversible and respond to pollution abatement. The exception may be when marine mammals and birds are endangered by mass mortalities or reproductive failures resulting from toxic contaminants. Recovery can, however, be problematic and recovery times long, particularly with regard to persistent contaminants and permanent landscape changes that affect the delivery of pollutants from the watershed.

The nation's ocean and coastal ecosystems are being simultaneously affected by fishing activities (exploitation of target species, "bycatch," and effects of trawling), habitat modification from coastal development, and climate change, as well as by pollution. The relative importance of pollution as a threat to living resources depends on the region. Pollution is a fundamental concern in areas such as Boston Harbor, the northern Gulf of Mexico continental shelf, or the Chesapeake Bay. It is difficult to imagine environmental restoration and adequate resource management without controlling pollution. In other areas, pollution is much less a factor and habitat modification or fishing effects are far more important.

Most coastal ecosystems, in fact, experience multiple stresses. These stresses interact and, consequently, require integrated management solutions. Many coastal bays, for example, have been made less resilient to nutrient pollution because their oyster populations, which can filter out substantial amounts of organic matter, have been depleted. Furthermore, eutrophication will be influenced by the effects of climate change on freshwater runoff and water stratification (Justić et al.,1996; Najjar et al., 2000). And, overfishing of grazers makes coral reefs more susceptible to nutrient pollution (Lapointe, 1999). Multiple

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stresses can influence biodiversity on regional scales. For example, of 31 species of mammals, birds, and fish that have disappeared along the coast of the Netherlands over the past 2,000 years, 18 to 22 were as a result of overexploitation, 9 to 12 due to physical destruction of habitat, and 3 to 5 attributable to pollution (Wolff, 2000).

Priorities

Considerable strides have been made in reducing "conventional" forms of pollution over the last 30 years by implementation of the Clean Water Act and other federal, state, and local programs. Although further improvements are undoubtedly needed, technology-driven requirements and discharge permitting have been successful in greatly lowering the inputs of many contaminants into U.S. coastal waters. The dumping of sewage sludge and other wastes in the ocean was eliminated. The adverse effects of several manufactured chemicals (DDT, PCBs, and TBT) were uncovered and their use was discontinued or severely restricted.

This is not to say that protection of living marine resources from toxic wastes is no longer an important consideration for ocean policy. Decisions about managing legacy contamination and allowing the use of new chemicals still confront us. Atmospheric deposition and runoff from urban, suburban, and agricultural lands are now predominant pathways for toxic contaminants entering many coastal ecosystems. Abating these sources will require major commitments and innovative approaches.

We now realize that nutrients leaking from our land-based economy—from agriculture, transportation, power generation, and people—are having profound effects on coastal marine ecosystems over larger scales than imagined 30 years ago. The National Research Council (2000a) recommended that reducing nutrient pollution should be a national priority. Our society has just barely begun to accept and address this problem. Significant challenges lie ahead, particularly in ameliorating nitrogen pollution from diffuse sources.

Scales of Pollution Abatement

Meeting environmental quality objectives for the coastal ocean will require pollution abatement efforts at several scales. At the largest scale, managing anthropogenic alterations of the atmosphere and landscape well beyond the traditional "coastal zone" is required. Abating diffuse sources of pollution necessitates national laws and programs that harmonize agriculture, water resource, air quality, transportation, and land conservation policies with coastal environmental quality objectives. For example, the next reauthorization of the Farm Act should contribute to the reduction of nutrient pollution of coastal waters by targeting incentives, subsidies, and assistance while also ensuring economically and socially viable agriculture for the nation.

At the programmatic scale, controlling diffuse sources is clearly the principal challenge for marine pollution abatement. The missing link for the next level of environmental advance is the design and implementation of sustained programs and institutions that address these diffuse sources and provide solutions that are acceptable to American society. Watershed approaches provide a framework but are constrained by weak authorities and the preeminence of traditional governance at state and local levels. The National Research Council (2000a) noted that effective control of multiple sources of nutrients and contaminants on watershed scales would require a mix of voluntary and mandatory approaches and hybrids of these two extremes. Incentives and disincentives included in statutes and management practices can be very important in promoting and shaping voluntary actions involving agriculture and land uses. At the same time, more effective compliance with mandates, such as those already applicable to urban stormwater runoff, should be required.

At the individual scale, many discrete gains may be realized. More demanding treatment standards than those generally applicable can be required where water quality is seriously impaired. Such case-specific requirements generally force technological innovations that are eventually applied more broadly.

Marine Ecosystem Management and Science

Effective ocean resource policies and management regimes must be integrated. Not only must they manage the fish, habitats, and pollution of the coastal ocean more compatibly, but they must also consider and coordinate with land-based activities. Existing regional programs that link activities in the watershed with coastal ecosystem management represent an important start, but much more remains to be accomplished to achieve full integration.

Recognizing inherent uncertainties, policies, and management regimes must also be precautionary and adaptive. As stated in the United Nations' Rio Declaration, the precautionary principle requires that: "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Environmental decision-making in the United States has increasingly adopted a more precautionary approach—for example, in the testing of new pesticides and other chemicals before their release in the environment. While application of the precautionary principle may be straightforward in the screening of new chemicals or determining the suitability of dredged material for ocean disposal, it is harder when the ecosystems are already degraded or decisions concern which of many pollutant sources to reduce. Adaptive management involves periodic reevaluation and adjustment of the abatement approach based on careful observation of outcomes.

Integration, precaution, and adaptation in environmental policies and management all rely heavily on science. Scientific research and assessment must not only integrate across scientific disciplines but also address the interactions among the atmosphere, watersheds, and the ocean and relate pollution and other stresses to living marine resources and ecosystem services. The precautionary principle challenges science to quantify risk and determine the level of potential harm required to trigger its application. Adaptive management depends heavily on careful observations and comparison of outcomes to predictions.

Research, monitoring, and assessment relevant to marine pollution need improved strategic focus, organization, and commitment in order to fulfill these roles. The fundamental underpinnings of knowledge of complex environmental processes must be bolstered. The National Research Council (2000b) has identified grand challenges for environmental sciences, several of which are appropriate to marine pollution issues: biogeochemical cycles, biological diversity and ecosystem functioning, climate variability, hydrological forcing, land-use dynamics, and reinventing the use of materials.

Traditional environmental monitoring programs have emphasized relatively static parameters (e.g., contaminant concentrations in sediments or shellfish) rather than the dynamic parameters (e.g., primary production and dissolved oxygen) associated with the effects of nutrient pollution. Observing and understanding the effects of pollution should be an important objective of the sustained, integrated coastal ocean-observing system that is being developed for the nation (Nowlin and Malone, 1999). New sensor technologies, satellite measurements, and vast data storage and computational capabilities provide breakthrough opportunities to observe the environment on the appropriate space and time scales needed to address phenomena, such as eutrophication and harmful algal blooms, which occur over large areas but are highly variable in time.

Observations and research must be brought together in assessments that address key management questions and make useful predictions of probable outcomes. Predictions and observations must continually interact [illegible] adaptive management. This will [illegible] institutional arrangements and [illegible] commitments that support scien[illegible]gration and applied predictions.

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VI. Conclusions

"Overenrichment by plant nutrients, particularly nitrogen, has emerged as the most pervasive pollution risk for living resources and biodiversity in coastal ocean ecosystems."

Significant accomplishments were realized during the last 30 years in reducing the pollution of U.S. ocean and coastal waters by improving the treatment of waste discharges, ceasing most ocean dumping, and eliminating or restricting the use of certain persistent toxicants. Substantial reductions were realized in the inputs of a number of potentially toxic contaminants and organic wastes. Pollutant inputs from regulated discharges will likely continue to decline in order to attain water-quality standards. However, except for the banned and restricted chemicals, inputs of pollutants from diffuse sources—including land runoff—were largely unabated or actually increased during the same 30 years. Diffuse sources now contribute more than direct discharges for many pollutants.

Although it is difficult to extrapolate effects observed in laboratory experiments, it is clear that toxic contaminants chronically affect marine organisms at least over limited, but widely distributed areas in U.S. coastal waters near heavily populated areas. Toxicants can also affect marine mammals and birds that concentrate organic compounds in fatty tissues, sometimes far from the pollution source.

Persistent and bioaccumulative toxicants remain in the ocean and coastal environment for long periods after their sources have been eliminated or substantially reduced. In many cases little can be done until the substances are gradually degraded or removed from the ecosystem. However, isolated sites have extremely high concentrations of toxicants in bottom sediments, from which they can be reintroduced to the ecosystem. Capping and removal options should be thoroughly evaluated by carefully weighing risks of alternative options.

Overenrichment by plant nutrients, particularly nitrogen, has emerged as the most pervasive pollution risk for living resources and biodiversity in coastal ocean ecosystems. Many of the nation's coastal environments exhibit symptoms of overenrichment, including algal blooms (some of which may be toxic), loss of seagrasses and coral reefs, and serious oxygen depletion. Consequences include reduced production of valuable fisheries, threats to biodiversity on regional scales, diminished ecosystem services, and less resilient ecosystems.

Hard-to-control, diffuse sources—often from far inland—dominate nutrient inputs into most overenriched ecosystems. These sources grew dramatically in the last half of the 20th century as a result of increases in the use of chemical fertilizers, more intensive animal agriculture, and the combustion of fossil fuels that release nitrogen oxides into the air. Only recently has nutrient removal been incorporated in advanced treatment of point sources of wastes. New emission standards to meet air-quality objectives, if fully implemented, could reduce atmospheric deposition of nitrogen by 40 percent. Reduction of agricultural sources of nutrients has been more recalcitrant but it is feasible through improved practices and watershed restoration.

Reversing and controlling diffuse sources of pollution, including nutrients, requires an integrated approach on the scale of an entire drainage basin. The legal and institutional mechanisms available for reducing diffuse-source pollution have thus far been only modestly successful, but watershed management approaches are beginning to have an effect. A combination of voluntary and mandatory actions will be required, assisted by governmental incentives such as tax benefits and subsidies and disincentives. To be most effective, these incentives and disincentives should be targeted geographically. From the broadest policy perspective, effective ocean policy must extend well beyond the ocean and coastal zone to influence agricultural, energy, transportation, water resources, and land-use policies.

Science must play a key role in advancing marine ecosystem management that is integrated, precautionary, and adaptive. Sustained observations of changes related to pollution should be a key part of the nation's integrated ocean-observing system. These results should be coupled with strategic research and models to improve predictions needed for adaptive ecosystem management.

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Pew Oceans Commisssion

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The Pew Oceans Commission is an independent group of American leaders conducting a national dialogue on the policies needed to restore and protect living marine resources in U.S. waters. After reviewing the best scientific information available, the Commission will make its formal recommendations in a report to Congress and the nation in 2002.

Pew Oceans Commission
2101 Wilson Boulevard, Suite 550
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Article 7

Technical Note #15 from Watershed Protection Techniques 1(1): 30-31

Sources of Urban Stormwater Pollutants Defined in Wisconsin

For the past two decades, most urban runoff monitoring activity has been focused at the end of a pipe or storm drain. Consequently, our knowledge about the concentration of pollutants in urban runoff has been confined to broad land use categories, such as residential, commercial, industrial, or combinations thereof.

With recent advances in runoff micro-monitoring pioneered by Roger Bannerman and his colleagues, we are starting to get a better resolution of the various source areas in the urban landscape that collectively contribute to the pollutant levels measured at the end of the pipe. Urban source areas include lawns, driveways, rooftops, parking lots, and streets.

Using specialized sampling devices, Bannerman *et al.* (1993) collected over 300 runoff samples from 46 micro-sites in two watersheds (Figure 1). The samplers collected runoff from lawns, driveways, rooftops (both residential and industrial), commercial and industrial parking lots, and a series of street surfaces (feeder, collector and arterial).

Up to nine samples were collected at each of the micro-sites over a two month period, characterized by small and moderate sized rainfall events. Geometric means of pollutant concentrations were calculated for each of the micro-sites (see Table 1). Runoff volumes were obtained by hydrologic simulation models that were calibrated for each subwatershed.

The monitoring revealed that streets were the single most important source area for urban pollutants in residential, commercial, and industrial areas. Not only did streets produce some of the highest concentrations of phosphorus, suspended solids, bacteria, and several metals, but they also generated a disproportionate

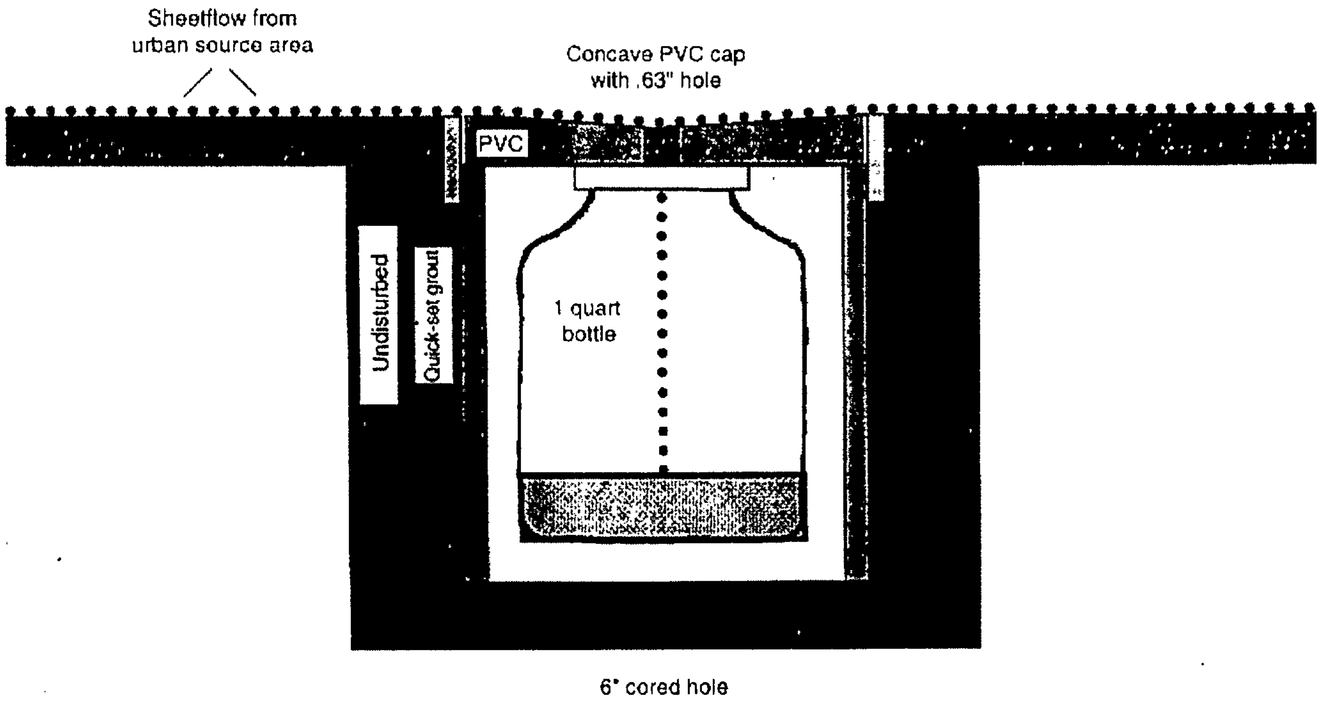

Figure 1: Diagram of a Street Sampler (Bannerman *et al.* 1993)

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Table 1: Geometric Mean Concentrations of Pollutants in Stormwater Runoff From Selected Urban Source Areas (Bannerman *et al.*, 1993)

Source Area	Total P (mg/l)	Solids (mg/l)	E. coli (C/100ml)	Zinc (μg/l)	Cadmium (μg/l)	Copper (μg/l)
Residential Feeder Street	1.31	662	92,000	220	0.8	46
Residential Collector Street	1.07	326	56,000	339	1.4	56
Commercial Arterial Street	0.47	232	9,600	508	1.8	46
Industrial Collector Street	1.50	763	8,380	479	3.3	76
Industrial Arterial Street	0.94	690	4,600	575	2.5	74
Residential Roofs	0.15	27	290	149	ND	15
Commercial Roofs	0.20	15	1,117	330	ND	9
Industrial Roofs	0.11	41	144	1,155	ND	6
Residential Lawns	2.67	397	42,000	59	ND	13
Driveways	1.16	173	34,000	107	0.5	17
Commercial Parking	0.19	58	1,758	178	0.6	15
Industrial Parking	0.39	312	2,705	304	1.0	41

amount of the total runoff volume from the watershed. Consequently, streets typically contributed four to eight times the pollutant load that would have been expected if all source areas contributed equally.

The importance of street runoff for urban pollutant loading is due to a number of factors. First, as streets are directly connected to the drainage system, they possess a very high runoff coefficient. Second, the curb and gutter system along streets is very effective at trapping and retaining fine particles that blow into them. In addition, as most other source areas are "upstream" from streets and their gutters, pollutants delivered from sidewalks, driveways, rooftops, and lawns ultimately pass through street gutters on their way to the storm drain.

Lastly, streets are strongly influenced by local emissions and leaks from vehicular traffic. Metals that are strongly linked to cars, such as copper and cadmium, reached their highest levels on streets and parking lots. The same pollutants were rarely encountered in roof and lawn runoff.

Rooftop runoff tended to be relatively clean. Low concentrations of phosphorus, solids, coliforms, and metals were observed. A major exception was zinc, which was found at higher concentrations in runoff from rooftops than any other source areas. This was presumably due to leaching from galvanized roofing material, particularly on flat industrial roof sites.

Runoff from lawn areas yielded the highest overall phosphorus concentrations, which may be attributed to excessive lawn fertilization. Lawns typically were a very important source area for fecal coliforms, as were residential streets. Parking lot source areas had moderately high concentrations of all pollutants, but did not exhibit the "hotspot" levels that have been noted in other regions of the country.

As more runoff micro-monitoring data is gathered, it may soon be possible to select and size stormwater treatment practices to control the runoff and pollutants for specific source areas in the urban landscape. **See also article 15.**

—*TRS*

Reference

Bannerman, R., D. Owens, R. Dodds, and N. Homewer. 1993. "Sources of Pollutants in Wisconsin Stormwater." *Water Science & Technology*. (28):3-5 pp. 241-259.

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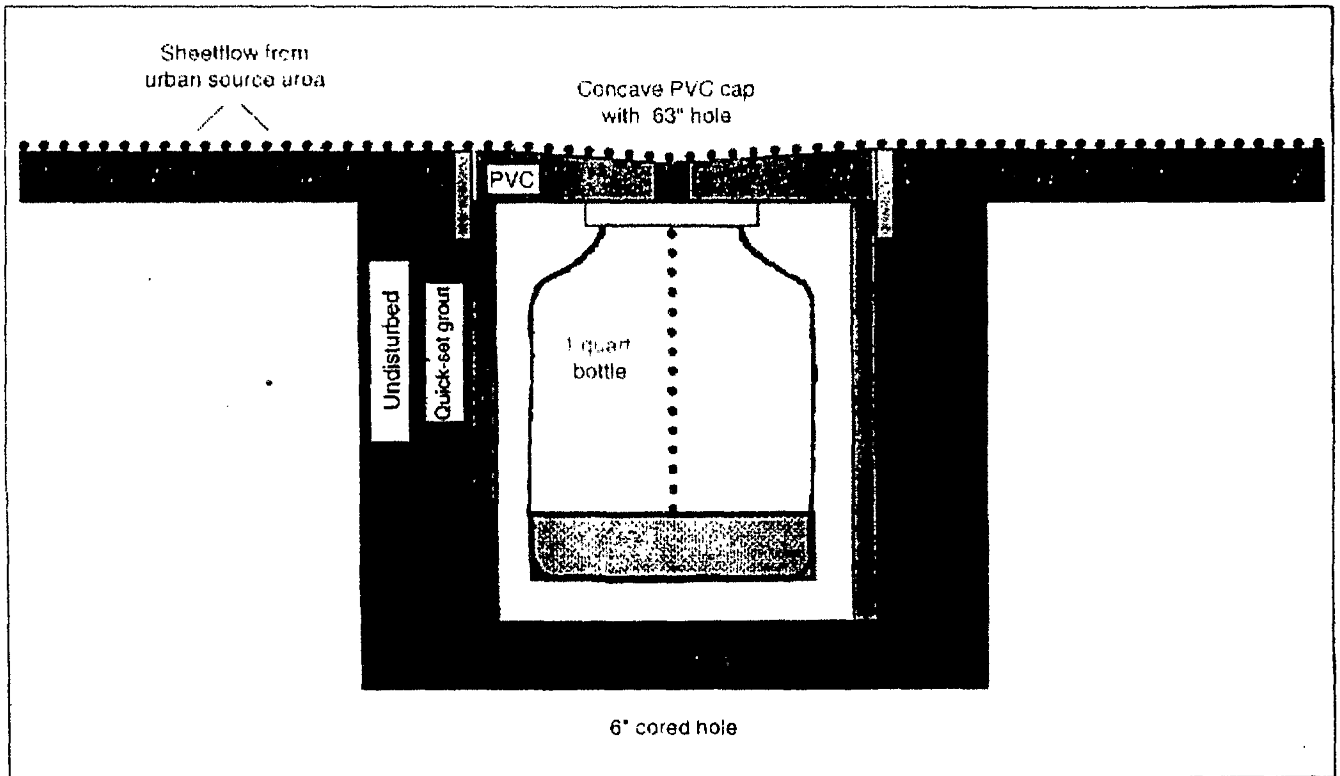

Figure 1: Diagram of a Street Sampler (Bannerman *et al.* 1993)

R0011811

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As more runoff micro-monitoring data is gathered, it may soon be possible to select and size stormwater treatment practices to control the runoff and pollutants for specific source areas in the urban landscape. **See also article 15.**

—TRS

Reference

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R0011812

Article 15

Technical Note #105 from Watershed Protection Techniques. 3(1): 609-612

Stormwater Pollution Source Areas Isolated in Marquette, Michigan

Much of our knowledge about the source of stormwater pollutants in urban watersheds is confined to broad land use categories, such as residential, commercial, or industrial. Often, engineers need much more detailed information on the individual source areas of pollutants to design more effective stormwater management practices or to craft better pollution prevention plans. For example, residential land use is actually a mosaic of streets, driveways, rooftops and lawns. Each of these individual source areas can contribute vastly different runoff volumes or pollutant concentrations. Consequently, engineers are interested in discovering precisely which source areas in the urban landscape contribute the bulk of the pollutant loads measured at the end of the stormwater pipe, particularly for those pollutants that are potentially toxic.

Urban source area monitoring methods were first pioneered by Roger Bannerman and his colleagues at the Wisconsin DNR (see article 7). They typically involve the installation of very small and specialized sampling devices that collect stormwater runoff from a few thousand square feet of each source area. Several hundred samples are collected, and then geometric mean concentrations are computed. The first major source area monitoring study was conducted in a subwatershed located in Madison, Wisconsin (Bannerman *et al.*, 1993).

A second major source area monitoring study was recently completed in Marquette, Michigan by Jeff Steuer and his colleagues (1997). They investigated a 289 acre subwatershed that drains to Lake Superior. The subwatershed is primarily residential with most of the development built 50 to 100 years ago (Table 1). Although the subwatershed had 37% impervious cover, its sandy soils generated relatively little surface runoff (runoff coefficient of 0.14 during the course of the study).

Steuer and his team deployed 34 different source area monitoring devices in the subwatershed and collected more than 550 source samples during 12 storm events. The source area monitoring was performed during the growing season (i.e., snowmelt and winter runoff were not sampled). Eight key source areas were targeted in the sampling effort: commercial parking lots; low, medium and high traffic streets; commercial and residential rooftops; residential driveways and lawns. More than 40 different pollutants were measured in the study, including sediment, nutrients, total and dissolved metals and a wide range of polycyclic aromatic hydrocarbons (PAHs). The study team also sampled pollutant levels at the bottom of the entire subwatershed. This enabled them to calibrate the Source Load and Management Model (SLAMM). The SLAMM model simulates subwatershed hydrology and source area pollutant concentrations to relate the how pollutant loads from individual source areas compared to the subwatershed as a whole (Pitt and Voorhees, 1989).

Table 1: A Profile of the Marquette, a Michigan Subwatershed

Drainage Area	289 acres
Land Use	
Residential	55 %
Open Space	29 %
Commercial	9 %
Institutional	7 %
Pervious Area	63 %
Impervious Area	37 %
Soil Type	Sandy, HSG "A"
Runoff Coefficient	0.14
Age of Development	50 to 100 years
Average Annual Precipitation	31.9 inches
Total Rainfall During Source Sampling	13.2 inches

The SLAMM model did an excellent job of predicting pollutant loads from for the subwatershed. Typically, the pollutant load computed from component source areas was within 90 to 110% of the total subwatershed pollutant load measured over the 12 storm events.

Source Areas: Runoff Production

The load of a stormwater pollutant from any source area is a product of its pollutant concentration and its runoff volume. Thus, it is of considerable interest to discover how much runoff volume a particular source area actually generates. The team employed the SLAMM model to assess the relative runoff contribution from the eight primary source areas within the Marquette subwatershed (Table 2). The "effective runoff coefficient" was dramatically different for many source areas, ranging from 0.01 to 0.58. As might be expected, the sandy soils of the residential lawns had the lowest runoff coefficient observed during the monitoring study. Despite the fact that lawns comprised more than 60% of subwatershed area, they generated only 6% of subwatershed runoff. The highest runoff coefficient was recorded for commercial parking lots, followed by streets. In contrast, residential rooftops and driveways had relatively low runoff coefficients, suggesting that these source areas were only partially connected to the storm drain system.

Table 2: Relative Runoff Contribution From Different Source Areas During 12 Storm Events

Source area sampled	Percent of total area	Percent of runoff	Effective runoff* coefficient
Commercial Parking Lot	4.6	19.1	0.58
High Traffic Street	1.4	4.5	0.45
Med. Traffic Street	1.8	5.5	0.43
Low Traffic Street	8.9	26.9	0.42
Commercial Rooftop	3.5	10.2	0.41
Residential Driveway	4.2	9.8	0.32
Residential Rooftops	9.8	12.8	0.18
Residential Lawns	62.4	5.8	0.01
Sidewalks	3.0	ns	ns
Basin Outlet	100.0	95.0	0.14

* Effective runoff is defined as the relative contribution of the source area to the total runoff volume produced in the basin over the 12 storm events.
ns = not sampled

Nutrients and Oxygen Demand

One of the clear trends in the Marquette source area monitoring was that pervious areas had higher nutrient concentrations than impervious ones (Table 3). In particular, nitrogen and phosphorus concentrations in residential lawn runoff were five to 10 times higher than any other source area. Rooftop runoff, on the other hand, had the lowest nutrient concentration of any source area, which is not surprising given that atmospheric deposition is probably the only pollutant pathway. The study also confirmed the strong relationship between greater street traffic and higher nutrient and organic matter concentrations first observed by Bannerman *et al.* (1983). The Marquette team found that nutrient and organic matter concentrations in runoff from high traffic streets were two to three times higher than runoff from low traffic streets.

Hydrocarbons and Metals

The Marquette study also provided our first glimpse about hydrocarbon source areas in the urban landscape (Table 4). One might suspect that source areas dominated by vehicles would have the highest hydrocarbon levels, and this indeed was found to be the case. The highest PAH levels were recorded at the commercial parking lots (75 µg/l) and the high traffic streets (15 µg/l). In contrast, PAH levels at rooftops, driveways and low traffic streets were generally less than 2 µg/l. The team also monitored individual hydrocarbon compounds that comprise PAHs, some of which are known or suspected carcinogens, such as Pyrene. In general, the

Table 3: Geometric Means of Conventional Pollutants at Marquette Source Areas (mg/l)

Source area sampled	Total phosphorus	Total nitrogen	Total Kjeldahl nitrogen	BOD_5
Commercial Parking Lot	0.20	1.94	1.6	10.5
High Traffic Street	0.31	2.95	2.5	14.9
Med. Traffic Street	0.23	1.62	1.3	11.6
Low Traffic Street	0.14	1.17	0.9	5.8
Commercial Rooftop	0.09	2.09	1.6	17.5
Residential Rooftop	0.06	1.46	1.0	9.0
Residential Driveway	0.35	2.10	1.8	13.0
Residential Lawns	2.33	9.70	9.3	22.6
Basin Outlet	0.29	1.87	1.5	15.4

Table 4: Source Area Concentrations of Hydrocarbons and Soluble Metals (µg/l)

Source area sampled	Polycyclic aromatic hydrocarbons	Pyrene	Soluble zinc	Soluble Copper
Commercial Parking Lot	75.6	12.2	64	10.7
High Traffic Street	15.2	2.37	73	11.2
Med. Traffic Street	11.4	1.75	44	7.3
Low Traffic Street	1.72	0.27	24	7.5
Commercial Rooftop	2.1	0.33	263	17.8
Residential Rooftop	0.6	0.10	188	6.6
Residential Driveway	1.8	0.34	27	11.8
Residential Lawns	na	na	na	na
Basin Outlet	21.0	3.36	23	7.0

Notes: Pyrene is one component of PAH's./ All measured in units of micrograms/liter (= ppb)
na = not analyzed at the source area

greatest concentrations of these compounds were also detected at commercial parking lots and high traffic roads.

The team also investigated source area concentrations of total and soluble metals. While no clear trends were observed in total metal levels among most source areas, sharp differences were frequently noted for soluble metals. This is significant as soluble metals are much more likely to exert a toxic effect on aquatic life. Interestingly, the key source areas for soluble zinc were rooftops. Commercial and residential rooftops typically had soluble zinc concentrations that were three to four times higher than other source areas, which is consistent with other research on rooftop runoff.

Moderate levels of soluble zinc were also associated with commercial parking lots and high traffic street. Source areas for soluble copper, on the other hand, were distributed rather evenly across the subwatershed, with the highest concentrations recorded at commercial roofs and parking lots, high traffic streets, and residential driveways. A strong relationship between greater street traffic and higher hydrocarbon and metal concentrations was also found.

Contributions of Individual Source Areas to Subwatershed Pollutant Loads

Using the SLAMM model, the team was able to analyze which source areas contributed most of the stormwater pollutant loads for the subwatershed (Table 5). The team discovered that some source areas delivered a disproportionate share of the total load. Most notable were commercial parking lots, which produced 64% of the PAH load, 30% of the total zinc load and 22% of the total copper load, despite the fact they comprised less than 5% of subwatershed area. Similarly, medium and high traffic streets each generated about six to 10% of the subwatershed PAH, zinc and copper load even though each source area comprised less than 2% of subwatershed area. Surprisingly, residential driveways produced from 14 to 18% of the total phosphorus, copper and zinc load, despite the fact that driveways comprised less than 5% of subwatershed area.

Although residential lawns comprised 62% of subwatershed area, they were not believed to contribute to total load of many pollutants, such as PAH and metals. Lawns were the greatest source of phosphorus in the subwatershed (26%), which reflected the fact that while the sandy soils produced very little runoff, lawn runoff still had a very high phosphorus concentration. It is worth noting that if the study site had less permeable soils, lawns probably would have emerged as an even more important source area for nutrients and organic matter.

Summary

The Marquette source area monitoring study generally reinforced the findings of an earlier source monitoring study conducted in Madison, Wisconsin (Bannerman *et al.*, 1993). While the pollutant concentrations for each source area were not always the same, the relative rank among the source areas was basically the same in each study. This finding supports the notion that stormwater managers should seriously consider pollutant source areas when designing stormwater management practices or devising pollution prevention plans.

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Table 5: Comparisons of Source Area Loadings for Selected Pollutants, as Computed by the SLAMM Model

Source area sampled	% Watershed area	Percent of Total Subwatershed Load: Copper	PAH	Zinc	Total phosphorus
Commercial Parking Lot	4.6	22	64	30	8
High Traffic Street	1.4	6	7	10	2
Med. Traffic Street	1.8	8	6	8	5
Low Traffic Street	8.9	17	5	19	15
Commercial Rooftop	3.5	11	3	16	5
Residential Rooftop	9.8	5	1	15	3
Residential Driveway	4.2	18	3	18	14
Residential Lawns	62.4	ns	ns	ns	26
Basin Outlet	97%	87%	89%	116%	77%

ns = not sampled, as early monitoring indicated non-detection

Of particular concern are parking lots, which emerged as the dominant pollutant source for commercial areas in both studies. Parking lots produced a disproportionately high load of hydrocarbons and metals compared to all other source areas. As such, watershed managers can justifiably classify many parking lots as stormwater "hotspots." It may make sense to treat the quality of parking lot runoff directly at the source, using filtering practices such as sand, compost and bioretention filters. In any event, designers should probably avoid infiltrating stormwater runoff from parking lots.

Watershed managers should also take note of the strong relationship between pollutant concentrations and higher traffic streets. Runoff from more heavily traveled roads may require greater treatment volumes to control this important source area. Infiltration of roadway runoff should also be avoided, unless effective and reliable pretreatment can be assured.

The Marquette study also provides strong support for focusing the message of residential pollution prevention programs. Lawns and driveways were both implicated as key source areas for nutrients, organic matter and bacteria. Clearly, homeowners have an important role to play in residential source control. Less lawn fertilizer, more pet cleanups, safer car washing and more frequent driveway sweeping could collectively reduce the importance of residential areas as a source of stormwater pollution. —*TRS*

References

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Pitt, R. and J. Voorhees. 1989. *Source Load and Management model (SLAMM)—An Urban Nonpoint Source Water Quality Management Model.* Wisconsin Dept. of Natural Resources. PUBL-WR-218-89.

Steuer, J., W. Selbig, N. Hornewer and J. Prey. 1997. *Sources of Contamination in an Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality.* U.S.G.S. Water Resources Investigations Report 97-4242. Wisconsin DNR and EPA. 25 pp.

Designation: D 3977 – 97

Standard Test Methods for Determining Sediment Concentration in Water Samples[1]

This standard is issued under the fixed designation D 3977; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the determination of sediment concentrations in water and wastewater samples collected from lakes, reservoirs, ponds, streams, and other water bodies. In lakes and other quiescent-water bodies, concentrations of sediment in samples are nearly equal to concentrations at sampling points; in most instances, sample concentrations are not strongly influenced by collection techniques. In rivers and other flowing-water bodies, concentrations of sediment in samples depend upon the manner in which the samples are collected. Concentrations in isokinetically-collected samples can be multiplied by water discharges to obtain sediment discharges in the vicinity of the sampling points.

1.2 The procedures given in these test methods are used by the Agricultural Research Service, Geological Survey, National Resources Conservation Service, Bureau of Reclamation, and other agencies responsible for studying water bodies. These test methods are adapted from a laboratory-procedure manual[2] and a quality-assurance plan.[3]

1.3 These test methods include:

	Sections
Test Method A—Evaporation	8 to 13
Test Method B—Filtration	14 to 19
Test Method C—Wet-sieving-filtration	20 to 25

1.4 Test Method A can be used only on sediments that settle within the allotted storage time of the samples which usually ranges from a few days to a few weeks. A correction factor must be applied if dissolved-solids concentration exceeds about 10 % of the sediment concentration.

1.5 Test Method B can be used only on samples containing sand concentrations less than about 10 000 ppm and clay concentrations less than about 200 ppm. The sediment need not be settleable because filters are used to separate water from the sediment. Correction factors for dissolved solids are not required.

1.6 Test Method C can be used if two concentration values are required: one for sand-size particles and one for the combination of silt and clay-size particles. The silt-clay fraction need not be settleable.

1.7 These test methods must not be confused with turbidity measurements discussed in Test Method D 1889. Turbidity is the optical property of a sample that causes light rays to be scattered and absorbed; it is not an accurate measure of the mass or concentration of sediment in the sample.

1.8 These test methods contain some procedures similar to those in Test Methods D 1888 which pertains to measuring particulate and dissolved matter in water.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1129 Terminology Relating to Water[4]

D 1193 Specification for Reagent Water[4]

D 1888 Test Methods for Particulate and Dissolved Matter in Water[5]

D 1889 Test Method for Turbidity of Water[4]

D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water[4]

D 4410 Terminology for Fluvial Sediment[4]

D 4411 Guide for Sampling Fluvial Sediment in Motion[6]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[7]

3. Terminology

3.1 *Definitions*—For definitions of water-related terms used in these test methods refer to Terminologies D 1129 and D 4410.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dissolved solids*—soluble constituents in water. The quantity is determined by evaporating a water sample to visible dryness at a temperature slightly below boiling. The temperature is then raised to 105°C and held for about 2 h. This is followed by cooling in a desiccator and weighing the residue.

3.2.2 *fluvial sediment*—particles that are (a) derived from rocks or biological materials and (b) transported by flowing water.

3.2.3 *sediment concentration*—(a) the ratio of the mass of dry sediment in a water-sediment mixture to the mass of the mixture or (b) the ratio of the mass of dry sediment in a

[1] These test methods are under the jurisdiction of ASTM Committee D-19 on Water and are the direct responsibility of Subcommittee D19.07 on Sediments, Geomorphology, and Open-Channel Flow.

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[2] Guy, H. P., "Laboratory Theory and Methods for Sediment Analysis," *Techniques of Water Resources Investigations, U.S. Geological Survey*, Book 5, Chapter C1, 1941.

[3] Matthes, W. J., Jr., Sholar, C. J., and George, J. R., "Quality-Assurance Plan for the Analysis of Fluvial Sediment," *U.S. Geological Survey Open File Report* 90, 1990.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] Discontinued; see 1990 *Annual Book of ASTM Standards*, Vol 11.01.

[6] *Annual Book of ASTM Standards*, Vol 11.02.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

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water-sediment mixture to the volume of the mixture. As indicated by Table 1, the two ratios differ except at concentrations less than 8000 mg/L.

3.2.4 *supernate*—clear, overlying liquid in a sediment sample.

3.2.5 *suspended sediment*—sediment supported by turbulent currents in flowing water or by Brownian movement.

3.2.6 *tare*—weights of empty containers used in analysis procedure.

4. Significance and Use

4.1 Suspended-sediment samples contain particles with a wide variety of physical characteristics. By presenting alternate approaches, these test methods allow latitude in selecting analysis methods that work best with the particular samples under study.

4.2 Sediment-concentration data are used for many purposes that include: (*1*) computing suspended-sediment discharges of streams or sediment yields of watersheds, (*2*) scheduling treatments of industrial and domestic water supplies, and (*3*) estimating discharges of pesticides, plant nutrients, and heavy metals transported on surfaces or inside sediment particles.

5. Sampling

5.1 Flows and concentrations in river cross sections are usually unsteady; consequently, in a strict sense, samples represent conditions only at the time and location of sample collection.

5.2 A sample may consist of a single container of a water-sediment mixtures collected at (*1*) a specific point in a river cross section, (*2*) a specific vertical in a cross section (a depth-integrated sample), or (*3*) several verticals in a cross-section. If the verticals are equally spaced and the sample is collected at equal transit rates, it is referred to as an EWI sample. The acronym EWI (equal-width-increment) is synonymous with ETR (equal-transit-rate) which appears in many older reports. A sample may also consist of several containers filled at different points or verticals in a cross-section. If the containers are filled at centroids of equal discharge in a cross section, they are referred to as EDI samples. Details on sampling are given in Guide D 4411.

TABLE 1 Factors for Conversion of Sediment Concentration in Parts per Million (ppm) to Grams per Cubic Metre (g/m^3)[A] or Milligrams per Litre (mg/L)

Range of Concentration, 1000 ppm	Multiply By	Range of Concentration, 1000 ppm	Multiply By	Range of Concentration, 1000 ppm	Multiply By
0–7.95	1.00	153–165	1.11	362–380	1.30
8.0–23.7	1.01	166–178	1.12	381–398	1.32
23.8–39.1	1.02	179–191	1.13	399–416	1.34
39.2–54.3	1.03	192–209	1.14	417–434	1.36
54.4–69.2	1.04	210–233	1.16	435–451	1.38
69.3–83.7	1.05	234–256	1.18	452–467	1.40
83.8–97.9	1.06	257–278	1.20	468–483	1.42
98.0–111	1.07	279–300	1.22	484–498	1.44
112–125	1.08	301–321	1.24	499–513	1.46
126–139	1.09	322–341	1.26	514–528	1.48
140–152	1.10	342–361	1.28	529–542	1.50

[A] Based on water density of 1.000 g/mL and specific gravity of sediment of 2.65.

The following equation also applies:

$$C_l = C/(1.0 - C\ 622 \times 10^{-9})$$

where:

C_l = sediment concentration, mg/L, and

C = sediment concentration, ppm.

6. Sample Handling

6.1 When samples arrive at the laboratory, group them according to gaging stations and then arrange each group in chronological order according to times of sample collection. Separate the samples to be analyzed for concentration from those to be analyzed for particle-size distribution or other properties. A data sheet should then be completed for each concentration sample. Examples of three commonly used forms are shown on Fig. 1. Expanded notes can be written on the front of the forms in spaces reserved for other bottles or, if even more space is needed, remarks can be written on the back of the forms along with reference numbers keyed to the appropriate bottles.

6.2 Check each sample for: (*1*) loss of water caused by leakage or evaporation, (*2*) loss of sediment which is sometimes revealed by the presence of particles on the outside of the sample bottle, (*3*) accuracy of sample-identification notes, and (*4*) a container tare which is usually etched on the bottle. Enter all appropriate notes, observations, and data on the laboratory form. Be particularly careful to enter the etched tare reading on the form under the heading Weight of Sample—Tare.

6.3 Remove the bottle caps then weigh each container along with its water-sediment mixture to the nearest 0.5 g. Record each reading on the corresponding bottle and on the laboratory form under the heading Weight of Sample—Gross.

6.4 Replace the caps then store the samples in a cool, dark place to minimize microbiological and algal growth. Inspect the bottles frequently; if the sediment does not settle within about 14 days, use Test Method B (filtration procedure) for the analysis. If settling proceeds at an acceptably rapid rate, use Test Methods A, B, or C.

7. Reagents and Materials

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type III of Specification D 1193.

7.1.1 Requirements can usually be met by passing tap water through a mixed cation-anion exchange resin or by distillation.

TEST METHOD A—EVAPORATION

8. Scope

8.1 This test method can be used only with sediments that settle under the influence of gravity. This test method is applicable to samples ranging from 0.2 to 20 L in volume, from 5 to 550 000 mg/L in sediment concentration, and having less than 35 000 mg/L in dissolved-solid concentration.

9. Summary of Test Method

9.1 After the sediment has settled, most of the supernatant water is poured or siphoned away. The volume of water-sediment mixture remaining is measured so that a dissolved-solids correction can be applied later. The sediment is then

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Stream and location ________

	Date		
	Time		
	Gage height		
	Discharge		
	Temperature		
	Sampling Sta		
Weight of Sample	Gross		
	Tare		
	Net		
	Container no.		
Weight of Sediment	Gross		
	Tare		
	Net		
	D.S. Corr.		
	Net		
	Conc. (ppm)		
	pH		
Specific Conductance	R(KCl)		
	R(sample)		
	Temp. °C		
	Micromhos at 25°C		
Dissolved Solids	Vol (ml)		
	Gross Wt		
	Tare Wt.		
	Net Wt		
	D. S (mg/l)		

Stream and location ________

	Date		
	Time		
	Gage height		
	Sampling Sta		
	Temp. and Spec. Cond.	/	/
	Remarks		
Weight of Sample	Gross		
	Tare		
	Net		
	Container no.		
Weight of Sediment	Gross		
	Tare		
	Net		
	D.S. Corr.		
	Net		
	Conc. (ppm)		

	Date		
	Time		
	Gage height		
	Sampling Sta		
	Temp and Spec Cond.	/	/
	Remarks		
Weight of Sample	Gross		
	Tare		
	Net		
	Container no.		
Weight of Sediment	Gross		
	Tare		
	Net		
	D.S. Corr.		
	Net		
	Conc. (ppm)		

Stream and location ________

	Date		
	Time		
	Gage height		
	Discharge		
	Sampling Sta.		
	Temperature		
	Sampling depth, ft		
	Total depth, ft		
	Filling time, sec		
Weight of Sample	Gross		
	Tare		
	Net		
	Filling rate, cc/sec		
	Nozzle size		
	Velocity, ft/sec		
	Specific conductance		
	Container no.		
Weight of Sediment	Gross		
	Tare		
	Net		
	D.S. Corr.		
	Net		
	Concentration (ppm)		

FIG. 1 Alternate Forms for Recording Field and Laboratory Data for Sediment Samples

dried and weighed. Sediment concentration is calculated in accordance with Section 12.

10. Apparatus

10.1 *Evaporating Dishes or Beakers*—Preweighed containers of porcelain or glass with capacities of about 150 mL are needed for holding the sediment and water during drying.

10.2 *Vacuum System*, trapped to prevent sample carry-over to the vacuum source during removal of supernate.

10.3 *Drying Oven*, equipped with a 90 to 120°C thermostat is needed to control temperatures while evaporating water from the sediment. A gravity-convection type oven is preferred but a mechanically ventilated (forced draft) style can be used if air-flow rates are low.

10.4 *Desiccator*, for preventing air-borne moisture from collecting in the sediment specimens while they are cooling.

10.5 *Laboratory Balance*, top-loading type with a resolution of 0.0001 g and a capacity of 150 g is needed for weighing the dry sediments.

10.6 *Laboratory Balance*, top-loading type with a resolution of 0.1 g and a capacity of about 4000 g is needed for weighing sample bottles containing water and sediment.

11. Procedure

11.1 After the sediment has settled, decant or vacuum away as much supernate as possible without disturbing the sediment. This can be accomplished by connecting a J-shaped plastic, copper, or glass tube to the vacuum line and lowering the tube until the curved section is near the bottom of the sample bottle. Supernate enters the upward-facing end of the tube and thereby flows away without creating currents and eddies in the sediment layer. Save the supernate for a dissolved-solids correction factor to be determined later.

11.2 After decanting, about 40 to 70 mL of water-sediment mixture should be left. To determine the exact volume, place the sample bottle on a level support then mark the liquid surface an the outside of the bottle. Use water to wash all of the sediment and supernate into an evaporating dish, then refill the sample bottle to the mark with water from a small graduate. Record the volume added to the sample bottle on the sample-data form.

11.3 Place the evaporating dish in the oven with the temperature set slightly below boiling. Maintain this temperature until all visible traces of water have evaporated. Then raise and hold the temperature at 105°C for about 2 h.

11.4 Transfer the dish from the oven to the desiccator; allow the sediment to cool to room temperature.

11.5 Weigh the dish to the nearest 0.0001 g as quickly an possible to minimize absorption of moisture from the air. Record the weight of the dish and its contents and also the tare weight of the dish on the laboratory form. Subtract the tare from the gross, then record the net weight on the form.

11.6 For nearly all sediment samples, a single drying cycle is sufficient to obtain stable weight; however, a few samples, principally those containing high concentrations of organic materials, may have to be dried a second time. If weight shifts occur, the specimens should be dried and weighed a third time to verify that the weights are stable.

11.7 Determine the dissolved-solids correction factor by using a volumetric pipet to transfer an aliquot (measured volume) of supernate into an evaporating dish. Record the aliquot volume in millilitres on the laboratory form.

11.8 Set the oven temperature slightly below the boiling point of water and evaporate the supernate to visible dryness. Then raise and maintain the oven temperature at 105°C for at least 2 h. After this, cool the dish in a desiccator. Then weigh the dish and its contents to the nearest 0.0001 g. Record this gross weight and also the tare weight of the dish on the form. Subtract the tare from the gross and record the net weight of dissolved solids in grams.

12. Calculation

12.1 Determine the dissolved-solids correction according to Eq 1:

$$DSc = (DS/Va) \times Vs \quad (1)$$

where:

DSc = dissolved-solids correction, g,
DS = net weight of dissolved solids determined in 11.7, g,
Va = aliquot volume taken for dissolved solids in 11.7, mL, and
Vs = volume of supernate remaining with the sediment in 11.2, mL.

In Eq 1, DS/Va is the concentration of dissolved solids in the supernate (see 11.7). This concentration is multiplied by Vs to obtain the dissolved-solids weight in the dry sediment (see 11.5). Enter the value of DSc on the laboratory form under the heading D. S. Corr.

12.2 Subtract the value of DSc in 12.1 from the net weight determined in 11.5. Record the difference on the laboratory form under the second heading labeled Weight of Sediment—Net. Notice each laboratory form has two rows with this heading.

12.3 Divide the Net Weight of Sediment (second entry) by the Net Weight of Sample. Both weights must be in the same units, preferably grams. Multiply the quotient by one million, then enter the result under the heading Conc. (ppm) on the laboratory form.

12.4 Modern practice calls for reporting sediment concentrations in milligrams per litre instead of ppm as determined in 12.3. Conversion can be made with the aid of Table 1. For example, consider a sediment concentration of 41 000 ppm. The multiplier obtained from Table 1 is 1.03; therefore, the concentration is 41 000 × 1.03 = 42 400 mg/L. The equation[8] immediately following Table 1 can be used instead of the multipliers. Equation 1 is easier to use in computer programs and is applicable to concentrations beyond the range in the table.

13. Precision and Bias for Test Method A (Evaporation)

13.1 These precision and bias data meet requirements of Practice D 2777.

13.2 Samples for collaborative testing were prepared by dispersing a specially prepared dry powder in approximately 350 mL of distilled water. Mixtures were shipped in sealed glass containers to the nine participating laboratories where three Youden pairs at each of three concentrations were tested.

13.3 Bias was influenced not only by analytical procedures such as decanting, drying, and weighing but also by failure to remove all sediment from the containers and by losing particles through dissolution.

13.4 The following table shows the precision and bias for Test Method A:

Concentration Added, mg/L	Concentration Recovered, mg/L	Standard Deviation of Test Method (St)	Standard Deviation of Single Operator (So)	Bias, %
10	9.4	2.5	2.3	−6
1000	976	36.8	15.9	−2.4
100 000	100 294	532	360	0.3

TEST METHOD B—FILTRATION

14. Scope

14.1 Test Method B can be used only on samples containing sand concentrations less than about 10 000 ppm and clay concentrations less than about 200 ppm. The sediment need not be settleable because filters are used to separate water from the sediment. Correction factors for dissolved solids are not required.

14.2 Even though a high-concentration sample may filter slowly, users should not divide the sample and use two or more filters. Instead, the entire sample should be filtered through one disk.

15. Summary of Test Method

15.1 The sample consisting of river water, sediment, and dissolved solids is weighed and then filtered through a glass-fiber disk. The disk and sediment are dried and weighed, then the sediment concentration is calculated in accordance with Section 18.

16. Apparatus

16.1 *Gooch Crucibles*—Porcelain or borosilicate glass crucibles with fritted glass bases are required for holding the filters. Capacities of the crucibles are optional; sizes in the 25 to 130-mL range work best with 1-L samples. Small crucibles have the advantage of requiring less oven space during drying and absorbing less moisture during weighing; large crucibles are needed if filtering proceeds slowly.

16.2 *Glass-fiber Filter Disks*—Filter diameter and filter retention rating, sometimes referred to as filter pore size, are critical to this analysis. The sediment that accumulates on a filter traps some particles that are smaller than the filter's retention rating. As filtration proceeds and the sediment layer thickens, the retention rating of the sediment and filter acting as a unit gradually decreases. Users should use filters with retention ratings of 1.5 µm to agree with practices in

[8] Williams, D. T., "The Relationship of Milligrams Per Liter to Parts per Million," *Sediment Transport Modeling*, Ed. by Sam S. Y. Wang, *Proceedings of the International Symposium*, American Society of Civil Engineers, August 1989, pp. 428–433.

many sediment laboratories.[9] Filter diameters should equal or exceed 24 mm. Filters as large as 42 mm may be required to avoid filter plugging at high concentrations. Record filter retention rating in micrometres and filter diameter in millimetres at a convenient place on the laboratory form.

16.3 *Vacuum System*—See 10.2.

16.4 *Drying Oven*—See 10.3.

16.5 *Desiccator*—See 10.4.

16.6 *Laboratory Balances*—See 10.5 and 10.6.

17. Procedure

17.1 Wash the filter with water to remove soluble compounds; then dry the filter and its crucible at 105°C for at least 1 h.

17.2 Transfer the crucible and filter to the desiccator, then, after the parts have cooled to room temperature, weigh them to the nearest 0.0001 g and record the reading on the laboratory form under the heading Weight of Sediment—Tare.

17.3 While a vacuum is being applied to the bottom of the crucible, decant supernate from the sample into the crucible. Flush the inner surfaces of the sample bottle with water to complete the transfer.

17.4 As filtering proceeds, inspect the filtrate. If it is turbid, pour the filtrate back through the filter a second and possibly a third time. If the filtrate is still turbid, the filter may be leaking. In this case, substitute a new filter and repeat the process. If the filtrate is transparent but discolored, a natural dye is present; refiltration is not necessary.

17.5 When filtration is complete, place the crucible and its contents in the drying oven set for 105°C.

17.6 When the crucible and its contents are dry, transfer to a desiccator. After the crucible has cooled, weigh to the nearest 0.0001 g and record the reading on the laboratory form under the heading Weight of Sediment—Gross.

17.7 Refer to 11.6 for a discussion of multiple drying and weighing cycles.

18. Calculation

18.1 Subtract Weight of Sediment—Tare from Weight of Sediment—Gross and record the difference under the heading Weight of Sediment—Net. No dissolved-solids correction is required.

18.2 Refer to 12.3 and 12.4 for computations.

19. Precision and Bias for Test Method B (Filtration)

19.1 These precision and bias data meet requirements of Practice D 2777.

19.2 Samples for collaborative testing were prepared by dispersing a specially prepared dry powder in approximately 350 mL of water. Mixtures were shipped in sealed glass containers to the nine participating laboratories where three Youden pairs at each of three concentrations were tested.

19.3 Bias was influenced not only by analytical procedures such as filtering, drying, and weighing but also by failure to remove all sediment from the containers and by losing particles through dissolution.

19.4 The following table shows precision and bias for Test Method B:

Concentration Added, mg/L	Concentration Recovered, mg/L	Standard Deviation of Test Method (St)	Standard Deviation of Single Operator (So)	Bias, %
10	8	2.6	2	−20
100	91	5.3	5.1	−9
1000	961	20.4	14.1	−3.9

TEST METHOD C—WET-SIEVING-FILTRATION

20. Scope

20.1 This test method covers concentration measurements of two particle-size fractions. The term fine fraction refers to particles small enough to pass through a sieve with 62 or 63-µm apertures; coarse fraction refers to particles large enough to be retained on the sieve. The fine fraction need not be settleable. This test method is useful when large samples must be collected in the field but only small subsamples, typically 300 to 500 mL, can be shipped back to the laboratory.

21. Summary of Test Method

21.1 The sample is poured onto a sieve with 62 or 63-µm openings. Analysis includes the entire coarse fraction but only a small, measured aliquot of the fine fraction. Sieving and aliquot extraction can be performed either at the sampling site or in the laboratory.

22. Apparatus

22.1 *Sieve*, fitted with a screen fabric having 62 or 63-µm square apertures. An 8-in. diameter sieve is recommended for samples larger than 3L; a 3-in. diameter sieve is recommended for all other samples. (See Specification E 11.)

22.2 *Splitter*, for extracting an aliquot of the fines.[10]

22.3 Additional apparatus are listed in Section 16.

23. Procedure

23.1 Measure the gross and tare weight of each sample and record the readings on the laboratory form. (See 6.2 and 6.3.) Hold the sieve over a beaker or large, shallow dish while pouring the sample through the sieve. Some sediments require vigorous rinsing with water to disaggregate clumps retained on the sieve. Use a minimum amount of water, and retain in the dish along with the fine fraction.

23.2 Wash the coarse fraction from the sieve into a preweighed evaporating dish. Dry, desiccate, and weigh the sediment in accordance with 11.3 through 11.5. Record the net weight of the coarse fraction on the laboratory form.

23.3 If possible, the sample received at the laboratory should be analyzed in its entirety, but if the sample volume is unwieldy, it may be reduced by splitting. Mix the fine fraction by vigorously shaking and stirring then, without pausing, pour the mixture through the splitter and into a

[9] The sole source of supply of the apparatus known to the committee at this time is Whatman type 934-AH, Whatman Lab Sales Inc., Hillsboro, OR. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[10] A Federal Interagency Sedimentation Project US72A or a Jones Ott splitter have been found to be satisfactory.

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clean tray. Several splitting passes are required if the aliquot is to consist of only a small fraction, typically 300 to 500 mL, of the original mixture.

23.4 Determine the net weight of the aliquot to the nearest 0.1 g and record the reading on the laboratory form.

23.5 The aliquot is usually analyzed by the filtration method, but it can be analyzed by the evaporation method. If filtration is used, follow the procedure in 17.1 through 17.6; if evaporation is used, follow the procedure in 11.1 through 12.4.

24. Calculation

24.1 Calculate the coarse-fraction concentration as:

$$C_{cf} = C \times 10^6/S \quad (2)$$

where:
C_{cf} = coarse fraction concentration, ppm,
C = mass of sediment in the coarse fraction, g, and
S = mass of entire sample, g.

24.2 Calculate the fine-fraction concentration as:

$$C_{ff} = F \times 10^6/W \quad (3)$$

where:
C_{ff} = fine-fraction concentration, ppm,
F = mass of sediment in the aliquot, g, and
W = mass of the aliquot, g.

24.3 Convert C_{cf} and C_{ff} from ppm to mg/L in accordance with 12.4.

25. Precision and Bias for Test Method C (Wet-Sieving-Filtration)

25.1 These precision and bias data meet requirements of Practice D 2777.

25.2 Samples for collaborative testing were prepared by dispersing a specially prepared dry powder in approximately 350 mL of distilled water. Mixtures were shipped in sealed glass containers to the nine participating laboratories where three Youden pairs at each of three concentrations were tested.

25.3 Bias was influenced not only by analytical procedures such as sieving, filtering, drying, and weighing but also by failure to remove all sediment from the containers and by losing particles through dissolution.

25.4 The following table shows precision and bias for Test Method C:

Mixture Number	Part Sieve Diameter, µm	Concentration Added, mg/L	Concentration Recovered, mg/L	Standard Deviation of Test Method (St)	Standard Deviation of Single Operator (So)	Bias, %
1	>62 (sand)	1	3.4	2.8	2.4	240
1	<62 (fines)	10	8.7	4.3	2.9	−13
2	>62 (sand)	9	5	5.9	1.9	−44
2	<62 (fines)	91	79	15.2	11	−13
3	>62 (sand)	91	107	12.3	5.9	18
3	<62 (fines)	909	832	87.2	61	−8

26. Keywords

26.1 fluvial sediment; sediment; sediment concentration

CRITICAL SOURCE SELECTION AND MONITORING REPORT

September 3, 1996

Prepared for

Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, California 91803

Woodward-Clyde

Woodward-Clyde Consultants
2020 East First Street, Suite 400
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R0011823

[redacted] CRITICAL SOURCE SELECTION AND MONITORING REPORT

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R0011824

TABLE OF CONTENTS

1.1 INTRODUCTION

Los Angeles County (the County) is required to conduct a stormwater Critical Source Study. The objective of the study is to identify five industrial and/or commercial critical source types, and then monitor each source type for 2 years, the first year without controls, and the second year with controls. This report describes the methodology and results of the critical source selection process (Section 1) and describes the monitoring plan for testing the effectiveness of critical source BMPs (Section 2).

The County has previously conducted similar studies aimed at identifying critical sources of industrial stormwater pollution within the County as part of compliance with its National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit (Permit No. CA0061654). A planning study was conducted between March and December 1995 to identify the most common facility types and to select several key sites for conducting sampling. As a result of this work, three facilities (a trucking facility, a fabricated metal products facility, and a municipal corporation yard) were selected for study. The municipal yard has been monitored since the 1994-95 wet-weather season; the others were monitored in the 1995-95 wet-weather season. The work performed by the County provided considerable useful information for developing this Critical Source/BMP Monitoring Program.

A series of steps to be taken in conducting the Critical Source/BMP Monitoring Program has been outlined. These steps are as follows:

Step 1: The County first will develop an initial list of candidate critical sources, including industrial and commercial sources that are regulated under the General Industrial Activities Stormwater Permit (General Industrial Permit) and those which are not.

Step 2: The County next will develop a list of criteria for prioritizing the candidate critical sources developed pursuant to Step 1, including the following: runoff pollutants associated with each critical source; the impact of non-stormwater discharges associated with each source; whether or not the source is regulated under the General Industrial Permit; and ease of implementation of monitoring and BMPs.

Step 3: The County next will prioritize the candidate critical sources based on the selection criteria developed under Step 2.

Step 4: The County next will conduct a literature review and contact other municipal stormwater programs in California to identify what critical sources have been (or are planned in the next 5 years to be) studied elsewhere. Where studies have been conducted or are planned to be conducted elsewhere, such studies will be reviewed to assess whether the hydrologic conditions in the study area are representative of those in Los Angeles County, the quality of the study and any conclusions from already-conducted studies. This evaluation will be coordinated with the Stormwater Quality Task Force.

Step 5: The County next will take the list developed in Step 3 and refine and finalize it based upon the review conducted pursuant to Step 4.

As of July 1, 1996, the County has completed Steps 1 through 5. The following sections describe the County's approach and results from conducting each of these steps.

1.2 STEP 1 - DEVELOP INITIAL LIST OF CANDIDATE CRITICAL SOURCES

As part of their initial work on source monitoring, the County developed a list of candidate critical sources. These sources were selected based on prevalence in the County, regulation under the General Industrial Permit, and/or runoff pollutant potential. This initial list of candidate critical sources was deemed appropriate for the Critical Source/BMP Monitoring Program and is presented in Table 1-1.

1.3 STEP 2 - DEVELOP A LIST OF CRITERIA FOR RANKING INDUSTRIAL SOURCES

A ranking process was developed to prioritize the candidate critical sources in terms of the pollution potential of their stormwater runoff. The ranking scheme was based on five factors: **Q** (measure of pollutant unit loading, based on factors such as the type and number of industrial activities and the potential for non-stormwater discharges), **R** (measure of volume of runoff based on typical facility impervious area), **T** (additional measure affecting loading, based on types/toxicity of pollutants used at the facility), **E** (exposure factor, to account for the degree to which materials and activities are exposed to storm water), and **N** (number of facilities within Los Angeles County). The two factors affecting pollutant load, Q and T, were calculated using subfactors. Q was determined as a product of s (number of individual pollutant sources at a given facility, including various types of industrial activities and non-stormwater discharges) and l (likelihood of release). T was calculated as the product of n (amount of toxic pollutants) and I (inherent toxicity of the pollutants types present). In considering potential types of toxic pollutants, human viral contamination was not specifically considered. Such contamination is generally associated with feedlots, ranching, and cross-connections with sanitary sewers rather than with runoff from the industrial/commercial types of sites considered here. Each key factor and subfactor was assigned a value between 1 and 10, with the higher values representing a greater degree of significance. The pollutant potential, P, was then calculated as the product of the key factors:

$$P = Q \times R \times T \times E \times N$$

The data were normalized such that the value of P would fall between 0 and 100. The ranking scheme (along with instructions on how to use it) is presented in Table 1-2.

TABLE 1-1

INITIAL LIST OF CANDIDATE CRITICAL SOURCES

Rank (No. Facilities)	Industrial Category	SIC Code	No. Facilities
1	Automotive Repair/Parking	75	6,067
2	Machinery Manufacturing	35	4,223
3	Fabricated Metal Products	34	3,283
4	Automotive Dealers/Gas Stations	55	2,744
5	Personal Services (laundries)	72	2,515
6	Printing & Publishing	27	2,432
7	Electric/Gas/Sanitary	49	2,001
8	Apparel	23	1,900
9	Transportation Equipment	37	1,838
10	Electric/Electronic	36	1,636
11	Furniture & Fixtures	25	1,368
12	Food & Kindred Products (not including restaurant)	20	1,249
13	Miscellaneous Manufacturing	39	1,144
14	Chemicals/Allied Products	28	1,069
15	Rubbers/Miscellaneous Plastics	30	1,034
16	Instruments	38	1,029
17	Lumber/Wood Products	24	905
18	Motor Freight	42	872
19	Stone, Clay, Glass, Concrete	32	733
20	Primary Metals Products	33	703
21	Wholesale Trade	50	587
22	Paper & Allied Products	26	451
23	Textile Mills Products	22	440
24	Air Transportation	45	431
25	Local/Suburban Transit	41	336
26	Oil & Gas Extraction	13	327
27	Railroad Transportation	40	319
28	Petroleum Refining	29	231
29	Leather/Leather Products	31	163
30	Mining of Nonmetallic Minerals	14	39

Table 1-2
CRITICAL SOURCE RANKING SCHEME

P = Q x R x T x E x N

P = Pollution Potential	T = Toxicity of Pollutants at the Source
Q = Quantity of Pollutant	E = Exposure Factor (Extent of Contact with Rain)
R = Amount of Runoff	N = Number of Facilities in Los Angeles County

Q Q = s x l

Guidelines:

s = number of sources
"10" = >10 sources
"5" = 5 sources
"1" = <3 sources

l = likelihood of release
"10" = extremely likely to be released (>75% of the time)
"5" = likely to be released about 50% of the time
"1" = likely to be released <10% of the time

R R = relative size of paved area on a scale of 1-10, the higher the value, the more runoff

Guidelines:

"10" = >100 acres
"8" = about 10 acres
"6" = about 5 acres
"1" = less than ½ acre

T T = n x i

Guidelines:

n = number of toxic pollutants
"10" = if >5 types of toxic pollutants are usually present
"7" = if about 3 toxic pollutants are usually present
"5" = if about 2 types of toxic pollutants are usually present
"1" = if no toxic pollutants are usually present

i = inherent toxicity of the mix of pollutants that is generally present at the facility
"10" = extremely toxic
"7" = somewhat toxic
"1" = non-toxic

E E = Exposure factor

Guidelines:

"10" = if all industrial activities take place outdoors with significant exposure
"8" = if significant activities take place outdoors or are exposed to rainfall
"5" = if some activities take place outdoors or are exposed to rainfall
"1" = if most or all industrial activities take place indoors or are not exposed

N N = Number of Facilities in Los Angeles County

Guidelines:

"10" = >5,000 facilities	"5" = 300-400 facilities
"9" = 2-5,000 facilities	"4" = 200-300 facilities
"8" = 1-2,000 facilities	"3" = 100-200 facilities
"7" = 500-1,000 facilities	"2" = 50-100 facilities
"6" = 400-500 facilities	"1" = <50 facilities

1.4 STEP 3 - PRIORITIZE THE CANDIDATE CRITICAL SOURCES

Industrial and commercial facilities were evaluated based on their two-digit Standard Industrial Classification (SIC) Codes. There are over 50,000 industrial and commercial facilities within Los Angeles County. The study considered 36 different SIC code categories. Golf courses were not evaluated because they are not considered traditional industrial/commercial facilities, but rather, a type of recreational facility or land use type. Golf courses are being reviewed by the County as a land use type under the land use monitoring selection process. Thirty of these SIC code categories were analyzed for the purpose of this study (Table 1-1). Construction was excluded because it is transitory in nature, is covered by a separate General Permit, and has been extensively studied by others. Health Services (SIC 80) were excluded based on the assumption that most sites are probably storefront clinics and offices rather than large medical complexes. Agriculture was excluded from consideration, as it is currently exempt from the stormwater regulations and is not currently significant within the Los Angeles County. Metal mining and tobacco were excluded, based on the fact that there are very few facilities within the County. In addition, Water Transportation (SIC Code 44) was also excluded. The rationale for this exclusion is that the Port of Long Beach is currently conducting an extensive stormwater monitoring program at 21 locations at the Port. This monitoring effort began in wet-weather season 1995-96 and will be ongoing. Results from the first year of the monitoring effort will become part of the public record effective July 1, 1996 when the Port of Long Beach submits its Annual Report to the Regional Board. Given the extensive local effort underway at the Port of Long Beach, additional expenditure of effort to characterize storm water discharge from water transportation facilities appears unwarranted.

Values of the key factors and subfactors were determined on the basis of published data and the professional judgment of west coast stormwater experts. An Excel spreadsheet was then used to calculate the P value for each SIC code category to prioritize the candidate critical sources. The results of the ranking process are presented in Table 1-3.

The County is required to conduct the Critical Source/BMP Monitoring Program at five high priority industry types. The five highest ranked facility types from Table 1-3 are:

1) Wholesale Trade (including scrap yards and auto dismantlers)

2) Automotive Repair/Parking

3) Fabricated Metal Products (including electroplating)

4) Motor Freight (including trucking)

5) Chemicals and Allied Products

In order to conduct the monitoring, the County will need to identify six facilities from each of the five industrial categories to participate in the study. These six facilities should be as similar in terms of size, practices, materials, and activities as is possible so as to ensure consistency within the monitoring study. Given that six participating facilities are required from each category, it is

1.4 STEP 3 - PRIORITIZE THE CANDIDATE CRITICAL SOURCES

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TABLE 1-3

RESULTS OF RANKING OF CANDIDATE CRITICAL SOURCES

Rank (Pollution Potential)	Rank (No. Facilities)	Industrial Category	SIC Code	No. Facilities
1	21	Wholesale Trade (scrap, auto dismantling)	50	587
2	1	Automotive Repair/Parking	75	6,067
3	3	Fabricated Metal Products	34	3,283
4	18	Motor Freight	42	872
5	14	Chemicals/Allied Products	28	1,069
6	4	Automotive Dealers/Gas Stations	55	2,744
7	20	Primary Metals Products	33	703
8	7	Electric/Gas/Sanitary	49	2,001
9	24	Air Transportation	45	431
10	15	Rubbers/Miscellaneous Plastics	30	1,034
11	25	Local/Suburban Transit	41	336
12	27	Railroad Transportation	40	319
13	26	Oil & Gas Extraction	13	327
14	17	Lumber/Wood Products	24	905
15	2	Machinery Manufacturing	35	4,223
16	9	Transportation Equipment	37	1,838
17	19	Stone, Clay, Glass, Concrete	32	733
18	29	Leather/Leather Products	31	163
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21	28	Petroleum Refining	29	231
22	30	Mining of Nonmetallic Minerals	14	39
23	6	Printing & Publishing	27	2,432
24	10	Electric/Electronic	36	1,636
25	22	Paper & Allied Products	26	451
26	11	Furniture & Fixtures	25	1,368
27	5	Personal Services (laundries)	72	2,515
28	16	Instruments	38	1,029
29	23	Textile Mills Products	22	440
30	8	Apparel	23	1,900

possible that practical, non-technical considerations (e.g., lack of enough willing participants, inability to secure 24-hour/7-day access for sampling, etc.) may prevent the County from ensuring the participation of enough facilities from a given SIC category. As such, it may be necessary to select the next highest-ranking facility type for the study. In the event that this becomes necessary, the County will select facilities from the next highest ranking industrial categories. The next five highest-ranking facility categories are as follows:

6) Automotive Dealers/Gas Stations
7) Primary Metals
8) Electric/Gas/Sanitary Services
9) Air Transportation
10) Rubber/Miscellaneous Plastics

It is important to note that a numerical ranking scheme such as described above is designed as a semi-quantitative screening tool for a relative evaluation of critical sources. The values developed using the ranking scheme are not meant to be interpreted in any absolute sense.

1.5 STEP 4 - CONDUCT LITERATURE REVIEW

The objective of the literature review was to identify what critical sources have been (or are planned in the next five years to be) studied elsewhere (under conditions that are representative of Los Angeles County) so as not to duplicate efforts in the course of this study. Los Angeles County conducted an initial literature review and contacted various California municipal stormwater programs in order to identify which critical sources have been studied elsewhere. This search was conducted through a telephone survey and Internet data search. The survey was supplemented by conducting a computerized library search using DIALOG and Cambridge Scientific Abstracts Services to access specific data bases (e.g., Water Resources Abstracts, Water Net, NPIS, Enviroline, Pollution Abstracts, Aquatic Sciences and Fisheries Abstracts), as well as the EPA National Bibliographic Catalog. The focus of the computer data base searches was to identify published studies in technical and scientific journals conducted by universities, research groups, and practitioners (which were not targeted by the County's search). A summary of the studies that are pertinent to the Critical Source/BMP Monitoring Program is presented in Table 1-4.

The results of these searches indicated that much work on the runoff quality from specific industrial sites has yet to be done. Most of the studies, particularly those conducted by municipal stormwater management programs (e.g., Santa Clara Valley and Alameda County, California), monitored runoff from "industrial source areas" or "commercial catchments," rather than from specific industrial facilities. However, several studies were more specific. Pitt et al. (1995) looked at toxic pollutants in runoff from several industrial activity areas in Birmingham, AL, including parking lots and vehicle service areas. Stormwater samples from parking lots and vehicle service areas frequently contained organics and certain metals (notably, Ni in parking lots and Cd and Pb in possible that practical, non-technical considerations (e.g., lack of enough willing participants, inability to secure 24-hour/7-day access for sampling, etc.) may prevent the County from ensuring the participation of enough facilities from a given SIC category. As such, it may be necessary to select the next highest-ranking facility type for the study. In the event that this becomes necessary, the County will select facilities from the next highest ranking industrial categories. The next five highest-ranking facility categories are as follows:

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TABLE 1- 4

SUMMARY OF PERTINENT STUDIES FROM LITERATURE SEARCH

Authors	Name of Report	Publication	Subject of Study
M.A. Collins, K. Roller, G. Walton	"Managing Toxic Pollutants in Stormwater Runoff"	Water Environment and Technology, May 1992, p. 60-64	Monitored metals and ammonia in runoff from wood preserver, fertilizer mixer/packager, marine cargo handler, log home treating/packaging facility, and particle board manufacturer
E. Hoffman, J. Latimer, G. Mills, J. Quinn	"Petroleum Hydrocarbons in Urban Runoff from a Commercial Land Area"	Journal of the Water Pollution Control Federation, v. 54, no. 11, November 1982, p. 1517-25	Measured suspended solids and petroleum hydrocarbons in runoff from a commercial shopping mall
R. Pitt, R. Field, M. Lalor, M. Brown	"Urban Storm Water Toxic Pollutants: Assessment, Sources, and Treatability"	Water Environment Research, v. 67, no. 3, May-June 1995, p. 260-275	Monitored runoff quality from vehicle service areas and parking lots
Sacramento County	Special Study on Gas Station Runoff	Sacramento County	Conducted field screening monitoring at gasoline stations (the stations did not conduct vehicle repair)
Sacramento County	"Action Plan Demonstration Project at a Gas Station"	Sacramento County	Conducted wet and dry-weather monitoring at gas stations
Western States Petroleum Association	"Storm Water Best Management Practices for Retail Gasoline Outlets"	Western States Petroleum Association (WSPA)	Summarized runoff characterization studies conducted by WSPA and the American Petroleum Institute and described Best Management Practices for retail gasoline stations
Woodward-Clyde Consultants	1. Parking Lot Monitoring Report 2. Parking Lot Best Management Practices Manual	Santa Clara Valley Nonpoint Source Control Program	Conducted water quality monitoring and tested effectiveness of storm drain inlet inserts

vehicle service areas). The study indicated that organics were associated mainly with unfiltered samples, suggesting an association with particulates; metals were elevated in both the filtered and unfiltered samples, indicating that they are also present in the dissolved phase.

Hoffman et al. (1982) conducted a study to determine the relationship of hydrocarbon load to total rainfall and land use at a commercial shopping mall in Warwick, RI. Runoff was monitored for suspended solids and petroleum hydrocarbons only. Results suggested that suspended solids and hydrocarbons are present at elevated levels in the runoff (flow-weighted concentrations ranged from 20.5 to 112.7 mg/l for suspended solids, and from 0.69 to 2.15 mg/l petroleum hydrocarbons). The study did not differentiate between different types of hydrocarbons in the runoff, although gas chromatograms of the runoff samples from the site were similar to those for used crankcase oil, suggesting a probable source.

Collins et al. (1992) reported monitoring information for five industrial facilities for compliance with the Virginia Pollutant Discharge Elimination System (VPDES) stormwater permits. The facilities included a wood preserver, fertilizer mixing/packaging plant, marine cargo handling facility, log home treating/packaging facility, and a particle board manufacturer. Stormwater monitoring conducted at all five facilities indicated elevated metals and ammonia concentrations. Toxicity testing also revealed that the stormwater runoff was toxic for most of the samples. However, while this article contained some interesting information, the information presented was not adequate to justify exclusion of any of the facility types from the County's Critical Source/BMP Monitoring Program.

Sacramento County and the Western States Petroleum Association (WSPA) have conducted runoff characterization and control measure evaluations for retail gasoline service stations (SIC code 55). Since the studies were conducted in California, they may be considered representative of the conditions in Los Angeles County. However, SIC code 55 also includes motor vehicle dealerships and auto supply stores, both of which are common in Los Angeles County. Since neither of the studies addressed auto dealerships or supply stores, they do not appear to have adequately addressed runoff quality and control from this category of industry. Therefore, SIC code 55 should not be eliminated from consideration as a critical source.

Based on this review, the top five industry types developed through the ranking process are still good candidates for conducting the critical source monitoring program in Los Angeles County, as they do not appear to have been studied in detail in other areas, based on available published information.

1.6 STEP 5 - FINALIZE LIST OF FACILITY TYPES TO PARTICIPATE IN THE CRITICAL SOURCE/BMP MONITORING PROGRAM

Based on the prioritization developed in Step 3 and the literature review conducted in Step 4, the County has determined the top five facility categories to monitor in the Critical Source/BMP Monitoring Program. These categories are as follows:

1) Wholesale Trade (focusing specifically on scrap yards and auto dismantlers)

2) Automotive Repair/Parking (focusing on automotive repair service stations)

3) Fabricated Metal Products (including electroplating)

4) Motor Freight (including trucking)

5) Chemicals and Allied Products

As stated above, in the event that the County can not secure the participation of enough facilities within a given category, it may be necessary to select facility types from further down the list of priority industrial sites. Further, since critical source monitoring has already been initiated at a motor freight facility and a fabricated metals facility (beginning in wet-weather season 1995-96), the County may opt to continue monitoring at these facilities in future years to fulfill the requirements of the Critical Source/BMP Monitoring Program.

2.1 INTRODUCTION

Los Angeles County (County), is required to conduct a Critical Source/Best Management Practices (BMP) Stormwater Monitoring Program. The overall objective of the Program is to identify five industrial and/or commercial critical source types, and then monitor each source type for two years. The first year of monitoring will be performed without BMPs, and the second year with BMPs.

The following plan for the Critical Source/BMP Stormwater Monitoring Program presents the criteria for selection of stormwater monitoring methods, identifies the analytical methods to be used to detect pollutants in stormwater, describes the sampling methods, sampling locations, and frequency of monitoring, presents a quality assurance/quality control (QA/QC) program to ensure that all required elements of the monitoring program are conducted and that all monitoring is performed by trained personnel, and provides procedures and schedules for reviewing and evaluating the effectiveness of the monitoring program. This plan has been prepared as part of compliance with the Los Angeles County areawide National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit (Permit No. CAS614001).

As described in Section 1, the County tentatively plans to examine the following five critical source types over six rainy seasons, beginning during the 1996/97 rainy season.

1. Wholesale Trade (including scrap yards and auto dismantlers)
2. Automotive Repair/Parking
3. Fabricated Metal Products (including electroplating)
4. Motor Freight (including trucking)
5. Chemicals and Allied Products

During the 1996/97 rainy season, stormwater runoff from one of the top-ranking critical source types will be characterized. The County will make a good faith effort to obtain the participation of six facilities with similar characteristics (three control sites and three test sites) within each critical source type, so as to reduce the amount of variability inherent in sampling only a single facility. Selection of the six participating facilities will be based upon the following criteria:

- Willingness of the facility to participate in the program, including implementing BMPs, and provide written authorization attesting to such;
- 7-day, 24-hour access to the sampling point(s);
- Location within close proximity to other facilities within the test or control group (see below); and

- No confined space entry required.

Also, the number of sites may be less than three apiece if sites cannot be found in close enough proximity to be sampled by a single crew.

During the first year, stormwater runoff from all six sites will be sampled and analyzed during five targeted storm events. Stormwater runoff from the six sites will be split into two pools, reflecting the three control and the three test sites. Stormwater runoff from each pool will then be composited into a single sample for each storm event (compositing will be performed in the field). These samples will be neither time nor flow-weighted composite samples. The samples will be analyzed for those pollutants anticipated to be found in the critical source stormwater runoff, and such analytes will be partitioned, as appropriate, to measure the dissolved and undissolved portions (lists of analytical suites for each critical source type are provided in Table 2-1).

Based upon the first year of characterization data, appropriate BMPs will be selected and applied at the three test sites. (The same BMPs will be used at each site.) In the second year, ten storm events will be sampled and stormwater runoff quality from the control sources will be composited and analyzed, and the results compared to composited and analyzed samples from the test sites at which BMPs have been applied.

The process will be repeated, adding the second critical source in the second rainy season and so on, with the intent to complete two years of monitoring at each critical source type (with BMPs added during the second year each time) by the end of the sixth rainy season, which will be the rainy season of 2001/02.

Because of the semi-arid climate of Southern California and the inherent variability between storm events (both in terms of intensity/duration and geographic occurrence), it may not be possible to capture all of the targeted storm events at all stations within a given year. In particular, it may be difficult to capture ten storms in a given year, as there needs to be sufficient rainfall volume and intensity in order to collect the samples. The Critical Source/BMP Monitoring Program was designed to monitor each critical source type for two years only. Assuming the Program is conducted in good faith, sampling of a given critical source type will not extend beyond two years even if fewer than the targeted number of storm events are sampled.

2.2 PURPOSE OF CRITICAL SOURCE BMP MONITORING PLAN

The purpose of the Critical Source/BMP Monitoring Plan is as follows:

1. To provide procedures for conducting visual observations and collection of stormwater grab samples to ensure consistency over the six-year duration of the Critical Source/BMP Monitoring Plan.

TABLE 2-1
EXAMPLE ANALYTICAL SUITES FOR CRITICAL SOURCE MONITORING

Critical Source Type					Constituent	Sample Type	EPA Method	Detection Limit	Units	Holding Time	Container Type	Sample Volume
1. WT	2. ARP	3. FMP	4. MF	5. CAP								
X	X	X	X	X	pH	grab for comp	150.1	N/A	pH	immediate	plastic	25 ml
X	X	X	X	X	Electrical Conductivity	grab for comp	120.1	N/A	umhos/cm	28 days	plastic	100 ml
X	X	X	X		O&G	grab	418.1	1	mg/l	28 days	glass	1000 ml
X	X	X	X	X	Semivolatile organics	grab	8270	var	µg/l	7 days	glass	1000 ml
	X		X		TPH (diesel& gasoline)	grab	8015M	var	µg/l	28 days	glass	1000 ml
X	X	X	X	X	TSS	composite	160.2	10	mg/l	7 days	plastic	200 ml
X	X	X	X	X	TDS	composite	160.1	10	mg/l	7 days	plastic	200 ml
X	X	X	X	X	TOC	composite	415.2	1	mg/l	7 days	plastic	25 ml
	X				MBAS (detergents)	composite	425.1	1	mg/l	48 hours	plastic	250 ml
		X		X	Other*							
					Metals (total and dissolved)							
X	X	X	X		Cadmium	composite	213.2	1	ug/l	48h/6 months**	plastic	300 ml for Total and Dissolved Metals
X	X	X	X		Chromium	composite	218.2	1	ug/l	48h/6 months	plastic	
X	X	X	X		Copper	composite	219.2	1	ug/l	48h/6 months	plastic	
X	X	X	X		Lead	composite	239.2	1	ug/l	48h/6 months	plastic	
X	X	X	X		Nickel	composite	249.2	1	ug/l	48h/6 months	plastic	
X	X	X	X		Zinc	composite	289.2	10	ug/l	48h/6 months	plastic	

* Additional organic or inorganic constituents may be added after facility selection, to test for specific chemicals handled in the selected facilities.
** Samples should be filtered and preserved in nitric acid within 48 hours, and subsequently held for up to six months.

1. WT Wholesale Trade
2. ARP Automotive Repair/Parking
3. FMP Fabricated Metal Products
4. MF Motor Freight
5. CAP Chemicals and Allied Products

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2. To ensure that appropriate BMPs for implementation at the test facilities are selected and evaluated in a timely and consistent manner.

3. To evaluate the effectiveness of the BMPs in reducing or removing pollutants in stormwater runoff by comparing the control and test facilities.

4. To ensure that data is obtained with field and laboratory QA/QC procedures that will result in a stormwater quality database adequate for characterizing stormwater runoff, selecting BMPs, and evaluating the effectiveness of BMPs.

2.3 PROGRAM DESIGN AND EQUIPMENT

Monitoring Program Design

During the 1996/97 rainy season, stormwater runoff from one of the five critical source types will be characterized. The Critical Source/BMP Monitoring Program requires collection of composite and grab samples of stormwater runoff. One set of samples shall be collected from each discharge point (also referred to as an outfall) of each facility beginning in 1996/97 during each of five storm events in the first year, and ten storm events in the second year of testing for each critical source.

A total of six similar facilities from each critical source type will be selected within a limited geographic area. Initially, the County will conduct reconnaissance visits to numerous sites within a given critical source type and apply site selection criteria to identify the six most suitable sites. Site selection criteria will include: representativeness of facility type (within the critical source category), accessibility of discharge points or outfalls, feasibility of installing a device that would enable stormwater sample collection in the absence of operators (e.g., sample collection bucket installed within a drop inlet, or other pre-fabricated passive stormwater collection device), and health and safety. The County will then seek permission from the facility operators to conduct the Critical Source/BMP Monitoring Program at their facilities. In the event that a given facility declines to participate, the next most suitable facility will be considered.

After the six most suitable sites have been selected, the County will perform secondary selection to divide the sites into two triads (groups of three facilities) for control and testing purposes. Samples from each triad will be composited together for analysis. The criteria for dividing the sites will include: feasibility of implementing BMPs during the summer following the first year of monitoring, and location within close proximity to the other two sites (preferably within approximately 15 minutes driving time, assuming typical local traffic patterns during a rain event).

Logistics

A minimum of two teams of two persons each will be needed to sample the six facilities for each critical source type. Each crew will be responsible for a composite triad of three adjacent sites (either from the control or test group). Starting in the second year (1997/98) when a second critical source type is added, a minimum of four teams of two persons will be required. Two complete sets of sampling equipment (described below) will be needed in rainy season 1996/97, and four sets will be needed beginning in 1997/98.

Prior to sampling, County personnel will visit each facility to identify the outfalls or sampling points to be monitored. In some cases, special or modified sampling equipment may be needed (such as a sampling bucket on a pole to access an outfall located within a manhole). At sites with difficult access or sites that would be difficult to get to in time to capture the first flush (concentrated pollutants in runoff from the early part of the storm event), a simple, low-cost sample device such as a passive stormwater collector may be useful. Such samplers have a container installed just below ground with the opening flush with the ground surface such that they can fill up with runoff even if sampling personnel are not present. The County may consider using such a device on a case-by-case basis, if certain criteria regarding their use are met. Criteria for determining whether such devices are appropriate for use at a given facility include:

- Outfalls or stormwater sampling points at which runoff consists of sheetflow;
- Outfalls or stormwater sampling points at locations that would preclude collection of the first flush (e.g., due to difficult access);
- Facilities that have more than two outfalls; and
- Facilities that grant permission to the County to install such device(s).

At facilities where automatic collection devices are determined to be feasible, County personnel shall install the samplers prior to the onset of the rainy season. If the County determines that such devices are not appropriate or feasible for use at the selected facilities, labor (e.g., additional sampling crews) may be substituted for automatic collection equipment in order to achieve the same results.

When rainfall is forecast, every effort will be made to collect the first flush at each site. The crew will collect a sample of sufficient volume to satisfy the analyses to be conducted (see Table 2-1 for test possibilities), fill out the observations sheet, and drive to the next site in the triad, performing the same actions there, and moving on again to the next site.

Once the first round is completed the crew will immediately begin a second round (i.e., drive to the first site, collect one sample, perform observations and measurements, etc.). The crew will keep moving between the three sites as long as the rain continues and flows are strong enough to fill the water collection devices between visits. For purposes of this monitoring program, a viable storm event is defined as a storm that is of sufficient volume and duration to enable collection of a minimum of three rounds of samples (the initial composite and grab samples and two additional rounds for composite samples) at all stations within each triad. However, sampling crews should collect as many samples as possible over the course of the entire storm event. The end of the storm event is defined by a break of at least three hours in rainfall. This means that the crews will have to remain near their sampling sites for three hours after the rain stops to ensure that the event is actually over. In the event that a given storm is of very long duration, sampling will be terminated 12 hours after the start of the rain event.

Sample Collection

In the first round each crew will need to collect several bottles of runoff for the initial grab sample, plus the first sample to be composited . The grab will consist of three or four liters, depending on what is being analyzed (see Table 2-1). In subsequent rounds, a smaller amount of sample volume will be needed in order to create a composite sample that is representative of the entire storm event at each group of 3 stations. The County may consider purchasing and installing several low-cost automatic sample collection devices (with a volume of 3-4 liters), or may examine the feasibility of installing sample collection buckets of a similar volume inside selected drop inlets.

Some water quality parameters such as oil and grease, total petroleum hydrocarbons, and semivolatile organics must be collected in glass jars and analyzed separately (cannot be composited), either because they stick to the container walls or because they are volatile. Grab samples for these parameters will be collected only once during the event, during the first round, and analyzed separately. For the other constituents, the crew will collect several samples in plastic bottles during the course of the event and they will be composited in the field to create one composite sample representative of the three facilities within each triad.

Equipment

Equipment needed for proper collection of samples include the following items:

- Communication devices
- Site maps
- Sample bottles with proper labels (provided by the contract laboratory);
- Collection vessel or scoop;
- Paper towels;
- Tool to retrieve passive sample collector, if needed;
- Clipboard with pencils; waterproof pens, observation forms; and data collection forms;
- Watch;
- Latex gloves;
- Rain gear;

- Hard hat (as needed);
- Flashlight (and spare batteries);
- Distilled water (supermarket grade; to rinse hands, collection equipment, etc.);
- Chain-of-custody forms;
- Sample cooler, packing tape, bubble wrap, ice, plastic bags to wrap samples in and pack for proper transport to the contract laboratory;
- Health and Safety Plan; and
- Traffic cones (if applicable).

In most cases, there will be no equipment to calibrate. If the County decides to use a portable pH and/or conductivity meter, the meters will need to be calibrated. However, use of field meters is not recommended, because field pH meters take a relatively long time to stabilize, and because both pH and conductivity will be measured at the laboratory.

Recordkeeping is an important part of this monitoring program. The Critical Source/BMP Monitoring Program requires that records be kept of all site inspections, visual observations, and analytical monitoring efforts.

There are several forms which may be used to record this information. The forms include:

- Form 1: Wet-Weather Visual Inspections Recording Form
- Form 2: Chain-of-Custody Form

Copies of these recording forms are included in Appendix A.

2.4 SAMPLING GUIDANCE

The following section provides step-by-step guidance for each sampling team in collecting stormwater samples.

PRE-SEASON PREPARATION

Step 1: Conduct pre-season preparation

Prepare for sampling before the rainy season:

1. Prior to the rainy season, call the laboratory and request that materials be sent for stormwater sampling.

2. Work with the laboratory to develop a simple labeling system to ensure that grab samples and discrete (composite) samples are collected and handled properly.

PRE-STORM PREPARATION

Step 2: Contact the laboratory.

Immediately before the storm event, call the contract laboratory and tell them you will be delivering samples for analysis.

1. State your name and explain that you are conducting critical source stormwater monitoring.
2. Depending on the critical source type being monitored, you will need to sample for a different suite of parameters. A list of example parameters for each critical source type is provided in Table 2-1. Based on the table, tell the laboratory what you will be sampling for, and when to expect the samples.
3. Request that the laboratory send a cooler with pre-labeled sampling bottles and blue ice for stormwater sampling.

Step 3: Prepare equipment

Use the sampling equipment checklist (Table 2-2) to select the equipment.

Prepare your equipment:

1. Familiarize yourself with the sampling bottles provided by the laboratory and make sure you have the correct type and number of bottles for the critical source type you will be sampling.
2. Check equipment that could fail to make sure it is ready for use (for example, flashlights, pens, etc.).
3. Place all the equipment in a container to carry to the sampling site.

Step 4: Pre-label the sample bottles

This section explains how to fill-in the right information on the bottle labels.

Label the sample bottles before you go out into the field.

1. Sample Identification. Record the critical source type, and whether sample is from the "control" or "test" group. List site location, identification number, and type of sample (either grab or composite).
2. Sampler. Record the name of the person who did the sampling.

TABLE 2-2
SAMPLING EQUIPMENT CHECKLIST
EQUIPMENT FOR OBTAINING WATER SAMPLES

CHECK	ITEM	COMMENTS
	Latex Gloves	To protect your hands against acid preservative.
	Collection Vessel	Recommend clean glass when feasible.
	Waterproof Ink Pens	Sanford's "Sharpie" recommended.
	Recordkeeping Forms	Included in the Appendix of Monitoring Program.
	Paper Towels	For wiping off water from labels and your hands.
	Tape	Electrical, fiber, or duct tape for shipping.
	Watch	Ordinary wristwatch.
	Plastic and Glass Bottles	pH, oil and grease (glass bottle), specific conductance, and total suspended solids.
	Ziploc Plastic Bags	For keeping forms and sheets dry during transport.
	Chain-of-Custody Forms	For recording the time, place, and your company name.
	Packing Material	Plastic bubble wrap, vermiculite or similar.
	Blue Ice	To be kept frozen until sampling begins.

3. Sampling Date and Time. Record the date and time you collected the samples on the chain-of-custody form. Include AM or PM to denote what time of day.

Step 5: Determine if a storm is acceptable for sampling

Storms to be considered for sampling should generate at least 0.25 inches of rain and should be preceded by at least 48 hours of dry weather.

1. Designate a Sampling Coordinator to monitor storm forecasts (radio, TV, weather channel, etc.) and make formal go/no go decisions as to whether to sample.

2. Be prepared when a storm is forecast (sampling equipment and sample personnel are ready).

3. Every effort will be made by the sampling crew to collect the storm's first flush.

4. Drive to the first designated sampling location.

5. Once water is flowing enough to collect a sample, begin timing the storm event.

6. Begin to sample.

7. If, at arriving at a site, there is not enough water flowing to take samples, then wait until stormwater runoff increases.

8. If the storm is not acceptable, then you must sample the next time a storm occurs.

Step 6: Collect the sample

This section explains how to collect stormwater samples.

1. Put on clean latex gloves and open a sample bottle from cooler.

2. If using a passive sample collector, remove the sample collection container. Shake vigorously to remove any material on the sides or bottom of the container, being careful not to spill sampler contents. If using a collection scoop or bucket, dip clean sampler into the center of flow. If there is adequate flow, wash the sampler three times in the flow prior to collecting the sample. Keep sample free from uncharacteristic floating debris and bottom sediments.

3. Carefully pour sample from the container or collection pitcher into sample bottle to the appropriate level.

4. Cap sample bottle tightly and place in cooler.

5. Rinse sampling equipment with distilled water to prevent cross-contamination with the following sample. For every tenth sample, rinse the sampling container once and

discard the rinsate. Then wash the container a second time and pour the rinsate into a clean sample bottle. This will constitute an equipment blank for field QA/QC purposes.

6. Repeat steps 2 and 3 for the remaining sample bottles. Note that you will have three or four sample bottles for the first round of sampling and one or two bottles for subsequent rounds.

7. At one of the stations within each of the test and control triads, collect one additional complete set of grab samples during the first round of sampling. These samples will be analyzed as duplicates for the purpose of field QA/QC.

8. Make visual observations at the outfall and record them on the proper form (Appendix A). Visual observations should be recorded in detail during the first round of sampling and updated during subsequent rounds to document any observed changes.

9. Find a relatively dry area and fill in the chain of-custody forms.

10. Proceed to the next facility and continue sampling.

Step 7: Prepare forms and pack the samples for the laboratory

This section explains how you will package your sample bottles, complete the forms, and transport the bottles and completed forms to the laboratory.

Complete the Chain-of-custody form as follows:

1. Facility Location. Record the name and address of the facility.

2. Sample Description. Record the sample identification number, what the sample is to be analyzed for, the type of sample (grab or composite), and the number of the sample (i.e., first, second, third, etc.).

3. Sampling Date and Time. Record the date and time that you collected the sample. Include AM or PM to denote what time of day.

Pack the sample bottles and forms as follows:

1. Place a plastic liner bag in the sample cooler.

2. Place blue ice (frozen) or regular ice in the cooler. If regular ice is used, place in zipper bags.

3. Wrap glass sample bottle in bubble wrap or similar protective material. Plastic bottles do not need to be wrapped. Make sure all bottle caps are tightened.

4. Place all sample bottles in the chests and tie off the plastic liners.

5. Keep one copy of all your forms for your files.

Transport the sample chest to the contract laboratory as follows:

1. Before sealing the cooler, make sure you have completed all steps, and have included everything in the cooler.

2. Seal the cooler with strong tape (fiber, package sealing or the like) making sure the top and the handle are secured to the bottom portion of the cooler.

3. Call the contract laboratory to tell them that your samples are on the way, and the anticipated time of arrival.

4. Take samples to the laboratory per sampling protocol.

2.5 QUALITY ASSURANCE / QUALITY CONTROL

Field Sampling Procedures. All County personnel responsible for collecting stormwater samples will be familiar with proper sample handling methods, field QA/QC, and reporting requirements.

Field QA/QC Procedures. County staff conducting the sampling will perform field QA/QC by collecting duplicate samples and through the use of blanks. One complete set of grab sample bottles collected during the first round of sampling at one station from each triad will be analyzed as a duplicate sample. In addition, equipment blanks will be collected for 10% of the samples and analyzed to check for cross-contamination introduced during the sampling process. Trip blanks will not be needed because volatile organic compounds (VOCs) will not be analyzed.

Chain-of-Custody. Chain-of-Custody forms track the handling of samples from the point where they are collected through the completion of laboratory analysis. Chain-of-Custody forms will be completed for every stormwater sample that is collected.

Laboratory QA/QC Procedures. Stormwater samples will be analyzed by the contract laboratory. When feasible (i.e., when there is adequate sample volume), the laboratory will split the composite sample in half and analyze both halves separately as a check on the consistency of laboratory analyses. In addition, the laboratory will assure internal quality of its data using commonly accepted methods approved by the State.

2.6 EVALUATION OF EFFECTIVENESS

General. The effectiveness of the Critical Source Monitoring Program will be assessed annually, based on the results of the visual inspections and analytical monitoring. In addition, this evaluation will assist in the evaluation of BMPs.

Use of Wet Season Visual Observations. Visual observations will be included in the determination of the effectiveness of implemented BMPs.

Use of Analytical Monitoring Data. Since chemical concentrations may vary widely during a given storm and between storms, it is unclear whether statistically significant data can be collected using this protocol. Consequently, levels of constituents observed in water quality should be used as *indicators* rather than definitive data on chemical loading.

2.7 HEALTH AND SAFETY

Stormwater sampling activities may occur when the sampling environment and/or stormwater discharges create hazardous conditions. Although the OSHA 40-hour HAZWOPER training is not required for individuals performing stormwater sampling, it is important that you know that hazards do exist when sampling. This section outlines general health and safety issues and concerns.

Safety Guidelines

- Watch out for traffic when sampling or making observations.
- Do NOT remain in open areas or stand under trees if lightning is occurring in the vicinity.
- Be alert to high water or flash flooding conditions.
- Always wear clean latex rubber gloves when sampling.
- Be extremely careful of the acid preservative in the sample bottles (if present); protect your eyes and skin against contact.

Safety Equipment

The following safety equipment is recommended for use during stormwater sampling:

- Wet weather clothing
- Safety glasses
- Latex gloves
- Waterproof flashlight

Hazardous Weather Conditions

Use common sense when deciding whether you should sample during adverse weather conditions. Do not sample during dangerous conditions such as high winds, lightning storms, or flooding conditions which might be unsafe.

Chemical Hazards

You can also be at risk of exposure to hazardous chemicals that have been placed in the sample collection bottles for sample preservation.

A preservative is included in the sample for oil and grease. The preservative is sulfuric acid. If contact is made with the skin and/or eyes burning and blindness may result. If the eye comes in contact with the acid, wash immediately with running tap water for at least 15 minutes. Have someone contact a doctor immediately and follow his/her instructions. If direct skin contact is made, also flush with tap water and remove any clothing that may be soaked with the acid.

Physical Hazards

Other hazards you might encounter are traffic hazards, sharp edges, falling objects and, slippery surfaces.

SAMPLE FORM 1
WET WEATHER VISUAL OBSERVATIONS
LOS ANGELES COUNTY CRITICAL SOURCE/BMP MONITORING PROGRAM

Note: Record detailed information at each outfall during the first round of sampling. During subsequent rounds, complete additional forms as needed to document changing conditions observed at each outfall over the course of the storm event.

Facility Name:____

Inspector:____

Date:____

1. Time Storm Event Started: ______________________________

   Time Storm Event Ended: ______________________________

2. Time Of Visual Observations: ___________________________
3. Sampling Round Number: ______________________________
4. Active Worksite? Yes ❐ No ❐
5. Visual Observations:

Observation for: **OUTFALL ____**	Not Observed	Description (Include Location)	Potential Source
Floating/Suspended Material			
Oil and Grease			
Discoloration			
Turbidity			
Odor			
Other Abnormal Conditions			

FORM 2

CHAIN-OF-CUSTODY FORM

LOS ANGELES COUNTY CRITICAL SOURCE MONITORING PROGRAM

(to be provided by the County)

THE REPORT

Los Angeles County
Department of Public Works

Stormwater/Urban Runoff Public Education Program

Research Report on Issues, Pollutants and Materials

Prepared by:
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January 1997

A STORMWATER/URBAN RUNOFF PROGRAM REPORT
FROM THE COUNTY OF LOS ANGELES

R0011857

Research Report on Issues, Pollutants and Materials

Table of Contents

Executive Summary & Situation Analysis

Purpose of Report

As the first step in the development of the County's Five-Year Stormwater/Urban Runoff Public Education Plan mandated by the NPDES Permit (see "Regulations' Role" section) and passed by the California Regional Water Quality Control Board/Los Angeles Region on July 15, 1996, the following *Issues, Pollutants and Materials* Report focuses on:

- The many and complex issues surrounding stormwater/urban runoff prevention efforts
- The prioritization of pollutants of concern, land uses and associated target audiences so that the education campaign is a focused, targeted effort and results in the highest pollutant reduction per-unit cost
- The specific materials and programs being implemented by municipalities, government agencies and environmental organizations throughout the country and abroad to reduce stormwater/urban runoff pollution
- Overall recommendations on how to proceed in developing the Five-Year Plan based on the information and research conducted by our team and insights provided by the 125 entities nationwide that are actively involved in stormwater/urban runoff pollution prevention programs -- including 58 stormwater managers within the County of Los Angeles

This report will serve as a resource for reviewing and assessing the individual and collective efforts of Los Angeles County, 85 Co-permittees and some of the nation's leading stormwater/urban runoff prevention programs. This analysis will be valuable in the development of the Five-Year Public Education Plan for a number of reasons:

- It will help identify those programs that may have applications in a broad, countywide effort
- It will present information and programs that can be used as springboards to new programs designed for countywide use
- It will provide valuable lessons on what to do and what not to do
- It will maximize resources by reducing the risk of "reinventing the wheel" or duplicating existing efforts

Background: Why Stormwater/Urban Runoff Is A Problem

Every day, millions of gallons of untreated water flow into the County's lakes, rivers and the Pacific Ocean from storm drains. On rainy days, up to 10 billion gallons make it through the drains. Because the County's storm drain system does not filter or treat any kind of contaminates or debris, stormwater/urban runoff has become the most significant source of water pollution in California.

Stormwater/urban runoff pollution is a year-round, continually threatening problem. While the enormous litter problem associated with stormwater and urban runoff pollution is highly visible in the County's communities and waterways -- polluted runoff is even more harmful in a number of other ways:

- It kills marine life
- It contaminates fish and seafood
- It causes illness in swimmers
- It causes storm drains to back up, contributing to flood conditions
- It harms the freshwater habitat
- It reduces residents' quality of life
- It affects the region's $2 billion annual tourism economy

Addressing the issue -- and significantly improving water quality -- poses great challenges because the activities most likely to cause pollution are conducted hundreds of times a day by millions of individuals and thousands of commercial businesses. Fertilizers, herbicides and pesticides, automobile exhaust and oil drips, improper clean-up after house maintenance projects, dumped restaurant grease and other waste, construction debris and runoff, litter, even yard trimmings swept into the street -- all contaminate runoff.

Regulation's Role in Stormwater/Urban Runoff Pollution Prevention

Stormwater/urban runoff was first actively addressed when the Clean Water Act of 1987 established requirements for stormwater discharges under the National Pollution Discharge Elimination System (NPDES) program. To ensure compliance, the California Regional Water Quality Control Board in 1990 issued a five-year permit to the County of Los Angeles for municipal stormwater discharges. Since the permit was very general, compliance varied from city to city. Thus, the level of compliance and any resulting reduction in stormwater/urban runoff pollution was difficult, if not impossible, to track.

To create a more specific standard of compliance, a new NPDES permit was issued by the Water Quality Control Board/Los Angeles Region on July 15, 1996. The Board approved a permit that relies on public education as the dominant means of reducing pollutants to coastal and inland waterways and communities. The Permit advocates a well-targeted program designed to reach those audiences most likely to be the biggest polluters and/or those audiences most likely to adopt behavioral changes that will prevent or reduce pollution.

Target Audiences Defined by the NPDES Permit

Commercial/Industrial Businesses
New Development/Construction
Residential/General Public
School Children
Public Agencies and Employees

In addition, the permit promotes a "Watershed Management Approach" to protect and enhance water resources. By working together, regulatory agencies, Co-permittees, environmental groups and other stakeholders can combine resources and efforts to achieve the greatest environmental improvements within their watershed. The County's six Watershed Management Areas (WMAs) are:

- Malibu Creek and Rural Santa Monica Bay
- Ballona Creek and Urban Santa Monica Bay
- Dominguez Channel/Los Angeles Harbor Drainage
- Los Angeles River
- San Gabriel River
- Santa Clara River

The [illegible] pollutants of concern re[illegible]tedly detected in the watersheds of Los Angeles County include: [illegible] polycyclic aro[illegible] hydrocarbons (PAHs) [illegible] and viruses, sediment, litter and [illegible] biochemical oxygen demand (B[illegible]), [illegible] and grease, nutrients and other toxic [illegible]ials [illegible] chlorinated biphenyls (PCBs) and tri-butyl tin (TBT). Some of [illegible] pollut[illegible] are potentially toxic [illegible] high concentrations, others are potent carcinogens and mut[illegible] [illegible] causing [illegible] growth. Sediments can sm[illegible] pools, while litter and debris are a blight on our water b[illegible].

Public Education's Role in Preventing Stormwater/Urban Runoff Pollution

Public education campaigns have been implemented as part of the NPDES permit enacted in 1990 and have shown success in increasing awareness about stormwater/urban runoff pollution. For example, after a year-long advertising campaign sponsored by the County of Los Angeles and the City of Los Angeles, research showed a 50 percent increase in the number of County residents who knew that stormwater and urban runoff leads directly to the ocean -- a change from 48 percent in 1995 to 76 percent in 1996.

Under the new permit, the Principal Permittee and Co-permittees are required to develop and implement a stormwater/urban runoff public education strategy that will raise the awareness level of even more of the County's 9 million residents about stormwater/urban runoff pollution -- *and motivate them to stop polluting.*

In fact, one of the goals of the County and many of the Co-permittees is to measure and demonstrate actual behavioral change that leads to pollution reduction. While behavioral change does not happen immediately, there is enough evidence from other environmental and social marketing campaigns -- such as recycling, seat belts, AIDS prevention, etc. -- that people can and will change their behaviors if they understand the need and are given convincing reasons and a "reward" to do so. Thus, the challenges will be to:

- educate target audiences about the problems and solutions;
- discover what will influence behavioral change in the target audiences; and
- document and prove that the education outreach effort resulted in a behavioral change that reduced pollution.

As the Principal Permittee, the County of Los Angeles is ultimately responsible for developing a Five-Year Public Education Program that serves the needs of the County and the 85 Co-permittee municipalities. This umbrella program will be developed in consultation with the Co-permittees and will address education outreach strategies countywide -- by pollutants, land use, watershed and targeted audiences outlined in the NPDES Permit. In addition, the Program will identify the Co-permittees' responsibilities for implementation, including specific objectives for changing knowledge and behavior.

♦ General Public

It is necessary to review and evaluate the most effective communication approaches the County can use as part of a broad-based campaign that can influence as many residents as possible. In that light, the following points must be considered:

- In surveys conducted by the County and throughout the country, the general public rates mass media (television, radio, print) as the number one source of information and education about environmental issues.[1] Mass media -- especially television and radio -- is a top-down approach and has the greatest potential to reach the largest number of people with broad-brush overarching messages.
- Using mass media in a countywide campaign is supported by interviews with managers of other stormwater public education programs in California. These managers stated that, given their experience, they would use the mass media and advertising much more heavily in the County program than they do in their own programs which are designed for smaller communities. Most of these smaller programs depend on grassroots programs (bottom-up approach), targeted outreach, school programs, brochures, flyers, posters and other collateral materials for their outreach.

[1] The Sierra Group (April 1995); Godbe Research and Analysis (1996)

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- The County program must address the issues of diversity -- ethnic, cultural and socio-economic -- to have any broad effect. For example, surveys conducted by the County of Los Angeles and the City of Los Angeles confirmed that foreign language media -- particularly radio and newspapers -- is a highly effective tool in reaching ethnic populations. Other studies indicate that low-income people who are struggling with daily economic survival put the health and well-being of their families over concerns for the environment -- a fact that needs to be considered when developing messages targeted to that audience.
- Given the varying financial resources of the 85 Co-permittees, the countywide program must be cost-effective and practical to implement.

♦ Business

For the business community, many of the salient points for the general public apply. However, there are some distinct considerations that must be incorporated in the development of Best Management Practice (BMP) education outreach programs:

- BMP information must provide very specific guidelines on how to execute tasks to ensure compliance -- there should be no room for misinterpretation.

- BMPs must not only improve the conditions in the storm drains, but must have a bottomline, cost-effectiveness benefit for businesses to comply. This is of critical importance to businesses in lower income or blighted areas that are in a "survival" mode of operation and are more apt to comply if it improves their profitability.

- More research must be done within business audiences to identify who should receive stormwater/urban runoff prevention information to ensure that education and retraining reaches those people who are doing the polluting. In a restaurant, for example, who should receive the pollution prevention training to make sure that busboys, cooks and janitorial staff comply with BMPs every day, all day long? The general manager? The head cook? Someone else?

- Attention must be paid to developing materials in several languages depending on the type of businesses and workers most likely to have polluting behaviors. In the restaurant example, management may learn BMPs if they are in English, but busboys may not. BMP information needs to be understood by both types of employees.

- Many small businesses -- particularly in the ethnic communities -- operate with very slim profit margins and have very little extra capital for improvements. An understanding of the economies of implementing BMPs must be paramount, as well as the cultural business values inherent in each ethnicity.

♦ Other Audiences

In addition to the general public and businesses, the NPDES Permit identifies school children and public agencies and employees as key audiences of the public education campaign. Based on discussions with Co-permittees, these targets are considered secondary to the general public and businesses in terms of broad campaign outreach. However, employee training is recognized by the Co-permittees as a highly important element of the Permit.

Generally, this is due to:

- the relatively lower levels of pollutants they generate;
- the fact that mass media efforts will reach them; and,
- because targeting them with specific messages can be costly and time consuming.

Having noted these issues, Co-permittees did agree that some level of targeted communications to these audiences should be developed and implemented at some point during the Five-Year Program.

Challenges and Opportunities That Lie Ahead

Although significant strides have been made in raising public awareness about storm drain pollution, the County and the 85 Co-permittees are embarking on uncharted waters in many ways:

- Never has a *coordinated* and *comprehensive* effort of this magnitude that is founded on research and evaluation, been developed and implemented between a Principal Permittee and so many Co-permittees.

- Of all the stormwater and urban runoff pollution prevention programs examined for this report, the largest was the Chesapeake Bay Program with more than 14 million people. The City of Los Angeles was next with half as many residents as Los Angeles County (9 million people). Other major West Coast stormwater public education programs have audiences between 750,000 and 1.5 million people -- between eight and 16 percent of the County's population.

For the Five-Year Public Education Plan to be cost-effective and successful, an overarching theme must be developed that can:

- Be used throughout the County while still being adaptable for very localized use by Co-permittees
- Cross most regional, cultural and language barriers in the County
- Educate the public on how to prevent the problems of stormwater/urban runoff pollution in a succinct and memorable way, as "Reduce, Reuse, Recycle" does for the recycling movement
- Motivate the public and business to change their behaviors

Section 2: Issues & Program Considerations

Challenges to the Public Education Campaign

There are many challenges to producing a successful countywide stormwater pollution public education program, but challenge very often generates opportunity. Based on evaluation of materials and interviews with more than 100 cities and counties across the country[2], the County, in partnership with the Co-permittees, has the opportunity to produce the first coordinated, comprehensive program that can demonstrate it has changed behavior and reduced pollutants to the stormwater system.

This campaign also has the opportunity to address the largest audience to date of any stormwater program on the West Coast. While most other programs address smaller, largely homogeneous communities or cities/counties with approximately 1 million to 4 million in population, Los Angeles County's unincorporated areas and the Co-permittee cities encompass nearly 9 million people whose socio-economic levels vary from great wealth to welfare, and who collectively speak more than 50 languages/dialects.

While $5 million is a substantial commitment to fund a public education campaign, when it is spread over five years and needs to reach 9 million people, each dollar must be effectively spent and, whenever possible, leveraged to create additional resources.

Reaching these diverse audiences is a challenge. Reaching them successfully with a well-targeted, effective campaign has the potential to make our countywide program a national model for other large geographical areas. Achieving success is a challenge -- and a great opportunity. Achieving success requires a unified effort by the County, Co-Permittees and the consulting team and a creative, strategic plan of action.

Social Marketing -- Selling Behavioral Change[3]

Social marketing is the use of corporate marketing "technologies" (strategies and tactics) to influence a voluntary behavioral change in a target audience. While corporate marketing's bottomline is to influence the customer to "buy the product," social marketing's bottomline is to influence the customer to "buy-in to a behavioral change" that may be good for society, the environment and/or the individual.

[2] See Appendices for complete listing of cities.

[3] See Appendices for a social marketing program model.

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The definition and purpose of social marketing is quite different from that of traditional public education campaigns. In the past, public education programs were designed to raise awareness among the masses about a social issue or problem, with the ultimate hope that this awareness would encourage people to analyze their behavior and change it.

Social marketing takes a more strategic, aggressive and scientific approach. Using research, it identifies target audiences, appropriate messages, and the best vehicles to deliver those messages. In targeting audiences, social marketing strives to reach those segments of the population most affected by/or most likely to affect a certain situation. And by using behavioral and attitudinal research, social marketing programs look to reach these targeted audiences in a way that is highly personal and offer specific suggestions for behavioral changes. Given this highly personal approach, social marketing can motivate individuals to take action, if executed with sensitivity and care.

By using research ... social marketing identifies target audiences, appropriate messages, and the best vehicles to deliver those messages.

Communicating the Message

Communicating effectively to the program's diverse target audiences is one of the program's major challenges. As a first step in the research process and to obtain a thorough understanding of the programs already in place, interviews were conducted with 58 stormwater program managers in Co-permittee cities.

♦ Need for an Overarching Theme/Look

A majority of the stormwater program managers interviewed expressed a need for simplified concepts and "everyday" terminology to bring the stormwater/urban runoff issue home to the public. Communications research shows that the most memorable and effective themes or "sayings" are simple and relate to everyday life. Co-permittees are aware of and understand their demographics, and toward that end, have asked for concise, memorable "reader-friendly" messages that can be understood by all.

The initial step in the campaign process should be to develop an umbrella theme -- such as "Buckle Up" or "Reduce, Reuse, Recycle" -- to tie the campaign together. These themes have produced positive results because they do more than describe an issue, they tell people what they can do to solve it in simple, easy-to-remember language.

Developing an overall campaign theme will address another concern expressed by the cities: the need for unified messages and uniform quality of materials. While there is at least some degree of stormwater/urban runoff public education in every Co-permittee city, there is great variation in audiences targeted, materials used and the level of effort expended. In addition, city stormwater managers have expressed concern that their materials are not being picked up or noticed by the public, defeating their public education purpose.

In addressing this concern, one of the campaign's strategies is to produce materials that are uniform in look, with an identifiable theme and logo and messages that apply countywide. The cities must also be able to customize, produce and distribute these materials cost effectively.

For example, one Co-permittee suggested supplying copy and format for collateral materials on computer disk, allowing cities to communicate under the "countywide umbrella," and still customize the materials with their phone numbers and relevant city information. Another direction that has been discussed is to produce countywide materials centrally, listing the names and phone numbers of all 85 Co-Permittees -- a proposal with obvious cost advantages for the cities.

♦ Addressing Diversity

City stormwater program managers expressed opinions and insights on appropriate ways to address the County's cultural, ethnic and socio-economic issues to effectively reach the County's diverse population. Interviews with various cities and counties nationwide revealed that while many programs are written for non-English speaking audiences, most are simply translations from English and do not address differing cultural issues. The cities of Los Angeles and San Francisco are two of the few that have materials specifically tailored to various cultures. Producing such materials is another opportunity for Los Angeles County and the Co-Permittees to develop effective communication materials that fulfill a specialized and often overlooked need -- and more importantly, motivate the target audiences.

Approaching certain materials from a cultural point of view rather than a simple translation from the English language is important. Research shows that messages that ethnic audiences value most differ significantly by places of origin, and from traditional English-speaking audiences. For example, some cultures are highly influenced by role models and will change behavior based on what these models say; others are very family-oriented and will make changes to protect their family's welfare -- protecting the environment will not rank as high in their priorities.

♦ Broadening the Messages

In addition to cultural issues, there is the challenge of geography: While organizations such as Heal the Bay and the Santa Monica Bay Restoration Project have initiated highly effective education campaigns in beachside communities, messages and efforts now need to be broadened to include the Co-permittee cities whose watersheds drain into harbors and waterways other than the Santa Monica Bay, and inland cities whose watersheds drain into rivers, creeks and other waterways and who may have little or no physical or psychological connection to the ocean. In addition, care must be given to target messages to inland communities with a priority to clean up their own city that supersedes, but is complementary to, the mandated effort to reduce ocean pollution from the storm drain system. For countywide public education materials to be applicable to all communities, reference will be made to "oceans, waterways and communities" rather than to the ocean or Santa Monica Bay alone.

By the same token, the program needs to broaden its base of spokespeople beyond those known primarily for their association with the Santa Monica Bay. Program spokespeople also need to reflect the diversity of the County's geography as well as the target audiences and include the leadership models that research has identified as most believable: professors, doctors and environmental organizations.[4]

Finally, whenever possible, the communications program should work in conjunction with other relevant environmental public education programs in the region, including household hazardous waste and recycling efforts.

Co-permittee City Concerns

Given the regulatory environment under which the Permit was formulated, it is understandable that several cities have expressed concerns during the process. The Permit focuses on public education as a means of accomplishing a reduction in stormwater/urban runoff pollution. Final terms were negotiated and approval was reached after 18 months of negotiation, with the resulting permit a product of compromise between the Regional Water Board, the County, the Co-permittee cities, environmental groups and the trade associations of targeted industries.

A major sticking point in the negotiations was the original Permit provision that the targeted industries should be subjected to formal inspections. To reach consensus, educational site visits -- with no penalties for noncompliance -- were substituted for these inspections. Because the Permit went from a compliance-based approach to an educational approach, it is even more critical that educational site visit materials and tools be persuasive in order to achieve the desired results.

[4] The Sierra Group, April 1995 Stormwater/Urban Runoff Public Opinion Poll. County of Los Angeles.

Despite the challenges in reaching agreement on the Permit, most cities interviewed want to have a successful program. In general, the cities support a unified countywide effort as the most viable way to achieve success, but have expressed a need to have materials allowing them to retain their autonomy.

The cities vary in size and financial resources and have varying levels of financial support available for the countywide public education effort. In fact, the very diversity that makes the countywide program unique also poses the challenge of developing a Plan that accounts for the resources of all Co-Permittees. In developing the Five-Year Plan, individual cities' financial resources will be considered with an eye to producing a program that is both easy to implement and affordable.

Regional Considerations

With many issues being regional in nature, the Permit defines six Watershed Management Areas (WMA)[5] and calls for the cities within these WMAs to work collaboratively to implement a public information program within their watershed. Currently, many cities are looking only to their own jurisdictions rather than the entire watershed, a point that was highlighted during the Co-permittee interviews by the few program managers who discussed issues regional in nature.

In addition, stormwater public education program managers in other parts of California have stated that it has been extremely challenging to forge the cooperative partnerships that are necessary for Co-permittees to work beyond their jurisdictions for the benefit of the entire watershed. A similarly challenging situation is anticipated in Los Angeles County with 85 Co-permittees, the County as the Principal Permittee and six WMAs.

During the research phases of the Public Education Program, it will be determined how and when communications-by-watershed will be specifically addressed. While it is clear that the public needs to understand how and what they are contributing to stormwater pollution, other public education efforts -- including the State of California AIDS Prevention Campaign -- have learned that using technical terms usually leads to confusion and lack of understanding. The term "Watershed Management Area" is not part of the general public vocabulary and the team needs to ask the question -- Is it important to spend money educating about WMAs, or is it more important to motivate them to change their actions like not throwing litter in the gutters?

Given the need to change specific behaviors in order to improve water quality, it is likely that initial materials will not address watersheds per se, but that messages will be targeted to address pollution concerns and actions within the WMAs. This strategy is based on other social marketing campaigns where the value of first educating the public with simple, overarching messages that are relevant to their lives has been demonstrated.

[5] See Section 3 for a listing of cities within each WMA.

♦ Land Use Issues Within the Region

The difference in land use within the region must be understood to maximize the effectiveness of the campaign.

Areas with expanses of open land are particularly sensitive to erosion and pollution by sediment loads. Land where development is taking place on a large scale, where fires have removed protective vegetation from slopes, or other things have occurred to expose dirt to rainwater will require a concentrated educational effort with developers, builders, architects, and engineers.

To help target and track the outreach to this audience and as part of the research effort, a database of all construction projects in Los Angeles with current building permits has been -- acquired. The database includes not only the location of the proposed or ongoing project, but also the builders and designers involved.

Areas with a higher concentration of septic tanks are more sensitive to pollution by pathogens released from leaking tanks. In Los Angeles County, the highest concentration of septic tanks is in the Malibu area and in foothill communities. Maps of areas with varying concentrations of septic tanks have been produced by the City of Los Angeles Department of Public Works for a septage-related environmental impact study.

Groundwater quality is a major concern in areas that have suffered contamination from past business and agricultural practices. This includes the San Gabriel Valley which has had communitywide involvement in Superfund projects for more than a decade. Residents and business leaders in this Valley have a heightened awareness of the relationship between regional economic well-being and water quality. Education about pollution prevention to benefit drinking water supplies, local economics and regional surface water resources is both timely and relevant.

Economic revival is clearly evident in the Long Beach area with the massive Gateway Project. Sediment and trash flowing into the harbor from the Los Angeles River are consistent and serious problems for the Cities of Long Beach and Los Angeles, which have invested substantially in coastal resources. Targeting litter and erosion control upstream is essential not only for the quality of coastal waters, but also to help coastal communities that have to dredge accumulated sediments to unblock shipping channels and remove floatables that blight the surf.

Program Development Considerations

In developing the Five-Year Public Education Program, there are components that *must* be included, and a second tier of strong recommendations that *should* be included based on information collected thus far:

The program must:

- Provide an umbrella concept for Countywide stormwater outreach
- Gain participation by all Co-permittees
- Maintain Co-permittee involvement and allow for tailoring to Co-permittee specific needs; and be easily implemented and economically feasible

The program should:

- Build upon strong stormwater programs already underway in Los Angeles County and what other regions have done well
- Develop simple concepts that motivate behavioral change
- Focus on individual responsibility and actions to achieve results
- Educate the public that household and small business waste are now the major sources of pollutants to the storm drain system rather than waste treatment plants and large industries
- Target major sources of stormwater/urban runoff pollution within each WMA
- Provide efficient, cost-effective communication materials
- Coordinate and integrate with other existing programs countywide, including household hazardous waste, used oil recycling, solid waste recycling, and environmentally-oriented school programs

Summary -- The Five-Year Public Education Program Should Be:

- Broad-based, with an overarching theme
- Appropriately targeted
- Flexible
- Cohesive
- Results-oriented

Program Evaluation

The NPDES Permit (Section VII.C.1) requires the Principal Permittee to evaluate the general success of the Five-Year Public Education Plan. While it may take years of water quality monitoring to see measurable changes resulting from public education efforts, this public education program must plan for and be able to show research indicating attitudinal change, shifts in behavioral intent and actual behavioral changes after the program is implemented.

This type of public education research can be conducted in a formalized, scientific manner (e.g., focus groups, telephone or intercept surveys) or through informal data collection (e.g., number of incoming phone calls). Regardless of the method utilized, the goal of research is to validate and fine-tune program components and outreach efforts; and, to adjust and enhance the Five-Year Plan on a regular basis in relation to what is working and what isn't in the various communities and target audiences.

♦ The Role of Evaluation

Marketing experts agree that research plays a vital role in both the development and measurement of any public education campaign. To ensure that campaign messages are focused in a manner that is meaningful and compelling to the target audiences, research during the development phase of the process should seek answers to key questions, such as:

- What messages are most likely to draw attention, be understood and resonate with residents and business owners?
- What messages carry a sense of importance and urgency?
- What information delivery medium, amount of repetition and combination of resources will produce the greatest influence on intended behavioral change?
- Countywide, what combination of messages and information will affect the greatest level of behavioral change?

Steps Involved in Changing Behavior

- Build Awareness
- Change Attitudes/ Generate Concern
- Change Intentions
- Change Behavior

♦ Laddering -- Putting Effort Where It Counts

Understanding where the messages will have the greatest impact and where they will have little or no impact is also critical to creating a cost-effective campaign. This can be achieved by conducting segmentation -- or laddering -- research. This type of research assesses the degree to which various groups of people are part of the problem, their susceptibility and suitability to different messages, and their willingness or lack of willingness to try new behaviors.

This type of knowledge paints a clearer and more concise picture of the audiences who are the most realistic targets for changing behavior. Those groups of people who test as "not willing to try" should not be targeted, as the expense involved would not be justified or results realized.

♦ Baseline Research

There are two existing pieces of comprehensive research that address measurement of stormwater education.

- ♦ *County of Los Angeles Stormwater/Urban Runoff Quality Management Program Initial Public Opinion Poll* (April 1995), The Sierra Group
- ♦ *City of Los Angeles Storm Drain Public Education Program Knowledge and Awareness Survey* (October 1993, February 1996), Fairbank, Maslin, Maullin & Associates

The County of Los Angeles research was a point-in-time assessment of awareness of the storm drain system, attitudes about environmental pollution and awareness of previous stormwater education efforts. It encompassed the County's English- and Spanish-speaking residents who were 18 years old and older, and had a sampling error of 2 percent.

The City research contained pre- and post-methodology and was designed to measure changes in public knowledge of basic storm drain facts. It included English- and Spanish-speaking residents who were 16 years and older and who lived within the Los Angeles City limits. This research has a sampling error of 4.4 percent.

Overview of Findings -- Existing County and City of Los Angeles Research

Overall, the two studies are similar in their approaches and in the questions used to assess levels of awareness and concern about stormwater issues.

The City study provides an interesting benchmark in that it includes 16 and 17 year olds -- a potentially important segment -- however, the sample is limited to residents within the City limits, not countywide. The County research also provides a good benchmark because, although it does not include the 16 and 17 year olds, it draws its sample from residents countywide.

Taken together, the surveys include many questions that can serve as benchmarks for tracking the progress of the Five-Year Plan. They also serve as a springboard for further research necessary for the Plan.

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We recommend the following issues be formed as questions and be added to the mix:

- Perceived importance of issues facing the community
- Belief that the waterways in Los Angeles County are polluted
- Awareness and recall of information about the storm drain system
- Sources of information on storm drains
- Stencil awareness
- Do-it-yourself activities
- Awareness of stormwater slogan
- Willingness to change behaviors
- Attitudes toward various pollutants

Recommendations Based on Existing County and City Research

We recommend that the following modifications be made to the existing surveys and implemented with respect to the Five-Year Plan evaluation:

- A meaningful baseline measure of behaviors targeted for change is absent from both studies. Neither of these studies ask direct questions about the actual behaviors we want changed. This team recommends future survey questions not be focused on awareness, but on actions that will be a measure levels of activities that threaten the quality of the County's stormwater.

- The idea of asking a question about whose responsibility it is to clean up pollution is a good one (City of Los Angeles); however, for the purposes of the Five-Year Plan, the question should focus on whose responsibility it is to make sure that trash and other materials don't go down the storm drains -- instead of whose responsibility residents think it is to clean up pollution in Santa Monica Bay or the Los Angeles River.

- Media (radio, television, newspapers) usage questions are better addressed through MRI data (standard advertising/advertiser data) rather than tracking survey data.

- Many of the questions included in both surveys deal with behaviors which some participants will likely not want to admit. The order in which questions are asked in this type of survey is critical to collecting accurate data. We recommend organizing the questionnaire so that the content of previous questions do not "clue" the interviewee as to bad or good answers on preceding questions or "lead" them into answering a certain way.

- For open-ended questions we would "group" responses into meaningful categories of information instead of reporting only individual responses.

- Additionally, information will be more meaningful if the data is segmented into groups of respondents who are more and less important to the campaign efforts (e.g., weekly beach goers -- those most likely to change their behavior -- as opposed to non-beach goers). These breakouts can be determined through the laddering research.

– The coding needs to be consistent between wave one and wave two. If the County uses one of the two previous studies as a benchmark, the team needs to obtain the coding structure in order for data to be comparable.

– During the City survey, participants were told the following facts: "In the City of Los Angeles, the storm drain system is separate from the sewer system. The storm drain system empties into the Santa Monica and San Pedro Bays. The water, which carries other substances through the storm drain system, is not treated or filtered before it reaches the bays. What flows through the storm drains can pollute the beaches and the ocean." The County may wish to give respondents this information at the end of the survey as education. However we do not recommend giving them this information prior to asking survey questions because it would clearly influence responses. Costs associated with reading the statement would be minimal.

– Business owners are an important target group for the upcoming campaign and need to be addressed in the evaluation research.

♦ Formalized, Scientific Methods of Evaluation

Marketers and educators know that the best laid plans are useless if they do not "speak to" those whose behavior they are intended to change. Using focus groups and/or one-on-one interview techniques give the target audiences an opportunity to react to preliminary ideas in terms of their motivational power. To the extent that some of the ideas are found to be ineffective, the *reason for* their ineffectiveness can be identified by the research and alternative approaches can be developed.

Methods of measuring the effectiveness of the campaign will also be tied to assumptions about the steps involved in behavioral change efforts:

- Are residents and business owners more aware of the problems related to stormwater/urban runoff after the campaign, e.g., four or five years following the launch in early 1997?
- Do residents and business owners believe that certain pollution-causing practices are improper after exposure to the campaign?
- Are residents and business owners implementing stormwater-safe behaviors/best management practices that will ultimately improve the water quality in the County's storm drain system?

Measurement Tools	What Is Measured
Focus Groups	Concept testing Strategy exploration
In-Depth Interviews	Materials assessment
Laddering	Values exploration Target audience segmentation
Shopping Mall Intercepts/One-on-One Interviews	Copy testing Communications refinement
Public opinion surveys	Campaign awareness Changes in attitudes and levels of concern with key issues Intention to change behavior Behavioral change

♦ Informal Methods of Evaluation

During the interviews with stormwater education program managers in other areas, it was found that several informal methods of evaluation have been used. While these interviews do not provide in-depth information, and in many cases, may not have a high degree of accuracy, they do provide some valuable insight.

The following summarizes the evaluation methods discussed:

- Tracking and counting the number of incoming phone calls on a published telephone number; noting differences in call volume after the phone number has been advertised or printed in a brochure
- Changes in the number of participants in community household hazardous waste round-ups
- Results of citizen volunteer water quality monitoring (typically a creek or local waterway)
- Citizen participation in stewardship grant efforts; requiring grant recipients to provide an evaluation of effectiveness at the conclusion of the grant work
- Documenting the attendance at events
- Changes in the results of inspections of businesses (a reduction in the number of violations would indicate better implementation of pollution prevention BMPs)
- Teacher's evaluations of school programs and results of students' tests or activities after participating in an education program
- Results of examinations taken by contractors and trade professionals that have taken BMP training

The County and Co-permittees must create a measurement and evaluation instrument that can demonstrate that the education program meets a requirement far beyond public awareness -- actual behavioral change.

While the challenges are formidable, the County and Co-permittees show great promise in having what it takes to develop and implement a public education campaign that not only achieves its goal of behavioral change, but can serve as a national model for successful public education programs in large geographic areas. First, everyone understands and believes in the need for public education; and second, the County and a number of municipalities, including the City of Los Angeles have already executed award-winning public education campaigns that have heightened awareness among media, influential business and political leaders, and segments of the general public.

The Five-Year Public Education Program Should Be:

Broad-based
with an overarching theme
Flexible
Coordinated
Results-oriented

All these reasons and resources provide the information and the incentive needed to build a public education program that is based on a solid communications strategy. But, ultimately, it will take the County's leadership and a strong partnership with the Co-permittees to create and implement a campaign that has enough impact to change human behavior so stormwater/urban runoff pollution *can* be reduced.

The key to developing a Five-Year Plan for a coordinated, comprehensive stormwater public education program is an understanding of the big picture in Los Angeles County --

its large and diverse population,
its history of water and land use issues,
the issues within and across the boundaries of
Watershed Management Areas,
and the NPDES Permit requirements.

- Assessing the value of "in-kind" or financial donations received from grants and/or corporate sponsors

- The number of businesses that participate in "Ocean Safe Coalitions" or take training to get involved in other BMP-related programs

- Number of positive stories placed in newspapers, television, radio

- The number of ordinances sponsored by the public to require stormwater/urban runoff pollution prevention measures (i.e., picking up dog waste)

Section 3: Summary of Pollutants by Watershed Management Area Within Los Angeles County

A well-targeted stormwater/urban runoff public education campaign prioritizes pollutants of concern, land uses and associated target audiences so that the education program results in the highest pollutant reduction per unit cost. According to the 1996 NPDES Permit issued by the California Regional Water Quality Control Board/Los Angeles Region, pollutants of concern in stormwater/urban runoff vary considerably throughout the County, depending upon hydrology, geology, land uses, weather patterns, and storm events. Chapter V of the Permit recommends that the Five-Year Public Education Plan target pollutants and the audiences that typically create them. Therefore, this report examines the many sources of information about pollutants in Los Angeles County stormwater/urban runoff including the following:

Pollutants Most Frequently Associated With Stormwater (Source: 1993 *California Stormwater Best Management Practices Handbook*)	Pollutants Found in Every County WMA (Source: L.A. County Dept. Of Public Works water monitoring records)	Pollutants Found in the County's Water Bodies (Source: RWQCB, 1996 *Draft Findings of Assessment*)
♦ sediment ♦ nutrients ♦ bacteria ♦ oxygen demanding substances, ♦ oil and grease ♦ heavy metals ♦ other toxic chemicals ♦ floatables including litter and debris	♦ heavy metals ♦ polycyclic aromatic hydrocarbons (PAHs) ♦ bacteria/coliform ♦ sediment ♦ litter/debris ♦ biochemical oxygen demand (BOD) ♦ oil and grease ♦ nutrients ♦ other toxic materials (pesticides, chlorine, etc.)	♦ heavy metals ♦ coliform ♦ enteric viruses ♦ pesticides ♦ nutrients ♦ PAHs ♦ polychlorinated biphenyls (PCBs) ♦ organic solvents ♦ sediments ♦ trash and debris ♦ algae and scum ♦ odor

Several studies have been conducted locally and nationally to identify potential sources of the pollutants detailed above. The following table describes the activities that typically generate the stormwater pollutants discussed above.

Residential Activities	Commercial/Industrial Businesses	New Development/ Construction Activities
♦ automobile use and maintenance ♦ do-it-yourself home improvements and maintenance ♦ landscaping and gardening ♦ pet waste ♦ septic tanks or sewer leaking ♦ littering	♦ automobile services ♦ food service industry ♦ fabricators and manufacturing ♦ building maintenance ♦ landscaping/landscape maintenance ♦ operation/maintenance of fuel burning equipment ♦ dumpster ♦ littering	♦ construction trades: painting, plumbing, electrical, etc. ♦ operation/maintenance of fuel burning equipment ♦ clearing/grubbing, earthwork, and grading ♦ landscaping/landscape maintenance ♦ portable toilets and dumpsters ♦ storage of materials ♦ littering

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Pollutants by Watershed Management Area (WMA)

The 1996 NPDES Permit approved by the Regional Water Quality Control Board/Los Angeles Region promotes a "Watershed Management Approach" to protect and enhance water resources. By working together, regulatory agencies, Co-permittees, environmental groups, and other stakeholders may achieve the greatest environmental improvements within each watershed and the entire County with the resources available to all participants.

Los Angeles County Watershed Management Areas (WMA)

Malibu Creek	Ballona Creek	Los Angeles River	Dominguez Channel/Los Angeles Harbor	San Gabriel River	Santa Clara River
Agoura Hills Calabasas Malibu Westlake Village Los Angeles County	Beverly Hills Culver City El Segundo Hermosa Beach Los Angeles Manhattan Beach Palos Verdes Estates Rancho Palos Verdes Redondo Beach Rolling Hills Rolling Hills Estates Santa Monica West Hollywood Los Angeles County	Alhambra Arcadia Bell Bell Gardens Burbank Commerce Compton Cudahy El Monte Glendale Hidden Hills Huntington Park La Canada-Flintridge Long Beach Lynwood Maywood Monrovia Montebello Monterey Park Paramount Pasadena Rosemead San Fernando San Gabriel San Marino Sierra Madre Signal Hill South El Monte South Gate South Pasadena Temple City Vernon Los Angeles County	Carson Gardena Hawthorne Inglewood Lawndale Lomita Torrance Los Angeles County	Artesia Azusa Baldwin Park Bellflower Bradbury Cerritos Claremont Covina Diamond Bar Downey Duarte Glendora Hawaiian Gardens Industry Irwindale La Habra Heights La Mirada La Puente La Verne Lakewood Norwalk Pomona Pico Rivera San Dimas Santa Fe Springs Walnut West Covina Whittier Los Angeles County	Santa Clarita Los Angeles County

Based on the Water Quality Assessment, combined with the County's historic monitoring record and past work conducted by Santa Monica Bay Restoration Project, specific groups of pollutants in each WMA can be targeted for focused public education and outreach.

The table below indicates in broad terms pollutants of concern for each of the WMAs and is based on the 1996 *Draft Water Quality Assessment* by the RWQCB. The data that currently exists only tells if a particular pollutant has been detected -- not how much or how little of it is present, or if the quantity of that pollutant is harmful to the environment. Monitoring data that will be available in approximately two years will enable pollutant loads to be calculated for each WMA. The pollutant load projections will allow for a more accurate method of identifying and quantifying the most problematic pollutants.

Overview: Pollutants of Concern Found in Water Bodies in Each Watershed Management Area[6]

	Malibu Creek WMA	Ballona Creek WMA	Los Angeles River WMA	San Gabriel River WMA	Dominguez Channel WMA	Santa Clara River WMA
Heavy Metals	x	x	x	x	x	x
PAHs		x	x	x	x	
Bacteria/Pathogens	x	x	x	x	x	x
Sediment/TSS, TDS	x	x	x	x	x	x
BOD	x	x	x	x	x	x
Nutrients	x		x	x		x
Oil and Grease		x	x			
Litter/debris	x	x	x	x		
Other Toxic Material		x	x	x	x	x

Listed on the following pages are the pollutants of concern historically detected in the watersheds of Los Angeles County. This information was published in the *Report of Stormwater Monitoring -- Winter 1994 - 1995* (Los Angeles County Department of Public Works, Environmental Programs Division, March 1996). Also listed are the pollutants of concern that were detected in major bodies of water in Los Angeles County. The Regional Water Quality Control Board/Los Angeles Region included this information in the draft *Water Quality Assessment 1996* which was prepared for the Basin Plan.

Samples in the County's earlier monitoring program were not analyzed for the presence of pesticides; therefore, they are not included in the historic record. However, as a result of the July 1996 NPDES Permit, monitoring and laboratory work have been expanded substantially, and it is anticipated that additional pollutants, including pesticides, will be detected in the future.

[6] *Draft Water Quality Assessment*, Regional Water Quality Control Board/Los Angeles Region, 1996

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Watershed Management Areas	Detected Pollutants of Concern -- Storm drains[7]	Detected Pollutants of Concern -- Water Bodies[8]
Santa Monica Bay WMA (combined the Ballona Creek and Malibu Creek WMAs)	♦ PAHs/volatiles Heavy metals: cadmium, chromium, copper, lead, nickel, and zinc ♦ Bacteria ♦ Total suspended solids ♦ Chlorides ♦ BOD ♦ Oil and grease ♦ Phosphorus ♦ Nitrogen compounds ♦ Total dissolved solids ♦ Sulfates ♦ Ammonium ♦ Nitrate-nitrogen ♦ Nitrite-nitrogen	**In Santa Monica Bay** ♦ Metals ♦ Debris ♦ Toxic materials ♦ Pesticides ♦ Coliform ♦ PCBs ♦ PAHs **In Ballona Creek/Wetlands** ♦ Metals ♦ Debris ♦ Toxic materials ♦ Pesticides ♦ Coliform ♦ PCBs ♦ PAHs ♦ Pesticides **In Marina del Rey** ♦ Coliform ♦ Metals ♦ Pesticides ♦ TBT **In Malibu Creek** ♦ Sediment ♦ Ammonia ♦ Debris ♦ Nutrients ♦ Metals ♦ Coliform **In Malibu Lagoon** ♦ Coliform and enteric viruses ♦ Metals
Dominguez Channel/Los Angeles Harbor Drainage Area	♦ PAHs/volatiles ♦ Heavy metals: chromium, lead, nickel, copper, zinc ♦ Bacteria ♦ Total suspended solids ♦ Chlorides ♦ BOD ♦ Oil and grease ♦ Phosphorus ♦ Nitrogen compounds ♦ Total dissolved solids ♦ Sulfates ♦ Ammonium-nitrogen ♦ Nitrite-nitrogen	**In Dominguez Channel** ♦ Metals ♦ Pesticides ♦ PAHs ♦ PCBs ♦ Ammonia ♦ Coliform ♦ Toxic materials **In Los Angeles Harbor (Inner)** ♦ Sediment ♦ PCBs ♦ TBT ♦ PAHs ♦ Pesticides ♦ Toxic materials ♦ Metals

[7] Los Angeles County Department of Public Works, *Report of Stormwater Monitoring -- Winter 1994 - 1995*
[8] California Regional Water Quality Control Board/Los Angeles Region, *Draft Water Quality Assessment 1996*

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Watershed Management Areas	Detected Pollutants of Concern -- Storm drains	Detected Pollutants of Concern -- Water Bodies
Los Angeles River	♦ PAHs/Volatiles ♦ Heavy metals, including chromium, lead, nickel, copper, zinc ♦ Bacteria ♦ Total suspended solids ♦ Chlorides ♦ BOD ♦ Oil and grease ♦ Phosphorus ♦ Nitrogen compounds ♦ Total dissolved solids ♦ Sulfates ♦ Ammonium-nitrogen ♦ Nitrite-nitrogen	**In Los Angeles River** ♦ Oil and grease ♦ Ammonia ♦ Total dissolved solids ♦ Coliform ♦ Debris ♦ Metals ♦ Toxic materials ♦ Pesticides ♦ Nutrients **In Long Beach Harbor (Inner)** ♦ PCBs ♦ PAHs ♦ Pesticides ♦ Toxic materials **In Rio Hondo** ♦ Metals ♦ Toxic materials ♦ Debris ♦ Sediments ♦ Coliform
San Gabriel River WMA	♦ PAHs/volatiles ♦ Heavy metals, including chromium, lead, nickel, copper, zinc ♦ Bacteria ♦ Total suspended solids ♦ Chlorides ♦ BOD ♦ Oil and grease ♦ Phosphorus ♦ Nitrogen compounds ♦ Total dissolved solids ♦ Sulfates ♦ Ammonium-nitrogen ♦ Nitrite-nitrogen	**In San Gabriel River** ♦ Metals ♦ Toxic materials ♦ Nutrients ♦ Coliform
Santa Clara River	♦ PAHs/volatiles ♦ Heavy metals, including chromium, lead, nickel, copper, zinc ♦ Bacteria ♦ Total suspended solids ♦ Chlorides ♦ BOD ♦ Oil and grease ♦ Phosphorus ♦ Nitrogen compounds ♦ Total dissolved solids ♦ Sulfates ♦ Ammonium-nitrogen ♦ Nitrite-nitrogen	**In Santa Clara River** ♦ Metals ♦ Total dissolved solids ♦ Toxic materials ♦ Nutrients ♦ Coliform

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Typical Sources of Pollutants

There are certain everyday activities that residents, business people and the construction industry do that generate the types of pollutants detected in the County's stormwater and urban runoff. The following table indicates the activities and commonly used products and materials that contain the pollutants that enter the storm drain system.

	Residential	Commercial/ Industrial	New Development/ Construction	Other
Heavy Metals				
Chromium	♦ Exterior paints and stains ♦ Auto use	♦ Paint ♦ Metal corrosion	♦ Cleaning products ♦ Exterior paints and stains	--
Copper	♦ Gardening products ♦ Root killers ♦ Auto use	♦ Auto services ♦ Metal fabricators ♦ Anti-fouling paints ♦ Manufacturing (e.g., electroplating) ♦ Fertilizers	♦ Cleaning products ♦ Plumbing materials ♦ Electrical wiring materials ♦ Wood preservatives	♦ Water supply
Lead	♦ Paint ♦ Batteries ♦ Auto use	♦ Auto Services ♦ Paint	♦ Plumbing materials ♦ Electrical wiring materials ♦ Paint	♦ Water supply
Nickel	♦ Auto use	♦ Metal plating ♦ Industrial uses		♦ Water supply
Zinc	♦ Roof runoff (galvanized) ♦ Paint ♦ Auto use	♦ Galvanizing ♦ Auto repair ♦ Paint ♦ Metal corrosion	♦ Plumbing materials ♦ Galvanized metals ♦ Venting systems ♦ Paint and pigments ♦ Wood preservatives	♦ Water supply
PAHs	♦ Motor oil dumping ♦ Oil leaks and spills ♦ Auto use	♦ Oil leaks and spills ♦ Fuel and oil combustion	♦ Oil leaks and spills ♦ Fuel and oil combustion	♦ Natural oil seeps ♦ Brush fires
Bacteria	♦ Pet waste ♦ Septic tank or sewer leaks ♦ Illegal connections ♦ Organic waste (from landscaping, etc.)	♦ Food waste ♦ Organic waste	♦ Portable toilets	♦ Wildlife

	Residential	Commercial/ Industrial	New Development/ Construction	Other
Sediment/Total Suspended Solids	♦ Erosion, landscaping ♦ Pavement wear	♦ Dust and dirt	♦ Grading, earth work ♦ Materials storage	♦ Natural erosion
Biochemical Oxygen Demand (BOD) Debris	♦ Landscaping, plant debris ♦ Pet waste ♦ Litter ♦ Other organic matter	♦ Landscaping, plant debris ♦ Litter ♦ Dumpsters	♦ Clearing and grubbing ♦ Landscaping, plant debris ♦ Litter ♦ Portable toilets ♦ Dumpsters	♦ Natural Vegetation
Nutrients	♦ Detergents ♦ Fertilizers ♦ Organic matter, lawn clippings and leaves ♦ Auto exhaust ♦ Manure	♦ Detergents ♦ Facility cleaning ♦ Fertilizers	♦ Landscaping graded areas, fertilizing	♦ Natural erosion ♦ Air depletion
Oil and Grease	♦ Waste oil dumping	♦ Auto services ♦ Restaurants ♦ Vehicle and machinery maintenance, oil leaks and spills	♦ Vehicle and machinery maintenance, oil leaks and spills ♦ Exposed materials storage	
Other Toxics	♦ Household toxic products ♦ Auto use and maintenance ♦ Paint ♦ Gardening and landscaping (pesticides and herbicides)	♦ Manufacturing ♦ Landscape maintenance (pesticides and herbicides)	♦ Adhesives ♦ Paint ♦ Fuels, equipment use and maintenance ♦ Materials storage ♦ Landscaping (pesticides and herbicides)	

Sources:

- *California Stormwater Best Management Practices Handbooks, Municipal, Industrial, Construction*, March 1993
- *Summary of the Bay Restoration Plan*, Santa Monica Bay Restoration Project, December 1994
- *Residential and Commercial Source Control Assessment* (draft), prepared for Water Environment Research Foundation, Larry Walker & Associates, Harris & Company, San Francisco Area Pollution Program Prevention Group, August 1996
- *Urban Targeting and Best Management Practices Selection*, Woodward-Clyde, November 1990

Conclusions

There is not enough monitoring data currently available to narrow the list of pollutants for a public education program that targets specific contaminants by watershed management area. However, the recent work of the County, Regional Water Quality Control Board and Santa Monica Bay Restoration Project indicates that the following pollutant groups should be included in targeted public education:

- Heavy metals
- Oil and Grease/PAHs
- Sediment
- Oxygen Demanding Substances
- Litter/Trash/Debris
- Nutrients
- Other Toxic Materials, such as pesticides

Additionally, the activities that generate these pollutants should be the focus of targeted public education. Until more detailed monitoring data is available, and stormwater pollutant loads can be calculated for each watershed management area, the following everyday activities should be targeted.

Residential Activities	Commercial/Industrial Businesses	New Development/ Construction Activities
♦ automobile use and maintenance ♦ do-it-yourself home improvements and maintenance ♦ landscaping and gardening ♦ pet waste ♦ septic tanks or sewer leaking ♦ littering	♦ automobile services ♦ food service industry ♦ fabricators and manufacturing ♦ building maintenance ♦ landscaping/landscape maintenance ♦ operation/maintenance of fuel burning equipment ♦ dumpster ♦ littering	♦ construction trades: painting, plumbing, electrical, etc. ♦ operation/maintenance of fuel burning equipment ♦ clearing/grubbing, earthwork and grading ♦ landscaping/landscape maintenance ♦ portable toilets and dumpsters ♦ storage of materials ♦ littering

School education should emphasize stormwater/urban runoff public education in ways that facilitate students' passing along better habits to their parents/caregivers and that provide the foundation for nonpolluting habits as children grow into adulthood. Student education should focus primarily on BMPs associated with residential activities.

Lastly, municipal employees should incorporate BMPs associated with both commercial/industrial and new development/construction activities to their everyday work habits. This enables the County and Co-permittees to:

- reduce their own contributions to stormwater/urban runoff pollution;
- serve as role models for others in the county; and,
- empower municipal employees to pass along their own experiences/successes with BMPs to the public they encounter during work.

Section 4: Analysis of Co-permittee Programs

Interviews With Co-permittees

Telephone interviews were conducted in July, August and September 1996 with 58 of the 85 Co-permittees to solicit the following information:

- What individual cities have been doing to date to educate constituents about stormwater/urban runoff issues
- The unique needs of the cities as they apply to stormwater public education (e.g., multiple language materials)
- Local issues and insights for the Five-Year Plan

Each interviewee was asked the same six questions. These questions formed the core of the interview and were used as a starting point for an open dialogue. Interviewees were encouraged to elaborate on their responses to the questions and to freely offer all information they felt important to share. The core six questions were:

1) Who are the appropriate target audiences for stormwater/urban runoff public education in your city?

2) What stormwater pollution prevention public education resources/materials and programs are already available and being used in your city? How are they distributed/implemented? How long have they been out? Do you consider them effective?

3) Are there existing city newsletters, local access TV, or other methods of communications that could include stormwater messages?

4) What materials/programs would you like to see developed in the Five-Year Plan that would be particularly helpful to your city?

5) With respect to the public education element of the NPDES Permit, what will pose the most difficult challenge(s) to you as the stormwater program manager?

6) Are there any specific stormwater-related issues in your city that you would like the County and the stormwater team to keep in mind as the Five-Year Public Education Plan is developed?

Overall there is strong support among the Co-permittees for the public education component of the NPDES Permit. In addition, there is interest in unifying the public education messages and materials on a countywide basis to ensure continual and consistent reinforcement of positive pollution prevention behaviors regardless of the recipient's geographic location. In varying degrees of concern and importance, the public education managers discussed (1) lack of funding; (2) limited staff resources; (3) ethnic diversity of residents; (4) community geographic location and its bearing on the receptivity to messages; (5) success or lack of success of existing programs; (6) "wish list" programs; and, (7) and evaluation methods.

The following findings and comments came from the interviews and are applicable to current situations within each city and hold implications for the Five-Year Plan.

♦ Target Audiences

Target audiences cannot always be contained within a specific city or Watershed Management Area. On a daily basis, people travel from area to area, city to city, even county to county, for business, recreation and home.

Eighty-one percent (81%) of the Co-permittees identified the ***general public*** among their most important target audiences because they are the largest contributors to the countywide pollution problem. Eighty-three percent (83%) said that ***commercial businesses/industries*** were equally important. There is a strong interest in protecting the interests of businesses; making certain that stormwater pollution management does not cause loss of business or jobs, or weaken an already tenuous business climate.

School children were identified by 55 percent (55%) of the Co-permittees as important targets because of the ability to incorporate messages into existing school curriculums, children's natural interest in their surroundings, and the fact that children are a source of education when they carry information and questions home to their parents.

Schools are overwhelmed with requests for teachers to educate students about many different environmental and social issues. In order to compete with other programs trying to get into schools, stormwater school education materials and activities must be what teachers really need -- broad environmental information without agendas or partisan approaches, application to specific age groups, integration into several subjects, strong supporting activities and easy resources for additional information.

Countywide, Co-permittees indicated little interest in ***municipal employees*** and ***new development/construction*** target audiences for stormwater public education despite the fact that the Permit requires targeting these audiences. However, some Co-permittees recognized that municipal employee training was key to "having our house in order" and providing a model for the rest of the County's population. It should be noted that when the Alameda County public education program was kicked off, it did not have a municipal employee BMP training program. This omission created an initial negative impression that had to later be corrected in order to regain credibility.

With regard to the new development/construction target audiences, some Co-permittees were more concerned about their smaller remodeling and in-fill projects than about the larger construction jobs planned for the communities. The primary reason is that BMPs are well-developed for the larger jobs, and stormwater pollution prevention design measures are available for projects that have ample acreage. But smaller projects, which are often confined to sites as small as a single city lot, have significantly fewer BMPs and fewer design options to help them comply with stormwater/urban runoff prevention regulations. BMP development for situations such as this should be addressed with Co-permittees, contractors and the development field countywide.

Special needs audiences within some of the broader categories that have unique needs include landscape maintenance businesses, low-income and illiterate residents, and livestock owners. Co-permittees expressed an interest in having programs that target these special groups and other small businesses.

♦ Unified, "Corporate" Look

There also was consistent support for developing public education materials with a unified, corporate appearance. Approximately one-third of all Co-permittees interviewed mentioned their interest in this component of the Five-Year Plan.

A unified look will identify any stormwater/urban runoff materials and their own special entity and will set the tone and feel for the entire communications program. Once established, the unified look will become the way all targeted audiences instantly can identify the program and know that the information contained within relates specifically to solutions for stormwater pollution. Many of the Co-permittees also commented stormwater/urban runoff messages would be reinforced if the public saw a unified program on a countywide basis.

♦ Cost-Effective, Easy Production and Implementation

There is strong interest in a program that is "turn-key," considering limited staffing and funds available to many Co-permittees. There should be opportunities for cities to individualize materials that are prepared and distributed on a countywide partnership basis. For example, computer disks of artwork could be provided so that Co-permittees can incorporate their own contact names and telephone numbers.

Co-permittees discussed the viability of pooling information, vendor and funding resources to produce professional videos and advertising to get their umbrella theme and messages across to the public. Collaboration between existing stormwater public education programs is necessary to avoid duplication of efforts and to take advantage of good, existing materials while working jointly on future materials.

Integration of stormwater public education with other environmental and pollution prevention programs that already are in place (e.g., solid waste and waste oil recycling programs) is a logical step and an economical use of cities' resources in several departments.

In some communities, the Chambers of Commerce have joined efforts to help. Specifically, one chamber facilitated input from local businesses (e.g., architects and developers) as stormwater public education materials targeted to those businesses were being developed. In another, the Chamber hosted presentations given by the County Department of Public Works. Many opportunities exist throughout the County to utilize more organizations (e.g., business and trade associations, networking groups) as avenues of distribution with systems and audiences already in place.

♦ Information Distribution Methods

Sixty percent (60%) of the interviewed Co-permittees currently distribute brochures and/or posters originally prepared by the County or City of Los Angeles. Most distribution is accomplished by placing materials on public counters for easy pick up. However, as noted in Section 2, concern was expressed that the materials generally were not being picked up and when they were, there was no way to know if they were read or used.

Several Co-permittees felt that too many different brochures are being printed, utilizing too many natural resources for the return in public education value. Further discussion should be held on whether collateral materials are the best means of communications, or whether other, more efficient methods should be used to reach the Los Angeles County audiences.

More than 75 percent (75%) of the cities have newsletters and a cable access television channel, but an average of less than half have used either of these media for stormwater public education.

Co-permittees believe the obstacle with cable access television is that it is viewed by a very small portion of the overall community population and therefore is not an efficient use of limited funds. However, several interviewees suggested running a scrolled message about stormwater pollution on all the community cable stations across the County -- the same message, simple graphics, no video pictures, no/low production cost, wide distribution.

Several Co-permittees expressed an interest in a catchy Internet homepage that would be applicable to school children in the classroom and the growing portion of residents who "surf the Internet." According to a national report published in the September 23, 1996 *Los Angeles Business Journal*, the greater Los Angeles area is one of the most active users of the Internet. "Los Angeles is an Internet city. It's on the information superhighway," said Sky Dayton, chairman and chief executive officer of EarthLink Network, Inc.

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Co-permittees in some cities have recruited students and Eagle Scouts to distribute materials with varying degrees of success. They found that high school students are good peer educators because they find meaning in the work and, as their peers, other students are more willing to listen to and believe them.

Other methods of distribution utilized by the Co-permitees in varying degrees and with varying successes include school programs, community and environmental events, media relations and advertising.

Finally, the Co-permittees wanted the telephone hotline number to be restructured so that the countywide public need only to call one phone number.

♦ Cultural Diversity and Languages

There was a consistent recognition of the need for public education materials and strategies that accommodate non-English speaking audiences. Approximately one-third of all of the Co-permittees mentioned that their constituents spoke languages other than English.

While Los Angeles County has a widely diverse population, public education materials and strategies should avoid using cultural stereotypes that may not be appropriate or appreciated by the ethnic community[9].

♦ Best Management Practices

Best Management Practices brochures should be developed that can be used countywide. These need to be industry-specific and give enough information for audiences to implement changes that are logical and simple, yet significant. The specific targets of BMP materials should be carefully assessed. For example, in a restaurant, who actually has the greatest potential to dump oil and grease improperly? Is the appropriate target the kitchen workers, their supervisors, the restaurant manager or owner, or the property owner?

When talking about targeting and distribution of BMPs for "do-it-yourself" oil changes, an example of a weak target is residents of financially upscale communities who generally do not change their own oil. This is a function performed by automobile service businesses and these businesses, not the residents, should be the primary target of this type of education in certain communities.

In most cases, businesses need financial incentives to comply with Stormwater Best Management Practices. A possible incentive is to offer reduced business license fees for implementation of BMPs. While there currently are few working models of this incentive program, it has been discussed by several cities in California and other states. One example is Santa Clara County, which has reduced industrial permit fees for attending workshops conducted by the County, and then conducting self-audits.

[9] See Section 5, Cultural Issues.

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In another example, Manhattan Beach businesses are rewarded for their "Ocean Safe" plans with recognition by the City Council and identification stickers for their store windows.

Landscape workers were noted as an important group to include in Best Management Practices training. However, their clients should also be included in the training to ensure that they understand the workers' efforts and that environmental practices are correct and according to appropriate policy; and not mistaken as doing the job wrong.

♦ Inland Communities

Inland communities said that the Five-Year Public Education Plan and the printed materials should reflect not only the County's bays and beaches, but also rivers and creeks upstream. In fact, some of these communities said that materials that focused only on beaches and bays would alienate their constituents who rarely go to the beach. One of the messages used in the inland communities is neighborhood or city beautification.

By the same token, the Five-Year Plan should take into consideration the fact that stormwater pollution occurring upstream adds to the challenges for communities downstream. These communities not only have to provide public education related to the stormwater pollutants that are generated in their city limits, but also have to deal with the problems that flow from sources upstream.

An example of upstream pollution floating down is the City of Long Beach which continually deals with litter and sediments that blight the shipping channel from up-river pollution.

Public education materials need to be universal in consideration of the other water bodies involved. In Los Angeles County, there are rivers, creeks, lakes, harbors, beaches and bays -- not just beaches and bays.

♦ Needs and Issues by Watershed Management Areas

During the interviews, Co-permittees provided many insights based on personal experience with the target audiences, needs and issues within Watershed Management Areas.

WMA	Target Audiences	Needs	Issues
Malibu Creek	33% said materials in languages other than English are needed 33% said there were special needs in the city (e.g., landscape maintenance services) 33% many restaurants and/or automobile-related businesses	33% needed technical assistance related to training	33% concerned about being able to measure effectiveness 33% short on staffing and want easy implementation 66% stressed interest in school programs
Ballona Creek	11% ethnicity is important consideration 11% materials in other languages are needed 44% special needs (e.g., horse owners, low income, illiteracy, landscape maintenance)	11% needed technical assistance re: BMPs 22% needed technical assistance re: training 11% want to combine environmental issues (e.g., recycling, waste oil) 33% unified countywide approach 11% want polished looking materials 11% want easy-to-understand and to practice materials 22% need more information re: educational visits	44% concerned about measuring effectiveness 33% short on staffing and want easy implementation 11% short on funding 11% worried about alienating local businesses

Note: Percentages reflect the frequency that select comments were received. They do not necessarily add up to 100%.

WMA	Target Audiences	Needs	Issues
Los Angeles River	38% ethnicity is important consideration 24% materials in languages other than English are needed 24% special needs (e.g., horse owners, low income, illiteracy, landscape maintenance)	19% beach/ocean focus in materials will turn-off residents 5% need technical assistance re: BMPs 14% need technical assistance re: training 14% want to combine environmental issues (e.g., recycling, waste oil) 5% unified countywide approach 5% want ability to insert city's name/logo on materials 5% want polished looking materials 10% want videos 14% want easy-to-understand and to practice materials	10% concerned about being able to measure effectiveness 19% short on staffing and want easy implementation 14% short on funding
San Gabriel River	30% ethnicity is important consideration 40% materials in languages other than English are needed 10% special needs (e.g., gangs)	20% beach/ocean focus in materials will turn-off residents 10% need technical assistance re: BMPs 20% need technical assistance re: training 30% want to combine environmental issues (e.g., recycling, waste oil) 40% unified countywide approach 10% want ability to insert city's name/logo on materials 20% want polished looking materials 10% want videos 20% need more information about educational visits 10% want a business incentive program	10% concerned about being able to measure effectiveness 10% short on staffing and want easy implementation 20% short on funding 30% worried about alienating local businesses 10% suggested pursuing funding grants for the Five-Year Plan 10% expressed strong interest in school programs

WMA	Target Audiences	Needs	Issues
Santa Clara River		Beach/ocean focus in campaign materials will turn-off residents Need technical assistance re: training	Concerned about being able to measure effectiveness Is short on staffing and want easy implementation
Dominguez Channel/Los Angeles Harbor		10% need technical assistance re: BMPs 10% need technical assistance re: training 10% want to combine environmental issues (e.g., recycling, waste oil)	10% concerned about measuring effectiveness

♦ Program Evaluation

While most Co-permittees do not have an effective method for measuring the results of their public education campaigns, they are interested in knowing what can be done to measure their success or lack of success. Of the 58 Co-permittees interviewed, 18 felt -- without being able to conclusively prove -- that their programs were effective. They based these "feelings" on informal information like the number of brochures/information picked up, the increased number of telephone calls to a specific number and increased participation in household hazardous waste roundups. One program tried a more formalized method to evaluate success and distributed materials to residents with tear-off response cards to complete and mail back. The number of cards returned has been very low -- 25 completed cards from a mailing of 1000. This represents a two percent (2%) response rate which is considered by direct mail experts as the lowest acceptable response level. This may not, however, reflect the effectiveness of the communications effort.

Target Audiences by Watershed Management Area

The following table details the level of interest expressed by the Co-permittees in each WMA[10] for information by target audience.

Co-permittee Priorities For Materials By Targec Audience

Malibu Creek	Ballona Creek	Los Angeles River	Dominguez Channel/Los Angeles Harbor	San Gabriel River	Santa Clara River
100% Gen. Pub. 66% Comm. Bus./Industries 0% New Dev./ Construct. 33% Schools 33% Municipal Employees	89% Gen. Pub. 78% Comm. Bus./Industries 22% New Dev./ Construct. 33% Schools 22% Municipal Employees	86% Gen. Pub. 95% Comm. Bus./Industries 38% New Dev./ Construct. 57% Schools 19% Municipal Employees	100% Gen. Pub. 33% Comm. Bus./Industries 0% New Dev./ Construct. 33% Schools 0% Municipal Employees	70% Gen. Pub. 70% Comm. Bus./Industries 0% New Dev./ Construct. 50% Schools 10% Municipal Employees	General Public Commercial Businesses/ Industries Schools

Gen. Pub. = General Public
Com. Bus./Industries = Commercial Business/Industries
New Dev./Construct. = New Development/Construction

[10] See Section 3 for complete listing of cities within each WMA

Materials, Distribution Methods and Effectiveness by WMA

The following table represents a summary of responses from the Co-permittees regarding their methods and successes with materials and information distribution avenues. The numbers in parenthesis are the number of Co-permittees in the Watershed. When reviewing the percentages reflected in this table, please note the total cities counted. For example, 25% of a watershed with four cities equals only (1) one city.

	Malibu Creek (4)	Ballona Creek (13)	Los Angeles River (32)	San Gabriel River (28)	Dominguez Channel/ LA Harbor (7)	Santa Clara River (1)
Print Materials						
Use Co./City materials	50%	56%	33%	70%	67%	No
Use other prog. materials	25%	44%	10%	rarely	rarely	No
Produce own materials	25%	56%	10%	50%	33%	Yes
Dist. at kiosks/counters	25%	44%	33%	80%	67%	Yes
Mail to public	rarely	11%	rarely	30%	rarely	Yes
Mail to business	rarely	22%	5%	20%	rarely	Yes
Dist. by field personnel	N/A	N/A	N/A	N/A	N/A	Yes
Media						
Have city newsletter	50%	67%	76%	70%	100%	
Use city newsletter	25%	33%	33%	40%	33%	
Have local cable TV	75%	78%	62%	70%	100%	
Use local cable TV	rarely	11%	10%	10%	33%	
Use newspaper articles	rarely	22%	10%	10%	rarely	Yes
Events						
Use events	rarely	11%	14%	30%	33%	Yes
Training/Seminars						
Conduct public seminars	rarely	11%	5%	rarely	rarely	No
Employee BMP training	rarely	rarely	5%	rarely	rarely	No
Business BMP training	rarely	11%	rarely	rarely	rarely	No
School Programs						
Use school education	few	22%	few	10%	few	Yes
Bus. Incentives						
Use business incentives	rarely	11%	rarely	rarely	rarely	
Internet						
Have Website / interested	few	22%	few	10%	few	Has Page
Effectiveness						
Cannot measure	50%	33%	33%	80%	33%	True
Believe efforts effective	25%	22%	10%	20%	33%	
Efforts not effective	few	11%	few	10%	33%	

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Section 5: Cultural Issues

Defining the Populations

Los Angeles County's population is evolving at a rapid pace, with a marked pattern of increased racial and cultural diversity that will continue through the next five years -- and into the next century. For example, the County's Latino population, already well past 2 million, is growing rapidly as evidenced by the school population: currently, more than 65 percent of Los Angeles County kindergartners and 58 percent of all County school children are Latino. And according to the latest U.S. Census, Latinos and Asian/Pacific Islanders (APIs) are the fastest-growing populations in the County, with the growth rate in each group increasing at a rate of 50 to 100 percent per year.

Clearly, these diverse populations will be on the receiving end of stormwater/urban runoff education. Their increasing population alone, and their participation in target businesses such as restaurants, automotive services and landscaping validates further research into cultural nuances and possible messages that may need to be communicated these groups.

♦ County Demographics (18 years and older)

According to the 1990 U.S. Census, the adult population of Los Angeles County is:

African American	677,767
Latino	2,346,893
White	2,864,306
Other	88,075
Total	**5,977,041**

Note: the above numbers reflect the vast undercount of Asian Pacific Islanders in the Census. This is largely attributed to lack of participation because of language and cultural barriers, and lack of understanding of the importance of Census participation. The U.S. Census was used instead of the California Department of Finance because, until 1996, the Department of Finance did not include Asian Pacific Islanders in their projections.

The 1990 U.S. Census shows the County's total API population (all ages) at nearly more 1 million people, or 10 percent of the total population. Subgroups[11] of the larger API population include:

Chinese	25.7%	Japanese	13.6%
Filipino	23.0%	Vietnamese	6.6%
Korean	15.2%		

[11] These percentages reflect only the larger API subgroups

Communicating to Ethnic Audiences

The following section summarizes existing issues and conditions in Los Angeles County that are crucial to public education and outreach to diverse ethnic groups. Specifically, this section:

- Identifies issues that are important to the County's various ethnic communities

- Identifies key community leadership/messenger positions that must play a major role in any public education and outreach efforts to ethnic groups

- Identifies L.A. economic conditions that have affected minority residents and have caused a strong emphasis on survival issues among the County's minority communities. These conditions make it even harder for businesses to be concerned with environmental issues

- Contains information about the importance of interpretation and adaptation -- rather than mere translation -- to non-English speaking groups, and the importance of messages that are relevant to specific cultures

- Summarizes public awareness surveys conducted for the Los Angeles County Department of Public Works in 1995 and 1996 that relate how environmental information is received by various ethnic groups and preferred methods for outreach

Developing Program Messages

♦ Key Messages, Communication Vehicles & Special Issues

Stormwater public education messages will be effective to the degree that research is conducted and baseline information is used to identify key messages and messengers. To be successful, any messages targeting these groups need the endorsement and active involvement of local ethnic leaders who are critical models for Latino, African American and Asian/Pacific Islanders individuals and businesses. Our focus should include:

- Local business and community leaders
- Community-based organizations
- Local news media, including foreign language media
- Local elected and appointed officials

Moreover, further research is warranted regarding the way messages are delivered so they are meaningful to these target audiences. For example, program messages may include "neighborhood pride" for residents, "good-for-business/better business environment" for small businesses and "stewardship of resources" for church-based organizations. These messages may be better received in Latino, African American and Asian/Pacific Islander communities than traditional environmental approaches.

Some studies show that recent Latino and API immigrants tend to bring a weak environmental ethic from their former homes and may require education that is properly aimed at their needs and values. Conversely, acculturated immigrants and first and second generation populations may gain as much or more from a general public campaign than one targeted to their ethnic community.

Non-English language research is necessary to ensure that non-English language messages are received as they are intended and are most appropriate for the audiences. From all indications, clear, concise messages that consider idiomatic differences in language may also be crucial for ethnic groups. For example, when Kentucky Fried Chicken tried to translate its slogan "Finger Lickin' Good" for advertising in Taiwan, it came out "Bite Your Fingers Off."

In another example, the term "environment" for many minority communities may be understood as "environmental justice" -- a highly sensitive connotation to these audiences. Vice President Al Gore discussed environmental justice as follows: "...environmental burdens are disproportionately placed on disadvantaged and minority communities." For this reason, environmental issues will need to be positioned with sensitivity to communities that have been or will be the focus of construction-oriented outreach. For example, communities that have become sensitized regarding "environmental justice" are those affected by the construction of the Blue Line Light Rail, Pacific Pipeline, the Alameda Corridor Project, and in the San Gabriel Valley, the presence of Superfund groundwater sites.

In all materials, words and visuals must be culturally sensitive. During interviews with Co-permittee stormwater managers conducted for this study, one Co-permittee commented that, even though research has shown many Latinos are "do-it-yourselfers," presenting this scenario in public education materials has often been interpreted by the Latino community as a negative.

In addition, for APIs, the campaign must consider the language and cultural differences among the various subgroups if multiple language materials and outreach are to be developed -- this is not a homogenous group.

♦ Businesses

Minority-owned small business and their operational practices represent a full range of environmental protection measures -- from the best to the less than successful. Because the County and City of Los Angeles consistently rank first in the number of small businesses owned by Latinos, African Americans and Asian Pacific Islanders, these business owners are important targets to receive stormwater/urban runoff campaign messages.

In many cases, employment -- and sheer survival -- are the urgent issues for these businesses. These businesses may be poorly capitalized and their profit margins quite slim. This and other data indicates that environmental messages will be best received when they are directed at the positive affects on the economy of individual businesses.

Current Level of Stormwater/Urban Runoff Awareness

The Sierra Group conducted a public awareness survey of stormwater/urban runoff issues for the County of Los Angeles. The research included the ways various groups receive information.

	Overall	Asian/ Pacific Islanders	African American	Latino	White	Other
Newspapers	63%	68%	59%	55%	73%	64%
Broadcast T.V.	63%	66%	65%	72%	55%	61%
Radio	24%	23%	18%	27%	22%	24%
Cable T.V.	15%	14%	18%	13%	15%	19%
Magazines	12%	11%	10%	10%	14%	12%
Brochures	6%	5%	9%	6%	5%	7%
Newsletters	6%	5%	6%	5%	6%	6%
Billboards	5%	6%	8%	5%	4%	8%
School Child	4%	2%	4%	4%	3%	5%
Other	4%	7%	4%	3%	5%	5%
Don't know/NA	0%	0%	0%	0%	0%	0%

Ethnic language newspapers, television and radio are key to reaching large culturally and linguistically isolated segments of the County's population. The City of Los Angeles has a recent experience to prove the point -- recent success in a public service announcement program prepared for Spanish-language radio stations was a significant success.

Spanish radio stations also have been shown to be an effective medium to communicate information related to BMPs on automobile maintenance to this population segment. For example, the Marketing Research Survey of "Do-it-Yourselfers" conducted by The Sierra Group with Godbe Research and Analysis indicates that almost 75 percent of Spanish-speaking males in the survey changed their own oil. It also concluded that this audience listens to Spanish radio stations.

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Section 6: Review of Public Education Materials and Programs Conducted In Other Parts of The Country

Background

Stormwater and pollution prevention public education materials were requested for this research report from agencies and organizations located throughout the United States. Nearly 500 brochures, flyers, door-hangers, videotapes, school programs, posters, bumper stickers, and various guides and manuals were received from 25 states. Discussions in this section focus on materials received from the San Francisco Bay, Puget Sound, the Great Lakes, Massachusetts Bay, Narragansett Bay, Chesapeake Bay, the Florida coastline, and the Gulf of Mexico. Materials were also received from non-coastal communities in Arizona, Colorado, Iowa, and Texas. More detailed information about programs within the Southern California region is included in Section 4.

The audiences for the major programs that were examined varied between 500,000 and 14.2 million. Only Chesapeake Bay's program involves more people than the County of Los Angeles' 9 million residents.

	Population
♦ Chesapeake Bay Area	14,200,000
♦ Los Angeles County	9,000,000
♦ Los Angeles, California	3,500,000
♦ Dade County, Florida	2,000,000+
♦ Santa Clara County, California	1,700,000
♦ King County, Washington	1,600,000
♦ Alameda County, California	1,350,000
♦ Seattle, Washington	500,000
♦ San Francisco, California	750,000
♦ Milwaukee County, Wisconsin	650,000
♦ Greenville, Texas	18,000

Sources: *Rand McNally Commercial Atlas and Marketing Guide*, 1996;
"Pollution Prevention in our Cities and Counties," Fall 1995
Internet, Chesapeake Bay Program

Summary of Observations: Overall Programs

There is an abundance of materials being disseminated by programs throughout the United States, some of which are outstanding and will be very useful to the Los Angeles County program. However, many of the materials are too regionally oriented or too technical to fit the countywide program. Additionally, this team's evaluation found the programs and strategies from other programs extremely interesting; but the individual materials were not as strong as some of those we found in California. Specifically, we felt the graphics and text could have been stronger for the adult populations. Our exception to this observation was the materials for children, which were very good. Following are specific observations:

- Multiple jurisdictions are involved in most major stormwater programs and while the Chesapeake Bay program targets a larger population, none have as many Co-permittees or partnerships as the Los Angeles County program. For example: The Chesapeake Bay program involves three states, Washington D.C. and four agencies; the Milwaukee (Great Lakes) program targets 27 cities; the Alameda Countywide program has 14 Co-permittees; the Puget Sound is the focus of at least five public education programs conducted by King County, the Puget Sound Water Quality Authority, and the Cities of Seattle, Bellevue and Olympia.

- No stormwater/urban runoff program has yet to discover the message/concept that is equivalent to the "3Rs of Recycling -- Reduce, Reuse, Recycle."

- Several programs are producing quality products being adapted for use by others. Among them are: City and County of Los Angeles; Heal the Bay; Santa Clara Valley Nonpoint Source Pollution Prevention Program; Alameda County Urban Runoff Clean Water Program; San Francisco Pollution Prevention Program; Bellevue Washington; and Milwaukee.

- There is much "reinventing the wheel." The apparent reasons are:

  - Education materials produced by most programs are designed for specific audiences and use text and graphics that highlight local characteristics (e.g., the creeks of Northern California vs. the Great Lakes). While there will always be a need to customize materials, consistent themes can unify the overall campaign.

  - Few regions coordinate their education efforts. The statewide California Stormwater Task Force, Public Information and Involvement Program subcommittee is an exception to this, as it is also a vehicle for coordination. Yet materials being produced throughout the State have widely varying appearances and programs that are tailored to their local audiences, because the task force coordination is meant to assist the various programs rather than unify them under a common look or strategy.

- The messages conveyed in the educational materials reviewed have focused on raising awareness and understanding -- that the public, as individuals, are the nonpoint sources contributing everyday to the most significant water pollution problem still persisting in the United States. As a motivator to change behavior, the materials stressed the fact that the protection and future enjoyment of bodies of water depend upon each individual's efforts to make the changes necessary to reduce their portion of the pollutant load. Most of the materials included lists of activities that people could do to reduce pollution, to give concrete examples of individual actions that can be taken.

- Early stormwater public education programs focused on grassroots strategies, such as community participation in events, use of advisory committees, demonstration projects, workshops, and distribution of educational materials. Some of these programs have been in place for more than a decade -- and cleaner water quality has been measured as a result. One example is the Puget Sound, where, according to the public education manager for the Puget Sound Water Quality Authority, improvements in water quality have been accomplished. The manager attributed this measurable success to a comprehensive stormwater management plan, of which public education is a significant part.

Summary of Observations: Print Materials

- Most materials do not have a unified appearance and no stormwater/urban runoff program has yet created a representative graphic symbol on *how to* prevent stormwater pollution (e.g., "Reduce, Reuse, Recycle" or the chasing arrows of recycling.)

- The best materials were concise, used good illustrations and provided information that is practical and easy for the average person to understand and incorporate into his/her daily life. Materials that have been adapted for use by other programs tend to be very strong in both graphics and text.

- As it is relevant to Los Angeles County, preliminary research shows that California audiences respond best to materials aimed at specific target audiences, by ethnicity as well as age, and at common activities that produce pollutants. Examples[12] of stormwater programs that have effectively used these aspects of a targeted approach for large populations include: City of Los Angeles, Santa Clara Valley Nonpoint Source Program; Alameda County Urban Runoff Clean Water Program; and San Francisco Pollution Prevention Program.

[12] Does not reflect an all inclusive list.

Summary of Observations: Media Programs and Advertising

When publicity reinforces public education/outreach activities, greater success has been measured.

- In Greenville, Texas, a public education program was launched to reduce the levels of pesticides being detected in wastewater treatment plant effluent (after-treatment) and violations were issued by regulators on a regular basis. No treatment methods were available to reduce the specific pesticide, diazinon. The only option to achieve regulatory compliance was for the public to reduce diazinon usage. Greenville's public education program employed a wide range of grassroots strategies, but most important, it publicized every activity in local newspapers, magazines and radio. The end result was overwhelming public cooperation; levels of diazinon in effluent dropped and the regularly issued violations stopped.

- In the Puget Sound area, water quality is measurably better today than a decade ago, when several stormwater/urban runoff education programs were just getting underway. One element of the program has been broad print media coverage, and most recently, television advertising.

- In Los Angeles County, Heal the Bay has worked extremely well with the media to effectively gain awareness of stormwater issues, including the 1996 NPDES Permit. Annual media coverage is given to Heal the Bay's annual beach report card. As noted in Section 7, the organization was the number one source for technical information in newspaper articles.

Advertising, particularly billboards, has successfully raised awareness in several programs, including:

- The County and City of Los Angeles partnered to produce a billboard and bus shelter campaign in 1996. These messages are highly visual, and by joining forces, the City and County were able to reinforce stormwater messages over a broad region. This campaign was nominated for the 1995-96 Productivity Award, given annually by the County Productivity Commission.

- A billboard and bus shelter advertising campaign is underway in San Mateo County with the theme message, "A drop of oil goes a long way." The graphic that accompanies this message is a stylized upside-down fish.

- According to its "Pure Water" newsletter, the Alameda Countywide Urban Runoff Clean Water Program conducted surveys that documented a 34 percent increase in awareness of stormwater issues that resulted from a billboard campaign in 1994. The survey determined that 29 percent of the population had changed their behaviors as a result of this campaign.

Summary of Observations: Storm Drain Stenciling

- Nearly every community surveyed in the United States has some kind of storm drain stenciling program. In fact, public awareness polls in Santa Clara County determined that storm drain stencils are the number one medium for the public to become aware of stormwater pollution issues.

- The City of Oakland has not only recognized the effectiveness of storm drain stenciling, but also tried to reach more of its diverse population by stenciling in English, Spanish and Chinese.

Summary of Observations: Partnerships With Businesses

- Point-of-purchase campaigns have not been used to their full potential, but the oil recycling campaign conducted jointly by San Mateo County and Pennzoil demonstrates how effective they can be. Highly attractive stormwater/waste oil educational materials, a free oil funnel, and a display stand were distributed in automotive shops that carry Pennzoil products. The campaign resulted in a 12 percent increase in waste oil received at San Mateo's recycling centers.

- Clean business recognitions -- such as the Ocean Safe Coalition -- have been developed in several areas, including Southern California. Case studies in the area of pollution prevention have shown that businesses have actually saved money by following pollution prevention practices (many of which are similar to stormwater/urban runoff BMPs). This financial aspect will be crucially important to many of the County's smaller businesses. Businesses that have participated in these types of programs have received recognition and publicity for their efforts.

- Donated services by businesses are common in many stormwater programs. The City of Los Angeles reports that it has received more than $1 million in donated billboard advertising space, and more than $1 million in television, radio and theater advertising time for its public service announcement (PSA) and $250,000 in donated services related to making the PSA. These donations equaled more than the City's total budget for two years of stormwater public education.

Summary of Observations: School Outreach

- Some of the printed materials for children were excellent; others were not age-appropriate. The latter group used illustrations for grade-school children but the text was so technical that it would be more appropriate for junior or senior high school students. Literacy levels must be taken into consideration for school-aged audiences *and* adults.

- Most school education programs placed higher emphasis on activities associated with stormwater education than on printed materials. The school programs that appear to be most successful feature activities such as field trips, classroom experiments, creek monitoring and interactive theatrical presentations.

Summary of Observations: Collective and Cooperative Efforts

The following are summaries of the best education materials from cities/communities most applicable to the Los Angeles County program. In general, they meet the following criteria: (1) contain good information; (2) visually interesting; and, (3) easy to understand.

The materials described below originated outside Los Angeles County. The team searched for good materials being used elsewhere in order to borrow their best ideas that are applicable for the County. It is important to note that there are many excellent materials being produced within Los Angeles County. These are not included here because they already are familiar to stormwater public information managers countywide.

- **Alameda Countywide** Urban Runoff Clean Water Program and the **Santa Clara Valley** Nonpoint Source Program

  - These two programs have shared in the development of many of the publications described below. The materials were prepared in a way that only one printed panel needed to be customized for each of the separate programs -- all other parts of the brochures were identical.

  - These programs found that the cooperative efforts saved money in terms of design, production and printing, and unified the messages regionwide.

- **San Francisco Bay Area** Programs Collectively

  - The appearance of the Alameda, Santa Clara and other San Francisco Bay Area programs is uniform and corporate in appearance. Water-color graphics illustrate most materials for general public audiences. Illustrations show people of different ethnicities.

  - General public materials -- many in English and Spanish include:

    The Bay Begins at Your Front Door! -- general information. This brochure has been adapted for use by Los Angeles County.

    Home Maintenance Tips for a Cleaner Bay -- focuses on main activities that the residential public can do to prevent stormwater pollution.

    Bugged and *Pests Bugging You?* -- safer pest control strategies and products.

    Keeping It All in Tune -- car repair and pollution prevention tips.

  - Materials for businesses are thorough, and target the automotive industry, and industrial companies/construction and restaurants.

    Guidelines for Vehicle Service Facilities is a series of BMPs prepared and produced by Bay Area wastewater treatment plants and stormwater management agencies including the counties of Santa Clara, Alameda, San Mateo and San Francisco.

    Good Cleaning Practices to Protect Our Creeks and Bay is a restaurant package for the food industry that includes a thorough brochure (somewhat similar to a menu in appearance) of BMPs; a four-color, two-sided poster of good illustrations of BMPs (can be displayed vertically or horizontally, depending upon the space available); and wipes clean, multi-language checklists of BMPs to hand out to employees.

    Blue Print for a Clean Bay. Best Management Practices to Prevent Stormwater Pollution from Construction-related Activities is a BMP booklet for all construction activities. Research of existing materials found that this booklet has been adapted by several other programs. The booklet refers to additional resources for more detailed design information, and includes guidance in complying with the Construction General Permit.

Summary of Observations: San Francisco Bay Pollution Prevention Programs

- San Francisco's materials have been targeted at specific activities; and research has tested whether or not the campaigns using these materials have been effective. Two types of surveys were used in 1996 to measure effectiveness -- written and telephone questionnaires. The telephone survey indicated that 15 percent of city residents were aware of a home maintenance-targeted campaign called *Clean It!*. Results are still being determined from the written survey.

- *Clean It!* includes a wheel/fan of home maintenance BMPs for the residential target audience. This piece is highly visual, practical to use, includes numerous important telephone numbers and references to recycling centers, offers safe alternatives to toxic products, and succinctly explains how certain activities harm the San Francisco Bay. This has been translated to Spanish and Chinese. Similar wheel/fans are available for gardening and automobile maintenance.

- *Shop Information Package of Automotive Repair Businesses* is a good ready-reference package of BMPs for small auto businesses. It provides not only the applicable BMPs, the binder also includes a case study of a local success story and a list of vendors that provide supplies and services needed to comply with stormwater and pollution prevention requirements.

- The San Francisco Water Pollution Prevention Program prepared a binder of materials for automotive repair facilities. These materials included a *Green Wrench Guide* which has pollution prevention tips for auto repair and body shops; a checklist to help these businesses document hazardous materials and wastes; locations and phone numbers for recycling centers that take solvents, paint thinners, some solid wastes, and other auto services products; a case study of a business that saved money following the suggested BMPs; and a guide to vendors and services related to the industry. The materials also include a *Regulatory Agency Matrix for Automotive Repair Facilities*. The purpose of the binder of is to give enough information to overcome hurdles that might prevent auto shop managers and owners from following through with measures that prevent pollution.

- *Tips for Painting Contractors* is a comprehensive guide that describes BMPs for proper handling and disposing of paint waste. Options and phone numbers for more information are provided. The layout of the BMP brochure is attractive and easy for painters to follow.

- The city of San Francisco, which has a population of approximately 750,000, conducts one of the more multifaceted programs for targeting ethnic communities. This program has tried innovative ways of reaching the ethnic population. One of these was a series of workshops for Latina housecleaners that focused on messages that were secondary to the stormwater program but primary to the target audience. Because pre-workshop research showed that Latina housecleaners were more concerned about their health than the environment, the workshop taught stormwater BMPs in the framework of protecting the workers' health and well-being. The Los Angeles County Five-Year Public Education Plan may also need to present stormwater BMPs in terms of issues of primary importance to target audiences, such as protection of the health of families, neighborhood beautification, and cost savings.

- The San Francisco program created fan-style brochures for the Do-It-Yourselfers in the areas of pest control, home cleaning and maintenance, and automobile maintenance. These are extremely attractive and handy for users in the process of any of these activities.

- This program has also done a good job of documenting before and after public awareness. Public awareness surveys have been conducted to confirm the effectiveness of campaigns targeted at home and car BMPs.

Summary of Observations -- Bay Area Stormwater Management Agencies Association (BASMAA)

- *Pollution From Surface Cleaning*, produced in 1996 for mobile cleaners (steam and high pressure cleaners/wash the outsides of buildings, parking lots and sidewalks). This is an eye-catching brochure that first explains the pollutants of concern to mobile surface cleaners and the effects of improper disposal of wash water. The remainder of the brochure uses tables and easy to read bulleted summaries to demonstrate proper cleaning and disposal methods. The brochure was used in combination with training workshops that included a self-graded examination. Approximately 125 mobile cleaners were trained and certified in the first workshop.

- *Vehicle Service* brochure provides a set of comprehensive BMPs for vehicle service and maintenance facilities. It includes referral phone numbers for local agencies and an explanation of why pollutants from vehicle service facilities are a problem. This attractive brochure is easy to follow.

Summary of Observations -- Riverside County Flood Control and Water Conservation District

- Several materials including giveaways have been prepared by the District. Of particular interest is a videotape targeting new development and construction, which is suitable for most Southern California cities.

- This is the only video received for the research task that targeted a specific business; it is very good in that it is thorough and clearly communicates new development issues, construction BMPs, and long-term maintenance. It mentions Riverside, but subtly enough so that the video could be used by other stormwater public education programs.

Summary of Observations -- Sacramento Stormwater Management Program

- Overall, there were excellent materials and interactive displays for children.

- Posters are in Spanish and English.

- The program has a portable game that allows children to toss a ball into a "storm drain," it rolls through pipes and lands in clean water. This builds the connection between storm drains and nearby rivers. One potential drawback of the game is that children may think it is fun to drop balls down the storm drains and do it "for real."

Southern California Programs[13]

The City of Los Angeles began its stormwater public education program in 1993. It represented a departure from the earlier grassroots programs because of "unparalleled diversity of the population [that] creates a unique environment that poses as many challenges as it does opportunities."[14] According to the Public Information Director, the City has achieved its greatest successes with educational methods that reach large numbers of people with each effort -- such as radio programs for Spanish-speaking residents, a co-op outdoor advertising campaign with Los Angeles County which used billboards and bus shelter posters, and a bilingual school program that reaches hundreds of children at a time. The cost-effectiveness of each educational effort is essential in a market the size of Los Angeles.

[13] See Section 4 for a detailed discussion of Southern California/Co-permittee programs.
[14] City of Los Angeles, 1996 EPA Excellence Awards application

Managers[15] of other stormwater public education programs in California stated in interviews that, if they had to develop a program for Los Angeles County, they would use the media and advertising much more than they do in their own programs designed for smaller populations. Reasons cited were the size of the population and that, because Los Angeles County is a world center for the entertainment and advertising industries, residents are already conditioned to receiving messages via the media.

Heal the Bay, a major environmental organization in Los Angeles County, has an 11-year history of activism and accomplishment in cleaning up Santa Monica Bay. Its active stormwater/urban runoff public education program has:

- Effectively used the media to increase public awareness of the issue
- Established the organization as a credible source for the news media about stormwater issues
- Recruited visible spokespersons to communicate stormwater issues to the public and the media
- Effectively used political pressure to build support for regulatory decisions
- Produced creative, recognizable print and PSA materials
- Conducted a successful storm drain stenciling program, called the "Gutter Patrol"
- Provided authoritative technical expertise on scientific issues
- Effectively used the "carrot and stick" approach with agencies to promote water quality improvements

The Los Angeles County Department of Public Works has joined resources with both the City of Los Angeles and Heal the Bay in advertising, public education materials, and storm drain stenciling programs. While these united efforts were short-term (lasting up to six months) their positive results reinforce what can be achieved with messages delivered on a large scale.

[15]Managers of the Alameda County and Santa Clara Valley stormwater programs, August 1996.

Summary of Observations: State and National Programs

Chesapeake Bay (Maryland, Virginia, West Virginia, Pennsylvania, Delaware, Washington DC)

- Multi-jurisdictional, grassroots, highly targeted public education program for stormwater and pollution prevention issues.

- Materials were received from several agencies that focus on improving water quality of the Chesapeake Bay. The materials focused primarily on erosion control, nutrients and toxics as these are the three primary pollutants of concern. Some of the materials borrowed images created by the stormwater public education programs in Milwaukee, Wisconsin, and Bellevue, Washington.

- In addition to the print materials distributed by the Chesapeake Bay Trust and the four states in the watershed, public education has a strong grassroots emphasis. Storm drain stenciling, stream cleanups, and volunteer monitoring are major elements of the Chesapeake Bay program.

- Storm drain stenciling is similar to the programs in Los Angeles County.

- Stream cleanups organized and conducted by volunteers include education about urban stream ecology to emphasize ownership and understanding of the watershed.

- Volunteer waterway monitoring involves sampling specific water bodies for a range of characteristics. This program involves students, primarily in middle and high schools, but also elementary- and college-age volunteers.

- School outreach materials emphasize understanding of watersheds and are targeted to middle school students. Activities include interpreting topographic maps, building models and testing drainage under various conditions, solving a watershed puzzle, holding watershed races, planning and conducting a volunteer monitoring program, field trips and actual monitoring.

- The Bay is cleaner and marine life is rejuvenating; however, much public awareness must still be accomplished in the Chesapeake Bay area. A public awareness survey conducted in 1994 by the University of Maryland indicated that only seven percent of the population was aware that individuals caused water pollution.

- The state of Maryland has "Treasure the Bay" slogan on its license plates.

Southern Florida; Dade County

- Dade County, Florida, has a strong pollution prevention program that includes stormwater public education. The program is driven by the fact that Southeast Florida's only source of drinking water is the Biscayne Aquifer which lies three to 10 feet below the ground surface.

- The program combines several environmental issues: solid waste, wastewater, air pollution, energy conservation, household hazardous wastes, and stormwater/urban runoff. Support is provided to local businesses and industries because enforcement alone was not solving local pollution problems.

- Pollution prevention and BMPs were initiated at county facilities, which sent the message to the community that these actions were important to protect local environmental resources.

- Key elements of the overall strategy were workshops, printed educational materials, on-site technical assistance for county employees and local businesses, and integrating pollution prevention into enforcement agreements. One example of the outreach program is a "Solvent Alternatives Exposition" that brought together government and industry experts for a full day of workshops and featured vendor table-top displays.

- Success for this program is measured by participation in events. The program was reviewed by the National Association of Counties and was considered very successful in meeting its goals. The problems encountered by the program were related to availability of staff and the public's reluctance to make major changes.[16]

[16] "Preventing Pollution in our Cities and Counties," National Association of Counties, Fall 1995.

Great Lakes, Milwaukee, Wisconsin

- Wisconsin spent billions of dollars in the 1970s and 1980s on treatment plants and industries to clean up flows discharged to Lake Michigan and the Milwaukee River. To clean up stormwater runoff, a five-year public education strategy was prepared in 1994 by the University of Wisconsin with funding from the U.S. EPA.

- The public education program targets urban residents, local governments, and businesses/industry, and was well-documented in *"Spreading the Word on Storm Water -- A Strategy for the Milwaukee Area"*[17]

- Pollutant loads were calculated for the urban Milwaukee area. The calculations focused on sediments, nutrients, oxygen demanding material, bacteria, toxic pollutants, metals, pesticides, and other chemicals (e.g., PAHs, PCBs). While this technical information was documented, the report did not disclose how the information was ultimately used in the public education program.

- Research of existing pollution prevention practices and sources of information on water quality clearly helped shape the five-year public education strategy. A public awareness survey conducted in 1989 indicated a strong willingness to recycle oil, separate household hazardous wastes from trash, limit use of chemical fertilizers and weed killers, support ordinances requiring dog owners to clean up pet waste, and to route roof water to lawns rather than driveways.

- Elements of Milwaukee's five-year public education strategy built upon the willingness to implement these BMPs. The report stated that the public education strategy is intended to guide activities but should also be flexible in order to respond to new information and conditions.

- Evaluation of effectiveness is one of the major elements of the five-year plan. Evaluation methods include telephone surveys, focus groups, teacher evaluation forms, student test results, interviews with advisory committees, and business programs needs assessments.

[17] Southwest Area Water Quality Education, University of Wisconsin -- Extension, March 1994.

Puget Sound Water Quality Authority and King County, Washington

- The King County Surface Water Management Program has used many different strategies to build awareness and cooperation to protect local water resources, which include Puget Sound, local creeks and lakes. The Puget Sound Water Quality Authority implements a number of grassroots programs, including a Public Involvement and Education Grants Program that builds public stewardship of water quality.

- The King County Surface Water Management Program conducts a well-known stormwater public education program that focuses on one of the counties that borders Puget Sound.. The theme message is "Everyone lives downstream." The public education program follows the philosophy of empowering the public to act in the stewardship of water resources. The materials and outreach program targets a wide range of public interests and needs.

- The King County program includes:

  - Community Stewardship Grant-funded projects
  - Volunteer projects, including storm drain stenciling and volunteer monitoring
  - Citizen advisory committees
  - Public meetings
  - Student education for K-12 and college presentations
  - Public education using workshops and presentations
  - Targeted mailings
  - Stream signage
  - Public event displays
  - Media outreach

- The materials provided by King County included information about a business outreach program, encouraging the implementation of BMPs. They also included a newsletter that indicated an even broader public education program.

- The Community Stewardship program, active since 1988, has funded 88 projects and involved more than 2,700 citizens. In 1996, grant projects will remove invasive weeds from local creeks; create and install interpretive signage along one creek; create a Web page; create a volunteer monitoring program; distribute a watershed bike tour pamphlet and develop new educational watershed bike tour routes; coordinate monitoring and teacher training; create a watershed atlas; create and distribute a student-made brochure on community watershed stewardship; plant native species in a meadow; recruit and train urban youth in restoration projects; create a video on wetland birds; and build and maintain a native plant nursery.

- A local youth career center participated a "Businesses for Clean Water Program." The students' various language skills helped in promoting the program in the community: among them they spoke Cambodian, Vietnamese, Spanish, Samoan, and Russian. Businesses for Clean Water provides free publicity, window decals, and other incentives to businesses that implement BMPs related to stormwater and urban runoff.

- The King County program produced the best videotape for students of any reviewed in this research project. It was reinforced with an excellent teachers guide. The school materials support an activities-oriented program, rather than introduce new curriculum to the area's classrooms.

- A variety of teachers workshops are offered by the North Cascades Institute. Session titles include *Watershed Week for Educators, Where the Forest Meets the Stream, Aquatic Insects: Riparian Habitats and Stream Ecology*. The Internet is among the ways that teachers can find out about these workshops.

- Television advertising showed a man walking a fertilizer dispenser along the water's edge of a lake. The caption read: "When you're fertilizing the lawn, remember you're not just fertilizing the lawn." This advertising campaign was reinforced by programs sponsored by park rangers at the lakes targeted for protection.

- Developers and organizations such as the Boy Scouts and Girl Scouts joined forces to salvage native plants that would have been destroyed at sites slated for construction. Plants were replanted to stream banks and lakeshores that needed additional vegetative protection.

- Volunteers who monitor local water resources are trained in wetlands characteristics, hydrology, soils, wildlife, vegetation and the impacts of various land uses.

- Videotapes prepared for the general public combine groundwater protection and stormwater/urban runoff education.

- Puget Sound Water Quality Authority also has a diverse public education program, but the most outstanding effort is the Public Information and Education (PIE) Grants program that strives to involve community-based organizations, businesses, local and tribal governments, and schools:

  - The program has been an overwhelming success -- in the last nine years, the Authority provided more than $4 million in funding for 230 projects. The projects spread the word about clean water to at least 2 million people.

  - All applications for project funding must include a method of measuring success. The intent of this requirement is two-fold: there must be some tangible measurement of effectiveness for public funding and support for the program to continue; and by including this task along with the implementation of the project, the applicant learns important project management skills. In this way, the grants program gains from the community and gives back to the community.

  - The Authority found early in its creation that a variety of organizations and groups were asking for funding for their special projects. The Authority saw that many good ideas were being suggested by the public, and wanted to provide the funding. The grants program enabled this process to become formalized and well-organized.

- The PIE Grants program has evolved so that partnerships and alliances among groups with different missions are becoming commonplace. Projects aimed at involving a variety of ethnic groups, particularly non-English speaking people, have grown, and as a result language and cultural barriers are being bridged.

- The criteria for a PIE project are:
  - Move beyond "us versus them" attitudes and emphasize that good water quality is in everyone's best interest.
  - Emphasize interesting, innovative activities that involve people; put them in charge of decisions that lead to local action.
  - Be well-designed and clearly articulate effective methods for reaching identified target audiences.
  - Support cleanup and protection of Puget Sound waters.
  - Be carried out by groups which have demonstrated their abilities to implement the project they propose.
  - Clearly justify the expenditures.
  - Be guided by an advisory group that includes a cross-section of affected people (for example, a mixture of business people, local and government staff, citizen group representatives, and technical experts) as needed for the particular projects.

San Francisco Bay
Alameda Countywide Urban Runoff Clean Water Program

- The Alameda Countywide program has three main objectives: (1) to educate the public about non-point source pollution to eliminate illicit discharges, (2) monitor the quality of water in the storm drain system, and (3) to reduce urban runoff pollution by promoting BMPs.

- The program has developed partnerships among Co-permittees. In its newsletter, the County includes "City Spotlight," a regular feature that focuses on the efforts of local cities.

- Storm drain stenciling in Oakland, one of the participants in this countywide program, has been done in Chinese, Spanish and English.

- The countywide program manager suggests that first outreach efforts focus on those who most readily support stormwater/urban runoff pollution prevention: teachers who are enthusiastic about environmental issues and business leaders who are similarly positive about environmental responsibility. These people will carry the educational messages to many others and give the program momentum.

- The county program began by teaching basic BMPs, but has lately included a watershed focus. Groups are being formed to focus on the watershed of particular local creeks -- such as "Friends of San Leandro Creek." This aspect of watershed emphasis is highly localized and of a manageable scale; it is not equivalent to creating a WMA in Los Angeles County such as "Friends of the Entire Malibu Creek Watershed Management Area."

- The Alameda program received a second place award from the EPA for outstanding municipal stormwater program in 1994 for public education -- depth, creativity and effectiveness of the efforts were the judging criteria.

San Francisco Bay
Santa Clara Valley Nonpoint Source Pollution Control Program

- The Santa Clara Valley program has produced attractive, well-targeted public education materials that are used by many other stormwater public education programs. Research has shown that the most effective tool for communicating awareness of stormwater/urban runoff pollution prevention has been storm drain stenciling.

- The Santa Clara Valley program prepared focused pieces that explained BMPs for inspectors to use during visits to local businesses. As more public employees became aware of needs in the community for education about stormwater BMPs, they informed the Santa Clara Valley program manager and the necessary materials were developed.

- There are certain umbrella activities that are undertaken by the Santa Clara Valley program. Others that are more localized and hands-on are managed by the Co-permittees, such as taking an active role in school education programs in their individual communities.

- The program is restructuring its committee hierarchy. Since there were more subcommittees than were manageable, the organization is moving toward being staff-driven with a management committee that oversees decision-making.

- A community stewardship grants program will start up in Fall 1996. The budget will be $60,000.

- Measurement of effectiveness has not been easy. Surveys have been used to indicate public awareness, along with embedding a telephone number in newsletters monitoring response and tracking the number of people who sign in at events.

- This program is undertaking large scale advertising. Little advertising has been done to date, but advertising is considered important for the future to reach the large general public audience.

- Watershed educational materials are being created. Among the initial tools will be watershed maps.

- A fresh, crisp, unified corporate appearance is used in most Santa Clara Valley program materials. This clean overall "look" helps people remember the messages.

Section 7: Survey of Newspaper Coverage of L.A. County Stormwater/Urban Runoff Pollution and Related Environmental Issues

"All I know is what I see in the newspaper." That observation, made many years ago by humorist Will Rogers, could have been said today about stormwater/urban runoff pollution. In fact, surveys conducted in Los Angeles County and nationwide confirm that the media -- television, radio, advertising, magazines and newspapers -- are rated highest of all sources for the general public to learn about environmental issues (see Section 2). Because of their complexity, the deeper issues surrounding stormwater pollution have largely been covered by the press -- metropolitan, regional and local newspapers.

Los Angeles County-based newspapers -- especially the *Los Angeles Times* -- have reported on stormwater pollution for more than a decade. Press coverage increased in the 1980s, when organizations such as the Santa Monica Restoration Project (SMBRP) and Heal the Bay were formed and began drawing attention to the dangers of stormwater/urban runoff in the Santa Monica Bay. More recently, efforts such as Heal the Bay's annual water quality-based beach safety report card; annual Coastal Cleanup Day (September); and Gutter Patrol stenciling program have been featured on local television and covered in greater depth in the metropolitan and local press.

A review of recent newspaper coverage of stormwater/urban runoff pollution provides a baseline of the type and level of information County residents have already received. For the Five-Year Public Education Plan, this information will help form the basis of research and program strategies such as the direction of County resident and business-owner focus groups, the best times of the year to release information, and the development of key messages for collateral materials, advertising and general media outreach.

As a first step, a review of more than 200 articles covering stormwater/urban runoff in L.A. County-based newspapers[18] from 1994 to 1996 has been conducted. Preliminary results show approximately how many people have received information via newspapers; where they live and the papers they read; how much they may already know about stormwater pollution; reporters who write about the environment and/or who have shown continued interest in stormwater/urban runoff; authorities quoted or cited; and the general attitude of the press toward stormwater/urban runoff pollution.

[18] Articles from files of the Los Angeles County Department of Public Works and Heal the Bay.

Newspapers Surveyed: June 1994 -- September 1996

More than 20 newspapers carried stormwater/environmental articles in Los Angeles County communities from the far-northwest San Fernando Valley, to the Inland Empire, to the South Bay from June 1994 to December 1996. As anticipated, the greatest concentration was in the Los Angeles metropolitan area and coastal cities.

Following is a breakdown of the percentage of stormwater-related stories by each newspaper, each paper's average 1994-96 circulation and the number of impressions, which accounts for subscribers and "pass-along" newspaper readers such as subscriber-family members, business-subscriber employees and customers, and news-stand readers.

Newspaper	City/Area	Percentage	Circulation	Impressions
Los Angeles Times	L.A. Metro	50%	1.1 million 1.5 million	2.7 million (M-F) 3.7 million (Sun.)
The Outlook	Santa Monica	18%	26 thousand	65 thousand
Daily Breeze	Torrance/S. Bay	10%	82 thousand 122 thousand	200 thousand (M-F) 300 thousand (Sun.)
Daily News	S.F. Valley	5%	207 thousand 223 thousand	518 thousand (M-F) 559 thousand (Sun.)
S. Gabriel Valley Tribune	S. Gabriel Valley	3%	60 thousand 115 thousand	158 thousand (M-F) 288 thousand (Sun.)
Long Beach Press Telegram	Long Beach	2%	124 thousand 138 thousand	309 thousand (M-F) 345 thousand (Sun.)
Misc. Newspapers[19]	Los Angeles County	12%	50 thousand or less[20]	

[19] See listing on next page

[20] Except for L.A. Weekly; L.A. Reader; and La Opinion.

♦ Miscellaneous Newspapers Covering Stormwater/Urban Runoff 1994-96:

The Acorn/Calabasas
The Argonaut/Marina del Rey
The Beach Reporter
Easy Reader
L.A. Reader
L.A. Weekly
Malibu Surfside
The Malibu Times
The Metropolitan News Enterprise
The Observer
The Palisadian Post
The Santa Clara Signal
The Santa Monica Business Journal
La Opinion
San Pedro News Pilot
South Pasadena Review
Thousand Oaks News
Wilshire Independent
The Whole Life Times

Stormwater/Urban Runoff Issues Identified in the Press

The following summarizes the people, pollutants and issues that have been identified in the media over the past two years. While the public is somewhat familiar with this information, it is useful in identifying advocates and possible spokespeople and in formulating program messages for the Five-Year Plan.

♦ Major Focus and Most Coverage: Swimmer Health

By far, the major focus and greatest amount of coverage was given to Santa Monica Bay storm drain pollution and to Heal the Bay's cleanup efforts. The greatest concentration of articles[21] was the May-July 1996 announcement of Heal the Bay's monthly beach report card which gives grades "A-F" to County beaches for water quality/swimmer safety, alerts the public to unsafe beaches and highlights major stormwater/urban runoff issues. Typically, report card results are published near the end of May, to coincide with Memorial Day -- and the beginning of swimming season.

This year, these articles also tied in with the May 1996 release of the Santa Monica Bay Restoration Project's (SMBRP) landmark study which for the first time scientifically links storm drain runoff to illness. Several articles also combined this information with reporting on the July NPDES Permit hearings by the Regional Water Quality Control Board. It is noteworthy, however, that stormwater/urban runoff was identified as the number one pollutant fouling beaches and threatening marine life in only one of the articles reviewed, an editorial in the *San Gabriel Valley Tribune*.

[21] Nearly 10% of all articles reviewed.

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Concentration was in the *Los Angeles Times*, *The Outlook* and the *Daily Breeze* with additional articles, editorials and letters to the editor in the *Daily News, L.A. Weekly, La Opinion, San Gabriel Valley Tribune, Long Beach Post Telegram, Malibu Times, San Pedro News Pilot, Beach Reporter, Palisadian Post* and *The Argonaut*.

♦ Illnesses Identified:

Newspapers have published that storm drain-polluted seawater leads to a variety of symptoms and illnesses including:

- Sore throat
- Skin rashes
- Fever
- Chills
- Stomach flu
- Nausea
- Headache
- Viruses
- Bacterial infections

Importantly, several articles noted that swimming less than 100 yards from a storm drain poses the greatest health risk -- and in fact makes people sick -- and that risks are dramatically reduced the farther away swimmers are from storm drains. This is critical information -- and the first time anecdotal swimmer reports spanning more than a decade have been scientifically validated.

In a vital implication for the Five-Year Plan, it was also noted that swimmers tend to have cavalier attitudes about "dirty water" and often swim/surf in spite of the County's posted "No Swimming" signs. Given this attitude, it is possible that publishing the idea that swimming more than 100 yards from a storm drain is "OK" could possibly lead to reduced caution among swimmers, who generally lose distance perception while in the ocean. In addition, several articles quoted County Lifeguards as saying swimmers are more concerned about riptides than they are about the chances of getting sick.

As this applies to the Five-Year Plan, it would seem that health risks should be a component of messages to the public, particularly those in beach communities, despite the relatively widespread newspaper exposure given the link between storm drain runoff and illness. To determine the extent of the need for health risk-related messages, public awareness and attitudes will be further explored in focus groups and other research as the Five-Year Plan is developed.

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♦ Stormwater/Urban Runoff as Distinct From Sewage

Stormwater/urban runoff as a pollution source separate and apart from sewage was a running thread throughout the newspaper articles reviewed. Yet in proportion to other issues, this information was scanty, with approximately two percent of the articles covering it as a major issue. Most of the articles defining storm drains -- and their intended use as flood control -- were not directed at public education about the risks associated with pollution. In these articles, issues such as public health, community beautification and/or behavioral change were generally not mentioned or only mentioned as an aside.

Typical among these was a series of articles in July 1996 detailing L.A. Mayor Richard Riordan's $15 million plan to divert runoff from 14 storm drains to the Hyperion treatment plant to demonstrate support of the Permit. Rather than the risks to public health and communities, these stories focused on the City Council debates triggered by the Mayor's proposal.

There were also articles published in 1995 that covered the County's construction of the Hollyhills Storm drain. In fact, this latter article -- which focused on the inconvenience to nearby residents caused by the storm drain's construction -- was the only negative storm drain-related story of all the articles reviewed. Storm drains as flood-control mechanisms were also defined in articles written in 1995-96 which report on the debate over the County Department of Public Works' proposal to construct cement flood-control barriers adjacent to the Los Angeles River.

Given the relatively small amount of published information defining storm drains, it is likely that segments of the County population -- especially in inland communities -- are unaware that what goes into storm drains comes out untreated at the other end. As with the health issue, it is likely that measuring the level of public awareness will be part of the countywide baseline research that will be conducted during development of the Five-Year Plan.

♦ Regional Economic Concerns

Several sources, most notably those from the American Oceans Campaign, cited threats to the region's economy, to our $2 billion a year tourist business and more than 600,000 tourist-related jobs as a reason to address stormwater/urban runoff pollution. In one article, a County lifeguard is quoted as asking, "What messages do closed beaches give tourists?" In most articles, however, this concern was either ignored or not mentioned as a major focus. Again, research will tell us the extent of the larger business community's concern and resulting messages that need to be developed.

Level of Public and Business-Community Awareness

As reported in the media, the level of public awareness of stormwater/urban runoff pollution is low. In general, the public remains ignorant about the issues and indifferent about cleanup. A possible reason lies in the concentration of many efforts and outreach materials to beachside communities. The same observation holds true for small businesses, where it was noted several times that businesses responded only when organizations such as Heal the Bay and the watchdog group BayWatch contacted individuals, pointed out violations and compelled corrective action. Businesses identified in the press are restaurants, auto repair shops, gas stations, transportation facilities, freeways, streets, parking lots and construction sites, which are already targeted as major education campaign audiences. Overall, cost of corrective action was cited as a major concern of small business owners.

Advantages to the Program Generated by Media Coverage

There are several reporters, most notably James Rainey of the *Los Angeles Times* and *The Outlook's* Susan Woodward, who have covered the issue for several years and demonstrated extensive knowledge. These and other reporters have a generally positive attitude regarding the need to "clean up the act" countywide, their information is scientifically accurate and their articles strongly support corrective action.

That health risks of stormwater pollution have been reported in the media -- and that results of the SMBRP study have been published -- will add credibility to the campaign's messages. Again, determining how much information the public has read and/or retained will be explored during the program's developmental research phase. The same observation is true for the several examples of cleanup methods that appeared in the press and are listed below. How much information does the public know and retain?

Challenges to the Program Generated by Media Coverage

While newspaper exposure could raise public awareness of stormwater pollution as an issue, its concentration on beachfront areas could pose a challenge in developing the Five-Year Plan. As noted earlier in this report, inland residents and businesses have received far less information than those adjacent to the Pacific Ocean. The majority of articles reviewed focused on -- or emanated from -- communities adjacent to the Santa Monica Bay and other oceanside cities, with little or no attention to the inland rivers and creeks that have the same levels of pollution and that bring those pollutants downstream to the beaches and bays. Further research will determine how much people outside the communities near the ocean know about stormwater pollution, and in turn the level and type of education they will need.

And while newspaper stories make the public aware of the problem and the danger to health and the environment, these same stories indicate general apathy toward cleanup on a day-to-day basis. In fact, the most recent articles stressed one of the program's greatest challenges: solving the stormwater pollution problem depends on the everyday actions of hundreds of thousands of individuals.[22] To succeed, the public education program must reach the source of many people's motivations to change behavior -- and elicit that change. Following is a summary of the stormwater/urban runoff information published in the press that will be useful in achieving program goals:

♦ Local, California, Regional Authorities, Environmental and Political Figures Cited

James Alamillo, Heal the Bay Executive Assistant
L.A City Councilmember Richard Alarcon
L.A. City Councilmember Richard Alatorre
Ed Begley, Jr.
Ted Danson, American Oceans Campaign Founder
Julia Louis-Dreyfuss
Chuck Ellis, City of Los Angeles Stormwater Education Program Manager
L.A. City Councilmember Mike Feuer
L.A. City Councilmember Ruth Galanter
Mark Gold, Heal the Bay Executive Director
Nancy Golden, American Oceans Campaign
Roger Gorke, Heal the Bay Science Analyst
Dorothy Green, Heal the Bay founder
Robert Haile, USC School of Medicine (SMBRP Study)
Joan Hartmann, American Oceans Campaign (AOC)
State Senator Tom Hayden
Assemblyman Wally Knox (D-Los Angeles)
Maribel Marin, NRDC senior research associate
Bob Miele, L.A. County Sanitation District
Redondo Beach City Councilmember Bob Pinzler
L.A. City Mayor Richard Riordan
Gail Ruderman-Feuer, St. Attorney, NRDC
Robert Sulnick, American Oceans Campaign Executive Director
Terry Tamminen, BayKeeper
L.A. County Supervisor Zev Yaroslovsky

[22] *Los Angeles Times* editorial, "Individuals and Clean Water" July 17, 1996; *Los Angeles Times* feature story, "A Sea Change in Behavior Sought" by James Rainey, July 17, 1996; and the *San Gabriel Valley Tribune* editorial "Clean Oceans Start at Home," July 2, 1996.

♦ National Figures Cited

James Baker, Undersecretary, National Oceanic and Atmospheric Administration
Ross Baker, Rutgers University political scientist
Senator Barbara Boxer (D-Calif.)
Carol Browner, EPA Administrator
Senator John Chafee (R-RI) Chair, Senate and Environmental and Public Works Committee
Representative Jane Harmon (D-Palos Verdes)
Robin Roberts, Clean Water Network, Wash., D.C.
John Shanahan, environmental analyst for the Heritage Foundation
Representative Sherwood Rohlert (R-NY)

♦ Pollutants Identified

Restaurant food waste, grease and litter
Auto shops: Motor oil, radiator coolant & grease
Santa Monica Canyon horse corrals
Chemicals
Golf courses
Residential septic tanks
Fertilizer
Pesticides
Construction debris
Manufacturing solvents
Human and animal waste
Yard trimmings
Solvents
Metals, with lead and copper specified

♦ Cleanup Methods Cited

"Good housekeeping" practices in general
Restaurants constructing special drainage systems leading to treatment plants
Autoshops using solvents to neutralize oil-saturated runoff
Periodic Street sweeping
Watering lawns less often
Not dumping septic tanks into the storm drain system
Properly maintaining septic tanks
Heal the Bay Gutter Patrol
Catch basin stenciling
Controlling litter
Cleaning up oil leaks in driveways
Recycling used motor oil
Repairing broken sprinklers
Cleaning up after pets

Conclusions & Implications For The Five-Year Plan

The breadth of knowledge gathered in the "Issues, Pollutants and Materials" Report illustrates how much the stormwater/urban runoff prevention education movement has grown in the past several years. In addition, analysis of the information leads to some important conclusions that will serve as guideposts during the development of the County's Five-Year Stormwater/Urban Runoff Public Education Plan.

The County and the Co-permittees have discussed and acknowledge that a *coordinated* countywide education program must be implemented because of:

- The synergy the coordinated campaign will create -- and the potentially greater impact it will have on the region's highly mobile residents
- The need for simplified messages/concepts that tell people HOW to prevent stormwater pollution and influence them to act
- The research-based approach that should help the program to be strategic -- and increase its effectiveness and results
- The high-quality materials that can be created for a lower unit cost than if done individually by each Co-permittee
- Its flexibility in providing an overarching, consistent theme while allowing Co-permittees to retain their identity
- The limited resources (time, staff and funds) of most Co-permittees

Additionally, other stormwater pollution program managers interviewed from across the country recognize that stormwater/urban runoff pollution prevention campaigns are evolving beyond their grassroots outreach "roots." Program managers are looking for more in-depth research on target audiences to help ascertain motivational factors that will encourage behavioral change. And they know that not everyone can be converted to non-polluter status. They want to narrow the field so they can focus on those who *can* be converted -- and they want to reach those audiences in ways most likely to trigger response.

To this end, managers are wanting to implement more strategic social marketing programs, expanding beyond the traditional brochures and collateral materials to encompass mass media tools such as TV and radio advertising. For example, the Puget Sound, San Francisco Bay, Alameda County and the City of Los Angeles have all built research-based programs that utilize new and innovative media outreach approaches while still retaining important grassroots outreach efforts like brochures, "adopt-a-creek" programs and displays at community fairs.

Research shows, and managers agree, that stormwater public education has increased awareness. In fact, a recent study by the City of Los Angeles indicates that people recognize the difference between stormwater and sewage systems -- but they don't necessarily realize that stormwater is untreated when it reaches receiving waters. Therefore, it is time to expand and bolster the movement toward not only increasing awareness, but teaching people *how* to prevent pollution. For example, the stormwater/urban runoff prevention movement needs a meaningful and concise slogan or call-to-action that everyone can use with most any audience and get results. A slogan that does for the stormwater pollution prevention movement what "reduce, reuse, recycle" did for the recycling movement.

Moreover, as education outreach efforts are coordinated and expanded, it is necessary to clearly identify for the general public *why* stormwater/urban runoff pollution is so harmful -- so it becomes relevant, important and worth doing something about.

To better identify why stormwater pollution is harmful, more conclusive information about stormwater/urban runoff pollution must be obtained. This data will not only make the case to media, lawmakers and other influentials, but can be compelling to certain segments of the population just as concern for the rapid filling of landfills made a salable case for recycling with the general public.

For example, Santa Monica Bay Restoration Project's highly publicized, landmark research study offered the first conclusive evidence that there was a direct link between stormwater pollution and illness in swimmers. In addition, public agencies have continually monitored affected receiving waters and Heal the Bay has interpreted and publicized the meaning of the data to protect public health. However, additional research must be done to indicate not only which pollutants are found in receiving waters, but at what levels these pollutants are dangerous, and the specific ill affects they cause so that the public can be better educated.

For the countywide Public Education Program to succeed, it will take:

Research
Strategy
Creativity
Leadership
Teamwork
Vision
Commitment

In closing, while significant strides have been made in educating the public, the County and Co-permittees are taking on a challenging program -- the nation's second largest metropolitan area conducting a research-based, targeted outreach program to change the behaviors of a richly diverse population, and partnering with the largest number of Co-permittees known to ever be involved in a stormwater/urban runoff public education effort.

Aside from the expected program challenges of addressing ethnic, cultural, geographical and socio-economic diversity, there will be three greater challenges:

- discovering exactly what will influence behavioral change in the target audiences;
- measuring and documenting behavioral change; and
- demonstrating that the education outreach effort has indeed helped to reduce stormwater/urban runoff pollution.

Appendices: Glossary of Terms

Ammonium - Ionized ammonia found in human and animal wastes. Ammonium may be toxic to aquatic life depending upon pH, temperature and ionic strength of the water.

API - Asian Pacific Islander; representing Chinese, Vietnamese, Japanese, Korean and others who have come from countries in Asia and the Pacific Islands.

Best Management Practice (BMP) - The most effective and practical ways to control nonpoint sources of pollution from stormwater/urban runoff. Guidelines are usually provided to businesses to incorporate into their facility operation protocol.

Biochemical oxygen demand (BOD) - The amount of oxygen consumed in the biological process that breaks down organic matter in water. The greater the degree of pollution by organic matter, the higher the BOD. This pollutant depletes available oxygen in water for marine life.

Bottom-up approach - In public relations, this approach relies upon working with many groups of people to build support from "the bottom up." Also referred to as grassroots outreach.

Chlorides - Compounds of chlorine with another element or chemical group. The level of chlorides can affect the amount of dissolved solids/salts in water.

Circulation - Related to newspapers, magazines and other publications, this is the number of people who receive the paper directly through subscriptions..

Collateral - The variety of materials produced to support a marketing, outreach or public education program, such as videos, give-aways, brochures, newsletters, etc.

Community beautification - Cleaning up a community, especially litter control.

Corporate sponsorship - Funding provided by a corporate business to support a public education effort, usually in return for publicity.

Enteric virus - Disease-causing organisms that poses potential health risk to swimmers and waders exposed to polluted stormwater/urban runoff. Sources include leaking septic tanks, sewer lines, outdoor campers.

Environmental ethic - The willingness to protect the environment.

Environmental justice - The disproportionate burden of environmental impact on one group within a large community or region.

Evaluation instrument - The research tool used to evaluate, or measure, effectiveness or awareness; e.g., a survey or questionnaire.

Focus groups - A research method whereby small groups of people who have been pre-selected for specific characteristics such as where they live, their age or ethnicity, are convened to answer carefully focused questions. Their answers usually provide information on attitudes and behaviors to help guide a public education campaign.

Gatekeeper - Leadership role or allowing or disallowing information to pass from one group to another.

Heavy metals - This is a group of metals typically used in a variety of industrial applications, and associated with fuel combustion and automobile use. They are potentially toxic in high concentrations.

Impressions - Related to newspapers, this is the number of people who read the paper; it includes not only those who subscribe and purchase it, but also those who share the copies.

Interpretation - Translating not only the words written in English to another language, but also adapting materials to reflect cultural differences to ensure that the translation reflects what was actually meant. Not all words and phrases translate directly to another language without some means of interpretive correction.

Laddering - A research method designed to reveal a more complete and personal view of the public than is possible through traditional qualitative and quantitative techniques.

Land use - Activities that dominate an area, such as residential housing, commercial businesses, etc.

MRI data - Demographic collection of people who utilize a certain brand or product (e.g., fertilizer users or who buy Pennzoil motor oil). This demographic data group is then cross-referenced with the type of mass media that they normally use - newspaper, TV, radio, etc. In this manner, if a campaign is targeting homeowners who normally change their own oil, the type of people who buy motor oil can be categorized and then a media buy can be specifically targeted to the publications, TV, radio most likely to reach them.

New development - Planning and design of developing raw land into a new land use.

Nitrate - A form of nitrogen used by algae. Excessive concentrations result in nutrient enrichment and algae blooms.

Nitrite - A form of nitrogen that is toxic to aquatic life. Nitrites and nitrates are common by-products; bacterial breakdowns of organic matter. This process is called mineralization.

Nitrogen - Typical nutrient.

Nutrient - Includes fertilizers, runoff from livestock (e.g., horse corrals), detergents, etc. Excessive nutrients can cause algae growth. Algae can compete with other marine life for oxygen.

Organic solvents - Products used for heavy, industrial-strength cleaning. These can impair the health of aquatic habitat.

Overarching theme - A major theme that provides the "look," slogan graphics, etc. for a public education campaign.

Oxygen demanding substances - Materials that consume oxygen in water and will deplete oxygen content of receiving waters. They typically come from plant debris, animal waste, street litter and organic matter. These substances reduce the amount of oxygen available to aquatic life.

Pathogenic bacteria - Disease-causing organisms that pose potential health risks to swimmers and waders exposed to polluted stormwater/urban runoff. Sources include leaking sewer lines, illegal sewer connections or dumping, malfunctioning septic tanks, outdoor campers. Carried to beaches via storm drain runoff.

Phosphorus - A typical nutrient. Commonly found in fertilizers and detergents. It can cause excessive vegetation or algae growth, resulting in impaired use of water.

Pollutant load - A calculation of the volume of specific types of pollutants on an area of land.

Pollutant of concern - A pollutant that is known or believed to cause environmental harm.

Polychlorinated biphenyls (PCBs) - A group of 209 compounds, commonly used in electrical insulation and heating/cooling equipment. PCBs have been banned since 1979. Among the most persistent and toxic of organic compounds; biomagnifies. Accumulated in sediments, the most persistent and toxic of organic compounds; causes contamination of seafood.

Polycyclic aromatic hydrocarbon (PAH) - Results from incomplete combustion of organic compounds because of insufficient oxygen. PAHs are associated with oil and grease and other petroleum products, and are potent carcinogens and mutagens.

Sediment - Results from erosion, land grading activities. Soil particles suspended in and carried by water. Sediments can smother tidepools and artificial reefs, resulting in sedimentation of coastal lagoons. Can be a problem in some areas with limited circulation.

Segmentation research - Understanding where the messages will have the greatest impact and where they will have little or no impact can be achieved by conducting segmentation -- or laddering -- research. This type of research assesses the degree to which various groups of people are part of the problem, their susceptibility and suitability to different messages, and their willingness or lack of willingness to try new behaviors.

Social marketing - The use of corporate marketing strategies and tactics to influence voluntary behavioral changes in target audiences.

Stakeholder - Person who have a vested interest in something, such as a watershed. A stakeholder can be a land owner, resident, business interest, public agency, environmental organization, etc.

Stewardship - The act of taking responsibility for something, such as trying to improve the water quality in a creek, watershed, or storm drain system.

Sulfates - A salt of sulfuric acid.

Survival issue - Refers to status of a business, particularly one that is struggling to keep its doors open.

Target audience - The group of people targeted for public education, e.g., residents, small business owners.

TBT (Tri-butyl tin) - Very toxic pollutant found in anti-fouling paint; restricted in 1987. Bioaccumulates in all organisms.

Top-down approach - In marketing/communications, this involves using a mass-media strategy (TV, radio, outdoor advertising, print) for public education.

Total dissolved solids (TDS) - The volume of solids that are dissolved in water and carried through the storm drain system. The source is both erosion and organic matter; excessive TDS can interfere with aquatic life functions.

Total suspended solids (TSS) - The volume of solids that are suspended (not necessarily dissolved) in water and carried through the storm drain system. The source is erosion, organic matter and litter/debris. Excessive TSS can impair natural aquatic life functions.

Toxic material - Pollutants that can poison the environment.

Volatiles - Substances that evaporate at low temperatures. Examples are solvents and dry cleaning fluids. Some can cause toxicity in the environment.

WMA - Watershed Management Area.

Water Quality Assessment - An assessment of the condition of water bodies, including an identification of the particular pollutants of concern measured in them. This is a requirement of the Basin Plan.

Watershed - The land area that drains into a river, lake, or ocean.

Appendices: Databases

Comprehensive databases of (1) events, (2) VIPs, and (3) media are being developed in conjunction with the Five-Year Plan. The databases will enable continual tracking and response to implementation of scheduled events, outreach to key opinion leaders and media coverage.

♦ Event Database

This database will provide a complete listing of Los Angeles County events, from the L.A. County Fair to community grassroots festivals, and from trade shows to symposiums and seminars. This database will be coded by target audience/industry, attendance, geographic locale, date and frequency, with an emphasis on annual events. Utilization of existing events will provide maximum cost-effectiveness while bringing the stormwater pollution prevention message to a great number of people at one time.

The event database will be updated throughout the program, making it a "living document" that will enable strategic targeting of events for Program outreach and materials distribution. In addition, the database is structured so it facilitates tracking/monitoring of attendance, materials and benchmark Program response.

Event database sample categories:

Art festivals
Auto shows and races
Boating shows and races
Commercial construction
Craft shows
Dog shows and races
Engineering/architectural shows
Entertainment/performances
Environmental expos
Fairs, carnivals
Health and fitness
Home and garden, decorating and remodeling
Parades
Restaurant trade shows
Sporting events

◆ VIP Database

The VIP database will identify key environmental authorities, researchers, scientists, national, state and local political leaders, and key city staff/managers of the Co-permittees and other cities with notable stormwater programs. The database will be designed to sort by title, category (e.g., politician, expert, city staff) geographical location, and field of expertise.

These types of detailed lists will facilitate tracking and continuing relationships with spokespeople, movers/shakers and potential public/private partners. It will also allow near-immediate action on key events, breaking news, crises and emerging issues.

VIP database sample categories:
Local, state and national elected officials
Key city employees (mayors, city councilmembers, city managers, directors of public works, stormwater program managers)
Environmental experts, scientists, marine biologists and researchers
Construction/developers, restaurant, automotive and other industry leaders
Trade associations
Community activists
Special interest group leaders
Celebrities

◆ Media Database

The media database will be a comprehensive listing of Southern California electronic and print media outlets and the key media reporting on the environment, business and economy as it relates to the environment and lifestyle.

The media list will facilitate tracking coverage and County responses in the form of letters to the editor and opinion pieces. It will be sortable by reporter name and publication/outlet, geographic location, and reporter interest/expertise.

Media database sample categories:
Major Los Angeles County daily newspapers
Weekly community newspapers
Trade and special interest publications
Network and independent television stations
Cable television stations
Radio stations and specific talk shows/hosts

Appendices: Cities with Public Education Materials and BMPs Related to Stormwater

Public education materials and BMPs related to stormwater/urban runoff issues and pollution prevention were collected from 125 jurisdictions, agencies, organizations and individuals in the United States and Australia:

Alameda Co. Urban Runoff Clean Water Prog.
Albuquerque, New Mexico
Ashville, North Carolina
Assoc. for Environmental & Outdoor Education
Bay Area Stormwater Mgmt. Agencies Assoc.
Bellevue, Washington
Bellflower
Benicia
Boulder, Colorado
Calabasas
California Chamber of Commerce
California Coastal Commission
California Coastal Conservancy
California Conservation Corps
California Dept. Of Toxic Substances Control
California Dept. Of Water Resources
California Integrated Waste Management Board
California Lifeguard Program
California Museum of Science and Industry
Caltrans
Carson
Cedar Falls, Iowa
Center for Environmental Education
Center for Marine Conservation
Center for Marine Studies
Center for Urban Ed. About Sustainable Agric.
Central Contra Costa Sanitary District
Central Marin Sanitation Agency
Chesapeake Bay, Maryland
Common Ground for Environment
Concrete Products Industries
Covina
Culver City
Davis
Earthspirit
East Bay Municipal Utility District
EPA -- California
EPA -- U.S.
Gardena
Glendale
Greenville, Texas
Gold Ridge Resource Cons. Dist.
Sen. Tom Hayden
Hermosa Beach
Highlands, New Jersey
Hydrosphere Ocean Opportunities
Inland Empire West Resource Cons. Dist.
King County (Seattle) Washington
Lake Michigan Federation
Lee Co. Div. Of Natural Resources
Lindsay Museum
Livermore
Long Beach
Los Angeles, City of
Los Angeles, County Public Works
Los Angeles Conservation Corps
Louisiana Dept. of Env. Quality
Lower Colorado River Authority
Madison, Wisconsin
Malibu
Manhattan Beach
Mendocino County Resource Cons.
Metropolitan Washington COG
Metropolitan Water District of So. Calif.
Miami, Florida
Mississippi River Basin Alliance
Montana Watercourse
National Park Service
National Project Water Ed. For Teachers

National Oceanic & Atmosph. Admin.
New Bedford, Massachusetts
New York State
Northeastern Illinois Planning Comm.
Olympia, Washington
Seattle, Washington
Sunnyvale
Surfrider Foundation
Orange County
Palo Alto
Phoenix, Arizona
Portland, Oregon
Providence, Rhode Island
Puget Sound Water Quality Auth., Washington
Pomona
Rancho Cucamonga
Redondo Beach
Renew America
Reynolds Metals Co.
River Voices/River Network
Riverside Co. Flood Control & Water Conser.
Sacramento, City & County
San Bernardino
San Diego
San Francisco
San Francisco Estuary Institute
San Jose
Santa Catalina Island Conservancy
Santa Clara Valley Nonpoint Source Pollution Control Program
Santa Monica
Sarasota, Florida
Sierra Club
Surfers' Environmental Alliance
Sydney, Australia - Clean Up the World
Tallahassee, Florida
Terrene Institute, Virginia
TreePeople
Trenton, New Jersey
U.C. Santa Barbara
U.S. Coastal Guardian Campaign
U.S. Navy
Vallejo
Ventura County
Video Project, The (Oakland)
Washington Environmental Council
Washington Toxics Coalition
Water Education Foundation
Water Environment Federation
West Hollywood
Western Lake Superior San. District
Wisconsin Dept. of Natural Resources
Worchester, Massachusetts

Selling Behavioral Change

One of the best ways of explaining the difference between traditional public education and social marketing can be found in the article *"Selling Good Behavior"* from the November 1995 issue of *American Demographics* magazine. In it, Fred Kroger, a communications specialist at the Centers for Disease Control, explains a problem with some public health outreach efforts: "We pass out the truth and expect everyone to recognize it."

He goes on to illustrate his point by highlighting the publicity efforts surrounding the Surgeon General's 1964 report on the ill effects of smoking. Publicizing that report did persuade millions of Americans to quit smoking. However, today, one in four adults still smokes. Now, social marketing programs are in place throughout the country to target segments of the smoking population with messages that will influence them to quit. In addition, highly-focused campaigns are being executed to persuade segments of the youth population most at risk of smoking to never start.

♦ Conducting Social Marketing Programs

A good model for creating a social marketing program comes from an article in the *Journal of Public Policy & Marketing,* April 1994.

- Program managers understand the target audience's needs, wants, perceptions, and present behavior patterns before acting, in many cases through the use of specific formative research. Managers do not make assumptions about these characteristics.
- Program managers segment target markets wherever politically feasible and devise budgets and strategies that are specifically adapted to the characteristics of each defined segment.
- Whenever economically feasible, all major elements of program strategy and tactics are pre-tested with members of the target audience.
- Program managers conceive of the decision process by which target consumers come to undertake a target behavior as comprising the following steps.

  1) Acquire the necessary knowledge to be aware of the option

  2) Embrace the values that permit the behavior to be considered for adoption

  3) Perceive the behavior as potentially relevant to their own circumstances, those of a member of their family or those of the broader society

4) Conclude that the positive consequences of the behavior exceed the negative consequences to a degree that is superior to realistic alternatives

5) Believe that they have the ability to carry out the action

6) Believe that others who are important to them support their action

- The program explicitly recognizes that it faces direct or indirect competition for the target consumer's behavioral choices.

- Strategies designed to effect behavioral change always comprise all four elements of the marketing mix (The Four Ps = **P**roduct, **P**lace, **P**rice, and **P**romotion)

Product -- Design of a product (i.e., the behavior to be promoted) that is fully responsive to the target consumers' needs and wants, in other words, that is easy and satisfying

Place -- Making the place at which the behavior can be carried out convenient and accessible

Price -- Minimizing to the extent possible the economic, social and psychological price of the behavioral change

Promotion -- Seeking to promote the behavior with messages through personal or impersonal media appropriate to the target audiences lifestyle patterns and preferences